Lin-Lin Chen, Loe Feijs, Martina Hessler, Steven Kyffin, Pei-Ling Liu, Kees Overbeeke, Bob Young

Design and semantics of form and movement

DeSForM 2009

Program DeSForM 2009

Monday, October 26

11.00 - 12.00 Registration

12.10 - 13.10 Welcome Lunch

13.20 - 13.30 **Opening**
Lin-Lin Chen and Pei-Ling Liu

13.30 - 14.20 **Keynote Speech**
DeSForM: A Short History of a Design Conference
Steven Kyffin

14.30 - 15.30 **Paper Presentation 1**

Semantics session at IB201 (pp. 12-38)

1. Commutative product semantics
2. Occult, a tooth, and the canopy of the sky: Conceptualizing visual meaning creation of heavy metal bands
3. Exploring contradictory meanings in product semantics

Interaction session at IB202 (pp. 82-113)

1. Social radio: Designing everyday objects for social interaction with ambient form
2. Bringing back real-world richness in interactive story reading: Lessons from LinguaBytes
3. Designing for persuasion in everyday activities

15.30 - 15.50 **Session Discussion 1**

15.50 - 16.10 Tea Break

16.10 - 17.10 **Paper Presentation 2**

Representation session at IB201 (pp. 135-162)

1. Phorigami: Visualization of digital photo collections by origami arts
2. Designers' perceptions of typical characteristics of form treatment in automobile styling
3. Computer morphing as an effective approach to develop successful products half a step ahead of the market

Ambient session at IB202 (pp. 114-134)

1. Product adaptivity through movement analysis: The case of the intelligent walk-in closet
2. Using light, sound, and ripple motion to design the ambient display environment
3. The relationship between architectural media and elements: The emerging undefined digital architectural elements

17.10 - 17.30 **Session Discussion 2**

Program DeSForM 2009

Tuesday, October 27

08.30 - 09.00 Registration

09.00 - 09.50 **Keynote Speech**
Form is Void and Void is Form
Yi-Ping Hung

10.00 - 12.00 **Interactive Demos**

12.00 - 13.00 Lunch

13.00 - 14.40 **Paper Presentation 3**

Semantics 2 session at IB201 (pp. 39-81)

1. Rationalizer: An emotion mirror for online traders
2. The triggered association from motion
3. User-generated product semantics: How people make meaning from objects in the state beyond saturation
4. How people manage objects with shelves : Storage and forage
5. Categorizing product meaning: An investigation into the product language of clothing and fashion

Method session at IB202 (pp. 163-203)

1. A study on the application of story mapping to the innovative product design model
2. Embodied explorations of sound and touch in conceptual design
3. For future use: An initial categorization of designers' speech-accompanying gestures
4. Choreographic methods for creating novel, high quality dance
5. Making meaning: Developing an understanding of form in distance design education

14.40 - 15.00 **Session Discussion 3**

15.00 - 15.30 Tea Break

15.30 - 16.20 **Keynote Speech**
Creating Meaning in Systems Design
Philip Ross and Joep Frens

16.20 - 16.40 **Farewell** and Announcement next DeSForM Conference
Lin-Lin Chen and Steven Kyffin

Foreword

DeSForM 2009

Welcome to DeSForM 2009, an international workshop on Design & Semantics of Form & Movement. After four successful workshops in Europe, DeSForM has gone global and comes to Asia. This year, the College of Design at National Taiwan University of Science and Technology and the INSIGHT Center (INnovation and Synergy for IntelliGent Home Technology) at National Taiwan University jointly host the 5th DeSForM workshop in Taipei, the capital city of Taiwan.

DeSForM was initiated in 2005 by Philips Design, the Industrial Design Department at the Technical University Eindhoven, and the School of Design at Northumbria University. The conference aims to bring together researchers and practitioners to share findings about the aesthetics and meanings of human-object interactions. By going global in 2009, DeSForM seeks to expand the platform to encompass participants from the East and the West, and to look further into the cultural influences on object forms and movements. In coming to Taipei, DeSForM encourages reflection on the challenges faced by Asian designers and, in particular, Taiwan designers stemming from the pursuit of their own design languages and identity as the region works to transform itself from a manufacturing-based to an innovation-based economy.

DeSForM 2009 consists of the main program and a pre-conference, two-day workshop. In the main program, we are privileged to have three keynote addresses:

Prof. Steven Kyffin of Philips Design, one of the initiators of DeSForM, will introduce the founding ideas and review the progress made in the series of conferences.

Prof. Yi-Ping Hung, Director of the Graduate Institute of Networking and Multimedia of National Taiwan University, will present his works that successfully blend technology and culture in a talk entitled “Form is Void, and Void is Form.”

Dr. Joep Frens and **Dr. Philip Ross** from the Technical University Eindhoven will present “Creating Meaning in System Design.”

This year, 22 papers and eight interactive demos will be included in the proceedings and were accepted for presentation/exhibition in the conference. Among the accepted papers and demos, 14 come from Europe and North America, and 16 come from Asia and the Pacific, providing an overview of the research on aesthetics and semantics in the West and in the East. In addition, Dr. Joep Frens and Dr. Philip Ross run a two-day, pre-conference workshop entitled “Rich and Aesthetic Interaction: Learning from Doing.”

We would like to thank all the authors for choosing DeSForM 2009 for the presentation of their research and creative designs. We are deeply indebted to the reviewers for their invaluable contribution in establishing a high standard for the conference. Our special thanks go to the local organizing committee–Prof. David Sung, Prof. Regina Wang, Prof. Jeng-Neng Fan, Prof. Rung-Huei Liang, Prof. Hsien-Hui Tang, Dr. Yaliang Chuang, Prof. Ming-Huang Lin, Prof. Kuan-An Hsiao, and Dr. Jenn-Feng Li–for their dedication and hard work throughout the many months of preparation for the conference.

We hereby offer the 5th DeSForM proceedings, under the auspices of IFIP, Design Research Society, Chinese Institute of Design, Taiwan Institute of Kansei; with sponsorship and support from Philips Design, National Science Council (Taiwan), National Taiwan University of Science and Technology, National Taiwan University, Technical University Eindhoven, Northumbria University, and Hochschule für Gestaltung Offenbach am Main.

We hope that you will be inspired by the keynote addresses, presentations, demonstrations, discussions and debates in this conference, and will return to attend the 6th DeSForM workshop next year.

26 October, 2009

Lin-Lin Chen, National Taiwan University of Science and Technology, Taiwan
Loe Feijs, Technical University Eindhoven, the Netherlands
Martina Hessler, Hochschule für Gestaltung Offenbach am Main, Germany
Steven Kyffin, Philips Design, Eindhoven, the Netherlands
Peiling Liu, National Taiwan University, Taiwan
Kees Overbeeke, Technical University Eindhoven, the Netherlands
Bob Young, Northumbria University, Newcastle upon Tyne, Great Britain

A short history of a design conference

Steven Kyffin
Affiliation:
Senior Director,
Company Design
Research
Philips Design,
Eindhoven,
The Netherlands

Abstract

Way back in 2004, three of us were intrigued by the notion that the nature of things, the essence of what a fabricated object is, was about to be – and really should be – completely and fundamentally questioned, re-defined, and exploded. We knew our current conceptions needed to be shattered once and for all so that we could be truly creative in how we contributed to the conceiving of the NEW THINGS. We were intrigued because the three of us were working in three very different practicing contexts and represented somewhat different aspects of the design disciplinary spectrum. If we truly accumulated the views and the abilities we had in conceiving of ideas and things, then surely the results would be very, very different, and might even be important in driving the practice and discipline of Design forward in some way. Even more important is that we quickly concluded that we could not be the only ones to have had these thoughts! The only way to find out, we concluded, was to offer to host an event, a little conference, to enable all comers to share and build on the thoughts they we having and exploring in the territory we were all unraveling together.

In 2005 DeSForM was born!

We still believe that DesForm is the first international conference seeking to present current research into the nature, character and behavior of emerging new typologies of co-designed, content rich, connected and intelligent objects within adaptive systems. It aims to bring together researchers in the many related fields of design to assess the outcomes of this research and begin to identify issues and territories for future investigation and exploration. Our original working premise for this research was that forms, either concrete or abstract, always carry or mediate meanings. It is the responsibility of designers to make good use of these meanings, for example, to make products beautiful, to stress the importance of certain values, or to improve a product's ease of use. Further, it should promote or negotiate enriched experiences between people (communities) and people, people and objects, and in time between objects (systems of objects) and objects. Design uses its own languages for this purpose, just as poets, painters, journalists, sculptures, filmmakers and other artists do. Objects, whether hard, soft or digital, are still being designed using a mono-sensorial approach rather than a multi-sensorial approach. Design has long since practiced and developed its ideas on a cultural platform, rather than merely on a technological, marketing or a financial and business base. Understanding people, not as a single intellectual or physiological entity, but rather as a member of a cultural expression within a socio-political paradigm or 'world-view' is the essence of this cultural platform, which is why this year in 2009 DeSForM is hosted outside of Europe, here in Asia.
Here, through DeSForM 09, we can open even more widely the debate on what it means to represent or mediate ideas, function, and intelligence in a particular cultural context through a new language which has not hither to been over-run with modernist Western nuances, idioms and formal icons from bygone eras. Particularly this year in this Asian context, we can debate how objects, whether digital or physical, are moving from a functional relationship with us to a cultural and empathetic relationship—from short term 'forgettable' relationships to long term, sustained relationships.

As objects are beginning to be considered as part of multi-dimensional ECO system (potentially being physically, digitally and behaviorally different in nature) we need to be questioning how and out of what we could be creating them; and how might they be manifested over time through use by different hands and in different contexts? If we explore this new complexity in objects, we believe that we need to know how to 'read' the objects and how to design them to be read in the way we intend, irrespective of additional readings or meanings which people might add and re-appropriate. Tomorrow's objects, we expect, are in a continual state of becoming. As if this were not enough, we also challenged ourselves with the ambition to develop precise formulation of new theories and subsequent tools and processes which design thinkers and practitioners alike could work with in the creation of such new possibilities. For example, some 20 years ago, researchers started working hard to put most of the 3D and material design elements (engineering drawings, stress analysis, production manufacturing simulations and so on) into the language of the computer, which is why we have CAD now. Our ambition is to seek to promise the next contemporary breakthroughs of similar impact in the face of today's new realities.

What shall they be…?

In conclusion, the original three founders became five and it is our ambition that this key note will revisit the premise which DeSForM was built upon and provide a little glimpse of the main points of debate over the past years as a means to launch us into the heady challenges we have to share though the papers presented in the next few days.

Steven Kyffin is Senior Director of Design Research & Innovation at Philips Design. In this function he is responsible for the Design Research program within Royal Philips Electronics, and for the Ideas (innovation) Engine at Philips Design. Design Research is the domain of knowledge and competence building in the design-related domains of socio-cultural trends, cultural contextualization and understanding emerging technological (ICT) and material developments. He is also responsible for identifying new strategies in brand design, design-led innovation, as well as the more 'traditional' design practice disciplines such as product design, graphic & communication design, user interaction and interface design. The Ideas Engine is the key contributor for fuelling Philips' new business "Incubators." These Incubators generate future product service solutions and build upon IP territories across the entire Philips portfolio.
Before joining Philips in 1998, Steven was Director of the Industrial Design Master's program at the Royal College of Art in London for three years. There, he initiated and directed PhD studies and collaborative projects with major international and UK institutions. These projects saw the integration of design, engineering and cultural disciplines. Prior to his appointment with RCA, he ran his own design consulting company.
In addition to his current responsibilities, Steven is a member of the Philips Design Global Leadership Team. He also holds a number of adjunct professorships from leading design universities in Europe and Asia.
He is regularly published in conference papers and as a contributing author to books, and is often invited to give keynote speeches at international conferences. Steven plays an active role across a number of leading design universities. For example, he is Visiting Professor at the University of Northumbria, Hong Kong Poly U & the Southern Yangtze University in Wuxi Shanghai.
He also sits on a number of other university faculty steering & review boards.
Steven was born in Hong Kong and currently lives in Eindhoven, the Netherlands. He received his Master of Design, Industrial Design, Royal College of Art, London, in 1984 and was awarded an Honorary Doctorate in Design in 2009 from Northumbria University.

Form is Void and Void is Form

Yi-Ping Hung
Affiliation:
Professor and Director
Graduate Institute
of Networking and
Multimedia
Department of
Computer Science and
Information Engineering
National Taiwan
University

Abstract

Whenever there is perception of form, there is fraud. When you think you know something, you actually do not know it, for you are seized by the form of knowing something. When you feel you are not knowing anything, you begin to know something. In the ivLab (Image and Vision Lab) at National Taiwan University, we try to utilize multimedia technology to bring out the user's consciousness of form and void, and to guide the user back to oneness and peace, or at least to the pathway leading to oneness and peace. In our recent work "I am," we used a gaze tracking device to record and analyze the intent of a participant when he or she was browsing a colorful cabinet, and then suddenly displayed a digitized self portrait between the user and the cabinet. This was done to invite the participants to contemplate their volition and consciousness. In another interactive work, "Breathing between Present and Past," we made it possible for museum visitors to revive a famous rusty artifact by touching a virtual display of the artifact. The visitor could only be successful, however, if he or she had breathed slowly and deeply in sync with the breathing of the artifact (rendered with computer simulation) for a certain period of time. It was hoped that breathing could function as a bridge between form and void, and could help to build a good connection between the museum visitors and the museum artifacts. In our current project "i-m-Space," which is an Interactive Multimedia-enhanced Space for the rehabilitation of post-surgery breast cancer patients, we again use breathing and touching as the interaction elements for relaxation and rehabilitation. Some of our other related works will be introduced in this talk, including virtual touch panel, 3D magic crystal ball, eFovea, i-m-Top, and i-m-Tube.

Yi-Ping Hung received his B.S. in Electrical Engineering from National Taiwan University in 1982. He received an M.S. from the Division of Engineering, an M.S. from the Division of Applied Mathematics, and a Ph.D. from the Division of Engineering, all at Brown University, in 1987, 1988 and 1990, respectively. He is currently a professor in the Graduate Institute of Networking and Multimedia, and in the Department of Computer Science and Information Engineering, both at National Taiwan University. From 1990 to 2002, he was with the Institute of Information Science, Academia Sinica, Taiwan, where he became a tenured research fellow in 1997 and is now a Joint Research Fellow. He served as a deputy director of the Institute of Information Science from 1996 to 1997, and received the Young Researcher Publication Award from Academia Sinica in 1997. Since 2007, he has served as the director of the Graduate Institute of Networking and Multimedia at National Taiwan University. He was the program co-chair of ACCV'00 and ICAT'00, and the workshop co-chair for ICCV'03. He has served on the editorial board of the International Journal of Computer Vision since 2004. His current research interests include computer vision, pattern recognition, image processing, virtual reality, multimedia system and human-computer interaction.

Creating meaning in systems design

Philip Ross and Joep Frens
Affiliation:
Assistant Professor
Designing Quality in Interaction Group
Department of Industrial Design
University of Technology Eindhoven
Eindhoven
The Netherlands

Abstract

The face of design is changing. The products we use increasingly become part of larger systems that connect multiple people with multiple technologies. This emerging field of 'systems design' presents design research with new challenges. How can design research deal with the complexity of multiple people and multiple products that are intricately connected? In this joint presentation, we explore systems design with a focus on the question of how to create meaningful interactions. This question is addressed from a specific theoretical point of departure that looks at action as generator of meaning in human-product interaction. Respect for all human skills, e.g. perceptual-motor, emotional, cognitive and social skills, is key in our approach. We observe that current systems design tends to resort to abstractions to deal with the complexity of systems (think of on-screen social software for example).
We see much potential for creating meaning in human-system interaction by capitalizing on human skills in a more physical way.
The projects 'Rich Interaction' and 'Ethics & Aesthetics in Interaction' are presented to illustrate our research approach, and to lay the groundwork for our venture into systems design. Both research-through-design projects feature innovative designs that allow people to meaningfully interact with products through expressive, physical action. Despite the fact that these projects stay in the domain of one product-one person interactions, they provide valuable insights for the creation of meaning in systems design. We present a set of systems design explorations based on what we learned in our previous research. These designs share the intention to capitalize on all human skills, including the physical. By reflecting on them, a number of new issues, insights and questions for systems design emerge. These reflections provide researchers with refreshing considerations for moving into the field of systems design.

Philip Ross was born in Deurne, the Netherlands on the 21st of May 1978. He studied Industrial Design Engineering at Delft University of Technology. In 2003, he received his Master's degree cum laude with the design research project "Making atmospheres tangible: A research-through-design approach for designing a tangible, expressive product." The project's final design was awarded the ZH Vormgevingsprijs at a Dutch student design competition. In 2004, Ross started at the department of Industrial Design at Technische Universiteit Eindhoven as a PhD candidate. During the spring semester of 2006, he was a visiting researcher and teacher at Carnegie Mellon University's School of Design in Pittsburgh, USA. He received his PhD degree cum laude in December 2008, with the dissertation "Ethics and aesthetics in intelligent product and system design." This dissertation explored how to incorporate ethics in the design of intelligent systems, focusing on interactive lighting systems. A resulting interactive LED lamp design was awarded an STW Valorisation Grant, a stimulation grant for commercialization. Philip Ross is currently Assistant Professor in the Designing Quality in Interaction group at the Eindhoven Industrial Design department. In addition to his work at the university, Philip is a passionate jazz guitar player.

Joep Frens was born on the 11th of September, 1974 in Amersfoort, the Netherlands. After obtaining his master degree in Industrial Design Engineering from Delft University of Technology (the Netherlands) he went to Switzerland to pursue a career in research at the Swiss Federal Institute of Technology in Zürich. He returned to the Netherlands as a PhD student. In 2006 he received a doctoral degree from the Technische Universiteit Eindhoven (the Netherlands) on a dissertation titled "Designing for rich interaction: Integrating form, interaction, and function." Presently he is Assistant Professor at the same university. He teaches several courses at the undergraduate and master levels and continues his research on designing for interaction.

In the recent past he has been invited for teaching and lecturing to the USA (CMU), Germany (HFGSG), and South-Korea (KAIST).

Contents

Full papers

12 **Commutative product semantics**
Loe M. G. Feijs

20 **Occult, a tooth, and the canopy of the sky: conceptualizing visual meaning creation of heavy metal bands**
Toni-Matti Karjalainen, Antti Ainamo, Laura Laaksonen

33 **Exploring contradictory meanings in product semantics**
Wei-Ken Hong and Lin-Lin Chen

39 **Rationalizer: an emotion mirror for online traders**
Tom Djajadiningrat, Luc Geurts, Popke Rein Munniksma, Geert Christiaansen, Jeanne de Bont

49 **The triggered association from motion**
Ming-Huang Lin and Shih-Hung Cheng

57 **User-generated product semantics: how people make meaning from objects in the state beyond saturation**
Yong-Ki Lee and Kun-Pyo Lee

67 **How people manage objects with shelves: storage and forage**
Chen-Hao Wuang and Yi-Shin Deng

73 **Categorizing product meaning: an investigation into the product language of clothing and fashion**
Dagmar Steffen

82 **Social radio: designing everyday objects for social interaction with ambient form**
Rung-Huei Liang, Kuo-Chun Tseng, Meng-Yang Lee, Chih-Yun Cheng

92 **Bringing back real-world richness in interactive story reading: lessons from linguabytes**
Bart Hengeveld, Riny Voort, Caroline Hummels, Kees Overbeeke, Jan de Moor, Hans van Balkom

105 **Designing for persuasion in everyday activities**
Fang-Wu Tung and Yung-Ping Chou

114 **Product adaptivity through movement analysis: the case of the intelligent walk-in closet**
Martijn ten Bhömer, Kirstin van der Aalst, Emilia Barakova, Philip Ross

122 **Using light, sound, and ripple motion to design the ambient display environment**
Yi-Heng Lee and Chao-Ming Wang

128 **The relationship between architectural media and elements: the emerging undefined digital architectural elements**
Kai-hsiang Liang

135 **Phorigami: visualization of digital photo collections by origami arts**
Shuo-Hsiu Hsu, Pierre Cubaud, Sylvie Jumpertz

144 **Designers' perceptions of typical characteristics of form treatment in automobile styling**
Andre Liem, Shahriman Zainal Abidin, Anders Warell

156 **Computer morphing as an effective approach to develop successful products half a step ahead of the market**
Yaliang Chuang, Po-Hsuan Chuang, Huang-Shiu Shi, Kun-An Hsiao, Lin-Lin Chen
163 **A study on the application of story mapping to the innovative product design model**
Chen-wei Chang and Huei-shyh Hwang
173 **Embodied explorations of sound and touch in conceptual design**
Elif Ozcan and Marieke Sonneveld
182 **For future use: an initial categorization of designers' speech-accompanying gestures**
Stella Boess
188 **Choreographic methods for creating novel, high quality dance**
David Kirsh, Dafne Muntanyola, R. Joanne Jao, Amy Lew, Matt Sugihara
196 **Making meaning: developing an understanding of form in distance design education**
Miquel Prats and Steve Garner

Interactive demos

204 **Fuzzy zone**
Yi-Heng Lee and Chao-Ming Wang
206 **Dance rail: an interactive installation that provokes aesthetic movement**
Eric Toering, Pakwing Man, Frank de Jong
208 **Interactive design for older adults: design experience from a wireless intelligent medication-taking system**
Tung-Jung Sung, Pai-Yu Chang, Wei-Chih Hsu, Wen-Wei Chang, Chi-Wei Kuo, Yi-Ting Hou, Chi-Shiang Wu, Yao-Joe Yang
210 **SPACE JAM: non-pc user interface for inter-generational communication**
Hsien-Hui Tang, Wen-Jong Wu, Yanb Bee Lee, Chih-Ying Yang, Ching-Yi Chan, Wen-Chieh Fang, Gwen Hsiao, Cheng-Wei Chen, Poming Chen, W Po-Yu Chen, Chien-Chia Liu, Shiang Wen Cheng, Mu-Chern Fong, Yueh-Hsien Lin
212 **Information fluid in smart tiles**
Scottie Chih-Chieh Huang, Shen-Guan Shih
214 **The concrete & the ephemeral**
Maxe Fisher and Karna Sigurðardóttir
216 **Memory bricolage table for the elderly**
Chih-Ying Yang, Rung-Huei Liang, Wen-Jong Wu, Mang-Yang Lee, Kuo-Chun Tseng, Rong-Hao Liang, Hung-Jung Lin, Yi-Chu Lin, Yen-Hao Chen, Cheng-Dar Chiang, Bing-Yu Chen, Kai-Yin Cheng, Yu-Ming Chu
218 **AdMoVeo: an educational robotic platform for learning behavior programming**
Jun Hu and Sjriek Alers

Loe M. G. Feijs
l.m.g.feijs@tue.nl

Commutative product semantics

Abstract
This article describes a structured axiomatic theory in which important practical phenomena of product semantics can be described and analyzed. The approach includes and extends the well-known semiotic notions of icon, symbol and index. Several small-scale case studies illustrate the theory.

Keywords:
Product Semantics, Semiotics, Axiomatics.

1 Introduction
The goal pursued in this article is to have a structured axiomatic theory in which important practical phenomena of product semantics can be described and analyzed. It is well possible that this goal is too ambitious. One could compare it with the axioms of probability theory: since probability means coping with uncertainty, one could question whether it is possible at all to have an axiomatic basis for it. Kolmogorov did it nevertheless, in 1933. His theory does not predict the outcomes of all uncertain events in this world, but yet is a most valuable tool for developing practical tools and theories. For product semantics there is no such theory yet; I just have this vision and I can show how far I could get so far. The advantage of this kind of theory is that it will give rise to new tools, notably semantic tools.

This article is structured as follows. We begin with a very simple example (this section). Section 2 discusses language as a system. Next we identify the main notions to be described (Section 3). Then we introduce an axiom scheme (Section 4). After that we present several small-scale case studies to illustrate the theory (Sections 5, 6 and 7). In a final section we give a few concluding remarks. The article is written compactly with a focus on the examples and the formalization. For extensive introductions to the encompassing fields we refer to the other article submitted by the same author for this volume called Layers of Meaning. For a general introduction to product semantics we refer to e.g. Krippendorff [1]. For a general introduction to semiotics (the theory of signs) we refer to Chandler [2].

The approach we shall present is called commuting product semantics because of the specific approach of bringing structure into semantic insights and relationships In its purest form the approach amounts to drawing so-called commuting diagrams. The approach bears resemblance to the French structuralist approach to language. The work is open-ended and the underlying theory unfinished, but I see no better way to develop the theory than trying to push the approach as far as possible while doing case studies. It is equally valid to interpret commuting as traveling back and forth, emphasizing the dynamic nature of product semantics. The meaning of designed artifacts is how they are used,

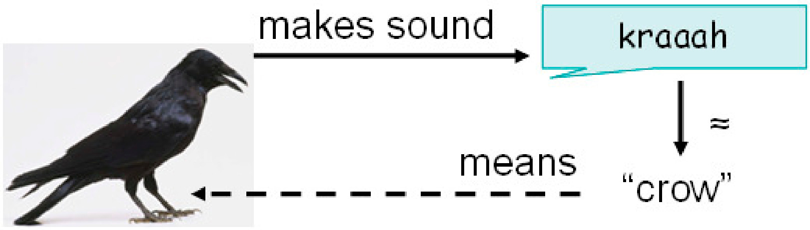


Fig. 1. Onomatopoeia as a commuting diagram.

how they change other things, how they are moved, and how they move people, how the meanings move back and forth. The approach rests on the idea that the meaning of a product always goes back to some fact which has occurred in the past, may occur in the future, or which may occur elsewhere.

The very first example comes from natural language semantics, It is about a so-called onomatopoeia. For example consider the familiar black bird calling "kraaaah" (an audio-book would serve my purpose better here, but let me assume this description also works). If I say the word "crow" I refer to such a bird. When I say the word, usually there is no crow and we can conveniently talk about crows whenever and wherever we want. Of course I may be with a child, see the bird and say "look Tommy, that's a crow", but this is not the easiest everyday use. This involves already the more complicated processes of teaching and learning.

Fig. 1 illustrates how the wrod "crow" got its meaning by means of a commuting diagram. The dashed arrow in Fig. 1 shows how the word "crow" has its usual meaning. It is derived from the other path of arrows which came into existence first. The arrow labeled ≈ denotes resemblance or similarity.

The situation is in fact already more complicated than suggested by the diagram. Not only the crow usually is not present when we mention it, the real crow we refer to usually is not calling at all at that moment. It is the bird, or a bird of this species, whose members in the past used to make that sound.

The right part of the diagram could be said to belong to a syntactic domain, the left part to a semantic domain. Just to avoid unnecessary confusion, there is a difference between linguistics and product semantics: in the above example, we looked for the meaning of a word and the meaning turned out to be a creature in 3D (the bird). In product semantics it often works the other way around: the syntactic domain is populated with 3D objects and the semantic domain is filled with other real-word matters, but in writings or diagrams they are shown as representations, often words.

Should we always go through such elaborate analysis before we can even use the simplest word? No, of course not, but yet this is the essence of how the bird got its name. Linguists analyze such matters. They invent terms such as "onomatopoeia" for useful linguistic patterns and study the usage of language by different authors and the usage of language in different communities. They look for commonalities and differences between languages and they study language evolution. They create dictionaries and grammar books and thus help society to have a culturally rich and economically successful use of language. The same can be done and should be done for the language of designed artifacts.

2 Language as a system

A language is a system. One cannot study a language by studying the syntactical elements and their meaning one by one. The most interesting phenomena happen because of relationships, similarities and differences between words. For the case of natural language this has been clearly recognized and exploited by the French structuralists such as De Saussure (1857-1913), Greimas (1917-1992), Derrida (1930-2004), the American linguist Chomsky (1928-), and semiotic scholars such as Eco (1932-). The relationships, similarities and differences between words arise because of the ease and frequency of replication and change, enriched with processes of resolving ambiguity, learning and teaching. Similar system aspects exist in biology (but until recently there was not much design freedom in biology) and in architecture (although the replication takes more effort in architecture). Similar aspects exist in industrial design too, which is what this paper is about.

Language is not static but dynamic. Although one can find books and lessons that describe for example English as a language with a given set of words and rules, the language is always changing and evolving. New words are being added and olds words forgotten. Old grammatical principles are violated, neglected and eventually removed from the language. To teach English at elementary schools, the static view is very useful. But for linguists at a university level, the dynamic view is indispensible and also is much more interesting. The same holds for product semantics. For daily usage it is very useful to know specific objects and how to use them. But for designers in higher design schools, the dynamic view is indispensible and again more interesting. Semiotic scholars describe the distinction between such dynamic and static aspects by the terms:

• first usage, and
• second usage.

Or, according to Eco [5], ratio difficilis (RD) and ratio facilis (RF). First usage is just to find or invent a new piece of syntax for something, invent it on the spot and speak it or make it or interpret something in a certain way, either deliberately or spontaneously. Second usage comes after that, re-using the same sign over and over again. What makes first usage difficult (difficilis means difficult) is to get the new sign into people's memory so it can be used and understood by many. Memory is essential for language and for product semantics. It includes both personal memory and institutional memory. The personal memory resides mostly in one's brain, but perhaps also partly in other areas of the sensor-motor system. The institutional memory resides in books, in the rules of schools and courts, and so on.

3 Notions to be described

Reading an object means to perceive a given object and then think of something else and act accordingly. The association from the given object to this "something else" is called meaning and is depicted by the dashed arrows as we did in the example of the crow. The arising of a meaning is conditioned by the existent set of moves (often depicted with the help of arrows). The moves include physical moves, memorized meanings, similarities and oppositions. Example, a door can be opened, "crow" means this type of big black bird, "crow" is similar to "kraaah" and rich is opposed to poor. Such moves (arrows) form a network around any given object, like a mind-map. If there is a chain of arrows and opposite arrows from a given object A to another, say B, then this chain yields a candidate meaning from A to B. The meaning which arises in reality is one of those candidate meanings, selected through a personal competitive process, partially unconscious, in which attention, emotional weight, and strength of memory connections play a role. Useful meanings tend to get standardized but only after a selection in a societal competitive process where the practicalities of language usage and the power of the various persons and institutions determine which meanings survive and which ones do not.

So these are the ingredients to be described: First, there are objects. These may include everyday objects, people, animals, people, images, words, sentences, concepts of culture and science, instruments, behaviors, and emotions. Next, there are moves. In the simplest case the move goes from an object to an object. Refinements such as contexts, multiple-input arrows and symmetric relationships between objects could be considered too (later). The moves represent the real or imagined changes that occur to objects during manufacturing, during usage, either in reality or in possibility. Also included are established meanings, similarities and oppositions. The term move should not be taken too literally: in some situations the term denotation or sign would have been more appropriate.

With these ingredients we have two describe the processes of using meaning arrows, notably ratio facilis (from now on abbreviated as RF) and ratio difficilis (from now on abbreviated as RD), the former being executed by a person, the latter usually by a society. These processes have the emergent effect that people develop shared understandings of objects, which will greatly benefit communication. The latter view is in line with the communication-oriented view on product semantics, as expressed amongst others by Crilly et al. [3].

4 Axiom scheme

The notions to be described can be cast into the form of ten rules, some of which are just introductions of a notion (a set of assumed objects), others being proper rules. The first seven rules are completely formal. Although the rules are very precise this does not mean they are already easily applicable. For that we would need to have the assumed notions (sets of objects), moves, utility function etc. at our disposition. Rules 8, 9 and 10 are less formal, they embody the transition to another paradigm than formal rules (perhaps an economic model). Rules 1-7 describe RF, rules 8 -10 describe RD.

1. There are objects. For objects think of everyday objects, technical artifacts, objects ready-to-hand (zuhanden, Heidegger's and Dourish' terminology), objects present-at-hand (vorhanden), but also plants, animals, words, icons, symbols, traces, finite-state-machines etcetera.

2. There are moves. Each move consists of an object called the source, an object called the destination, and an optional label. We write A → B if there is a move with objects A and B. The moves can represent the changes that occur to objects during manufacturing and during usage, either in reality or in possibility. Also included are established meanings, similarities and oppositions.

Intermezzo: For moves, think of moves through time and space, but also of all kinds of other associations. Moves also represent the semiotic concept of sign, which comprises both the signifiant and signifié (using De Saussure's terminology. We refer to (Chandler 2002) pages 83-85 for an introduction to De Saussure's terminology.

3. There are labels which can be associated with moves and which serve to classify moves. We write $A \rightarrow_L B$ for an arbitrary label L. The set of labels includes 1 for identity, φ for physics, μ for memory, ⊂ for part-of, ≈ for similarity, ≠ for opposition, and α for voluntary human action. The labels are closed under composition, written as xy for labels x and y, and under inverse, written as x-1 for label x. Note that we do not equate for example x-1x and 1.

4. For a given set of moves, its closure is the smallest set of moves which includes the given set and satisfies the three rules:
   a. for all objects A we have $A \rightarrow_1 A$,
   b. for all A and B we have $A \rightarrow_x B$ implies $B \rightarrow_{x-1} A$,
   c. $A \rightarrow_x B$ and $B \rightarrow_y C$ imply $A \rightarrow_{xy} C$.

Intermezzo: the labels carry the origin or the reasoning why A means B. Now we use Greek letters and mathematical symbols, but later, for example after semantic tools will have been developed, the Greek letters can be replaced by more convenient symbols, colors, or interactions. A body of knowledge is represented by a set of moves. A pattern is a set of labels, for example {μ⊂} which we call "pars-pro-toto".[1] The closure of a given set of moves can be restricted by a pattern which means that we keep only those moves whose label is in the pattern. Patterns are interesting because each individual may have his or her own patterns. Moreover, from a scholarly point of view it is interesting to restrict a study to specific patterns only, like the natural language scholars who study patterns such as onomatopoeia, homonym, synonym, causative etc.

5. Given an object A and a set of moves M, we call a candidate meaning any move A → B which is in the closure of M.

6. For a given set of candidate meanings, a utility function is a function u assigning a number between 0 and 1 to each candidate meaning such that the sum of these numbers equals 1. The numbers are called utilities. Given an A, M and u, any B for which A → B is a candidate meaning with maximal utility is called a meaning of A.

7. A semantic event consists of a context, which is a triple (A, M, u), and an outcome which is a human action. More precisely, the outcome must be a move with the same source A and destination B as the meaning of A (or one of the meanings of A). The outcome must be labeled α, for human action.

Intermezzo. A semantic event occurs in the life of an individual i who sees an A and decides to interpret it as B because his knowledge of the world and his symbolic memory, all of which are represented by the closure of a personal set of moves Mi, lead him to the interpretation. The utility ui reflects the internal competition inside i among candidate meanings. The competing candidate meanings differ in memory strength, priming, emotional relevance, psychological repression, plausibility of the reasoning chain, etc. The utility thus depends both on the practical situation and the emotional state of the individual, all of which are not formally detailed except through the assumed utility function.

[1] If memory (μ) gives meaning to (Dutch) "groene baretten" namely (real) green barets, and if green barets are part of (⊂) of a specific type of soldiers then the pars-pro-toto pattern is why "groene baretten" refers to such soldiers.

The previous axioms all dealt with one person reading the object. But next we must also assume that there are others who shall observe such an outcome. Others may notice that i acts, but the relabeling to α models the fact that they cannot see his or her associations or reasoning chain. In the development of a society there is a common understanding of the world and a common symbolic code, some elements of which are given a more formal status through schools, laws, books, television shows, court rooms, group discussions, exercises, examinations and social rules. All of that will be summarized by the term school, which clearly should not be taken too literally. Depending on the case study one could consider giving the school a special status in the model but in other cases we may prefer Axelrod's idea of no central authority [4].

8. One way for individual i to adapt is to increase his or her understanding of the principles of physics and add a move $A \rightarrow_\varphi B$ to his or her personal set Mi . Alternatively he or she can just learn a move without specific understanding, adding $A \rightarrow_\mu B$. We call such additions learning. Forgetting is also possible. Forgetting is the removal of a move.

9. A semantic interaction consists of a semantic event followed by changes which add or reinforce certain meanings and remove or weaken others. Individuals thus learn. Reward and punishment often play a role. The semantic interactions involve multiple persons or one person and a school.

10. Semantic interactions may have the effect that many individuals share memorized moves $A \rightarrow_\mu B$, which will greatly benefit communication.

Intermezzo: The production and observation of meanings is a dynamic social process. The dynamic social process allows for innovation and at the same time maintains large commonalities in interpretation. Stability of the commonalities becomes an emerging phenomenon. Assume that individual i holds the move $A \rightarrow_\mu B$. But assume individual j holds that $A \rightarrow_\mu B'$. We consider some typical cases, for example, B = B' in which case nothing happens. Otherwise, assume B differs from B' and that j has a higher ranking authority than i and thus person i may learn that $A \rightarrow_\mu B'$. The repeated application of rules 8, 9 and 10 constitutes a process RD in which such updates happen regularly. But under normal circumstances, on average they will happen with a lower frequency than the application of the RF rules 1 - 7. The details of such an RD process are not formally modeled further in this paper. We leave them as an option for further research.

Pleasant and unpleasant experiences are drivers for learning and unlearning. Pain and fines are unpleasant. For example, interpreting a red traffic sign (A) as a cue to drive forward (B') instead of stop (B) could lead to a crash (the other driver representing the school) or a fine (the police officer representing the school). In this example, there is not even a candidate meaning of type $A \rightarrow B'$ in M_j so the police officer j punishes. Next time i acts according to $A \rightarrow B$.

Typically an interpretation which works out in practice is considered a positive reinforcement, like in Wittgenstein's language games, when the builder j says "brick" (A) and the assistant i is choosing between giving him a brick (B) or giving him a slab (B'). Delivering a brick, that is, $A \rightarrow_\alpha B$ will work out well. But an uninformed assistant i with $A \rightarrow_\mu B'$ perhaps takes $A \rightarrow_\alpha B'$, and thus runs the risk of being stormed at by the builder. The first builder to work this way probably had a competitive advantage over other builders, which gave him even more social power and allowed him to form a school by training assistants.

5 Icon, Symbol and Index

The traditional concepts of symbol, icon and index as proposed by Peirce appear as special cases of simple commuting diagrams, as shown in Fig. 2 (images from wikipedia/commons). We refer to (Chandler 2002) page 36 and 37 for an introduction.

The no-parking sign is a symbol. It must be learned by memory. Once one knows it, the candidate meaning "no parking" will pop-up upon seeing the sign. The dashed arrow in the diagram indicates this candidate meaning. The left hand side woman image is an icon. For an icon, there must be a physical or perceptive similarity. The concept index is illustrated by the specific concept of trace. The meteor makes a crater by the physical move of impact. Later, the crater means: there was a meteor.

Fig. 2: Examples of signs (symbol, icon and index).

6 Example

In many cases, moves represent changes of a state of affairs over time, as the next example demonstrates. Consider the type of chain closing shown in Fig. 3.

Fig. 3: Chain closing.

What does it mean? Well, the first meaning is what one can do with it. Hook the last bead into the closing and the chain remains closed, even under the force of slight pulling. It can be opened again by lifting the last bead and pulling. These moves, to be executed by the user are one type of meaning. This is depicted in Fig. 4.

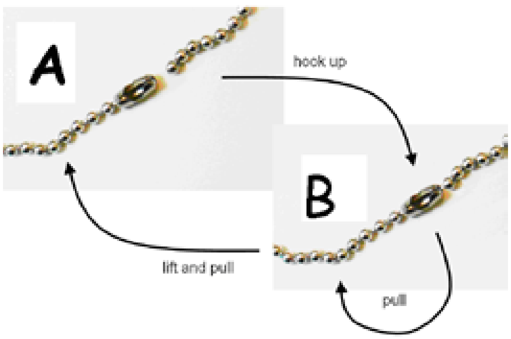


Fig. 4: Moves of chain closing.

So here the moves are what the user does and then the semantic arrow, pointing from the object to its meaning is given by the dashed arrow in the following composite diagram. Computer scientists would recognize the right-hand side structure as a finite state machine (FSM). This is shown in Fig. 5.

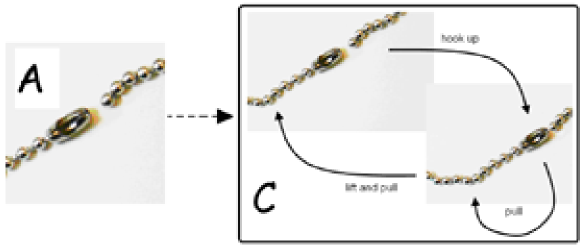


Fig. 5: Finite state machine meaning of chain closing.

The closing also has other meanings. This is a cheap kind of closing, which appears cheap for several reasons. These reasons can be understood in terms of moves as well. The first move occurred in the past: it is the manufacturing of the closing. A simple piece of plate metal, cut into a butterfly shape is folded and deformed, a not too difficult manufacturing step, easily imagined and doable by a fully automated machine. Now the meaning of the closing is the opposite of that move, as depicted in Fig. 6. The closing means “something made of plate metal”.

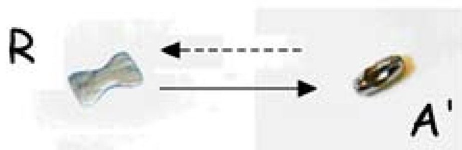


Fig. 6: Manufacturing meaning of chain closing.

The next move we like to discuss occurs in future, or at least, one easily imagines this to happen in future. When pulled heavily, the folded plate metal of the closing bends open and the bead gets out of the closing, which is now broken. This then is one meaning of the closing, that it is a thing which easily gets broken. The meaning (dashed arrow) goes parallel to the physical move. The example illustrates an important idea already mentioned: many meanings arise because of situations which have occurred in the past or situations which might occur in future. An object just being sensed in the present moment, here and now, without any interpretation is not semantically active (perhaps we should say that observer is not semantically active). But otherwise, the object is "saying" things which are not true; at least not true here and now. This is usually not wrong, like when someone is telling deliberate lies with wrong intentions. The idea expressed in Fig. 7 is that objects refer to other objects not here, other situations (not here, or not now), dangerous situations (hopefully never), and desirable situations (hopefully soon).

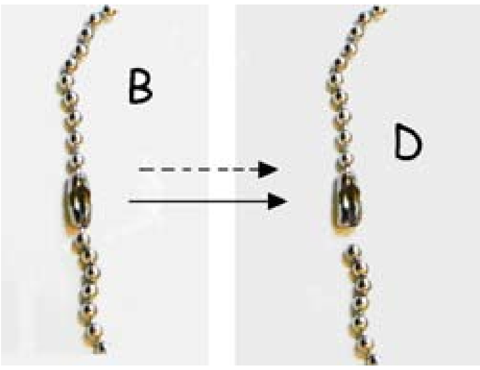


Fig. 7: Failure meaning of chain closing.

How does all of this appear formally? We have $A \rightarrow_{\varphi} B$, the physical move to close the object. And $B \rightarrow_{\varphi} A$ by lift and pull, next to $B \rightarrow_{\varphi} B$ by pull. The move $A \rightarrow_{\mu} C$ models that one knows that the device affords repeated close, pull and open behavior. The move $R \rightarrow_{\varphi} A'$ described the physical possibility of folding a butterfly-formed piece of sheet metal to get something similar to the main body of the device. The inverse of the latter move is $A' \rightarrow_{\varphi^{-1}} R$ which is a candidate meaning, viz. the meaning that A' is made from sheet metal indeed. It could have been made by casting melted metal, but I consider that very unlikely (low utility). Therefore I express my opinion that it is made from sheet metal. Expressing this in public is an act by me, so now $A' \rightarrow_{\alpha} R$. This is a semantic event. Perhaps my act is wrong and I could be blamed for it by a manufacturing expert, which would be a semantic interaction. I know sheet metal is cheap, $R \rightarrow_{\mu}$ cheap. The main body is a part of the chain itself, that is $A' \rightarrow_{\subset} A$. Combining $A \rightarrow A'$ with $A' \rightarrow R$ and $R \rightarrow$ cheap a new candidate meaning emerges, viz. $A \rightarrow$ cheap. It has the label $\subset^{-1}\varphi^{-1}\mu$, which is a kind of formal code of the underlying reasoning. Yet-another candidate meaning is that, under load, physics implies that the device breaks up, $B \rightarrow_{\varphi} D$.

7 Another example

We present the commuting diagram in Fig. 8 concerning the way in which the meaning arises for two of the signs on a Nokia phone 63101 (the model called "Triton" and other models launched around 2002).

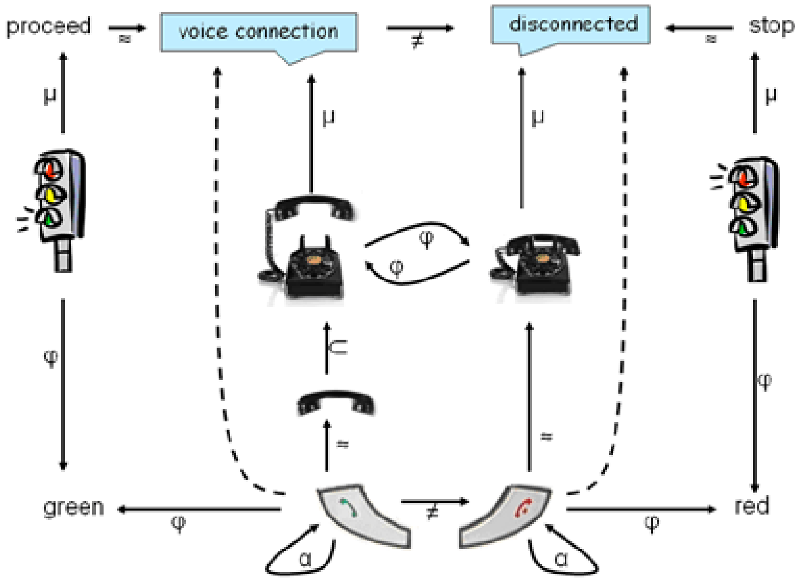


Fig. 8: Commuting diagram of Nokia phone signs.

Different manufacturers use subtly different signs to indicate similar meaning, for example Philips DECT phones have just the hook, either green or red. The hook is either upside or downside, and the relict of the old phone body is gone. See Fig. 9 (image adapted from Wikimedia commons). The physical movement between an onhook and off-hook phone must have been assumed to be a rotation of the hook in space, rather than the separation of the hook and the phone body.

7 Concluding remarks

The proposed axiom system forms a solid basis for studying specific aspects of product semantics and doing case studies. Rules 1 - 4 cover aspects belonging to the physical world and also belonging to part of the psychological domain: perception, action and memory. These rules do not rely on a mind-body dualism. On the contrary, Rules 1 - 4 address notions which are in the intersection of Newton's world (the laws of physics) and

Fig. 9: Different Philips DECT phone signs.

Freud's world (what's in a man's mind). Rules 1 - 4 not even have negation and allow for candidate meanings through chains of association. This is intentionally so to model the associative nature of the human mind.

In more refined case studies it may be necessary to extend the set of labels. Next to φ for physical action and μ for memory there may be more subtle labels in-between, like φ_1 for physics according to present-day university-level physics, φ_2 for physics as observed in daily life, and φ_3 for physics as assumed in a user's mind. Similarly, user actions α could be subdivided into actions for distinct persons. The utility function involves emotions, priming, taboos, and human values, which are best not addressed axiomatically but by the tools of the psychologists. Sensory pleasure and bodily pain can be added as objects, but this is near the boundary of the approach.

We mention two limitations of the formalism presented so-far, which probably can be addressed quite well by future extensions of the formalism. First limitation is the notion of context. Context is essential and many meanings are context-dependent. The meaning of a screw-driver becomes relevant when there are screws and things to screw in. Technically, the context can be added to the moves, perhaps as in formal logic, writing $C \vdash A \rightarrow B$ when C is a context. In formal diagrams and in tools, the context can be depicted as a background or at a given position in a pictorial composition scheme. The second limitation is mediation. Certain objects behave as carriers, media or tools. They transform the spatial, temporal and physical qualities of other objects. The function concept from mathematics, could be helpful for mediation. The axiom system entails the possibility of developing semantic design tools.

Loe M. G. Feijs
Department of Industrial Design, Eindhoven University of Technology, Eindhoven, The Netherlands

References

1. Krippendorff, K. (2006). The semantic turn. Boca Raton, FL: CRC Press.
2. Chandler, D. (2002) Semiotics, the basics. London: Routledge.
3. Crilly, N., Good, D., Matravers, D., & Clarkson, P. J. (2008). Design as communication: Exploring the validity and utility of relating intention to interpretation. Design Studies, 29 (5), 425-457.
4. Axelrod, R. (1997). The dissimination of culture, a model with local convergence and global polarization. The Journal of Conflict Resolution, 41(2), 203-226.
5. Eco, U. (1976). A theory of semiotics. Bloomington, IN: Indiana University Press.

Toni-Matti Karjalainen, Antti Ainamo, Laura Laaksonen
toni-matti.karjalainen@hse.fi

Occult, a tooth, and the canopy of the sky: conceptualizing visual meaning creation of heavy metal bands

Abstract
The paper explores how heavy metal bands narrate unique stories and concepts around their music and, by doing so, create recognition among music consumers. Creation of symbolic value through narrative concepts and visual identity has been a key issue for several Finnish heavy metal bands that have gained success in the highly competitive field of music. Our objective is to analyze the narrative concept creation of selected heavy metal bands and the strategic role of visual artifacts as carriers of specific meanings. By using descriptive examples of the bands and their visual communication strategies, we identify visual “signature elements” that the bands use as means of communication to signify their musical concepts. Moreover, we adopt the approach of design semiotics to analyze visual communication in heavy metal. This results in a framework that infuses the cultural view of meaning creation together with the view on artifacts as meaning carriers. This framework will be further developed and deconstructed in our future studies.

Keywords
Cultural Meaning Creation, Design Semantics, Heavy Metal, Music Industry.

1 Introduction
“The greatest music is all about great moments; moments that send a shiver down your spine, moments that bring a tear to the eye; moments of exhilaration, of exquisite beauty, of monstrous physical power or bewildering emotional strength. Like life itself, the greatest music is all about feeling alive and relishing every second.” [1]

The meanings generated by music are personal constructs by which strong emotions, associations, and memories are entwined into an overwhelming experience. While involving such a powerful experience, artists and bands can use their musical concept, the music itself as well as other communicative artifacts, to evoke strong meanings for their potential audience. For this audience, music generates associations that help them, not only to experience great personal moments with music, but also to tell something about themselves within their social environment, identify themselves as members of specific sub-cultures.

These meanings are mediated by the various elements of the music itself; its individual tonal, structural and lyrical elements and their total gestalt composition.

The aesthetic experience of music has yet its auditory, physiological, sensorial, even neural dimensions, both emotional and cognitive, but the symbolic dimension is also strongly represented. Richness of symbolic, “external”, meanings is attached to specific music styles and their various conventions as well as to the specific artist or band that is performing the music. The holistic experience of music consists of numerous offerings the bands and their various stakeholders produce: such as albums, gigs, websites, and different accessories.

1.1 Background

Hence, we assume that, like any kind of a product, music artifacts can be used as a communicative means of transforming a deliberate "strategic intent" into an artifact-mediated experience. Elements of the music and various supporting or self-standing visual artifacts, carrying strong symbolic meanings, have been traditionally used to a great extend within specific music genres such as heavy metal.

As is often argued by artists themselves, the starting point for making music may not be strategic per se. The musical concept may function as a means to channel their creativity, make a statement about the culture or society, or simply as a means of having a good time. But as soon as the music production becomes an economic activity, lots of strategic incentives are brought into the picture. For music producers, bands and their stakeholders, creating recognition, as well as managing meanings is as important as for any other economic artifacts, but the processes and constructions of meaning creation may be different.

Building recognition is getting increasingly important, as the bands are facing an increasingly growing competition in the rapidly changing global music industry. The core product – music and the musical concept in its various forms – is still usually the most important artifact of differentiation and the closest touch point of creating loyal fan base, but the role of various "extended" artifacts is arguably increasing.

1.2 Research Gap and Objectives

According to our initial observations, creation of symbolic value through narrative concepts and visual identity has been a notable element for several bands in the area of heavy metal and hard rock. This field also provides a promising starting point for academic research on the role of visual identity and the mechanism of symbolic meaning creation. Despite its symbolic contents, let alone cultural, social and economic significance, music industry in general, and heavy metal in specific, is surprisingly little studied from the communicative/semiotic point of view.

It is interesting to study what kinds of means the rock bands and their stakeholders have at their disposal when communicating a specific intent to their audience, and how meaning creation could be conceptualized in the music field in general. From the design semantics point of view, in particular, to study the visual artifacts of music as carriers of intended meanings can provide rich insights into the field of design management. In other product areas, communicating strategic intent and brand values through distinctive and meaningful visual identity has been the key interest of practitioners and academics [2][3][4][5][6]. We believe that insights from music may produce ideas for more traditional industries, and vice versa.

We explore meaning creation in the BogFires research project (2008-2012), conducted in the Helsinki School of Economics and funded by the Academy of Finland. The project comprises three main areas of inquiry, of which a part titled "contents, concepts, and brands" is one. The purpose of this part is to identify the instrumental, aesthetic and symbolic mechanisms in Finnish metal, with a focus on understanding the interaction of the various band-specific and collective strategies at play. In more concrete terms, the study explores how band (brand) concepts are built in the music industry, within the genre of heavy metal in specific, and how they become manifest in the musical and visual offerings of the bands.

Data is being collected through a number of case studies, concerning the most notable Finnish metal bands in international markets (Nightwish, HIM, Children of Bodom), other influential Finnish bands in the field (e.g. Amorphis, Diablo, Sonata Arctica, Stam1na) and a complementary collection of certain foreign bands. Data sources comprise interviews with the members of the bands and their stakeholders, analysis of their visual communication, as well as supporting sources such as expert interviews, consumer interviews, and various secondary materials.

In this paper, we present an early conceptualization of visual meaning creation in the case of heavy metal bands, to be further developed in forthcoming publications. The general objective of the paper is to discuss a holistic approach to meaning creation in the heavy metal genre, present descriptive examples derived from our initial studies, and identify various means of meaning creation the bands have at their disposal. To address meaning creation, we explore the applicability of the approach of design semiotics to the analysis of visual communication in heavy metal. Therein, we utilize the application of the sign theory of C.S Peirce, as based on our earlier analyses in product design [4]. As a result, we construct a model (chapter 4), or a mediating framework, to infuse the cultural view of meaning creation (chapter 2) together with the view on artifacts as meaning carriers (chapter 3). This model will be further developed and deconstructed in our further studies.

Our contribution to the DeSForM workshop is both theoretical, as we discuss the construction of meaning and perception with a touch point to the Gestalt theory and compositionality of meaning, and practical, while our paper is based on descriptive case studies. Moreover, we offer a perspective on the workshop theme of "appropriation of the everyday" and generate typologies of music artifacts.

2 Heavy metal bands as meaningful cultural artifacts

As a generic frame, we follow the cultural approach in marketing, which considers marketing and consumption fundamentally as cultural phenomena [7]. Following this stream, we regard metal bands, and their various representative products, as informative examples of cultural artifacts – artifacts whose consumption is, to a great extent, culturally defined.

2.1 Cultural signification, symbolic interaction, and context dependence

The artifacts of music have strong potential of becoming "cultural icons", thus invoking powerful cultural narratives and myths, as well as cite culturally shared meanings, norms and values [8]. Such icons function as social and cultural symbols, as products whose meaning is created within the cultural systems of signs in economies [9]. The production and consumption of music within such systems is characterized by processes of symbol creation and interpretation, which we aim to describe through qualitative case studies.

We regard symbols in accordance with the traditional view of semiotics presented by Charles Peirce: "A symbol is a sign which refers to the object that it denotes by virtue of law, usually an association of general ideas, which operates to cause the symbol to be interpreted as referring to that object" [10]. Peirce considered symbols to be conventional signs that depend on habits and agreements and function through associations. In light of this notion, artifacts of music become meaningful primarily through symbol creation and interpretation. Having said that, we are not forgetting the "pure" aesthetic experience of music, which may exists as a self-governing construction in theory but, as we argue, is inherently connected with the symbolic dimension in real-life experience.

Nor do we want to underestimate the meaning of music as individual experience, although our view is predominantly cultural and regards heavy metal as a socially constructed and experienced phenomenon.

Our view of music artifacts as cultural symbols, thus as "conventional signs", agrees with the concept of "symbolic interactionism" of Blumer [11]. As this stream suggests, human beings act towards things according to the meanings the things have for them. The meaning of artifacts is thus largely derived from the social interaction people have with other people. Ultimately, these meanings are handled in, and modified through, an interpretative process as the person encounters and deals with artifacts.

In line with both Peirce's and Blumer's views, meanings are regarded as arising fundamentally in the process of interaction between people and the artifacts.

The artifact can be regarded as an interface between the substance and the organization of the artifact itself ("inner" environment) and the surroundings in which it operates ("outer" environment) [12]. These environments are inseparable in reality, but useful for our analysis on music artifacts. Meanings are analyzed in the context of the outer environment, but seen as carried and mediated by the artifact and its features.

From the symbolic signification, thus from the notion that interpretation of music artifacts is particularly affected by acquired or inborn habits, follows an ontological view according to which meaning creation is always context dependent. People perceive artifacts, products and brands through preconceptions constructed by their experience and their prior encounters with them. Music artifacts mean different things in different contexts and for different perceivers. In our case of heavy metal bands, in specific, potentially strong meanings can be created within the target audience, the fans of specific bands and the heavy metal genre(s) in general. In order to create meaningful interaction, we argue that the audience must be familiar with the context, the habits and agreements and the history of the genre. Such familiarization, and its impact, may occur on implicit or explicit level. A listener of heavy metal may experience pure aesthetic pleasure generated by elements such as the powerful sonic landscape, high volume, distorted sound, riffing and grooving, that can be almost literally felt in one's viscera. However, if the listener is not accustomed to recognize and identify, explicitly or implicitly, the familiar elements of heavy metal, such elements can be interpreted as meaningless noise, even generating a detestable experience.

2.2 Contextual meanings: heavy metal as a subculture

Meanings are contextualized through specific subcultures. One thus has to be part of the culture in order to fully understand and grasp the meanings created within it. The dawn of Heavy Metal as a genre has generally been traced back to the establishment of the British band Black Sabbath in 1968 and their debut album released in 1970 [13][14]. The genre thus has a 40 years long history, with various sub-genres and bands emerging and fading out, and popularity ranging from underground to mainstream depending on time and country. The music and its culture have been strong and prevailing, and also documented as an important cultural phenomenon [15]. This culture has a rich symbolic heritage and reinforced myths, musical and visual, on which both bands and fans are building contextual references. Visual aspects is regarded as a key element within the genre [16] which comprises a richness of visual symbols such as band logos [17] and mascots [18]. These symbols are important recognition elements for the bands, but they often bare direct references to the heavy metal tradition and its conventional symbols, as well as the cultural background of the bands.

We may thus conclude that a there exists a certain "cultural landscape" of heavy metal. The notion of cultural landscape of an artifact [19] refers to the totality of cultural interpretations and meanings that are related to a specific artifact. This concept resembles the notion of "product milieu" that represents the aggregate of objects, activities, services, and environments that fills the lifeworld [20]. The cultural landscape or milieu of heavy metal is shaped by the meanings that the members of the specific culture attach to music artifacts. Again, for perceivers not familiar with this landscape, products may have rather different meanings. Within the cultural landscape, music artifacts also function as mediators of interaction and self-expression for fans. Certain bands can become integral to one's lifestyle and part of self-definition and thus embody an active role as cultural codes. Trends of personalization and individualization are emphasized within the contemporary reality that can be characterized as the "experience society" [21], "dream society" [22], or "experience economy" [23]. The production of narratives and the consumption of experiences seem to be characteristic of the time, especially in cultural fields. Within this reality, artifacts are not only used as symbols of a person's status or social position, but more often as means to communicate the overall personality, values or world view of their user. The choice may represent an individual personality or membership in a specific social or cultural group. Consumption of heavy metal can function as a statement, made visible to the world through the visual symbols.

2.3 Meanings from country-of-origin

Besides the generic traditions of heavy metal genre, the basis of meanings and categorizations often stem from the country-of-origin or cultural background of specific bands and their acclaimed similarities in music and style. There exist acclaimed genres such as Norwegian Black Metal, Gothenburg Metal, Bay Area Thrash Metal, and many sub-styles with distinctive names are connected to certain geographical areas (e.g. Grunge to Seattle, Hair Metal in L.A.).

Such meanings that are based on the country-of-origin can play an important role in building a unique concept for the band. Many elements of a national and cultural background may be well known in the place of origin, but the new way how these elements are combined, or how these re-combinations meet international awareness, may be less known [24]. In Finland, the cultural and national origins and background has played a major conceptual role for many bands as the band name, lyrics, visuals, and other aspects of the bands' product include reference to Finland in all our analyzed cases. This reference can be either implicit or explicit.

As an example of the former, technical talents and skillfully elaborated artistic concepts have become generally associated with music from Finland, a country with a highly developed system of music education and research. Finnish background can function as a generator of unique meanings [25]: "Over the past ten years or so, Finland … has become awash with metal bands. And many of them are of such high quality that they have made serious inroads into the global

market… The biggest acts to come out of Finland have spearheaded entirely new movements."
Serendipitously or by design our preliminary evidence of the Finnish metal bands and of the phenomenon as a whole suggests that this strategy of differentiation has appeared "naturally" or endogenously. Consequently, and despite the history tracing only to the late 1980's, Finnish Metal has been recognized as its own phenomenon/scene in various magazines in Europe, Japan, and US, as well as books. The cultural disposition of Finnish Metal, have thus enabled competitive differentiation, which is a further construction addressed in our study. In the current highly competitive markets, bands and their key stakeholders (record labels, managers, promoters, and agents) are forced to consider various means through which the bands can be made to stand out from the mass. Through uniqueness, Finnish metal bands have been favorably adopted by specific niche audiences in countries such as Germany, Japan, the US and Argentina.
Hence, Finnish Metal is regarded as an "umbrella brand", entailing specific meanings, under which various bands with different music and style are positioned. Our study aims to specify what these meanings are and what kind of role they have in the recognition of specific Finnish metal bands.

2.4 "Co-branded" meanings

Another interesting phenomenon in music industry, and heavy metal in specific, is the habit of many bands to collaborate with other brands from the music field or from other industries. Such "co-branding" activities naturally have their economic incentives in the core, but they can also work as a strong means of reinforcing the band's messages, transferring new meanings from the domain of the partner brand, or co-creating entirely new meanings in collaboration with the partner.
First and foremost, co-branding in heavy metal concerns can concern different "endorsement" deals. Bands, for instance, often use specific instrument and equipment brands. Endorsement deals are important part of creating certain heavy metal (and sub-genre) identity and credibility. For example, the guitar company ESP has built high awareness in metal circles by teaming up with high-profile metal guitarists such as Alexi Laiho from the Finnish band Children of Bodom. For the band, ESP guitars (especially, the ESP "Alexi Laiho" signature series) have become strong signs of visual recognition.
Using "assigned" designers and artists to create bands' visual identities is another example of "natural" co-branding that is largely used by many metal bands.
An interesting example of this "artistic co-branding" is the collaboration that the Grammy Award –winning Californian metal band Tool has nurtured with Alex Grey, a famous visual artist from New York.
Tool is famous for its strong and mythical identity, characterized by strong musical and visual references to occult, the "knowledge of the hidden", which has made the band one of the biggest "cult" bands of the history [26]. The musical sound landscape of Tool can be described as: "the thinking person's metal band, cerebral and visceral, soft and heavy, melodic and abrasive, tender and brutal, familiar and strange, western and eastern, beautiful and ugly, taut yet sprawling and epic… a tangle of contradictions" [27].
This distinctive musical identity and occult references are supported and created by strong visual features that the band has used in its albums, accessories, concerts, videos in an extremely consistent manner. Adam Jones, the guitarist of the band, who functions also as the band's art director and director of their music videos, has had a strong interest in the power of various visual media as generating Tool-specific meanings [26][28].
In its two latest albums ("Lateralus", 2001, and "10 000 Days", 2006), related artifacts and videos, as well as concert images, Tool has worked in close collaboration with Alex Grey (see Figure 1). Grey is specializing in spiritual and psychedelic (visionary) art, and the co-founders of the Chapel of Sacred Mirrors Chapel, a non-profit institution supporting Visionary Culture in New York City. The distinctive art work of Grey (see figure 1) has become an eliminate part of meaning creation in the case of Tool. And the relationship is mutual, as Alex Grey describes his work [29]:
"Because of its mass audience, it reaches people that contemporary painting rarely does… If you don't get to see a painting in the flesh, then how are you going to get to see it? Maybe you'd see it in a magazine. Maybe you'd see it in a book. But if you'd see it associated with powerful music and you love that music, maybe it even engenders a love onto the artwork."

A further approach of co-branding is to transfer meanings by hooking up with a partner from another area. For example, HIM has been sponsored by Jägermeister in some of its tours, and another Finnish

Fig. 1. Art work of Tool alums ("Lateralus" and "10 000 Days") created by Alex Grey

band Nightwish recently teamed up with the Finnish premium water brand Veen.

Moreover, the issue of country-specific meanings, discussed above, can be regarded from the viewpoint of co-branding. In the creation of the concepts of the Finnish metal bands and their symbolic contents, as outlined, such collective meaning creation, whether intentional or not, may play a remarkable role in creating success. Forming a collective national identity for different fields such as music has been regarded as an important starting point for Finnish cultural exports [30].

3 Artifacts of music as carriers of meaning

Music artifacts are regarded as carriers of contextualized meanings that become manifest through the qualities of the artifacts. The key question concerns: How do the bands reason about their concepts and how are they transformed into product attributes including various visual representations? In this chapter, we proceed towards a typology of communicative elements used by the bands.

3.1 Meaning transmission and creation

Producers of music (as any companies) can use their products intentionally to transmit meanings to potential target audience. However, despite the possibilities to manipulate perception, the interaction view proposes that meaning creation is eventually out of the producer's control – meanings are actualized in the interaction between the artifact and the user. Meaning transmission and creation, in fact, are two generic in communication research [31], and there appear fundamental differences in the views of predefined meaning transmission and shared meaning creation. Firstly, communication can be considered a transmission of embodied meanings from a sender to a recipient (i.e., from the band to the fan in our context). Secondly, communication also deals with creating shared meanings in the social context.

This semiotic perspective as a production and change of meanings stresses the process nature of communication, according to which identity (of a band, for example) is under constant evolution. Therefore, specific identity can only be seen as a cross-section at a certain time point. This has implications on our methodological choices. In addition to analyze the visual representations of the bands at some specific point of time, we need to apply a historical view and ponder how meanings are created within the representational continuum.

Also in brand literature, there exists a growing interest in meanings and symbolism being "co-created" within specific physical and virtual brand communities for instance through "tribal marketing" [32][33] and joint cultural production of marketers and consumers [34]. The notion of co-creation of meanings also refers to the modern comprehension of branding and identity building, so-called "holistic perspective on branding"

[35][36][37][38][39]. This interactional or holistic perspective on brands implies that the meaning of the artifact and that of the band (as a brand) are intertwined, and that together they lead to a powerful mix of associations. Therefore, when analyzing the visual identity of metal bands, the whole "brand system" needs to be looked at, consisting of the band's narrative concept (intent), name and symbols, as well as supporting products and services.

The notion of shared meaning creation also underlies our interactionist and cultural view on symbols. Nonetheless, as a pure methodological choice, intentional transmission from the music producer to its audience is our primary context of analysis. In any case, as meaning transmission happens in a context, and our discussion later suggests the inevitable interaction between the representational realm of the artifact, its reference relation and the context of interpretation. In the view of transmission, message is dependent on the meanings the "sender" encodes into it.

Most theories of communication are based on the following four principal components [40][41]: 1) the message, signal, or code, 2) an output or transmission, 3) an input or reception, and 4) a response. These components operate in linear fashion: firstly, a signal needs to be created, then sent, and finally responded to. In interactive reality, as noted, these two views are inseparable. While encoding intentional meanings, for instance, into a music artifact through specific semantic aspects to be subsequently transmitted to recipients, the producer is also surmising potential interpretations of these aspects, thus in the actuality of shared meaning creation. As a generic approach, we regard concept building and visual communication through the basic product communication model that has been used in various applications in design research and related areas [42]. The model distinguishes three main parts in the (process) of communication: (1) intent, (2) media, and (3) response.

3.2 Construction of the band intent and identity

In order to clarify how producers (particularly the bands) charge meanings with various artifacts (musical and visual elements, in specific) in an intentional manner (i.e., to obtain certain communicative goals), we need to analyze, how the intent of the band is constructed. According to our tentative findings, there are few larger (yet inter-connected) constructions underlying the narrative concept of heavy metal bands. The process of signification is influenced by the context: the traditions and categories of heavy metal, the cultural or country-of-origin background of the bands, and the quest for reinforcing differentiation. These constructions may be referred to in an explicit fashion, but more often they are implied inherently in meaning creation.

To these contextual constructions of the external environment, we have identified another important component. Strong personal ideology of the establishing member(s) and other stakeholders is the starting point and reason for existence for most bands.

The reason to create and play music may range from expressing personal feelings, telling personal stories, to transmitting political, social, and other messages, or simply to the ideology of having fun. Personal ideology and aspirations also dictate the development of the band's musical, visual and media identity. Band "leaders" such as Ville Valo of HIM, Tuomas Holopainen of Nightwish, and Alexi Laiho of Children of Bodom with their personal intent (at least to start with) all act as the main architects of defining and shaping the concepts of their bands.

Our initial analyses and observations suggest that many bands that are successful in the field are paying careful attention not only to creating a strong and distinctive concept but also to the communicative aspects of their musical and visual product to support the concept.

The intent of HIM, Nightwish, Children of Bodom, and many other bands, seem to be strongly communicated through and supported by various elements in their offerings. Regarding the bands' communicated identity we have identified a number of features – categorized under four tentative aspects (musical identity, visual identity, behavioral identity, and co-branding) – that the bands use as communication media (see Figure 2).

Musical identity is in most cases functioning as the most important product aspect and media of the band. The elements of the musical concept can then be supported by visual features, media presence and behavior, as well as various means of co-branding. In all of our cases, music itself is of course the bands' main communication media and often the key determinant of the whole identity [43]. This concerns the band's music (tonality and structure, instrument use, song structure, vocal style, etc.), lyrics, and album concepts.

In terms of visual identity, our analyses concern the visual features the band uses in its album art, print and electronic media. Visual communication in the concert context (named here "stage design") is another key area of concern. Band looks (personal style, gear and wear) is the third focus point. It is important to ponder how the visual features work in interaction with the musical elements of the band, together communicating the intent. The third identity category refers to the media (and stage) presence and behavior of the band and individual band members. This category can in some cases form an integral part of the band's perceived identity. For example, the mythical image of the earlier discussed band Tool 3 is, in addition to the strong musical and visual concept, much based on their strategy diminished media presence. Finally, the above pondered topic of co-branding is added in the framework as the fourth focus area.

3.3 Distinctiveness and coherence of the narrative concept

As discussed, and as proposed by the contemporary holistic view of branding, in order to differentiate, be unique, and attain strong meanings, the communication of the band needs to be consistent. The various artifacts of the band must evoke coherent meanings. In addition to the previously discussed band Tool, such coherence has also been clearly visible in the early findings of our study in the successful Finnish bands.

To give a closer example, Amorphis, one of the pioneering Finnish metal bands in international markets, consistently builds on and strengthens its image of "Finnishness" as the core concept of the band. Amorphis (established in 1991) uses references to the Finnish cultural heritage. These "prog-death experts … with strong folk leaning" [44] created awareness with albums titled "The Karelian Isthmus" (1993) and "Tales From A Thousand Lakes" (1994) and songs like "My Kantele" (from "Elegy", 1996) and have used the Finnish national epic "Kalevala" as a key ingreadient of their concept.

Interestingly, concept Although The Karelian Isthmus with a name reference to a historic Finnish battleground, the album's lyrics contemplated universal themes of warfare and religion, drawing on Celtic mythology rather than the traditions of Amorphis' own native land. Tales from the Thousand Lakes was then a concept album based on the Kalevala, and ever since Amorphis has rather consistently nurtured their Finnish heritage, with a one notable exception though. The album "Far From the Sun" (2003) namely made a folk-oriented journey into Turkish and Persian territory. After this side step, the band made a thematic return to Kalevala. The latest three albums are also consistent in incorporating the Kalevala theme, built on the lyrics. The lyrics on the "Eclipse" (2005) album were written on the basis of "the story of Kullervo", the most tragic character of the epic, by recently deceased Finnish poet and writer Paavo Haavikko). The successor "Silent Waters" (2006) continued the story, recounting the tale of Lemminkäinen's hunt for the Swan of Tuonela. The most recent Amorphis album "Skyforger" (2009),

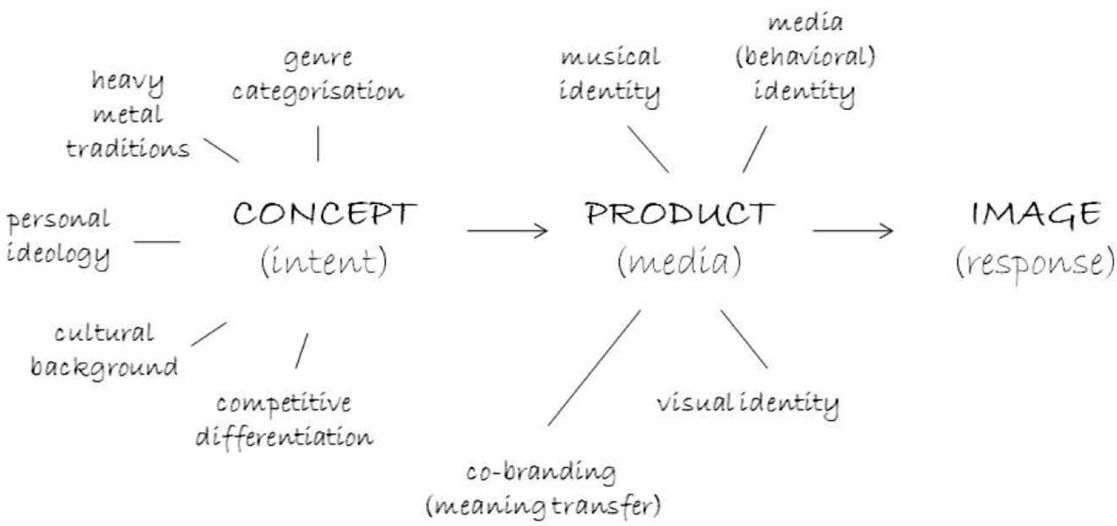


Fig. 2. Construction of intent and band identity.

in turn, told Kalevala stories wrapped around "Seppo Ilmarinen", the god-like figure of Kalevala who had forged, among other things, the canopy of the sky and the "Sampo", the mystical device generating the richness of the World.
The references to the Kalevala are reinforced not only by the lyrics and specific passages in the band's musical identity inspired by the Finnish folk music, but also by the visual themes of the Amorphis albums and related artifacts (see Figure 3).
This distinctive and unique concept and its' cultural specific meanings function as a means of differentiation and recognition building in international markets. According to the band's guitarist and main character Esa Holopainen, this story line seem to interest many Amorphis fans and make a difference for instance in US and Japanese markets [45]. This was also commented by a US fan in our email conversation: "… I also found their use of the Kanteletar as lyrics very interesting because Amorphis was the first band I ever encountered that used poetry as a source for their lyrics. Amorphis' focus on Finnish lore is really cool, and I wish more bands would explore interesting topics lyrically the way they have."

3.4 Signature elements

A person can interpret and understand the artifact's content through its material representations. Each artifact (either physical or immaterial) has an interface that we can describe broadly as the aggregate of characteristics with which the user initially engages in order to make use of an artifact [46]. This aggregate refers to the topics of gestalt theory and compositionality of meaning within design semantics. It is the holistic appearance of the artifact that counts in meaning creation [47], which suggests the analysis of holistic impressions as an important entry point for our research. However, the meaning is carried by specific product features, interacting with other features, which could be categorized and analyzed in detail from the semiotic perspective. Our focus is on tracing the associations of bands' concept to certain features of their music artifacts, or merely identifying how certain elements support the intent of the bands. In this signification context, we talk about "signature elements" of the bands. In our analysis, the purpose is to identify the signature elements of each studied bands, and then draw connections back to the underlying constructions of the band concept. Figure 4 presents a tentative

Fig. 3. The covers of the three latest Amorphis albums telling visual stories from the Kalevala (from top left: "Eclipse" (2006), "Silent Waters" (2007), and "Skyforger" (2009).

typology of signature elements that we have identified in the early phase of our study and utilize as a basis for our case-specific analyses.

4 Heavy Metal Signification Process

Next, we take a closer look into the process of signification, adapting the Peircean view of semiotic to our study on heavy metal bands. The model described here also works as a mediating framework to infuse the cultural view of meaning creation (chapter 2) together

Product identity		Signature elements	
			Band name
			Band "theme"
Musical identity	Music		Tonality & structure
			Instrument use
			Song structure
			Vocal style
	Lyrics		Themes and style
	Album concepts		
Visual identity	Visual features (print & e-)	Band logo	
	… album covers	Typeface	
	… posters, adds	Motifs	
	… web pages	Pictures	
	… accessories	Graphics, colours	
	… videos	Details	
	Stage design	Motifs	
		Architectural elements	
		Lights, pyros, smoke, etc.	
		Gear	
		Gimmicks	
	Band looks	Gear	
		Wear	
Behavioral identity	Media presence & behavior		
Co-branding (meaning transfer)	Gear endorsements Co-op artists Accessories National, Local		

Fig. 4. Initial typology of signature elements in the case of music artifacts.

with the view on artifacts as meaning carriers (chapter 3). We also present few illustrative examples to apply the model to practice.

4.1 ROI framework

The key question concerns how signature elements function as signifiers, and how the signification process in heavy metal could be comprehended in general. Within the context of communication, artifacts can be regarded as signs carrying meanings. Specific signature elements embody particular meanings In this context, the theory of signs by Peirce [10][48] provides a potential entry point, especially as it has been applied to the semantic analysis of products [4][49][50][51]. This approach is relevant in the pragmatic context and is fundamentally applicable to the analysis of communicative artifacts that takes on meaning through interaction.

According to the Peircean perspective, the semantic references of objects (of communication) can be regarded as modes entailing a fundamental division (as "trichotomies"). Peirce's theory of signs suggests that the process of signification is regarded as a triadic relationship between the Representamen ("perceptible object", R), Object (of reference, O), and Interpretant (meaning of the sign, I). Signs are thus divisible by this triadic construction. Firstly, the Representamen, the sign in itself, is a mere quality, actual existent, or general law. In Peirce's division there is a clear distinction between the sign as the complete triad and the Representamen as its first correlate. The idea behind the Representamen is close to what other semioticians have called symbol, sign vehicle, signifier, or expression [52]. Secondly, in relation to its object, the sign has some character in itself, or is in some existential relation to the object or to the Interpretant (reference relation). Thirdly, the Interpretant represents the sign as a sign of possibility, fact, or reason (interpretation relation). Meanings are constructed through, and only through, this triadic interaction.

If applied to the purposes of our study, R can be regarded as consisting of a specific signature element (or feature) that functions as a replica of the sign through its characteristics (form). The object of reference relates to an attribute (intent in our analysis) with which the signature element has a reference relation. Interpretation is connected to the interpreter (fans or potential audience of the band) within the semiotic process and thus involves subjective interpretation that occurs within a certain context. Above discussed context-sensitive meaning creation, within the sub-culture(s) of heavy metal, and groups, construct framed "possibilities" for meaning creation. In whole, this construction generates meaning in the artifact-perceiver relationship and thus evokes associations in the mind of the perceiver.

Figure 5 presents an application of the R-O-I framework to the purposes of our study. In terms of the Object of reference (0) the focus of analysis is on the intent (concept) of the bands; what do they want to communicate to their audience. Signature element functions as a replica of the Representamen (R), carrying specific references to the R, and I relation to the interpretation context of the sign. In Figure 5, we also distinguish two levels of analysis. First, the inner level of the sign, the signification process per se is under scrutiny: How do the identified signature elements refer to the intent, and how this process occurs within the specific interpretation context. The signification process, relationships between O, R, and I, are affected, and dictated, by the underlying constructions that we identified earlier and that function as the second level of our analysis. In terms of personal ideology, competitive differentiation, cultural/ national background, heavy metal traditions and genre categorizations, we aim to explicate how such underlying constructions create conventions that generate context-specific (and bands-specific) meanings.

The R-O-I division of the sign is of course a theoretical construction. In effect, the semiotic sign as a whole is a conceptual device. The meaning of the sign resides in the interaction; sign is not located anywhere. "Meaning is not in the signs, the things, or the head; it is in the processual rush of semiosis" [53]. This notion has implications in the study of semantic references in music

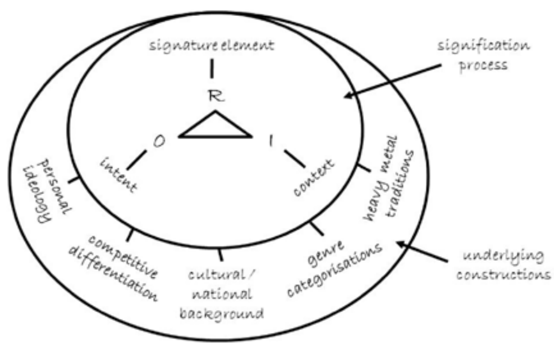


Fig. 5. The R-O-I framework integrated with the underlying constructions of the heavy metal signification process

artifacts. Systematic and mechanistic approaches to connect specific signs (or meanings) to specific signature elements have their limitations. The study has to utilize qualitative assessment only in describing the possible, and perhaps likely, correspondences and natures of reference relations. This is implied through descriptive case studies in our project, which helps us to identify particular examples of reference relations, but will not paint the whole picture of the signification process in the case of heavy metal bands.

4.2 Association Strings

Bands can thus use signature elements as a construction of signs and symbols that their target audience would interpret coherently. This is, of course, the main purpose of "strategic communication" of the intent. As discussed earlier, the target group of this communication is always limited, and, even within this target group, the interpretations vary. In reality, references relations are not as straightforward as presented in Figure 5, but meaning is merely constructed by a "web of sign" called also semantic strings (or strings of signs). When interpreted, certain associations and meanings potentially generate new associations and meanings, for instance, between signature elements and the intended message.

An encounter that the perceiver experiences with the artifact triggers associations that relate to earlier experiences with the artifact and various other artifacts of the band, as well as other signs (bands, etc.) within the interpretation context. The complexity of associations is increased by the fact that the relation between the sign and the object of reference is bi-directional. Associations created by the signature elements are connected to band-specific attributes, but, simultaneously, the existent set of attributes, and its historical representation, affects the interpretation of the elements, and thus adds provisional biases to the process of signification.

Sometimes the string of associations is partly predictable. Many associations (and their representative product characteristics) are "coupled", and this coupling can bring new interpretations to an initially simple relation [54]. For example, "big" is often associated with "heavy". Such coupled structures can be formed on the basis of inherent interpretation (like the big-heavy pair suggestively is) or learnt perception. In the context of heavy metal examples, certain symbolic cues are understood "correctly" within this context but may not have the same symbolic power outside the context. In addition to a semiotic perspective, we can also regard product design from a rhetorical perspective and, more precisely, use the perspective of visual rhetorics [55] that deal with the capability of a visual image to persuade or communicate a compelling message. In line with this view, we may make a difference between "the poetics of products" – the study of products "as they are" – and "the rhetoric of products" – the study of how products come to be vehicles of argument and persuasion [56]. In our study, we emphasize the view of transmitting intentional (thus, persuasive) messages, and approach that supports the rhetorical perspective. However, we need to keep in mind that identity is manifest also on an unintentional, implicit, level. The rhetorical dimension is part of the manifestation that also involves subconscious forms of representation.

4.3 A Tooth that Bites

As an illustrative example of visual meaning creation, we take a brief look into another Finnish band Stam1na. This band has been one of the most successful Finnish bands in recent years, but almost entirely inside the Finnish borders (while no significance effort is yet made to export the bands). Stam1na for instance won most of the prizes in the Finnish Metal Awards 2009, including the first prize in the album cover art category for their "Raja" album (2008) (see Figure 6).

The name and logo of the band are used as strong visual elements that also bare direct references to the concept of the bands. Stamina literally means energy, endurance, resistance, strength, and determination, which well describes the music and concert appearance of the band. Number 1 in the name has simply the meaning of making the band more unique and differentiating the name from other bands and brands.

The tooth logo (see Figure 6) is another strong signature element that the band is also consistently using in their various products. This symbol also has a specific communicative purpose. It appeared first in the cover of the "Väkivaltakunta" EP (2003) (difficult to translate, but basically meaning "violent empire"). As the singer/guitarist of the band, Antti "Hyrde" Hyyrynen, outlined in our interview, tooth is a very personal and intimate thing. In this case it is detached from its context (mouth) in a violent manner, which served well the storyline of that song. By chance, the wisdom tooth of Hyyrynen was removed at that time, and they actually used the real photo of his tooth in the cover. The band them developed the idea further by pondering that the three roots of the tooth also represent the three establishing members in the band. The tooth then appeared as a graphical symbol in the first self-titled “Stam1na” album (2005). As commented by Hyyrynen, the logo has proved very functional, while it is simple and organic and also very distinctive.

Other examples of strong visual communication in the Finnish metal bands include the “Heartagram” of HIM and the reaper theme of Children of Bodom) (see Figure 7). Heartagram (getting almost 50.000 hits in the Google image search) is a trademarked logo and a nice example of visual symbolism, as it strongly denotes the “Love Metal” concept of HIM by combining

Fig. 6. Stam1na album covers with the tooth theme (from left): ”Väkivaltakunta-EP”, ”Stam1na”, and ”Raja”.

Fig. 7. The Heartagram symbol of HIM (left) and the reaper theme of Children of Bodom in the covers of the “Follow the Reaper” and “Stockholm Knock-out Live” albums.

a pentagram, a traditional heavy metal icon, with the heart symbol. This combination, supported by other communicative elements within the musical and visual identity of HIM, thus generates rather rich meanings and strongly supports the intent of HIM. The mood and lyrics of love and despair are combined with heavy metal traditions. Ville Valo, the singer, song writer and leader of the HIM, often talks about, for instance, the Black Sabbath influences in HIM’s music (especially in the most recent “Venus Doom” album). The original name of the band, “His Infernal Majesty”, is also strongly contextualized within this specific music genre.
In the case of Children of Bodom, the reaper theme is not only derived from the traditional imagery of heavy metal but also supports the bands’ intent and musical identity. The theme represents the melodic death metal music elements of the band. The name of the band is also consistent with the identity, as it refers to the tragic event in the Finnish history, when a group of youngsters were killed while camping by the Lake Bodom in Espoo, Southern Finland. The reaper theme is presented in both pictorial and graphic format in the various artifacts of the band.

5 Concluding Remarks

In this paper, we have discussed the creation of symbolic value through visual identity in the music industry. Building unique concepts and recognition through musical and visual elements has been a key issue especially for several Finnish heavy metal bands that we have explored in our paper. Through specific examples, we have analyzed the artifacts of music as carriers of specific meanings. This was done by identifying the visual signature elements that the bands and their stakeholders use as communicative means to signify their musical concepts. Moreover, we discussed the meaning creation in heavy metal and, as initial findings of our study, presented few underlying constructions behind the intents and concepts of the bands studied. These constructions were then drawn together with a conceptual model of signification process. In this combination, we specifically explored the sign theory of C.S. Peirce. As a result, we constructed a mediating framework (chapter 4) to infuse the cultural view of meaning creation (chapter 2) together with the view on artifacts as meaning carriers (chapter 3).
From the perspective of heavy metal bands, the process of producing meanings within the predefined context occurs at least implicitly. The visual landscape can also be explicitly utilized for the purposes of positioning the band as a metal band, in general, and within specific subgenres of metal, often having their own visual codes. Categorization is a means to structure the band concept

by building references to other bands with the same kind of music style. In the case of Finnish metal bands, for example, we have noticed that the traditions, and the symbolism, of heavy metal are either explicitly or implicitly carried on by most contemporary bands. The current bands often explicitly admit their connection to the genre and many elements in their musical and visual identity seem to continue the traditions of the genre.
In addition to implicit meaning creation, the bands have seemingly paid much attention on creating and nurturing unique and strong concepts through explicit communicative means, which shapes the bands more competitive in the global music markets that requires clear differentiation. These concepts are consistently supported through the musical, visual and behavioral identity of the bands, through deliberate and well-thought signature elements.
Our study on heavy metal symbolism and bands' design strategies is on its early phase, and more insights and more consistent theoretical contributions will be revealed as the project proceeds. In addition to shedding more light into the signification process within the area of heavy metal music in general, our aim is to explore the design and artistic processes and practices behind the bands' visual communication. In specific, we will explore the R-O-I framework in more detail. By analyzing our case studies in the light of the Peircean Sign Theory, we aim to identify different kinds of visual references in bands' communication; indexical signs that in the case of the music artifacts primarily refer to the music style and details, and contribute to the internal coherence of communication (e.g. Stam1na's name and logo referring to the band's musical concept), and symbolic (and iconic) signs that have a primary reference relation with the external domain (e.g. HIM's Heartagram, in addition to the music, referring to the heavy metal symbolism, and Amorphis visuals to the Kalevala and Finnish cultural heritage).
Finally, by comparing the processes and practices of strategic meaning creation between the producers of music (providing entertainment and cultural artifacts) and those of physical products and services (more focused on providing specific functionalities), we can come up with interesting insights on the later stages of our study. Such knowledge, we believe, can make a notable contribution to the design practice not only within creative and cultural industries, but also within more traditional fields of product and graphic design.

References

1. Lawson, D. (2003). Foreword, cover of the Lamentations. DVD of Opeth.
2. Schmitt, B. & Simonson, A. (1997). Marketing Aesthetics: The Strategic Management of Brands, Identity and Image. New York: The Free Press.
3 Stompff, G. (2003). The forgotten bond: Brand identity and product design. Design Management Journal, 14 (1), 26-324.
4. Karjalainen, T-M. (2004). Semantic transformation in design – Communicating strategic brand identity through product design references. Helsinki: Publications of the University of Art and Design Helsinki.
5. Karjalainen, T-M. (2004). It looks like a Toyota: Educational approaches to designing for visual brand recognition. International Journal of Design, 1 (1), 67-81.
6. Vossoughi, S. (2008). The best strategy is the right strategy. In Lockwood &Walton (eds.), Building Design Strategy (pp.97-107). New York: Allworth Press.
7. Moisander, J. & Valtonen, A. (2006). Qualitative marketing research: A cultural approach. London: Sage Publications.
8. Holt, D. (2005). How brands become icons – the principles of cultural branding. Cambridge, MA: Harvard University Press.
9. Lash, S. & Urry, J. (1996). Economies of signs and space. London: Sage Publications.
10. Peirce, C. S. (1955). Philosophical writings of Peirce. New York: Dover Publications.
11. Blumer, H. (1998). Symbolic interactionism – Perspective and method. Renewed edition. Berkeley: University of California Press, Berkeley. (Original work published 1969)
12. Simon, H. A. (2001). The sciences of the artificial (3rd ed.). Cambridge, MA: The MIT Press.
13. Christe, I. (2004). The complete headbanging history of heavy metal. New York: Harper Collin.

Toni-Matti Karjalainen
Helsinki School of Economics, IDBM Program, Helsinki, Finland

Antti Ainamo
University of Turku, Department of Sociology, IASM, Turku, Finland

Laura Laaksonen
Helsinki School of Economics, IDBM Program, Helsinki, Finland

Wei-Ken Hung and Lin-Lin Chen
hwkm@mail.mcut.edu.tw

Exploring contradictory meanings in product semantics

Abstract

When investigating the semantics projected by product forms, researchers often use the semantic differential method with bipolar adjectives, such as "modern-classical" or "simple-complex". The image projected by a product is assumed to centered somewhere in the continuum between the two opposite adjectives. However, in design practice, some design examples clearly exhibit the simultaneous use of contradictory meanings in product semantics. For example, retro cars evoke nostalgia by borrowing characteristics from classical cars, but at the same time exhibit modernness. In this research, we examined the results of applying the semantic differential method to measure contradiction in product semantics. Our results show that, the distributions of semantic differential ratings for the stimuli with contradictory meanings have higher standard deviations deviate from the (symmetric) normal distribution with negative kurtosis values. In addition, we found that the "novelty-in-typicality" chairs are likely to have prototypical shapes with additional functions or embedded stories; and that the "simple yet complex" chairs are achieved through the use of material and texture, and product forms. In general, successful embedding of contradictory meanings into product forms are based on simple, typical, and rational forms that are made to simultaneously exhibit complex, novel, and emotional images by introducing additional elements.

Keywords

Contradiction, Product Semantics, Semantic Differential, Janusian Thinking.

1. Introduction

Product forms play an important role in communicating messages and eliciting responses from consumers [1] [2]. The image of a product is communicated via its elements—such as dimensions, materials and finishes, the composition—how the elements are mixed together, and even workmanship—the execution of design details. Although most products seek to deliver a unified message, some design examples clearly exhibit the simultaneous use of contradictory meanings in product semantics. For example, retro cars evoke nostalgia by borrowing characteristics from classical cars, but at the same time exhibit modernness. Figure 1 shows some design examples that make use of contradictory meanings in product semantics. Volkswagen's New Beetle is both traditional and modern; the Block Lamp by Harri Koskinen conveys both warmness and coldness; and the Bubble Club armchair by Philippe Starck is typical in the shape, but novel in the use of material. As Hekkert [4] proposed about design aesthetics, the principles of pleasure in design include "unity in variety" and "most advanced, yet acceptable" [5]. Embedding contradiction might be an effective way to elicit pleasurable responses by introducing novelty into familiar product forms.

Fig. 1.

Traditional or Modern?
New Beetle by Volkswagen

Warm or Cool?
Block Lamp by Harri Koskinen

Typical or Novel?
Bubble Club Armchair by
Philippe Starck for Kartell

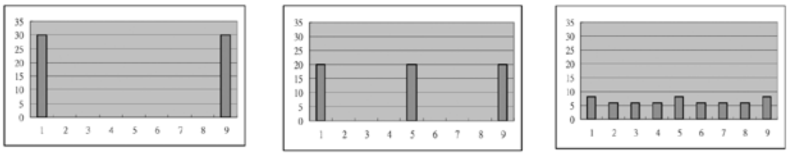
How are product forms with contradictory meanings perceived by consumers? How do we measure contradiction in product semantics? How should designers appropriately embed contradiction in product form to introduce novelty into a familiar product form? These are the questions we intended to explore in this research.

When investigating the semantics projected by product forms, researchers often use the semantic differential method [7]. Usually, a participant rates a product form by using 5-, 7-, or 9-point scales according to several pairs of bipolar adjectives, such as “modern-traditional” or “simple-complex”, as illustrated in Figure 2. With the implicit assumption that the image projected by a product form lies somewhere between a pair of opposite adjectives, and that the distribution of the ratings follows the normal distribution, the average of ratings by different participants is taken as the expected rating value for a product form.

Modern	□	□	□	□	□	□	□	□	□	traditional
Simple	□	□	□	□	□	□	□	□	□	complex

Fig. 2.

However, for product forms with contradictory meanings, can the semantic differential method still be applicable for measuring product semantics? We conjectured that the semantic differential rating results could be distributed in three different ways. First, if the participants perceive either of the contradictory meanings, but not both, the distribution of semantic differential ratings could have double peaks, as illustrated in Figure 3(a). Second, if the participants perceive both of the contradictory meanings, they might check either extreme of the rating scale, or the mid point due to uncertainty, as illustrated in Figure 3(b). Third, if the participants perceive inconsistent meanings, the results could be closer to random guessing, resulting in a nearly uniform distribution. In all of these three potential scenarios, the distributions all have high standard deviations and negative kurtosis parameters.



(a) double peaks
M=5; std=4.03
S=0; K= -2.07

(b) triple peaks
M=5; std=3.29
S=0; K= -1.53

(c) uniform
M=5; std=2.68
S=0; K= -1.24

Fig. 3. (M: mean; S: skewness; K: kurtosis)

In this research, we applied the semantic differential method to measure the responses to 88 chairs, some of which with contradictory meanings.

We then analyzed the resulting rating distributions, and computed the standard deviations, the skewness parameters and the kurtosis parameters to explore the possibility of measuring contradiction in product semantics by using the semantic differential method.

2 Method

2.1 Stimuli

We choose “chair” as the product category for this research, because it is one of the most representative products in design history with a very wide range of designs. We first collected 523 photos of chairs, from the book 1000 Chairs [3], from websites of furniture companies, and by using search engines. Two experienced designers (with more than 5 years of experience) examined the chairs and eliminated those similar in shape to reduce the total number to 213. We then asked 5 senior students with design background to independently sort the chairs into groups according to the chairs’ similarities in shape. We then analyzed the sorting results by using the hierarchical clustering function in SPSS. Finally, we arrived at 88 representative chairs, of which 41 are from the book 1000 Chairs (produced between 1900 and 1997) and 47 from the internet (produced during the last two decades).

2.2 Participants

Two groups of college students participated in the study: 30 with design background and 30 without. The first group consists of senior students from Industrial Design department (18 males and 12 females). The second group consists of sophomore students from Engineering (16) and Management (14) Departments (21 males and 9 females).

2.3 Procedure

We select four semantic differential scales (adjective pairs) to operationalize on typicality [5], and the top three fundamental dimensions of affective responses [6]:

1. Typicality: typical-unique
2. Trend: traditional-modern
3. Emotion: rational-emotional
4. Complexity: simple-complex

The participant evaluated the chairs in four sessions, one for each pair of adjectives. In each session, the participant was first asked to divide the chairs into three groups representing low, medium and high levels with respect to the scale, and then further divided each group into three subgroups, to arrive at a total number of 9 groups. The number of chairs was allowed to be uneven or void in each group. At the end of each session, participants were asked to review the grouping again, and to make adjustments where necessary. The participants performed the grouping tasks at his/her own pace, and completed the four sessions of grouping tasks in about one and a half hours.

After the statistical analysis of experiment was finished, we further interviewed 10 participants with design background whose ratings on semantic differential method were close to the mid-point (neutral) for the four adjective pairs. Participants were presented with three pictures of chairs with largest standard deviation in each adjective pairs, and then were asked to recall what they considered during their evaluation and whether contradictory meanings were sensed.

3 Results

Tables 2~5 show the statistical analysis results for all 60 participants, with respect to typicality, trend, emotion, and complexity scales. In each table, we listed three chairs that were rated the lowest (or highest) for the particular scale and with small standard deviations in the left (or right) column, respectively; and we listed three chairs whose ratings have the largest standard deviations in the middle column.

Table 1 summarizes the results for typicality ratings, where the three chairs having the largest standard deviations in the participants' ratings for the typicality scale are shown in the middle column. In the later interview, most respondents pointed out that these chairs convey both typicality and uniqueness, by adding "additional functionality" or "stories" to a prototypical chair. For example, Figure 4 shows the chair in the middle left column of Table 1, which makes double use of one of the legs as an umbrella stand and a flower pot, allowing water to drip from the umbrella into the pot. Figure 5 shows the chair and the table in the middle right column of Table 1, which have prototypical shapes, yet tell an interesting story via the carved silhouettes of a cat on the chair and the birds on the table. Both of these examples successfully embed both typicality and uniqueness into a product form by introducing novel, abstract concepts into prototypical, physical forms.

Highly Typical Small Standard Deviations			Both Typical and Unique Large Standard Deviation			Highly Unique Small Standard Deviations		
M=1.20	M=1.43	M=1.50	M=3.60	M=3.82	M=4.65	M=8.45	M=8.27	M=7.95
Std=0.51	Std=0.85	Std=0.91	Std=2.67	Std=2.59	Std=2.50	std=1.24	Std=1.13	Std=1.56
S=2.60	S=2.26	S=2.43	S=0.66	S=0.63	S=0.37	S=-3.24	S=-1.49	S=-1.67
K=5.98	K=5.35	K=6.44	K=-0.82	K=-0.62	K=-0.80	K=11.48	K=1.21	K=2.32

Table 1. Typicality
(M: mean; S: skewness; K: kurtosis)

Fig. 4.

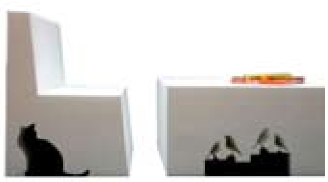


Fig. 5.

Table 2 summarizes the results for complexity ratings. In the middle column are the three chairs having the largest standard deviations in the participants' ratings for the complexity scale. In the later interview, respondents felt that chairs were designed with simple forms as the basis while making use of patterns and textures (Figures 6 and 8), as well as small variations in forms (Figure 7) to create an image of both simple and complex.

Highly Complex Small Standard Deviations			Both Simple and Complex Large Standard Deviation			Highly Simple Small Standard Deviations		
								
M=8.63	M=8.42	M=8.40	M=4.20	M=4.67	M=4.00	M=1.42	M=1.48	M=2.07
Std=0.92	Std=1.37	Std=1.22	Std=2.86	Std=2.72	Std=2.67	Std=0.94	Std=1.11	Std=1.36
S=-2.57	S=-3.26	S=-2.37	S=0.41	S=0.29	S=0.47	S=2.56	S=3.06	S=1.20
K=5.78	K=11.50	K=5.17	K=-1.25	K=-1.23	K=-1.12	K=6.33	K=10.93	K=0.17

Table 2. Complexity
(M: mean; S: skewness; K: kurtosis)


Fig. 6.


Fig. 7.


Fig. 8.

Table 3 summarizes the results for emotion ratings. In the middle column are the three chairs having the largest standard deviations in the participants' ratings for the emotion scale. In the later interview, respondents stated that two of the chairs (Figures 4 and 9) add additional elements to the prototypical chairs to tell stories. An interesting case is the chair in Figure 10. By covering soft clothes over a prototypical chair, half of the respondents perceived the chair as both rational and emotional while half of the respondent perceived the chair of no particular feelings as neither rational nor emotional.

Highly Emotional Small Standard Deviations			Both Rational and Emotional Large Standard Deviation			Highly Rational Small Standard Deviations		
								
M=7.23	M=7.13	M=7.10	M=4.6	M=4.73	M=4.68	M=1.85	M=2.42	M=2.55
Std=2.00	Std=2.12	Std=2.03	Std=3.23	Std=3.02	Std=2.81	std=1.39	Std=1.84	Std=1.69
S=-0.98	S=-1.20	S=-0.96	S=0.23	S=0.11	S=0.24	S=1.77	S=1.62	S=0.70
K=0.04	K=0.98	K=0.14	K=-1.63	K=-1.54	K=-1.30	K=2.17	K=2.80	K=-0.93

Table 3. Emotion
(M: mean; S: skewness; K: kurtosis)


Fig. 9.


Fig. 10.

Highly Modern Small Standard Deviations			Both Modern and Traditional Large Standard Deviation			Highly Traditional Small Standard Deviations		
								
M=8.20	M=7.73	M=7.72	M=5.03	M=4.98	M=4.72	M=1.35	M=1.62	M=1.75
Std=1.33	Std=1.31	Std=1.57	Std=3.00	Std=2.95	Std=2.75	std=0.78	Std=1.24	Std=1.39
S=-1.60	S=-0.83	S=-1.08	S=-0.12	S=0.03	S=0.09	S=2.43	S=3.06	S=1.97
K=1.51	K=-0.08	K=0.29	K=-1.42	K=-1.38	K=-1.29	K=5.32	K=11.94	K=2.78

Table 4. Trend
(M: mean; S: skewness; K: kurtosis)

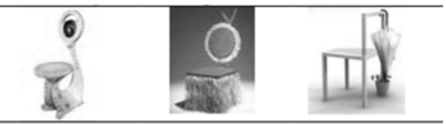
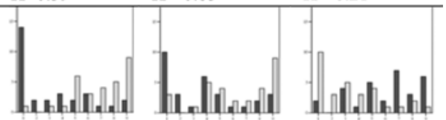
			
Design Background ■	**M=3.23** Std=2.67 S=0.89 K=-0.45	**M=3.80** Std=2.78 S=0.65 K=-0.80	**M=6.07** Std=2.41 S=-0.56 K=-0.57
Non-Design Background □	**M=6.83** Std=2.10 S=-0.86 K=0.39	**M=6.17** Std=2.67 S=-0.53 K=-0.83	**M=3.37** Std=2.41 S=0.85 K=-0.21
			

Table 5. Trend ratings for participants with and without design background (M: mean; S: skewness; K: kurtosis)

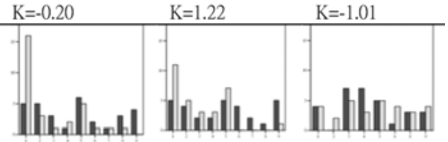
			
Design Background ■	M=4.57 Std=2.81 S=0.28 K=-1.27	M=4.77 Std=2.79 S=0.14 K=-1.21	M=4.50 Std=2.40 S=0.56 K=-0.39
Non-Design Background □	M=2.63 Std=2.16 S=1.02 K=-0.20	M=2.87 Std=2.00 S=1.06 K=1.22	M=4.80 Std=2.61 S=0.22 K=-1.01
			

Table 6. Typicality ratings for participants with and without design background (M: mean; S: skewness; K: kurtosis)

Table 4 summarizes the results for trend ratings. In the middle column are the three chairs having the largest standard deviations in the participants' ratings for the trend scale. Table 5 shows the breakdown of the rating results for the two groups of participants with and without design background. We can observe that these three chairs mean differently for the two groups of participants: where participants with design background perceived as being more traditional, participants without design background perceived as more modern; and vice versa.

To further investigate the possible influences of a participant's background on rating results, we take the typicality scale as an example and analyze the rating results for the two groups of participants with and without design background. As can be observed from the bar charts in Table 6, in either group, there are some participants who perceive the stimuli as typical, while some perceive the same stimuli as unique, with distributions similar to those hypothesized in Figure 3.

We concluded that, relatively large standard deviations in semantic differential ratings can result from three possible reasons:
First reason can be regarded as "at odds". As the examples in Table 5 illustrate, two groups of participants interpret the stimuli differently, but for each group, the meanings of the stimuli are relatively consistent. For this case, the semantic rating results can be analyzed more accurately by considering important factors, such as participants' backgrounds.
Second reason is "contradictory". As the examples in Table 6 illustrate, the stimuli themselves might convey contradictory meanings. Thus, the ratings results in either group exhibit distributions with several peaks, similar to those hypothesized in Figure 3. Because the distributions might not follow the normal distribution, the average of ratings is not a good estimator of the responses.
Third reason can be treated as "insensitive". As found from the interview about the chair in Figure 10, respondents could simply not be able to detect any particular meaning of the chair. The result could be large stand deviation due to random guessing. In this case, a new method needs to be developed to accurately measure the responses towards these products.

4 Conclusions

In this research, we examined the results of applying the semantic differential method to measure contradictions in product semantics. The results show that, the distributions of semantic differential ratings for the stimuli with possible contradictory meanings have higher standard deviations. Further analysis indicates that these distributions deviate from the (symmetric) normal distribution, with several peaks and negative kurtosis values. This means that, for stimuli with contradictory meanings in product semantics, the usual implicit assumption that the image projected by a product form centered somewhere between a pair of opposite adjectives, and that the ratings follows the normal distribution, do not hold. Thus, the average of ratings by different participants is no longer a good estimator. A new method needs to be developed to accurately measure the responses towards products with contradictory meanings.

We caution that, relatively large standard deviations in semantic differential ratings could not only result from the stimuli themselves conveying contradictory meanings, but also from different groups of participants interpreting the stimuli differently, or from participants not being able to detect any particular meaning. When analyzing rating results, it is therefore important to examine the rating distributions for possible group differences, before using average ratings as estimators for subsequent analysis.

Finally, by examining Figures 4~10, we found contradictory meanings are embedded into product forms, by basing on simple, typical, and rational forms, and then introducing additional elements to simultaneously exhibit complex, novel, and emotional images. For example, the "novelty-in-typicality" chairs are likely to have prototypical shapes with additional functions or embedded stories; and that the "simple yet complex" chairs are achieved through the use of material and texture, and product forms. We hope to further explore ways to successfully embed contradictions into product forms to elicit pleasurable responses in our future research.

References

1. Bloch, P. (1995). Seeking the ideal form: Product design and consumer response. Journal of Marketing, 59, 16-29.
2. Crilly, N., Moultrie, J., & Clarkson, P. J. (2004). Seeing things: Consumer response to the visual domain in product design. Design Studies, 25(6), 547-577.
3. Fiell, C., & Fiell, P. (1997). 1000 Chairs. Italy: Taschen.
4. Hekkert, P. (2006). Design aesthetics: Principles of pleasure in design. Psychology Science, 48(2), 157-172.
5. Hekkert, P., Snelders, D., & Van Wieringen, P. C. W. (2003). Most advanced, yet acceptable: Typicality and novelty as joint predictors of aesthetic preference in industrial deign. British Journal of Psychology, 94(1), 111-124.
6. Hsiao, K. A., & Chen, L. L. (2006). Fundamental dimensions of affective responses to product shapes. International Journal of Industrial Ergonomics, 36(6), 553-564.
7. Osgood, C. E., Suci, G., & Tannenbaum, P. (1957). The measurement of meaning. Urbana, IL: University of Illinois Press.

Wei-Ken Hung
Mingchi University of Technology, Taipei County, Taiwan

Lin-Lin Chen
National Taiwan University of Science and Technology, Taipei, Taiwan

Tom Djajadiningrat, Luc Geurts, Popke Rein Munniksma, Geert Christiaansen, Jeanne de Bont
jpdjajadiningrat@yahoo.com

Rationalizer: an emotion mirror for online traders

Abstract
Philips and ABN AMRO have joined forces in the development of Rationalizer, a product concept which aims to support serious home investors who trade online. Investors are typically driven by two emotions, fear and greed, which can compromise their ability to take an objective, factual stance. Rationalizer acts as a kind of 'emotion mirror' in which the user sees reflected the intensity of his feelings in the form of dynamic lighting patterns. An intense reflection alerts the user when it may be wise to take a time-out, wind down and re-consider his actions, enabling him to take financial decisions which are less emotionally charged and more rationally founded. We see this project as relevant to design practice in two ways. Firstly, we feel that the domain of emotionally intelligent products is burdened with unrealistically high expectations. This results in the development of complex emotion sensing technologies which may work in a strictly conditioned lab setting but falter when exposed to the experiential complexities of a real-life use situation. Using Rationalizer as an example, we argue that with more modest expectations and an understanding of the constraints of more basic emotion sensing technologies, interesting applications can be found which are feasible in the short term. Secondly, in the design of Rationalizer we encountered a number of semantic issues, including the connotations of emotion sensors, the aesthetic fit to the domestic context from an appearance and behavioural perspective, and the new product typologies which Rationalizer may point towards.

Keywords
Emotions, Online Investment, Intelligent Products, Ambience, Semantics, Behaviour, Aesthetics.

1 Introduction
In recent years, more and more non-professional investors have become active in the financial markets and are offered an increasingly complex and wide-ranging set of services and instruments. What was once the sole province of professional investors is now accessible to a much wider user base. European legislation [1] ensures that non-professional investors receive a higher level of protection from the bank than professionals get.
A well-known way for the bank to assess the knowledge, experience and personality of a potential investor is establishing the user's investor profile through a questionnaire. This questionnaire consists of two sections. One section, known as the risk profile, relates to the user's investment objective, his preferences regarding risk taking and his financial position. The questions in the other section relate to the user's experience in and knowledge of investment. The questions on risk taking are very much about the personality type of the user and his emotional response to fluctuations in the value of his assets portfolio.

When an investor trades via online trading applications without consulting the financial experts of the bank, the investor's profile helps the bank to validate that the intended transaction matches the investor's financial position, his financial objective, his knowledge and experience and the risk he is willing to take.

Now that trading through an online applications from the privacy of one's home has become commonplace, decisions are easily and quickly made. Unlike trading through written orders and phone calls, trading through the web allows the user little time for reflection and reconsidering his actions: the user can commit himself to his decision within seconds. Research shows that investors who switched from traditional discount brokerage to an online service nearly double their number of trades [2] and experience lower returns caused by poor decisions [3].

The traditional way to help the online investor perform better is education. Similar to many other banks and brokers, ABN AMRO has an online trading academy that helps to educate investors. Furthermore, ABN AMRO publicizes online bulletins, email newsletters and market reviews to help online investors gain more knowledge on the stock markets. All these measures are based on the assumption that investors make rational decisions according to the Efficient Markets Hypothesis [4] and therefore benefit from knowledge and information. However, critics of this Efficient Markets Hypothosis argue that investors make more often irrational than rational decisions. The sources of these irrationalities are attributed to psychological factors such as fear, greed and other emotional responses to price fluctuations and changes in an investor's wealth [5]. For example, driven by fear, investors may sell too hastily when share prices drop. Driven by greed, they may be overenthusiastic—too 'eager'—buying too many shares at too high a price. Whilst the risk profile may help the user in building a portfolio that is in balance with his emotional response to risk, it provides no protection from emotional decisions made during trading 'in the heat of the moment'.

A well-known way of representing emotional response is in the form of a two-dimensional plot, the affect circumplex model [6]. One axis of this model, called 'valence', indicates whether an emotion is experienced as positive or negative; the other axis, called arousal, indicates the intensity of the emotional state. According to [7], a clear link can be found between emotional reactivity and trading performance. Investors whose emotional reactions to monetary gain or loss were more intense on both the positive and negative side exhibited significantly worse trading results. This implies a negative correlation between successful trading behavior and emotional reactivity. This then leads to the following insight: non-professional investors may benefit—in addition to traditional education and risk protection—from a real-time alert that identifies their emotional response to market fluctuations and helps them to make more rationally founded decisions. This insight triggered a joint exploration project by the ABN AMRO Dialogues Incubator and Philips, leading to the Rationalizer product concept described here.

In the remainder of the paper, we first describe how Rationalizer addresses our insight. Then we explain how we worked within the limitations of current emotion sensing technologies. Finally, we discuss a number of design considerations in which we believe semantics [8] to play an important role, including the choice of sensor location, the fit between product and use context, the connotations of how emotions are rendered, the expression of dynamic light and the resulting new object typologies.

2 Description of the Rationalizer product concept

Rationalizer consists of two components: the EmoBracelet and the EmoBowl (Figure 1). The EmoBracelet measures the intensity of the user's emotion, also known as the arousal level, through a galvanic skin response sensor. This arousal level is rendered as a dynamic light pattern on either the EmoBracelet itself or on the EmoBowl. The higher the user's arousal level, the more intense the dynamic light pattern becomes: the number of graphic elements in the pattern increases, their speed increases and—in the case of the EmoBowl—their colour shifts from a soft yellow via orange to a deep red. One can think of Rationalizer as a kind of 'emotion mirror' in which the user sees reflected the intensity of his feelings. An intense reflection alerts users when it may be wise to take a time-out, wind down and re-consider their actions. Rationalizer thus makes users conscious of their emotions during financial decision making.

The reason for creating two display objects is that we intend to test user preference for different ways of rendering emotion. The advantage of rendering the

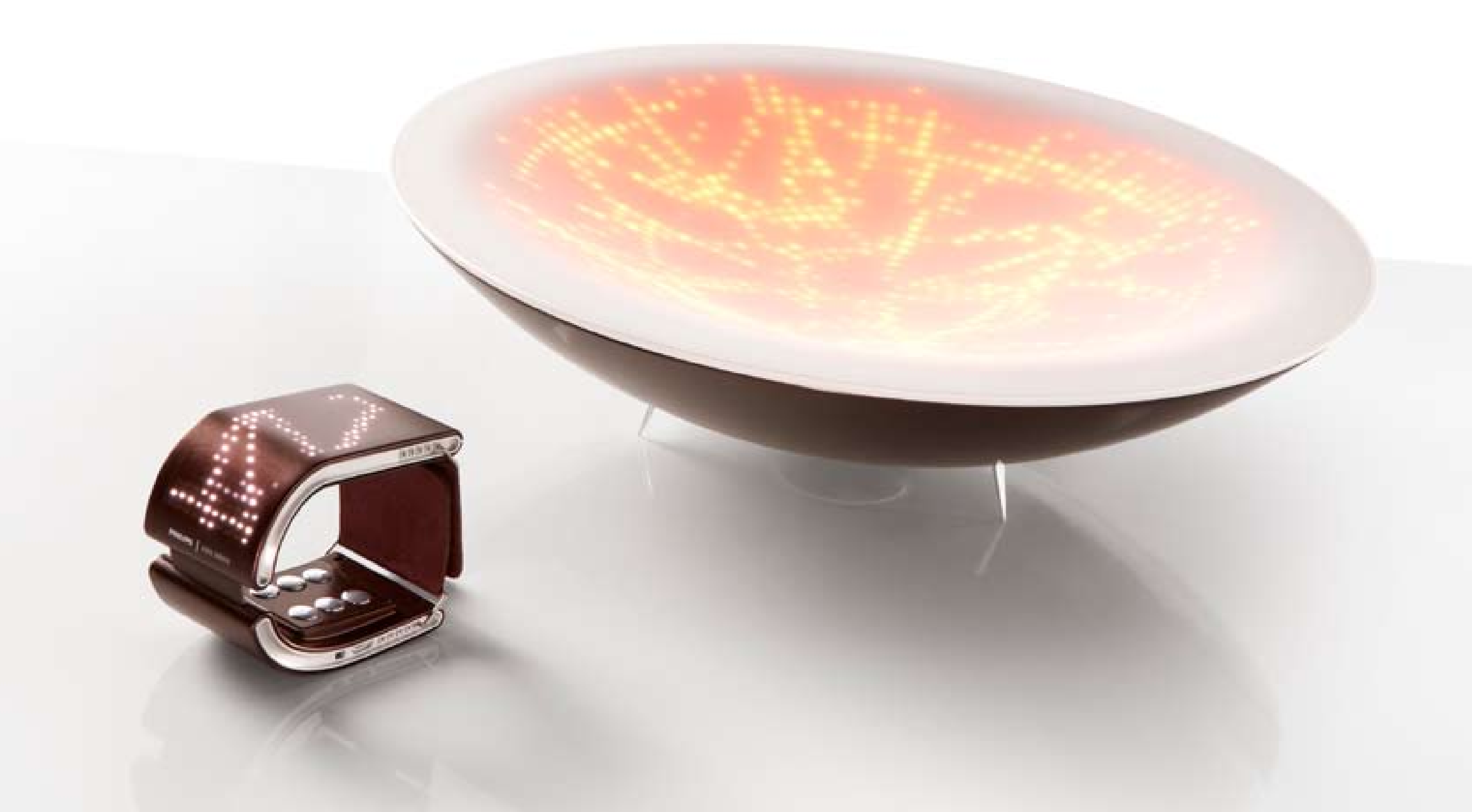


Figure 1. EmoBracelet and EmoBowl.

dynamic light pattern on the bracelet is that sensing and rendering become integrated in a self-contained device and no further objects are necessary. At the same time, we expect that some people may feel that a light pattern on a bracelet may simply be 'too much' and that they feel uncomfortable with the idea of 'a Christmas tree on their wrist'. When using a separate object such as the EmoBowl for rendering, the bracelet could be reduced to a simple measuring instrument without display capabilities and thus become more modest in size and more restrained in appearance.

3 An application suited to the limitations of sensing technology

Possibly cultivated by science fiction movies and novels, the domain of emotionally intelligent products [9, 10] is burdened with unrealistically high expectations. One such expectation is that emotion sensing needs to be able to determine the most sophisticated of human emotions with pinpoint accuracy, before emotionally intelligent products can be of value to the end user. This leads this research domain into a downward spiral of ever more complex and experimental emotion sensing technologies. Such technologies may work in a controlled lab setting but lead to a host of practical problems when exposed to a real-life use situation and its associated experiential complexities, pushing their application into the distant future.

What makes the Rationalizer use case interesting from a emotions theory point of view is that measurement of the arousal component of emotion suffices. A well-known way of describing emotions is through Russell's valence-arousal model in which valence indicates whether an emotion is experienced as positive or negative and arousal indicates the intensity of the emotion [6]. Russell's emotion circumplex plots the valence and arousal components of emotions in two dimensions. Typically, using physiological sensing the arousal component of emotion is much easier to determine than valence. Usually, the lack of a valence measurement is considered a serious shortcoming: whether we experience an emotion as positive or negative is such a fundamental aspect of everyday experience that it seems no emotionally aware product could do without it. However, in this use case it does not really matter whether the user is highly negatively or highly positively aroused: both situations may lead to tainted decision making. To put it simply, the online

trader should be made aware when entering either extreme state of arousal, be it positive or negative. This means that this application is well suited to the current limitations of emotion sensing technology.
We chose to use galvanic skin response (GSR) sensing technology for Rationalizer, which is a method of measuring the electrical resistance of the skin. GSR indicates emotional arousal only: it reacts to a startle response in the user without considering whether this response is positive or negative. In essence a GSR sensor is an Ohm meter, measuring the electrical resistance between two points. The sensor and signal processing software used in the EmoBracelet have been developed by Philips Research [11, 12].

4 Choosing a sensor location

The semantics of sensor location

Part of the design brief was to make sensing as unobtrusive as possible. One approach is to follow the 'no-sensors-on-the-body' principle and to put sensors in the environment instead. In the case of GSR, a possibility is to embed the GSR sensor in a mouse. We rejected this option for a number of reasons. First of all, movement of the body relative to the sensor tends to create much noise in the GSR signal. Also, when the user happens not to be using the mouse, emotion events may be delayed or even be missed altogether. Finally, the user may alternate between a mouse and keyboard navigation or, in case of a laptop, use a trackpad instead.
Having to put a sensor on the body after all, an important consideration became its location as GSR is easier to measure on some parts of the body than on others. As GSR reacts to 'microsweat'—bodily transpiration which influences the skin's electrical conductivity but may not be perceived by the user—the best signal is obtained at places with sweat glands. Prime locations of eccrine sweat glands are the palms of the hands, the forehead and the soles of the feet. Whilst in a scientific lab situation these locations can be used to obtain the best possible signal, in a real world product these locations pose problems. Using a GSR sensor on the hand palm gives a good signal but only when the hand is stationary. In an everyday situation the GSR signal is easily disturbed by movements of the hand and fingers. Gloves or partial gloves may help holding a GSR sensor in place but are difficult from a user acceptance point of view: they are highly encumbering and are reminiscent of the old days of VR data gloves, giving the user a cyborg-like appearance. Using head bands or sensors on the feet may be even more problematic. Interesting here is that these are predominantly semantic issues. Though sensing devices designed for these locations may work fine from a technical and ergonomic point of view, the values and connotations which come with these sensor embodiments are at odds with the values associated with the application. Even when a sensor head band is dressed up as a wireless tiara, even when the sensors are elegantly embedded within shoes or socks, the associations that come with these sensor locations are simply unacceptable for a business-like application such as online trading.
For these reasons, we settled for embedding the GSR sensor in a watch-like product (Figure 2). Although the wrist is not the most optimal location to measure, it is a well accepted location for wearing technological devices.

Figure 2. The EmoBracelet is an integrated emotion sensing and rendering device worn on the wrist.

Making the best of sensing on the wrist

We use two measures to improve the suboptimal quality of the GSR signal obtained on the wrist. The first is that the Philips Research sensor features adaptive ranging, meaning that the signal processing software automatically maps its range to the strength of the available signal.
The second is the use of multiple sensor tips. The current prototype of the EmoBracelet is equipped with six tips, even though only two out of six tips need to be active at one time. Close contact between tips and skin is crucial for a good signal and multiple tips provide some flexibility in finding the best measuring spot and

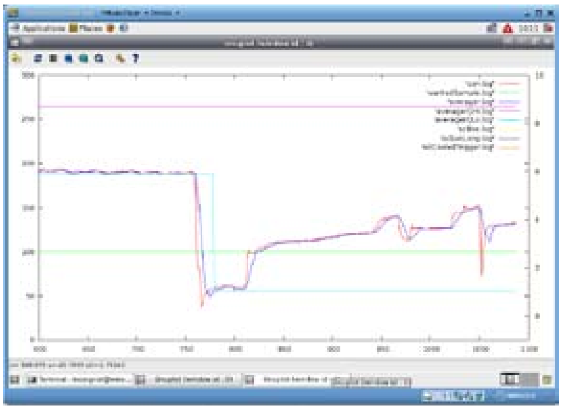


Figure 3. A plot showing galvanic skin response.

accommodating for different wrist sizes. Currently, the active tips are appointed manually. However, we envisage that the software could automatically identify the two tips which provide the best signal.

Figure 3 shows a plot of a GSR signal. The signal processing algorithm determines an upper and a lower limit. When the signal exceeds either limit an 'emotion event' is generated and the limits are adjusted. This particular plot shows a sharp drop in resistance corresponding to heightened arousal, triggering an 'emotion event', followed by a 'recovery'. Though there are some small 'emotional aftershocks', these stay within the new limits.

5 Product Semantics: fitting the domestic environment

As Rationalizer is targeted at non-professional rather than professional investors, the main use context is the home. Within the home, we envisage two use situations. The first is the user at a desk in his home office, an increasingly common space within the home for teleworking and doing administrative tasks. The second is using a computer notebook in the living room (Figure 4). The home being our use context, we decided to work with a domestic design language: rather than creating a visually obtrusive hightech gadget or an 'executive toy', our aim was to create a low-key object which would blend in rather than stand out in a domestic setting. Since the appearance of the EmoBracelet and EmoBowl is highly influenced by the dynamic light patterns, we discuss the semantics of their static as well as of their dynamic appearance.

Static appearance

As we were looking for a simple decorative object which would fit naturally in a domestic environment, we came to work on a bowl. The notion of ambient objects—a visually restrained breed of consumer electronics which fits in with the environment rather

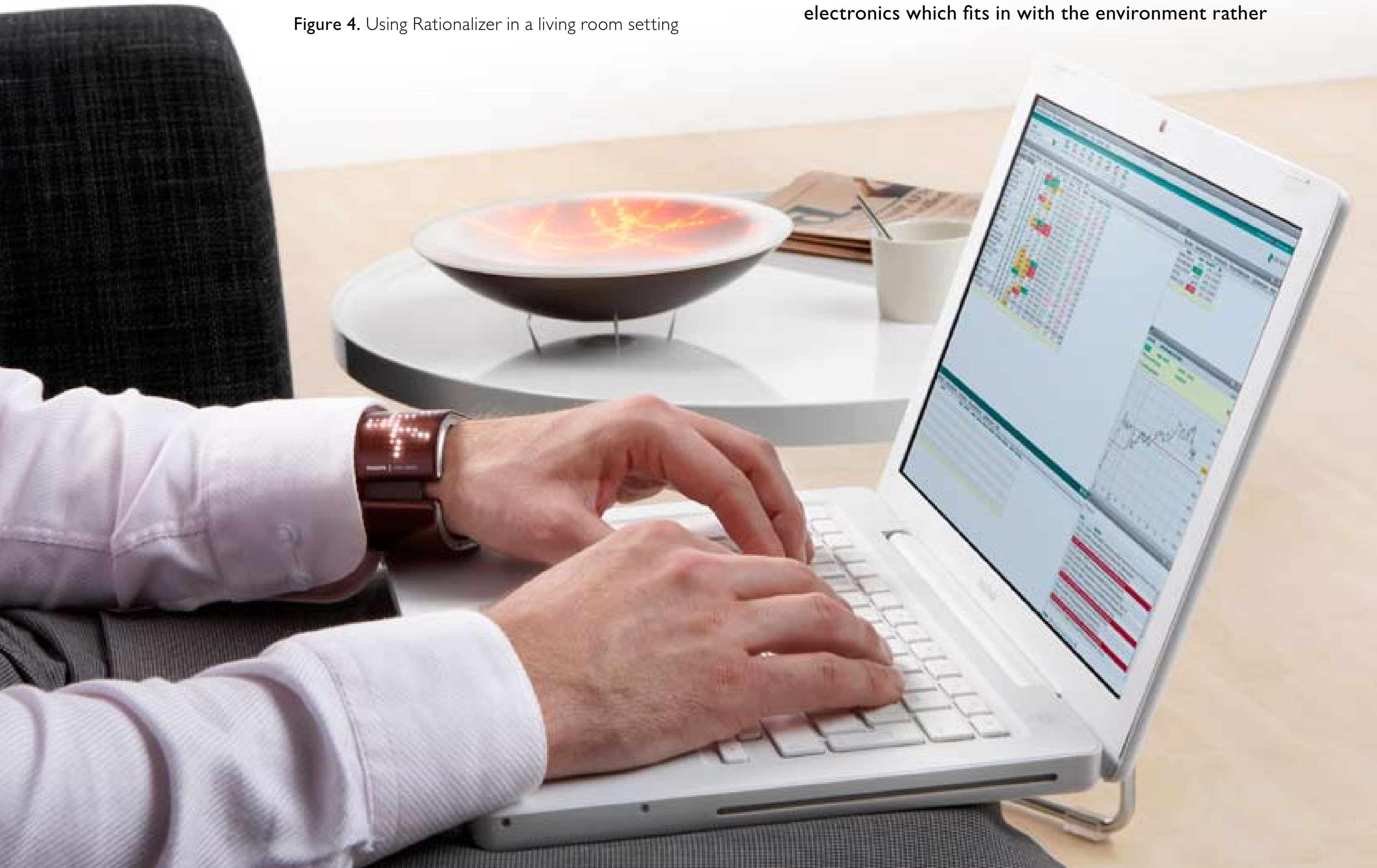


Figure 4. Using Rationalizer in a living room setting

than shouts out at the user—is a recurring theme within Philips Design. The Philips Design ambition with regard to ambient objects [13] is summarized by three pictures (Figure 5): the first one is a picture from the early 20th century in which consumer electronics are as yet absent. All other objects are typically domestic objects: a painting on the wall, a clock and a vase on the mantlepiece. The second picture is from the 1970s or 1980s: by this time, the living room had been invaded by a multitude of electronic devices, which all had their own aesthetic and fought for the user's attention. The third picture shows what a living room of the future may look like: electronic products have taken on a far more restrained aesthetic, inspired by traditional domestic products. The painting has become a flat TV, the loudspeaker and the remote control have become pieces of furniture. In a similar vein, the bowl on the table in the first picture could become an EmoBowl in the last picture: an object which historically fits the domestic context is augmented into an ambient object with behaviour.

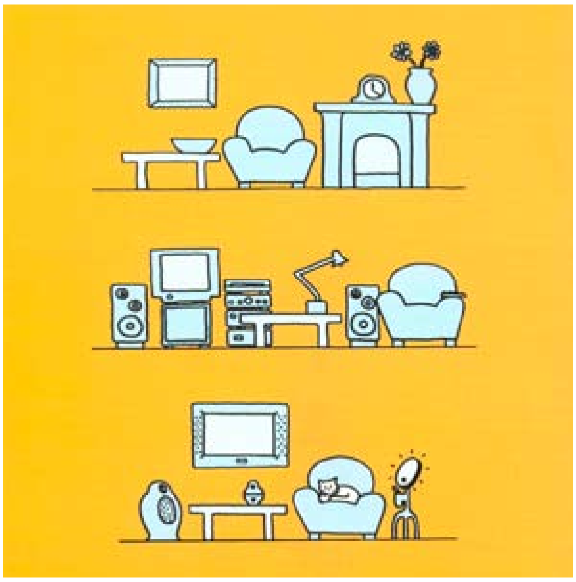


Figure 5. The Philips Design 1999 vision on ambient objects

Dynamic appearance

Many currently available devices which measure physiological signals show these measurements on LCD displays in the form of graphs and numbers. To improve the fit with the domestic context, we were intent on avoiding the clinical, laboratory connotations of these products and on rendering the user's arousal level in a manner more appropriate to such an intimate subject [14]. Rather than using graphs and figures which require reading and interpretation, we set out to represent the user's arousal level through animated light patterns which are intuitively clear. In ambient technology terminology these objects should classify as 'glancables': their status should be clear at a glance.

Both the EmoBracelet and the EmoBowl have four modes: (i) a fully-off mode, (ii) an ambient mode corresponding to low arousal in which the objects do not draw attention to themselves (Figures 6 and 9), (iii) an alert mode corresponding to high arousal in which the objects become the focal point (Figures 7 and 10) and (iv) an information mode in which messages (e.g. share prices, stock exchanges opening or closing) can be displayed (Figure 8 and 11). A change in the user's arousal level results in a gradual transition between the ambient and alert modes, similar to crescendos and diminuendos in music.

Both the EmoBracelet and the EmoBowl are executed as 'dead panel' displays. That is, the translucency of the product housing is such that in the fully off mode it is invisible that there are display elements underneath. This adds to the objects being perceived as non-electronic in the fully-off mode. Only when the displays are switched on does it become visible that these objects are in fact electronic devices.

Clearly, from a display point of view, the EmoBowl is more sophisticated than the EmoBracelet: it has a higher number of LEDs and its LEDs are of the full colour type rather than monochrome. The animations for both EmoBracelet and EmoBowl are based on a pattern of wavy lines. When shifting from the ambient to the alert mode, four parameters change: the number of lines increases, the number of curves in a line increases, the pattern's speed increases and, in case of the EmoBowl, the colour of the lines shifts from a mild yellow to an intense red. In the case of the EmoBowl, the transition from ambient to alert mode may be compared to breathing life into a fire: when the user's arousal level exceeds a certain threshold the light effects 'flare up'.

Figure 6. EmoBracelet in ambient mode, corresponding to low-arousal.

Figure 7. EmoBracelet in alert mode, corresponding to high-arousal.

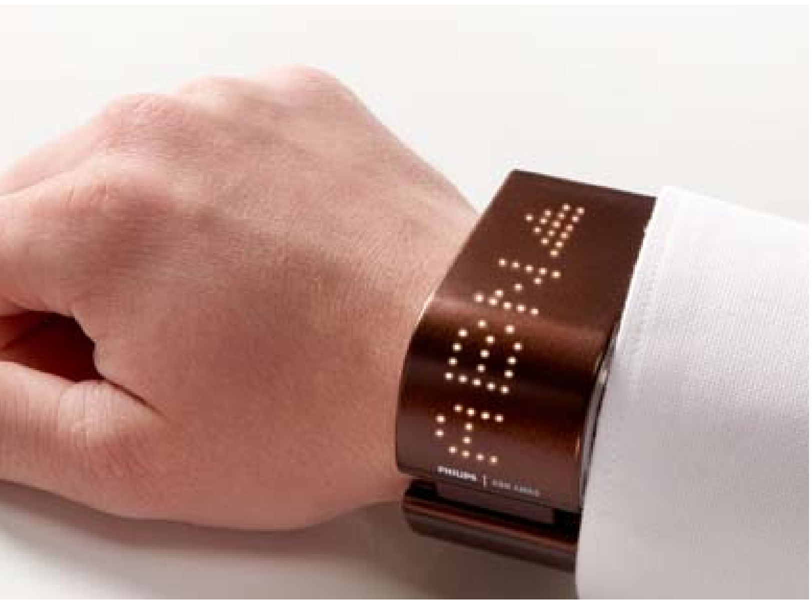


Figure 8. EmoBracelet in information mode, acting as a tickertape display with stock info.

6 New object typologies

#1: The product is the display

In the Rationalizer project, we have experimented with both single curved and double curved displays. The aim behind our use of curved displays is the blurring of the distinction between product form and display. Current electronic products show a clear separation between form and display, often with the display being stuck onto a product without respecting its formal qualities [15]. Because displays are flat, the possibilities to integrate product form and display are limited.

In the EmoBracelet, the display curves with the product's form, if only in one direction. In the EmoBowl, the dish shaped display surface is curved in two directions. Though the current execution of the EmoBowl is still low in resolution, eventually this will lead to products with 'living skins' of which the double curved surface is a display at the same time. The notion of living skin will stretch the current understanding of product semantics. In a product with a 'living skin', the appearance and behaviour design will need to be considered holistically as the two will interact towards the meanings attributed to the product.

#2: Low-res display or high-res luminaire

Currently, luminaires and displays are separate product categories: luminaires are meant for illumination, displays are for information. The EmoBowl blurs these boundaries. it can be seen as a new type of product which 'hesitates' between being a high-res luminaire and a low-res display and as such may serve multiple purposes. It has the flexibility to simply offer light, function as an ambient display or as an information display.

The EmoBowl as high-res lamp

Since the EmoBowl features almost 1600 LEDs—which collectively have approximately the same light output as a 100W incandescent bulb—it is far brighter than an LCD display of the same size (Figure 12). This means that it may act as luminaire with display capabilities. As such, it can be seen as a next generation LivingColors lamp [16] which instead of showing one colour at a time can show abstract patterns of animated light. Apart from their decorative effect, such dynamic light patterns could be imbued with meaning. For example, dynamic light effects could be used used for non-goal oriented communication [17] (e.g. a particular pattern becomes the light signature of someone thinking of you), for showing the emotional value of communication (e.g. to support e-mail or instant messaging) or as a music visualizer.

The EmoBowl as low-res display

The bowl can also be used as a low-res display showing tickertape-style messages. For the Rationalizer use case, we made the EmoBowl show stock prices (Figure 11). Other applications may be to use the bowl as a additional rendering device for other electronic products. When paired with a DECT phone, it could be used to show incoming SMS messages; when paired with an audio system it could show album title, artist and track information. An interesting aspect of EmoBowl is that it may act as a centrepiece on a dining or coffee table to share information in a group setting. As the tickertape information is displayed at a slant and travels in a circle around the bowl, it will eventually be readable to everyone gathered around the table.

7 Summary

Overly high expectations regarding emotionally intelligent products have a stifling effect on the uptake of emotion sensing technology in consumer products. Ever more complex technology is being developed in the hope of finding solutions which capture human emotion in its full complexity yet are robust and practical. Such a demanding requirement, effectively a moving target, causes the application of emotion technology to remain a promise.

If emotion technology is to provide true value to end users, solving the practicalities of emotion sensing won't suffice. For emotional products to be accepted, the values embodied by a new product proposition need to match our existing value system. This is by no means self-evident. The clinical and intrusive manner in which physiological signals are measured and rendered often seems strangely at odds with our everyday understanding of emotions.

The Rationalizer case study shows how with lower expectations and an awareness of the possibilities of currently available sensing technology it is possible to create emotionally intelligent products which are feasible in the short term.

Rationalizer can also be seen as a first step to come to a product language in which emotions are communicated in a domestically appropriate manner. We shared some of our considerations in developing

Figure 9. The EmoBowl in ambient mode, corresponding to low arousal.

Figure 10. The EmoBowl flaring up to alert mode, corresponding to high arousal.

Figure 11. The EmoBowl in information mode, showing tickertape messages

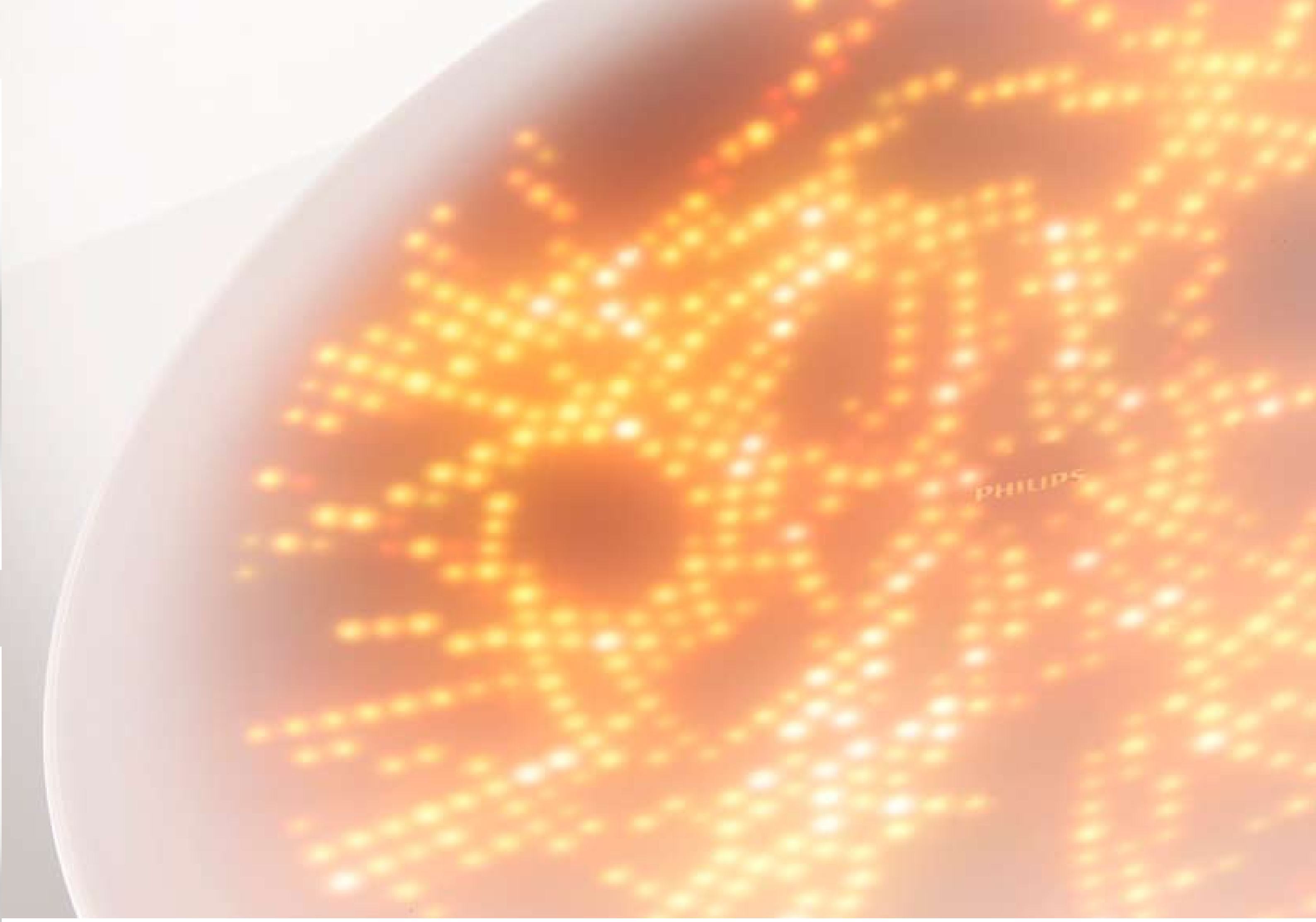


Figure 12. The EmoBowl can function as a 'high-res luminaire': the 1600 LEDs together are the equivalent of a 100W light bulb

this product language and improving the user experience of emotionally intelligent products from a semantic point of view. These considerations concern the aesthetic fit with our domestic environment, the connotations of sensor placement and the appropriate display of emotional information. Moving emotion technology from the laboratory into the home requires semantic considerations on many levels. Whilst this may hold for any type of innovation, it is especially true for emotion technology: the contrast between technology and human values is perhaps nowhere as jarring as here.

Future research

We have planned a consumer confrontation test to evaluate how users react to both the concept of Rationalizer and its execution.

Acknowledgments

We gratefully acknowledge Dr. Paul Iske (Senior Vice President ABN AMRO Bank) and Jaspar Roos (Corporate Entrepreneur Dialogues Incubator) for their invaluable input and support. We are also indebted to Joyce Westerink (senior scientist GSR UX) and Martin Ouwerkerk (principal scientist GSR sensor) of Philips Research for sharing their knowledge and hands-on expertise in GSR sensors and software. Within Philips Design, we kindly acknowledge Steven Kyffin (Senior Director RD&I), Anja Janssen (project assistant), Jacqueline Janssen (Senior Consultant Visual Trend Analysis), Patrick Lerou (Senior Manager Marketing & Sales) and Tonnie Saanen (modelmaking coordinator). Our interns, Rick van de Ven, Rob van Gansewinkel, Mark van Hagen, Willem Horst and Katrien Ploegmakers were a great help in exploring the first stages of this project. Finally, we would like to thank Henk van der Weij of Bigcamp Multimedia, Pepijn Herman of Metatronics, and Marc van Schijndel and Marc Kemkens of KEMO for the production of the prototype.

References

1. Directive 2004/39/EC of the European Parliament and of the Council of 21 April 2004 on markets in financial instruments (n.d.). Retrieved September 13, 2009 from http://www.cesr.eu/index.php?docid=2117.
2. Barber, B., & Odean, T. (2002). Online investors: Do the slow die first? Review of Financial Studies, 15(2), 455-487.
3. Choi, J., Laibson, D., & Metrick, A. (2002). How does the internet affect trading? Evidence from investor behavior in 401(k) plans. Journal of Financial Economics, 64(3), 397-421.
4. Samuelson, P. (1965). Proof that properly anticipated prices fluctuate randomly. Industrial Management Review, 6(2), 41-49.
5. Lo, A., & Repin, D. (2002). The psychophysiology of real-time financial risk processing. Journal of Cognitive Neuroscience, 14(3), 323-329.
6. Russell, J. A. (1980). A circumplex model of affect. Journal of Personality and Social Psychology, 39(6), 1161-1178.
7. Lo, A., Repin, D., & Steenbarger, B. (2005). Fear and greed in financial markets: A clinical study of day-traders. The American Economic Review, 95(2), 352-359.
8. Krippendorff, K., & Butter, R. (1984). Product semantics: Exploring the symbolic qualities of form. Innovation, Journal of the Industrial Designers Society of America, 3(2), 4-9.
9. Picard, R. W. (1997). Affective computing. Cambridge, MA: MIT Press.
10. Wensveen, S. A. G. (2005). Designing for emotionally rich interaction. Unpublished doctoral dissertation. Delft University of Technology, Delft, The Netherlands.
11. Westerink, J. H. D. M. (2008). Experience in products. In J. H. D. M. Westerink, M. Ouwerkerk, T. J. M. Overbeek, W. F. Pasveer, & B. de Ruyter (Eds.), Probing experience: From assessment of user emotions and behaviour to development of products (Philips Research Book Series, Vol. 8, pp. 5-8). Dordrecht, The Netherlands: Springer.
12. Westerink, J. H. D. M., Van den Broek, E. L., Schut, M. H., Van Herk, J., & Tuinenbreijer, K. (2008). Computing Emotion Awareness Through Galvanic Skin Response and Facial Electromyography. In J. H. D. M. Westerink, M. Ouwerkerk, T. J. M. Overbeek, W. F. Pasveer, & B. de Ruyter (Eds.), Probing experience: From assessment of user emotions and behaviour to development of products (Philips Research Book Series, Vol. 8, pp. 149-162). Dordrecht, The Netherlands: Springer.
13. Marzano, S. (1999). La casa prossima futura The home of the near future.. Booklet to accompany exhibitions at the International Furniture Fair, Milan 13-18 April 1999 and at Saks Fifth Avenue, New York, 15 September - 9 October 1999.
14. Djajadiningrat, T., Geurts, L., Christiaansen, G., & Kyffin, S. (2008). MindSpheres: Play your skills, relax your mind. In Proceedings of the 4th Conference on Design & Semantics of Form & Movement DeSForM.(pp. 92-96).
15. Djajadiningrat, T., Wensveen, S., Frens, J., & Overbeeke, C. J. (2004). Tangible products: Re-dressing the balance between appearance and action. Personal Ubiquitous Computing, 8, 294–309.
16. Philips Living Colors (n.d.). Retrieved July 24, 2009, from http://www.lighting.philips.com/microsite/living_colors/
17. Strong, R., & Gaver, B. (1996). Feather, scent and shaker: Supporting simple intimacy. In Proceedings of the Conference on Computer-Supported Cooperative Work (pp. 29–30). New York: ACM Press.

Tom Djajadiningrat, Luc Geurts, Geert Christiaansen, Jeanne de Bont
Philips Design,
Eindhoven,
The Netherlands

Popke Rein Munniksma
ABN AMRO,
Amsterdam Zuid-Oost,
The Netherlands

Ming-Huang Lin and Shih-Hung Cheng
achille.shc@gmail.com

The triggered association from motion

Abstract
Involving strong visual images and associations with users' experiences, form is helpful to retrieve users' memories about something similar. It offers us basic visual detections. Additionally, operation is the further active behavior which drives our visual and haptic perceptions continue working to update the information and comprehension in the process of interaction. The physical interaction feedback mainly helps us to confirm objects' functions. However, for the metaphor design, during interaction, the motions of objects caused by operation continually deliver signals to trigger more semantic associations. In this case, motions do not only play the role of confirming but also give the soul to the objects and rich their meanings. In this study, the simple designs are taken to illustrate our viewpoints. Among them, the operation clues could be more or less detected in visual manners before physical interaction, but their designed motions strengthen the retrieval of meanings and experiences.

Keywords:
Product Design, Semantics, Semotion, Retrieval, Motion.

1 Introduction
As product designers who are sensitive to forms and styles, ones might collect their own design favorites. Inevitably I have built my own collection. Among of these products, I most appreciate Artemide's Tizio lamp and Alessi's kettle designed by Richard Sapper, Alessi Anna G corkscrew designed by Alessandro Mendini, and Rexite's tape dispenser designed by Julian Brown. Curiously enough they have divergent styles and were designed in different period, as Fig. 1~4 shown. This makes me to think the reason I enjoy to have them. I realize that they have not just fascinating forms but also the motions that could impress my guests. We take pleasure in playing them. All of them afford the possibility of physical interaction or dynamic motion that share the common character.

In its broadest sense, design is the conscious creation of forms to serve human needs [10]. With highly developed aesthetic, a sophisticated form is helpful to arouse consumers' desires and become the crucial factor. The visualization of aesthetics is usually the central phase in the design process. Creating a relevant and pleasing design aesthetic is a fundamental aim designers endeavour to achieve [15]. As regards relevant aesthetic or human aesthetic experience, "form follows function" in 1970s had been the undoubted guideline and mostly been used to convey the relation between form and human needs (function). After the principle of "form follows function", product semantics was ever advocated and prevailing in 1980s. However, it did not much focus on interaction but still form or interface. The former connotation of the physical relationship of man to objects has now been largely discarded: interface replaces interaction [8]. In recent years, the issue of movement semantics (semotion in short) has emerged and we have begun to pay more attention to human interactions with products. Concerning interaction would make us refine products into more appropriate and relevant forms. The information conveyed by objects is possible via visual, tactile, auditory, olfactory, and gustatory perception and retrieve their meanings based on our daily living experiences. In terms of product design, visual and tactile are major sensations of motion, hence they are concerns of ours in this paper.

Fig. 1. Tizio, Richard Sapper, 1972. **Fig. 2.** 9091 kettle, Richard Sapper, 1982. **Fig. 3.** Hannibal, Julian Brown, 1998. **Fig. 4.** Anna G, Alessandro Mendini, Alessi, 1994

2 The visual and physical interaction

It's a common sense that one movable object is more attractive than others. Many studies in psychophysiology have evidenced that human attention could be mainly elicited by motion information in visual system [6]. Our attentions elicited by a movable product placed in a cluster of unmovable products are obviously bigger than elicited by a different-colored or different-shaped (other attributes are the same) product placed in a group. However, motion is not the initial channel between products and human. Some products convey information just via visual perception. In most time, our visual explorations are working before physical interaction. This mechanism is working continually whether physical interaction happens, and it can avoid over-consuming our energies. The majority of our energies are spent on difference monitoring. If physical interaction affords us to explore the transformation of form or color, we would compare at least two or upward visual appearances as well as be affected by this transformation and our motion whether this interaction is humor or not. This may be the reason I like those master's pieces that can be operated physically.

2.1 The effect of clues during interaction

James Gibson expounded the theory of affordances and gave us an ecological approach to see the environment around us. The affordances of the environment are what it offers the animal. The "values" and "meanings" of things in the environment can be directly perceived [5]. The affordances of objects are what they offer us spontaneously when we interact with them in visual, cutaneous, auditory or olfactory manners. These all give clues to users about what to do or what they can do. According to Gibson, a clue can be given more than one interpretation. This infers obviously the fundamental drawback of the semantic approach in product design. Donald Norman argued that well-designed products are easy to interpret and understand. They contain visible clues to their operation. On the other hand, poorly designed products provide no clues - or sometimes false clues that make us confusing and frustrating [12]. When we see a product, its appearance will lead to one or upward interpretation. And then we will probably touch, detect, and try to operate it in order to confirm what it is and how it works. During this process of interaction, the functions, meanings, and emotional response to products will be gradually realized and confirmed. There is no absolute meaning that a clue implies. The interpretations are confirmed only through our exploration and interaction in the certain context and environments. Thus, interaction offers designers a chance to provide users a second relevant clue after initial visual explorations. The quality of the interaction can significantly affect our abilities of use [13]. If designers provide an appropriate motion as a clue to the functional meaning, the product will be more comprehensive than just only visual ones.

2.2 Motion is more impressive

It's human instinct that we tend to retrieve experiences or something similar that we have used when we are interacting with a object. During interaction, motion clue is acquired as a series of temporal information in visual perception. This implies that the motion might offer other information than the form does. Through it, we will recall and associate more retrieval clues to comprehend its connotations easily. Craik and Lockhart ever presented the levels of processing for the memory theory. They emphasized that clues can be encoded at different depths from shallow to deep, besides, deeper encoding leads to better retrieval performance [2]. The shallow level relates to the analysis of physical or sensory characteristics, such as form and color. The deep level involves conceptual and meaningful analysis as well as relates to comprehension and interpretation. Furthermore, deeper processing makes memory traces last stronger and longer [1],[2]. This is the reason why motion is easier to remember and impress us.

3 The Process of Interaction in Semotion

Products act as media which convey ideas, information content and emotion-loaded messages [4]. These media could be considered as a communication system. In the interaction research, Crilly et al. quoted Shannon's information theory to describe the system of communication. This system comprises five elements: source, transmitter, channel, receiver and destination. The source produces a message which is encoded into a signal and transmitted across a channel. The receiver decodes the signal and the message arrives at the destination. Crilly et al. adapted it for interaction between designs and users, as Fig. 5 shown [3]. "Source" refers to the meaning that designers want to deliver. "Transmitter" is the physical values of product form as a whole is consisted of shape, scale, material, color, texture and so on. "Channel" is the manners of interaction. "Receiver" is our physical senses including vision, touch, smell, and so forth. "Destination" is our responses subdivided into cognition, embodiment, and emotion. By embodiment we mean the bodily states that arise during the perception of an emotional stimulus and the later use of emotional information [11]. Users feel happier in the happy posture, sadder in the sad posture. The embodiment relates closely to users' operations. Based on this clear and simple procedure, it will go further to discuss form, operation, and motion of embodiment in the following.

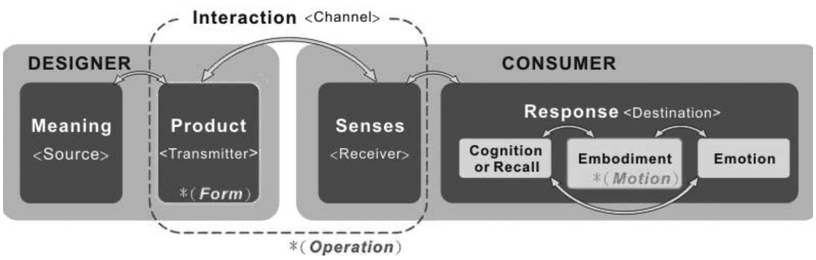


Fig. 5. The basic process of communication. (adapted from Crilly et al. [3])

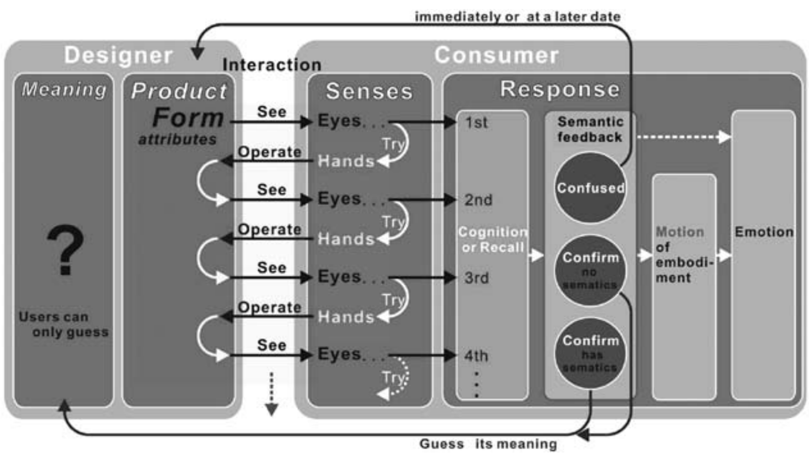


Fig. 6. The basic process of interaction.

In this paper, we expand Crilly et al.'s model as Fig. 6 to clarify the process of interaction. Once a product is designed, manufactured and sold on the market, its designer won't communicate with its users. The users can only guess its possible meanings through its form. Whether he operates it or not, he'll retrieve his memory and get the first cognition. If he doesn't try to operate it, he'll just use his existing experiences to comprehend it. Then, he would continue to see whether it has some semantic association. Perhaps he might also obtain some emotional impact. During this process, if users feel confused, they will mostly give up trying and guessing it. Only a minority will detect it again immediately. When he encounters this product at a later date, he might reopen this process again. If he doesn't feel confused, the product meaning for him will be generated whether he catches the correct meaning or misunderstands it.

Once a user tries to operate it, he will see the object's response and connote possible semantic association by his motion in the context. And this process brings the second cognition. The confusion may happen until user finds his own explanation; however, users will have chances to clarify the semantic association if it does have. After that, the removal of confusions from visual and haptic explorations will satisfy and please users. Thus physical interaction helps concept embodiment and increase users' emotion.

Furthermore, if the explanation never be found or the second or the following cognitions are different from the first cognition acquired before operation, these cognitions will be compared with each other and then integrate to diverse guesses or even something completely lost. The integration of form and motion information is crucial for the unified perception of moving objects and for our successful interactions in complex and dynamic environments [9]. Even unsuccessful integration would happen, but it is the challenge of the designs.

3.1 The cognition depended only on visual sense is shallower

"Form" is the most essential in design, which affords us initial sensation and elicits the first cognition. The theories of affordances and product semantics have a similar suggestion that a form can self-express. In the process of interaction, the crucial issue is whether users receive and recognize the available clues. Gibson meant that people sense the environment, not in the meaning of having sensations but in the meaning of detecting [5]. In terms of product design, every attribute of the form can be treated as a clue to detect the functional meaning. However, a form is interpreted in a subjective manner. It depends on what users can retrieve while they interact with this product. People tend to make associations with forms based on their experience of the world, their mood and their personal preferences [14]. In other words, a semantic form is helpful to retrieve our memories to interpret its meaning. Before physical interaction with products, we can only guess its meaning by retrieving our experiences. Therefore, the cognition depended only on visual sensation is usually much shallower encoded in our brains and easier to misunderstand than that integrated with motion sensation.

3.2 The integration of visual and haptic information

We usually use more than one sense to detect objects. Visual and haptic perceptions are two main manners. The interaction in visual manner can not operate products, thus it's called the passive or non-physical interaction. On the contrary, haptic interaction is an active and physical manner to detect product. Operation is users' further actions after observing. Haptic perception is the ability to identify three-dimensional objects based on exploration of an object with the hands and fingers. In the course of active physical detection, three systems are conducted: sensory, motor, cognitive. Sensory is about cutaneous sensation like touch, temperature, and movements of our hands and fingers. Motor is to move our hands and fingers and also able to be treated as user's operation. Cognition is to identify the product by dealing with the information provided by the sensory and motor system. These three systems must be coordinated with one another [7].

During the operation, we keep our visual perceptions working to update information. The first and the following updated visual information will be compared with each other, and this comparison will lead us to clarify whether there is a semantic context or to become confused and frustrated in this process of information integration. Furthermore, "Intersense" composed of haptic and simultaneous visual senses should also be unified to interpret product meanings and to elicit emotional responses. Vision is the sense we habitually use for perceiving shape. Touch is usually dominated by vision when they are placed in conflict with each other for shape perception tasks [7]. This effect of intersensory dominance explains that user motion plays a vision-dominated role. If the visual cognition is congruent with the following motion, it's easy for users to confirm the association but feel confused. On the other hand, Gibson said that a tactual sensation has not to become associated with the visual sensation in order for the affordance to be perceived [5]. This incongruent situation will somewhat confuse users, and then they may give up to try again or be aroused their curiosities to continue detecting.

We take the famous upholstered sofa "Joe" for example, as Fig. 7 shown. It's an oversized baseball glove with leather patch. We may be surprised to see such a huge glove and then retrieve our memories to find a similar object in scale with this leather grounded object. Initially, we may guess that it is a sofa and feel confused at the same time. If we not try to detect and seat ourselves on it, we'll have little or no chance to guess. Once we try to sit, motional association will enhance our comprehending and emotional response.

3.3 The triggered association from motion

We are easy to confound motion with operation. By definition, a motion is an act, process, or instance of changing place; an active or functioning state or condition; an act or instance of moving the body or

Fig. 7. Joe, Gionatan De Pas, Donato D'Urbino, Paolo Lomazzi, 1970

its parts [16]. In this paper, "Motion" is divided into two stages in the interaction: human motion and the motion of objects after operation.

Human motion can educe emotional response. During operation, usually users will sense the changes such as in the dimension, color, and illumination, even sound if these really happen. This causality is effective to enhance users' embodiments as if they dominate completely these products. These motions can also be considered semantic signals. Because a motion doesn't occur at the beginning, the connotation is subconscious and more implicit than one only implied in visual semantic manners. Users tend to find out new concrete objects related to this motion, and then to associate the attributes of these objects with this product until he find out the most approximate attribute to integrate and comprehend the all associations. However, users will not ignore other attributes that remind users of a little difference between this product and its association. These differences are helpful to avoid users operating in a manner that endangers them.

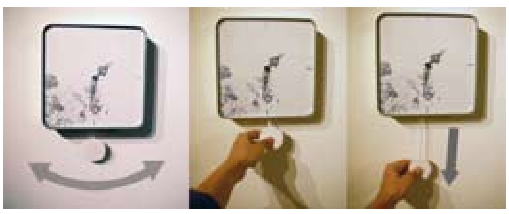


Fig. 8 (left) MUJI CD player, Naoto Fukasawa, 1999. **Fig. 9** (median) Lumalasch, Henk Stallinga, 1993. **Fig. 10** (right) Time Is Up!, Chih-Wei Huang, 2007.

This type of design would make users defer their interaction and finally might realize why it was designed in this way. This effect is rather similar to "later wow" proposed by Naoto Fukasawa. The motion mostly could be considered as the key to "later wow" because designers could strategically conceal the crucial attribute at the beginning and reveal it after operation. To take MUJI CD player designed by Fukasawa for example, as Fig. 8 shown. Fukasawa searched for an essential design approach and tried to see what people do and feel in their daily lives and to find solutions that are shared senses and memories. This CD player mimics a ventilation fan as it spins its exposed compact disc. It consists of a single speaker, no cover, and a vertical power cord that evokes users' memories of operating ventilation fan. When users pull this power cord, music starts to play. Its power cord is the most decisive attribute to make users enter into the operation process shown in Fig. 6. Users can also be aware that it should be a CD player via watching the CD disc and its perforated surface of speaker before operating. The confusion about how to operate won't obstruct the discrimination about what it is but the following interaction. This confusion will be removed when users become conscious that its cord can be pulled down and then do it. If the physical interaction can proceed, the effect of "later wow" will arise.

Suspension lamp "Lumalasch" designed by Henk Stallinga shown as Fig. 9 is another example. It looks like bus flying rings or gymnastic rings, and its fluorescent tubes are just these rungs. When we see it at first time, we'll retrieve and recognize it as the rings. Then, we will tend to operate it in a way of using bus rings or gymnastic rings – to pull it. However, it's obvious that these rings are not really bus rings due to the differences in size, material and location. Users may be confused but they are not so unintelligent to ignore the fragility of fluorescent tubes and hold and pull them down hardly. After trying to operate gently, we'll realize that the switch and dimmer are integrated at another end of power cord. We can make it on/off as well as adjust its illumination via pulling in a much gentler manner. Its ambiguous meanings, form, operation, and user's motion are integrated interestingly to build a semantic context. Similar to these two above concepts, "Time Is Up!" is a clock with a countdown timer whose form looks like a normal clock pendulum, as Fig.10 shown. Its timer function is not easy to be uncovered by only visual exploration. However, it won't make users confused but consider that there is no semantic context on it until they try to swing its pendulum just out of curiosities or incidentally see others use its timer function. Then they will realize that its pendulum can be elongated and gradually restore its length to count down. After restoring completely, the alarm will start up to remind users "Time is up". This concept inspired from baby musical cot mobile whose handle ring could be pull to play music until it restore its length. The designer applied this motion to interpret the countdown of clock as well as to associate its pendulum with the timer of musical cot mobile in visual, tactile, and auditory aspects.

4 Practical Design Approach

During the past several years, in the design courses specially related to product semantics, the motion is usually helpful to encourage our students' creative ideas. The approach of these works is to use a form as a medium for the initial cognition and then to treat operation as the key to continue the process of interaction. The students were taught to arrange a cognitive variation between before and after operation, eventually, to utilize this variation to form a context that makes users embody their motions into the emotional level. In these courses, the concepts of chair and lamp are easier to conceive than others. Some outcomes of chair or lamp design are illustrated below to explain the effect of motion in semantic design.

4.1 Cupid

"Cupid" is a mood lamp that looks like a baby bottle at first sight, and it has not an obvious switch. Most people can realize that it is a lamp by its semi-transparent material and power cord, and then tend to rotate the cap of the bottle to turn on the light. However, the user will discover that there is a pair of vertical tracks for the ring as well as find out that it is not allowed to rotate but to push down or pull up, by which the one can turn it on/off and control the number of growing bulbs to adjust the length of luminant. When one pushes down the ring, he will see the length of luminant increasing gradually till it luminesces entirely. During interaction, the user will retrieve another image "putting on the condom" that seems to be not associated directly with baby, and then he will be a little confused. In fact, its semantic context is built on the causation between baby

Fig. 11. Cupid, Shih-hung Cheng, 2003

and sex. As he wants to pulls up the ring to turn it off, he will see the luminant length decreasing gradually until it is turned off entirely. The latter variation conveys the concept "taking off the condom". Then he might be able to remove his confusion and comprehend why the ring is designed to move vertically. Thereupon he will experience the embodiment of his motion and then feel somewhat shy.

4.2 On/Off

"On/Off" armchair consists of a floor lamp and an armchair made of semi-translucent material. When people see it in a dim room, the armchair is luminous as a mood lamp. Once one sits on it, the lamp installed inside the armchair is immediately turned off and the floor lamp beside the armchair is turned on spontaneously in substitution for armchair lamp. This variation is switched by user's weight. As the user leaves, its lights return to the original situation. It's a good example for the embodiment of motion.

Fig. 12. On/Off, Boson Huang, 2002.

4.3 Match Striking

"Match Striking" is a lamp whose main body has a hole on the top with a match-like stick located on the upper corner. When a user sees it at first time, it is easy to associate with light. However, he might be curious about what will happen if putting the match into the hole. Once he does it, the light installed in the box will be turned on and project a shape of a candle on the facade. And then he will also be aware of that the stick is the

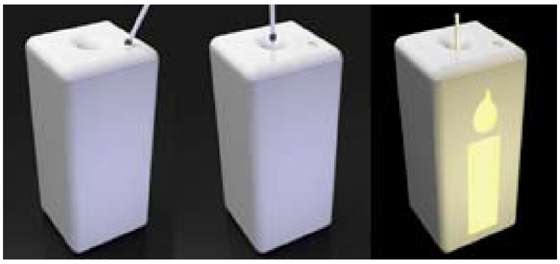


Fig. 13. Match Striking, Hung-Min Liang, 2003.

switch of this candle. These sophisticated signs and symbols make it self-express and convey a great quality of motion semantics.

4.4 Brush

"Brush" is a child rocking chair consisted of a hand bar, saddle-shaped cushion, and brush which plays the function of legs, as Fig.14 (B) shown. Its original concept is Hawaiian grass skirt, as Fig.14 (A) shown, that makes a girl look like dancing hula when she seats herself on it. During the design process, concerned with the direction of movement, the designer adapted it for the final result. When a child sees this rocking chair, he could be attracted to its physical dimensions which seem to invent him to sit. As he starts to rock it, the movement helps it to brush and sweep the floor as if he was really cleaning. Although he doesn't know its semantic meaning, his parents will realize and sincerely like this design because they embody their child's motion into their emotion. In the case, form, operation, and motion are integrated to shape the design.

Fig. 14. Brush, Boson Huang, 2003.

5 Discussion

Motion can uphold the level of interaction and give a product a kind of soul. It offers designers another channel to interpret products. From the design practice, we learned that semotion could be considered as the manner of using the retrieval of memory to reinterpret the forms, operations, and our motions. In this paper, the simple objects like lamps and chairs are taken to describe our viewpoints. We know that the framework submitted here is just the beginning, and this design approach has its limits. For instance, too profound semantic associations should avoid so that users are able to unfold them. And it is not suitable for all kind of product, especially the functional orientation electric appliances. However, many relevant theories, studies and practices are wealthy for further exploration. For our further studies, the various categories of products and grounded theory in social research will be taken to modify our hypothesis and continue to sort out the knowledge of semotion.

Acknowledgements

The authors would like to thank financial support by the National Science Council under grant number NSC 97-2221-E-009-094-MY2.

References

1. Brown, S. G., & Craik, F. I. M. (2000). Encoding and retrieval of information. In E. Tulving & F.I.M. Craik (Eds.), The Oxford handbook of memory (pp.93-107). New York: Oxford University Press.
2. Craik, F.I.M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 11, 671-684.
3. Crilly, N., Moultrie, J., & Clarkson, J. (2004). Seeing things: Consumer response to the visual domain in product design. Design Studies, 25(6), 547-577.
4. Feijs, L., & Kyffin, S. (2005). A taxonomy of semantic design knowledge. In Kyffin, S., Feijs, L., & Young, B. (Eds.), Proceeding of 1st International Workshop on Design and Semantics of Form and Movement (pp.71-83), Newcastle: Koninklijke Philips Electronics.
5. Gibson, J.J. (1986). The ecological approach to visual perception. London: Lawrence Erlbaum.
6. Girelli, M., & Luck, S. J. (1997). Are the same attentional mechanisms used to detect visual search targets defined by color, orientation, and motion. Journal of Cognitive Neuroscience, 9(2), 238-253.
7. Goldstein, E. B. (1999). Sensation and perception (5th ed.). Pacific Grove: Brooks/Cole.
8. Gros, J. (1986). Small but sophisticated - Microelectronics and design. In Volker, F. (ed.). Design now – Industry or art? (pp. 268-270). Munich: Prestel.
9. Korutzi, Z., Krekelberg, B., & van Wezel, R. J. A. (2008). Linking form and motion in the primate brain. Trend in Cognitive Sciences, 12(6), 230-236.

10. Krippendorff, K., & Butter, R. (1984). Product semantics: Exploring the symbolic qualities of form. Innovation, 3(2), 4-9.
11. Niedenthal, P. M., Barsalou, L.W., Ric, F., & Krauth-Gruber, S. (2005). Embodiment in the acquisition and use of emotion knowledge. In L. F. Barrett, P. M. Niedenthal, & P. Winkielman (Eds.). Emotion and consciousness (pp.21-50). New York: Guilford Press.
12. Norman, D. (2002). The design of everyday things. New York: Basic Books.
13. Shannon, C. E. (1948). A mathematical theory of communication. Bell System Technical Journal, 27, 379-423.
14. Young, R., Pezzutti, D., Pill, S., & Sharp, R. (2005). The language of motion in industrial design. In S. Kyffin, L. Feijs, & B. Young (Eds.), Proceeding of 1st International Workshop on Design and Semantics of Form and Movement (pp.7-12), Newcastle: Koninklijke Philips Electronics.
15. Zuo, H., & Jones, M. (2007). An exploration into aesthetic association of product form. In L. Feijs, S. Kyffin, & B. Young (Eds.), Proceeding of 3rd International Workshop on Design and Semantics of Form and Movement (pp.12-18), Newcastle: Koninklijke Philips Electronics.
16 The Merriam-Webster Online Dictionary. Retrieved June 20, 2009, from www.merriam-webster.com/dictionary/motion

Ming-Huang Lin,
Shih-Hung Cheng
Institute of Applied Arts, National Chiao Tung University, Hsinchu, Taiwan

Yong-Ki Lee, Kun-Pyo Lee
ykl77@kaist.ac.kr, kplee@kaist.ac.kr

User-generated product semantics: how people create the meaning of objects in the state beyond saturation

Abstract
This study is reflecting on the cultural practice of producing meaning, and the mutation of products to signs throughout the history of designed artifacts, offering implications for designers to understand and reconsider the prevailing subject-object relationship. Moreover, a model of a user-generated meaning production is introduced, identifying basic categories, which classify today's products according to their sign value. Consumer objects nowadays are open to be formatted with arbitrary values and meanings. Not only do the product manufacturers have the power to manipulate those product expressions, but also the people discover their capacity to change and construct the meaning of a product. This paper proposes to conceptualize this shift from passive to proactive consumers and users, in order to reflect upon the changes in contemporary design: Arriving at the state beyond saturation, design's purpose is having people make meaning of things. The shift from material and functional values to sign values as described here is only a milestone in the progress of design's progressing informatization. The people-object relationship is continuously evolving from physical to ideological and performative values, which the people themselves create.

Keywords
Meaning and Perception, New Typologies and Ecologies of Objects, Product Semantics, Experience in Design.

1 Introduction – the consumer product
A differentiated culture of consumer products first developed itself in the 18th century. It was preceded by the democratization and individualization of the society. Only after these processes had been established, a general wealth of the masses was possible. This again enabled freedom of choice at a time when product variety was about to boom. In contrast to this, products of a society that had not yet been individualized were characterized by tradition and durability. Many things did not belong to just one person; instead they were family property being passed on from generation to generation. In these times people inhabited the same house where their ancestors had lived in the past and where their descendants were going to live in the future. It was common to use the same furniture or even the same flatware and china for generations. Every item of age had the potential to become a symbol of the family's perpetuity; and to use such a thing meant to break out of one's own limitations and to be a part of something bigger and more persistent than the own existence. In these terms, people regarded objects as vessels or container in which they discovered as well as added human values. This concept of receiving and passing on non-materialistic ideals through materialistic objects explains the continuity in which people surrounded themselves with the same family objects for generations. Therefore, a careful handling of those objects was a matter of course and not just

simple frugality. Though handled with care these objects did not even need to look new for a long time. In fact, traces of use were quite welcomed. Only patina proved their age and their durability and heritage. The meaning of family became even more tangible and substantial this way. The Canadian consumption theorist Grant McCracken analyzed this distinct value that patina for a long time has had [6]. He stressed that it was not used like a status symbol, but that it applied and amplified objects that were considered status symbols with additional authority. For example, a person owning passed-on jewelry, silverware or a piece of furniture that had been patinized over the times declares him-/herself wealthy and signals he/she belongs to a well established family that can prove a history of generations living in high standards. Thus, patina protects from being suspected of being a New-Rich. Things had to wait until the 18th century that a fundamental change within the culture of products occurred. Now it was not all about how much family history could be recognized in one's household anymore, but instead it was about the capability to buy the newest things. In place of everlasting wealth, people started to exhibit their current purchase-power and their personal style through consumer products. Consumption had become more than just a necessity. Dynamics, which were to become characteristic for the emerging consumer society evolved for the first time initiating the age of style and fashion. Consumer products were upgraded or renewed in foreseeable and short-lived cycles and were given the task to support the individual in its quest for a unique identity. The sociologist Colin Campbell pointed out that the modern consumer society specifically is not materialistic, because it puts forth objects that play important roles in fantasies and in processes of bestowing meaning and significance. The primary arguments for the purchase of objects were not their material features but rather their suitability to stimulate the consumers' imagination: "the real nature of products is of little consequence compared with (...) their potential for dream material" [2]. To Campbell it is not surprising that this consumer society of short-lived fashions and of the quest for the new emerged at the same time when people started to discover and enjoy novels. Both seem to express the longing for passionate and versatile feelings which could best be satisfied and revived with the help of fiction. Just as readers of novels dream themselves into new adventurous worlds and dramatic biographies in person of a story's protagonist, consumer goods can also inspire to escape from an everyday routine. To overcome the fear of powerlessness and to counter the limitations of human existence, the individualized consumers developed strategies of fictionalization.

2. Meaning – strategies of fictionalization

2.1 The consumers' products - or the personification

The objects in the world of consumption are increasingly personified. Thereby, they take over the roles of friends, acquaintances and partners. Turning to objects in this manner displays a compensation of a missing human and social factor. Although for a quite long time it was considered as fetishism, or at least as an infantile gesture, when objects were anthropomorphized and seen as a partner, in today's developed culture of brands and images this kind of behavior has found its way to general acceptance. Moreover, since the 1950's marketing professionals advised companies to turn their products into a brand and give them a face; and this in fact has been implemented literally. Mascots, commercial characters and testimonials of celebrities were and still are just the tip of the iceberg, where humanization of objects is driven so far that psychologists believe, a brand could actually be treated with the means of psychoanalysis, for it possess charisma and a character just like every other person. Qualities that people expect from objects are condensed within brands. Since they do not only have to stand for the guarantee of the quality standards, brands have become the most important signifiers of consumer objects. Thereby, brands fulfill multiple functions: they convey a certain life style, they support self-assurance, they help to gain a significant and unique profile and they open up new horizons and cultivate optimism. Almost every modern image design nowadays is focused on the humanization of a brand in order to make it easier for the identification with it. The desire to discover one's own attributes in objects seems to be an intrinsic behavioral pattern of humans. Just because one can buy and own all objects that in their beauty appear humane and full of character, covetousness is aroused that resembles the behavior of falling in love with someone. As soon as an object is animated and declared as a partner it typically fulfills various functions. In the way someone likes to show off with an attractive friend, expects support from him/her in situations of need or just wants to be encouraged by him/her when decisions have to be made, consumer objects on the one hand have an outward, representative effect by identifying their owners as part of a certain life style and on the other they have an inward, psychological impact by changing their owner's mood and inspiring them to move to new frontiers. Hence, it is not surprising anymore that people develop their self-image primarily out of consumer goods. Quality products convey the feeling of security and protection while offering to be a part of a larger entity. Consumers fantasize their own life as if they were part of a movie or a fictional story. An expensive car for example can thereby stand for a fictional success story that, in all its detail, only exists in the consumer's imagination. Thus, consumers dream their dreams closer and closer to reality. In his book "Generation Golf" [3] the German author Florian Illies diagnoses a turn from an educated social class (Bourgeoisie) to a consuming social class "The purchase of certain pieces of clothing is like reading sophisticated literature in former days, a form of ideology." The simple fact that the term "Bourgeoisie" currently is almost not used at all signals how this phenomenon of a social class that possessed precise and extensive knowledge about established cultural assets is dissolving. The contemporary definition of a Philistine, which is often considered to be the antonym of Bourgeoisie, is not a person who cannot cite the classics of literature or name the ten most influential western philosophers anymore, but someone who is unable to classify a fashion label with its social milieu. It is not uncommon that brand products which seem to transport entire ideologies can be the reason for fierce discussions and arguments whereas in past times discussions were held over politics, society or philosophy for instance. Brand products that actually unleash fights can often be observed at schools in clubs or at the local pub where people try to differentiate themselves by their outward appearance and by their accessories. The emergence of peer-grouping and social exclusion thereby happens according to the slightest differences, since there are no real distinctions or disparities anymore. For instance, in former days group identities through products were established along clearly defined ideologies and precise distinctions of social classes. Today this segregation can be done by even the most trivial piece of clothing: it distinguishes between friend and foe and gives the individual the good feeling of being different while at the same time offering a "homeland" of likeminded people. The consumer objects therefore fulfill an individualizing as well as socializing function. Consumer objects constitute those milieus needed to create an enclave in which individuality can evolve.

2.2 The appearance of things - or the fictionalization

In an affluent society the consumers are freed from the urge to demand as much practical value as they can possibly get for their money. Consumers are no longer completely occupied with satisfying their basic needs and still have capabilities and resources left for their inner yearnings. Saturation therefore is the first requirement for a consumption behavior that is directed inwardly. Yet, saturation all by itself is not enough to have the consumers want more meaning in their objects and products. This will only happen, if the quality of various goods has reached an equally high level. As long as a product class is not fully developed, the competition between different brands will still be driven and determined by the comparison of their practical use. But as soon as manufactures launch products that are of similar quality and of identical practical value, these have to be differentiated from each other through extra features that are usually non-functional. Only from this moment on, the ideologically upgraded objects or products, which can more easily be adopted and processed by the consumers fantasies, have a competitive advantage. Hence, in an affluent society there is a shift away from the production of goods, and instead turning towards the production of imageries. A brand like NIKE does not just sell shoes, but rather offers dreams, attitudes and ideals. Accordingly, somebody buying sneakers of that brand get the chance to fictionalize their lives. The individual person obviously feels stronger when surrounded by objects that will offer more possibilities. If a person purchases a Sports Utility Vehicle (SUV) it is not solely because of its practical value, but more likely because of its actual sign value; it serves to expand the person's options and to enhance the readiness for future eventualities: one could drive off-road (despite the high improbability in a city). Another important task for consumer goods thus consists in the expansion of one's own world, by having them tell imaginative and impressive stories. With the

purchase of banal objects, consumers also buy potential material for exaggerations of their own life. The sociologist Jeremy Rifkin claims that status symbols do not primarily exist in materialistic objects, but instead in the possibility and in the ease to access experiences and feelings through consumption. The emotional benefit of the purchased objects becomes the actual economic value. Rifkin labels this phenomenon with "Cultural Capitalism" [7] since non-materialistic products like experiences, atmospheres or cultural values are transformed into marketable goods. Since the 1990's the widely used term in Germany "Erlebnisgesellschaft" (society of spectacle and experiences) has been coined for this development. Emotional and fictional values have replaced those of utility and status. Primarily, it is all about what objects trigger within consumers. But this does not mean that objects are about to vanish. Experiences still remain bound to objects because consumers need the physically present and tangible items to affirm and consolidate their insubstantial fantasies and fictions and to transfer these into their own constructed realities. Especially to whom an object might not fit in the first place, its possession opens up the possibility for that person to become a part of a milieu that would otherwise be out of reach. In this case, the object works as a symbol for an event or for a promise to an adventure that only exists in the world of imagination.
The selling of consumer objects has become a production of dreams and these do not have any boundaries or limitations. That is why teenagers consider shopping as an equal hobby to e.g. surfing the internet or chatting with friends on the phone. Shopping is entertainment in dialog with oneself. Teenagers in particular can delve into their individuality and shape it at will. Thereby, weaknesses, fears and personal flaws are mentally eliminated, and a new augmented and improved version of their ego is constructed.

roducts are intended for young consumers, just because 14 to 17 year old teenagers still work intensely on the development of their identity and still have a lot of day-dreams. Marketing professionals exploit this predisposition for day-dreams by producing fictional sceneries. Products that have the flair of vacation and the touch of the exotic are actually souvenirs or bibelots of (fictional) journeys that one perhaps could make in an undefined future. They are timeless "memories" of one's desires and inner yearnings and they remind of the possibility of an optimistic future. These bibelots paradoxically do not function in a chronological way. Instead of recalling past events they visualize hypothetical projections that have become constructed memories and that might happen in an unspecified future or even never at all.

2.3 The parallel biographies - or the simultanization

The force of marketing and economy supports a phenomenon of parallel biographies by conceiving assortments and products that define the personal identity of consumers in a multi-optional way. Thereby, almost anything becomes possible or available at anytime. The surplus of products however exceeds by far the amount that one person could ever consume in a lifetime. But since a decision or selection is most often not made by the consumers, they start to condense and parallelize their actions. The consequence of this is that many different lives of consumption exist simultaneously next to each other. Consumers seem to welcome this kind of trend and even actively as well as subconsciously aggravate it with their behavior. Due to the advancing individualization of people which transforms the consumer into an absolute singular, the only logical countermeasure seems to be an internal pluralization. Foremost, this is expressed by the annulment of the former ideal of a linear and unidirectional life. Nearly everybody nowadays appears to reject the conception that a job is a permanent, unchangeable and everlasting vocation, or that social origin determines a fixed position within society; quite the contrary, people pursuit a life full of change and flexible alternations between different biographies. Constant modification of one's identity instead of holding on to it is considered a key-virtue of a life that has been fragmented and delinearized. One's lived life is no longer measured by its target-orientation or whether it works its way towards the essence of one's existence. Much more than self-discovery which operates centripetal people act on the maxim of self-development that functions centrifugal. New role models are people who are able to constantly reinvent themselves by taking on various different personas and engaging with diverse biographies. Consumer objects increasingly gain the significance of theatrical props which indicate the just mentioned biographies. With acts of consumption most diverse identities can be displayed as well as lived out.

Similar to the function of props in films or in a theatre the objects create the atmospheric and referential space that imparts meaning and dramatic impact to the whole scenery. Thereby, the objects achieve a double-benefit: first, they communicate inner values and personality to the outer world by operating as indicators or symptoms and second, they materialize and simulate various constructed biographies to the consumer by carrying multiple transient meanings. Objects thereby disengage from their actual practical or use-value, which by now is taken for granted anyhow, and lose their originally intended purpose. This phenomenon has been observed and described by Immanuel Kant, as he referred "Zweckmäßigkeit ohne Zweck" (Expedience without function) [5] to the beauty of art and nature. Just like a tree or an ornament animates to diverse fantasies and neither is perceived indifferently as something just there nor functionally as something usable, an object especially a branded product can still appear useful beyond its functional value, although it cannot be defined what exactly it could be useful for. This formula "Zweckmäßigkeit ohne Zweck" thus names the ideal constitution of a consumer product in the age of individualization and of multi-optional simultanizations, because the consumers are being inspired by its openness and its universe of possibilities, rather than being constrained. They can format the respective object individually and autonomous by just projecting desires and longings onto it and by using it as their specially configured props for their numerous "designed" lives. Many products that are consumed beyond the state of saturation affirm this indeterminacy of their practical use and function. They just have an abstract "Aura" and the slogans in their advertisements are mostly empty codes that claim something indefinable. Even in advertisements it is avoided to reduce a product to a single (use-) value. For instance, slogans for Coca-Cola are "The real thing" or simply just "It" ("Coke is it"). Differences are pointed out but never discussed in detail. In reference to Kant one could claim that commercial slogans deal with significance without meaning. Furthermore, the indeterminacy of consumer products has continuously increased in the past decades. Because of marketing's and advertising's heavy use of imagery and pictures. The texts in ads have been reduced to stubs, and cinema-spots even get by without any words and simply focusing on the visuals. An explanation for this is obvious: a picture is more open for interpretations than words or claims. Just by putting it into a certain context, it gains meaning through its ability to adapt to almost every basis of an ideological environment. Multi-optionality, else wise mentioned as key feature of modern consumer society, is the optimal term with which the specialization of pictures and images can best be described. With multi-optionality a picture can be utilized as a screen for personal projections while the fantasies of each particular observer complement it just the way they like or need it.

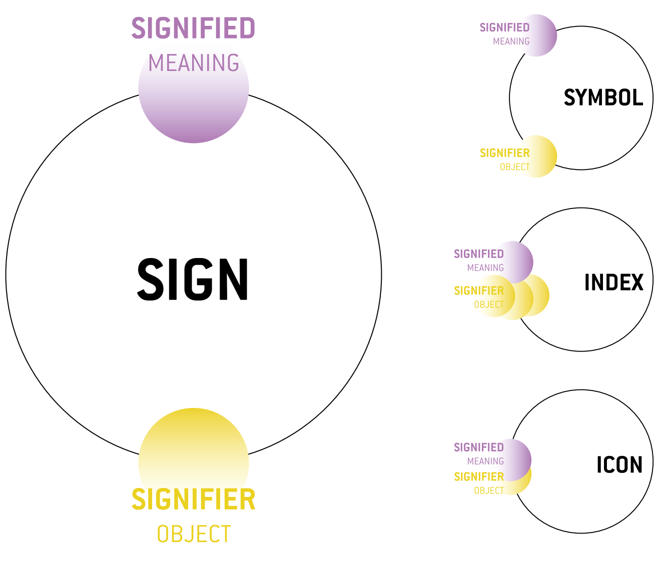


Fig. 1. Construction of a sign.

3. Evolution – the mutation of the artifact

3.1 The construction of a sign

As discussed previously, consumer objects in the state beyond saturation have mu¬tated to object signs which can be differentiated according to their sign value. Sign value or significance here stands for the meaning which is assig¬ned to an object and through which an object gets its function.

To understand the concept of mutating signs in product design, the basic construction of a sign is discussed first. Two essential parts of a sign determine its value; the signifier or the object and the signified or the meaning. Only in their combination they constitute a sign. Semio¬tics classifies three basic categories of signs which are dis¬tinguished by their relation between the signifier and the signified. [8]

The Symbol is an arbitrary sign in which the object neither has a direct nor indicative relationship to a meaning. Instead it stands for a meaning that is just based on constructed conventions. The sign only is understandable if the relationship between the signifier and the signified are learned.
Example: A red star is a symbol for communism [Fig. 1]
The Index is a sign with a compulsory relationship between object and meaning. The signifier can be understood as a hint or indication to the signified. The more signifier there are the more precise the sign gets.
Example: Coughing, sneezing and a headache are indices for a cold. [Fig. 1]

The Icon is a sign in which the object displays the meaning by its resemblance to it. Signifier and signified are almost identical and very easy to understand without anything that has to be learned first.
Example: A campfire is an icon for warmth and comfort. [Fig. 1]

The following three object signs that will be presented here are archetypical mutations discovered in the course of this study. These are: STATUS SYMBOL™, PROP™, and BIBELOT™. They have been labeled as trademarks, simply to point out their metaphorical impact and to emphasize the importance of the concepts that lie behind the terms rather than the terms themselves. The archetypical mutations ironically are turned into brands, in order to broaden their meaning and to avoid a literal understanding.

3.2 STATUS SYMBOL™ - or the Representation

STATUS SYMBOL™ is a symbol for a societal and social class. Since ancient times laws that regulated the use of clothing and jewelry were passed on in nearly all countries and cultures. For instance, in the year 1564 Elizabeth I had determined in the "Enforcing Statutes of Apparel" [10] which vestures, decorations and colors were reserved for the gentry and thus prohibited to the common populace. The existence of such laws shows the lack of leeway and tolerance in terms of expressing oneself through consumption given to the individual. These laws even can be understood as an attempt to unambiguously code its status-indicating qualities with the intention of creating a language of objects. Apparel and accessories thereby clearly signal which societal standing a person has. Such kind of consumption laws were supposed to stabilize social conditions. What is eminently striking is the fact that the material value, which made up the difference between coveted objects and items of daily use, was exceeded by sign values that displayed the societal reputation and social class of a person. An example for this is Thorstein Veblen's "Theory of the Leisure Class". Veblen does not distinguish between ancient and at that time contemporary phenomena nor does he separate western from non-western cultures, because he thinks that the idea behind status symbols are the same everywhere: it always deals with the "proof of financial solvency" which is best brought forward by demonstrative lavishness and profuseness as well as by displaying that one does not need to work and thus possesses extra leisure time. To belong to nobility therefore means, to buy things made out of substances, which are more expensive than materials that guarantee at least the same or sometimes even a superior usability of the objects. A handcrafted silver-spoon for example might be a hundred times more worth valuable than an industrially produced one made out of aluminum, yet it does not suit the functional requirements as well as its cheaper counterpart. [9] Those who still prefer the silver-spoon reveal that money does not play a role to them and that they have the freedom not to depend on the most practical and affordable solution.
In the original sense a status symbol can only be acquired as long as the owner already is in the position of that particular status. For example, that can be a monarch to indicate natural superiority, a doctor title as a sign of an academic career or a membership in an exclusive golf club to underline a privileged social status. Objects take over or enhance the functions of non-materialistic titles (crowns, medals, vestures, etc.) by referring to its symbolic meanings. For an observer even objects that were not intended to be status symbols can be considered as such simply through their proximity to "true" status symbols.
In colloquial language the term "status symbol" is used nearly synonymous to the expression "prestige object". However, there are also status symbols for a lower social class. For example, the lack of etiquette and bad manners could be a hint to a poor education, or an Iroquois hair style could indicate an affiliation with the punk milieu. Especially signs that express affiliation to a sub-cultural scene are often deliberately used to show that one does not stand alone and that one is part

of a larger community. Usually these signs cannot be declared with the criteria of “upper” or “lower”, since it is not uncommon that even wealthy kids can be part of punk culture.

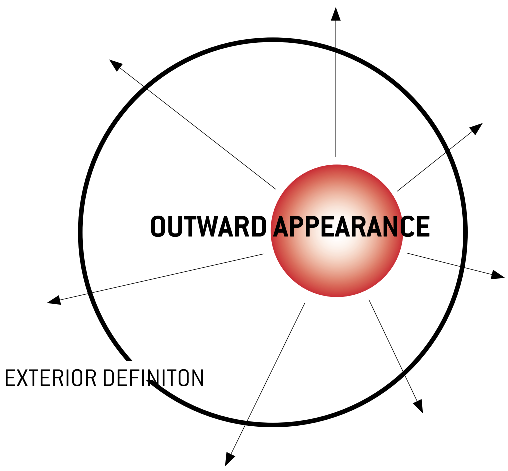


Fig. 2. STATUS SYMBOL™

The concept STATUS SYMBOL™ hence achieves a representation function by an arbitrary linkage of an object with a general and collectively defined meaning. Although the individual, subjective perception of STATUS SYMBOL™ is immediate as long as one has learned the particular conventions of meaning, the signification of this object sign is abstract und fuzzy. Furthermore, no extra information or meaning can be added to STATUS SYMBOL™ so that it is a generalized and inflexible sign.

3.3 PROP ™ - or the Portrayal

The concept PROP™ is an indication for an identity and mental attitude. In order to point out the analogy that is drawn to theatrical props, it is useful to first define that term. The prop in its original sense is a movable object that serves to equip sceneries in theatres, operas or in TV- and movie-productions. During a theatrical performance the spectator not only gets to see the stage setting in which the actors play, but they also see a number of movable things that complement the general appearance. Props create an authentic and credible atmosphere by referring to special circumstances or a certain historical, social or psychological context.

Consumer products resemble props in so far as they are indications of a scenographic context or an identity-producing environment. They fulfill the function of a portrayal. An early example for this portrayal function of objects is the novel “Portray of a Lady” [4] by Henry James published in 1881. In this novel the author describes the statements of Madame Merle, whereupon the identity of a person is essentially constituted by the things one owns, and that one should pay special attention to it. The own personality is even supposed to be nothing else but what one expresses through the habitation, the furniture or the vestures as well as through the books that one reads and the societies which one keeps in touch with. While the attitude of Isabel’s character exactly matches the assumption that objects in the 19th century primarily define social class and that they would not ever function as precisely controllable media of communication, Madame Merle in opposition recognizes something even in such simple things like a wardrobe or a dress that according to her reveals and even creates the character of its owner. The things with which a person identifies oneself are actually crucial parts of a person: “I´ve a great respect for things! One´s self - for other people - is one´s expression of one´s self; and one´s house, one´s furniture, one´s garments, the books one reads, the company one keeps - these things are all expressive.” [5] This tactic of equipping the objects with more meaning than they actually have is a behavior that has become natural to us and that is a univocal feature of our affluent, contemporary consumer society.

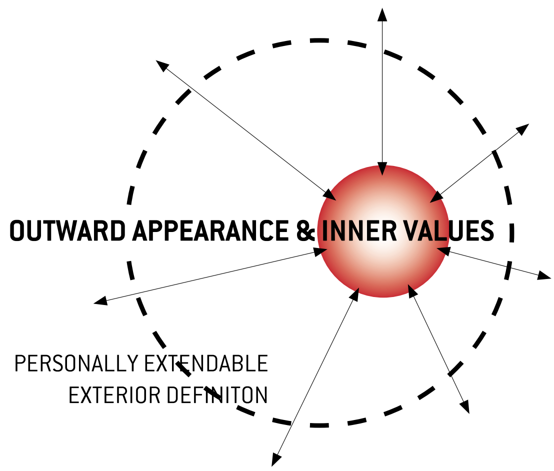


Fig. 3. PROP™

Quite similar to STATUS SYMBOL™, the concept PROP™ is dominated by its perceived image which is the representative function of the object signs. At the same time, the free interpretations and very personal perspectives allow for psychological correlations. Unlike STATUS SYMBOL™, PROP™ does not only describe a certain status or formal attributes, but it also comments on the interpretations of identities, inner values and mental attitudes. PROP™ therefore allows to extend the fixed meaning that has been imposed from outside by an objective convention, with more personalized meanings. This openness for interpretations makes it possible to take first steps towards fictionalization. To exemplify this, the two French photographers Pascal Rostain and Bruno Mouron had conceived to examine the trash of American celebrities that allowed drawing conclusions on shopping behaviors or life styles, or even more private things like passions or sicknesses. [11] The trash to some extend would be the symptoms of one's thinking and acting according to which speculations about a person in whole can be made.

3.4 BIBELOT™ - or the Projection

The concept BIBELOT™ is an icon for a life style and activity. A bibelot in its original sense is an object that somebody takes and preserves as a memory to a specific event, place or person. In many countries it is also called souvenir coming from the French and meaning remembrance or just memory. In the following explanations the term bibelot and souvenir are used synonymously.

Quite often people bring souvenirs for other or for themselves from journeys and holiday trips abroad. Thereby, it usually is something typical for that particular country. Souvenirs need not always to be bought in shops. As objects of random character, which could be stranded goods, stones, shells, sand or perhaps even wood chips, souvenirs solely constitute their meaning through the attribution of the souvenir-owner and thus cannot be identified as an ordinary bibelot. In some cases, the plain memento-character of a souvenir is often exceeded, so that there is a need for other expressions to describe this type of object. Instead of bibelot or souvenir, also the term "devotional object" or in a more exaggerated version "Relic" is used to closer explain a complex subject-object relationship. Such an "enhanced" artifact for instance can contain political statements in addition to its reminder function. Originally, objects of devotion are items which are supposed to assist and strengthen piety. These are for example a crucifix, rosaries, statues, vessels for holy water, rings or medals with religious images, just to name a few. Objects of devotion in a more secular context meet the needs to take home a piece of memory from a striking experience that can range from religious encounters to profane entertainment events like a soccer match. Thus, fan articles like scarves, flags or t-shirts are sometimes called devotionals as well.

A relic is an artifact of religious worship which is part of the belongings of a saint or even can be the remains of the saint him-/herself. By worshiping and touching those, believers hope to find deeper connections to something higher and greater, something they believe in. In general terms it is a way for people to find peace of mind.

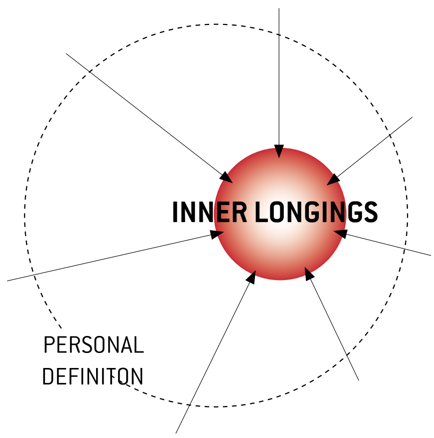


Fig. 4. BIBELOT™

To understand the object sign of BIBELOT™ the just examined definitions of souvenirs, devotionals and relics serve as analogies. BIBELOT™ describes objects that mentally project personal yearnings, memories or parts of fictional worlds of refuge. For each consumer these objects represent very precise and private meanings, which they like to remember in detail, similar to a souvenir. BIBELOT™ helps to reconstruct the fictionalized ideal whenever a consumer feels the urge to make a particular life style tangible and livable. This way they can reference complete parallel worlds, they have previously created. Objects then are used as a kind of bookmark for a reentry to these worlds.

4. Summary

How does the Relationship to the Consumer in the State beyond Saturation change?

As the mere persuasiveness of products diminishes due to the multitude of variants manufacturers start to apply Loading techniques, which generate additional benefit to the customer. The strategies discussed here can be categorized into three groups. However, in practice they frequently appear in combination and allow conclusions to the relationship between commodities and consumers in the state beyond saturation.

Personification - Products are increasingly anthropomorphized by transferring and attributing character traits and human behavior. This profiling is taken to such heights that objects are equipped with relations as one may find them between people.

Fictionalization - Nowadays, the appearances of things extend the products to boundless fictions in almost all areas of consumption. This phenomenon can noticeably be encountered with semi-luxury items. Such items are loaded with aesthetics, appeal, trends, brand image, etc. To equal extends, an enrichment of the meaning of objects is carried out on part of the consumers, who use commodities as a non verbal way of communication and as a means to position themselves in society.

Simultanization - In present days, the choice of commodities and the possibilities of personal lifestyle follow the model of the multi-optional. At any time and any place, everything becomes possible or available. The affluence exceeds the amount and complexity that a person could ever consume in one life. A decision and selection is usually substitutes by a parallelization and compression of actions. The motto is: Living and consuming simultaneously. Commodities serve as scenographic props that accordingly feign the chosen biography.

How does the Consumer Object in the State beyond Saturation change and behave?

How the objects per se have changed is described in the following brief outline of three metaphors coined in this study. These metaphors explain the significant change, in which objects beyond the state of saturation turn away from their predetermined utility value and move towards the construction of personalized sign values.

STATUS SYMBOL™ - The status symbol shows which social and societal state a person occupies. It is defined by collective conventions and as a sign its communicative mode is representation.

PROP™ - Not only does the prop work as an indicator for outer features, but also it implies inner states and unspoken thoughts. Partly enriched by subjective interpretations, it refers indirectly to identity and attitudes of the mind. As a sign its communicative mode is that of portrayal.

BIBELOT™ - The bibelot is the most personal object sign which characterizes itself by a complete internalization. It reminds one of inner longings and serves as a bookmark to enter one's own fiction. Its communicative mode as a sign is that of projection.

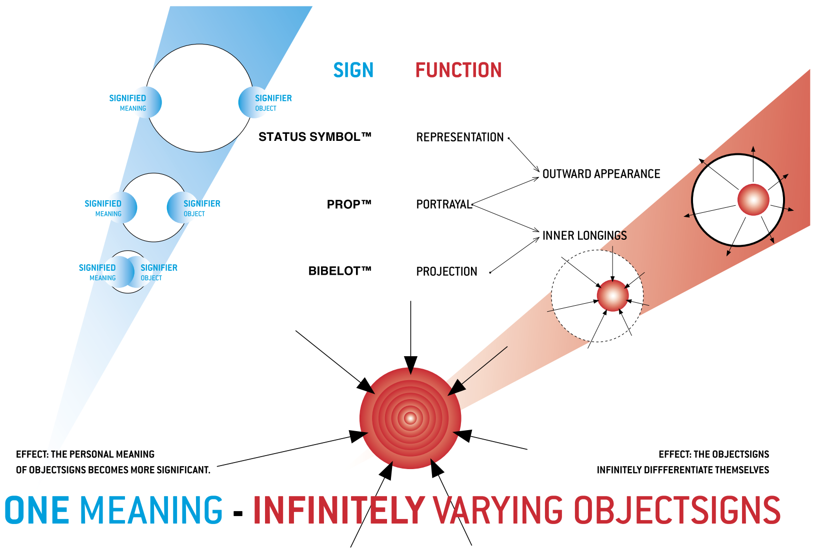


Fig. 5. Theory of object signs

5. Model – Extension of the Product

Figure 5 illustrates a theory of object signs. The function of the three above mentioned object signs are: Representation, Portrayal, and Projection. A quantitative differentiation does not make sense since all three functions usually are found simultaneously in the object signs (actual meaning of the object of the consumer). However, a qualitative structuring can be made to point out their relationships and to picture their systemic function.

6. Conclusion

In conclusion, while the practical functions of consumer objects are increasingly displaced into the fantasies and inner life of the consumers, the individual and subjective meanings of the objects are more clarified and sharpened. This internalization has a decisive effect: By displacing the production of meanings to one's inner life one starts to fictionalize it. The meanings become part of one's imagination, which obviously is infinite. The complexity of today's object signs and object language therefore is not a consequence of pure mass (quantity), but rather the result of an infinite differentiation and thus a qualitative dimension which then in a second step produces the quantity. The adequate counteraction to this are strategies of reduction that are mostly not just acts of ignoring, but primarily of parallelization- tactics, self-referencing and iterative cycles of fictionalization, and infinite meaning-production that lead to an inward compression causing the "implosion of signs". [1] Consumption is a cultural everyday phenomenon which runs through the entire society as an efficient means of communication and Commodities support the consumers in their individual and critical discussion with society and culture.

7. References

1. Baudrillard, J. (1972). For a critique of the political economy of the sign. St Louis: Telos Press.
2. Campbell, C. (2004). I shop therefore I know that I am: The metaphysical basis of modern consumerism. In K. M. Ekstrom & H. Brembeck (Eds.), Elusive consumption (pp. 27-44). Oxford, UK: Berg.
3. Illies, F. (2000). Generation golf. Berlin: Argon.
4. James, H. (1997). The portrait of a lady (penguin classics). London: Baker & Taylor Books.
5. Kant, I. (1790). §42 Vom intellektuellen Interesse am Schönen.
6. McCracken, G. (1988). Ever dearer in our thoughts. Patina and the representation of status. Bloomington: Indiana University Press.
7. Rifkin, J. (2000). The age of access. Frankfurt: Tarcher.
8. de Saussure, F. & Harris, R. (1998). Course in general linguistics. Chicago: Open Court.
9. Veblen, T. (2007). The theory of the leisure class. New York: Oxford University Press.
10. Explore the world of Elizabethan England. (n.d.). Retrieved March 3, 2009, from http://elizabethan.org/ sumptuary/ who-wearswhat.html
11. La Photographie. (n.d.). Retrieved March 3, 2009, from http:// www.mep-fr.org/actu/bm. html accessed 03/2009

Yong-Ki Lee,
Kun-Pyo Lee
Human-centered
Interaction Design
Lab, Dept. of Industrial
Design, KAIST

Chen-Hao Wuang and Yi-Shin Deng
funkyfoot@gmail.com

How people manage objects with shelves: storage and forage

Abstract
Computer interfaces have been directly associated with the key metaphor "desktop" for a long time. This should be readdressed, since the rapidly development of technology, such as multi-touch. People manage objects not only on the table top, mostly within a space or environment. This paper presents the results of studies on how people manage objects in space by observing participants handle objects in shelves set. We used qualitative way to analyze the video data. The results show that two hands collaborate very smooth and their role would exchange. Object orientation, attributes, and environmental factors have strong influence on people's behavior. And people would try to review objects and keep things in order. These finding have implications for interface design and we use a case to show them.

Keywords
Bimanual Action, Physical, Action, Human-computer Interaction.

1 Introduction
In daily life, people apply all kinds of tools to manage things such as bookshelf, closet, drawer, and photo album. The same behavior can be found in performing storing, searching, and organizing files while using computer. In WIMP environment, people are trained to use Window Explorer® to manage files and information such as catalogs and folders.

Nowadays, people are gradually surrounded by high quality touch interface technology due to the highly developed field and less costly manufacturing processes. Touch interface technology not only influence itself in the hardware market but also the supporting software. For example, the new software introduced by Microsoft®, window7®, supports multi-touch, touch screen mobile devices, and even the shadow tracking [1],the technology which allows users to operate the system without touching the screen or the related products. With these newly invented interface products, users will be experienced a more natural, rich, and intuitive interaction.

Because of the evolution of interactive interface technologies, people will be able to save heavier workload in the future than that in the days we rely on mouse and keyboard as our main controllers. Klemmer et al., Hartmann and Takayama[4] illustrated that our body plays a central role in shaping, understanding, and interacting with the surrounded environment, and the physical action could facilitate the cognitive development through repetitive actions as known as motor memory. From the papers, they also showed the errors that can be reduced since physical behaviors are highly related to commitment and risks. Buxton and Myers[9] demonstrated that performing compound tasks by two hands is faster than that with one hand. In terms of effectiveness, Kabbash showed that using both hands is most effective for "asymmetric dependent" tasks.

To make manipulation more meaningful to users, we try to match the meaning of metaphor [10] with interaction and object interface. Metaphor is employing user experience and familiarizing objects to let users have consistent expectation of interface manipulation, so we need to study people's daily experiences and the context behind that. With the thorough study, we will then be able to apply metaphor in a correct way. Several researches have brought up some implications for design by study human's physical actions, such as observing how people use orientation when they play the puzzle[3] with other people, and how the elder share photo to each other on the table[6], or focusing on bimanual interaction of hand and pen[2]. Most literature only focuses on desktop tasks, but the metaphor used in computer interfaces may not be desktop or table in the future. Therefore, our study probes into how people manage objects in the environment which is not on desk and how the condition of objects and space influence people's action.

2 Related work

Many researchers have devoted in bimanual interaction studies. Guiard's Kinematic Chain [9] suggests that two hands cooperate with each other and assemble in series; the dominant hand moves within the frame of reference set by positioning the non-dominant hand.
There are several approaches that are used to manage objects in computer system. On the desktop, Mander [8] used 2D piles metaphor for users organizing their files and creating some mouse gesture to manipulate the piles. Piles is a less rigid categorization system and self-revealing. Agarawala and Balakrishnan [5] created some 3D piles GUI for their desktop software - BumpTop.[5] They also created some mouse gesture for generating a pile from files, browsing piles, combining piles…etc. Scott and Carpendale [7] designed Sorage Bin on multi-touch surface which allow users to store and retrieve content in a collaborating situation. Users could move and adjust it to whatever they want.

3 Methodology

3.1 Design of the study

The following studies were performed to investigate the human behaviors on storing and arranging objects in space and important attributes to how objects and environment influence one's action. We chose bookshelf and clothes box as test environment since they store different type of objects. Books contain text-base information and people could read the title on the spine in order to decide whether to take it off from the bookshelf or not. Compared with clothes, books are harder and heavier, and we then discuss the differences in results due to the different textures. Clothes are similar to pictures, and both sides of T-shirt contain information such as pictures and words. Compared with books, clothes are lighter and softer. The kind of tasks people usually do in file manager is searching, taking out files and putting in files, so we asked participant to search, store and take out objects in bookcase and clothes chest. This design could let us observe the difference between the actions under these two conditions.

3.2 Participants and procedure

Our study participant were 6 adults volunteers (3 female, 3 male) for task of bookshelf, and other 6 volunteers (3 female, 3 male) for task of clothes chest; they were all right-handed and with corrected vision.
In the bookshelf task, all participants completed tasks in the library of National Chiao Tung University. First, they were asked to browse books on the shelf, and then picked three of four books which they were interested in. Second, they put those books back to the shelf arbitrarily.
In the clothes chest task, all participants completed tasks in their own chest. First, they were asked to browse and select some clothes from rack and piles of clothes. Second, they had to put clothes back to rack and piles.
We recorded the whole process (most are manual action). Then, we used nVivo® to analyze the video qualitative. We pointed out all different actions in nVivo®, and then categorized the behaviors into general or special type. To understand how and why people did the tasks, we would look further into the experimental results.

4 Results and implication

The majority of results were based on a descriptive video analysis; people interacted with shelves by many different ways. In the following paragraph, we highlighted some general and interesting action:

- General pattern of manual manipulation
- Action affected by condition of objects
- Action for different purposes

4. General Pattern of Manual Manipulation

4.1.1 Browsing and taking out clothes from clothes box

In this task, five participants faced the racks and then pushed clothes aside by both hands, then turned the clothes to themselves to preview. They used bimanual independent action-one hand to play the role of fixing and turning clothes, and the other hand to play the role of rummaging the clothes. Three of them used dominant hand to fix clothes, another used non-dominant hand, and the other changed between dominant and non-dominant hand.

The last one didn't change angle of the clothes, but moved clothes to the empty position on the rack, then she turned to see the clothes. She used dominant hand to move and fit clothes into the right position.

Besides clothes hanged on the clothes-rack, there were piles of clothes in four of six participants' boxes. When they took clothes out from the piles, five of them grasped the rummaged clothes that and rummaged them by another hand. The role of each hand would change very often during the whole process. The last participant grasped clothes by the dominant hand and used thumb to rummage them out. When her dominant hand could not grasp anymore, her non-dominant hand joined to help.

4.1.2 Storing clothes into the chest

According to our observation, no matter where the position is, on the center or sides, five participants used dominant hand to put clothes into the box and non-dominant hand to made spaces.

When it comes to putting clothes onto the piles, all of four participants used dominant hand to complete the work. If they put clothes on the top of the pile, they would hit the clothes to keep them in order.

4.1.3 Browsing and taking out books from bookshelf

Five participants only browse the book they wanted in the experiment, and only one of them moved fingers onto the top of book to help him search. When they took out the book they wanted, all participants would pull the top of book first, and then pulled the whole book out. But when there was some space near the target book, or the book was already stuck out, some participant would grasp the book to pull it out directly.

Fig. 1. Serial bimanual assembly

4.1.4 Putting the book into bookshelf

The remarkable phenomenon we found was that all participants used one hand (five participants used dominant hand) to grasp the top of book and put it into the space made by the other hand (five participants used non-dominant hand), but they would use the other hand(usually non-dominant hand) to push it into the shelf and align to the other books. The collaboration between two hands was very simple and smooth. (similar to Guiard's serial bimanual assembly)

The results show that when people took out objects from shelf, the roles of each hand changed often because of the spatial factors—the object user wanted to take out close to which hand or which hand grasp the objects they want. For example, when people took out the clothes, they used both hands to grasp them.

And when storing objects, people usually take objects by their dominant hand and made space by non-dominant hand, putting objects into the shelf by the dominant hand.

4.2 Action affected by the condition of object

4.2.1 Browsing by eye or searching by hands

Usually, participants only saw the bookbone when selecting books, which proved that titles on the bookbones provided the users with enough information to search whatever they wanted. When the book title attracted them, they pull them out to skim. But all participants used both hands to rummage clothes, which meant that the participants needed to see the front part of clothes clearly to make decision. It also meant that the side of clothes doesn't provide enough information for participants.

4.2.2 Storing objects into elastic sandwich structure

Clothes and books in the shelf belong to elastic sandwich structure; they are placed in the space with consistent width and align in order. They could recover themselves automatically after people change their positions. For example, if people don't support the book by hands, it would fall back to its place; if people don't arrange the clothes, it would turn back to original angle or the spaces between clothes would be fit in (when there are many clothes on racks or piles). So when people want to put objects into a specific position of this sandwich structure, they will make some space near that target position by their palm, their back of hand, or the fingers, and then put objects it it by the other hand. Usually use non-dominant hand to make spaces and dominant hand to put objects in. (similar to Guiard's Left-Hand Precedence in Action)

4.2.3 Progress of digging

When people dig the pile of clothes, there are four situations:

1. Few clothes: When rummaging few clothes, people will grasp the clothes that have been rummaged, and then dug clothes by the other hand or the thumb of the hand which grasp clothes.
2. More clothes: By number of clothes increase, people would use the back of hand to arrange the rummaged clothes, then dug them by the other hand.
3. Lots of clothes: When people want to rummage a lot of cloth, they will support clothes by palm because they need more strength against the gravity, then they use the other hand to rummage.

The results show that when people want to rummage

Fig. 2. Progress of digging

and arrange the clothes, they will change their action to according to the different volume and weight of clothes.

4.2.4 Affordance of books and clothes

Our observation showed that the top of books and clothes hangers have affordance. The top of books have affordance which could be pulled out and tilted. Most of the participants would tilt the top of book and then pull it out because the user could only touch the top of book when the books were very organized. And if user took the bottom of book as the pivot, the top of books would be the position for it to be pulled out easily. Clothes hangers have affordance which could be moved. Most of the participant moved clothes by holding the hanger. The hanger was hard so that the user could push it more easily than pushing soft clothes directly.

4.3 Action for different purpose

4.3.1 Keep in order

Objects on the shelf were organized. When participant stored things into bookshelf and clothes box, they would try to keep them in order. When they placed books, participants would make the book align to other books by their palms. When they put clothes on the top of pile, they stored the clothes by fingers or palms lightly. In our point of view, these actions meant that the user wanted to keep the whole bookshelf organized.

4.3.2 Differ of pushing objects aside of browsing from storing

To browse clothes, people turn the clothes to themselves when they pushed clothes aside in order to saw the front side of clothes. That is because the side part of clothes doesn't have enough information for people to decide what they want.

Fig. 3. Pushing objects aside of browsing

And to store clothes or books, people would just push clothes or books aside and wouldn't turn clothes or books around.

Fig. 4. Pushing objects aside of storing

4.4 Implication for interface design

Our results have several implications for interface design, and we explain them by a use case:"bicycle factory application". If we try to provide an application that let user fabricate a virtual bicycle by them self, this application could use a bicycle factory to be metaphor. It includes some shelves that store bicycle parts and tools and a place for fabricating bicycle. This application should provide such interaction technique as outlined below.
Free rotation must be supported. The observational data showed people would turn the object around to look the detail. System should provide user to user their hand to rotate tools and parts in 3-dimentional space freely, and allowing people to see what they want.
Objects in shelf could be pushed together. Participant in our study always push the objects on the shelve to make a space. System should provide user could push the tools or parts on the shelve free. It allows people use their hands to remember the position which the object store in.

5 Conclusion

In this paper, we present the results with rich bimanual action when people manage objects in shelves. People exchange the role of each hand flexibly in the space. And they use serial bimanual actions assembly when put the book back.
The different types of information would influence people's actions of browsing and searching, and people tended to change the supporting action according to the number of objects. The top of books and clothes hangers provided the affordance for users to manipulate.
Shelves are convenient tools for organizing things. They provide a tidy space for keeping objects and people will keep it in order. People need pull out or turn around the object to review before take it out. And people would try to keep the shelf in order.

6 Future work

Future studies should focus on organization manipulation, such as combining, moving, and splitting objects into different types. Moreover, we will be able to build a prototype system to test how people interact with a computer interface, which operates like a shelve, and to explore its potential to be apply in different aspects via the user interface.

References

1. Echtler, F., Huber, M., & Klinker, G. (2008). Shadow tracking on multi-touch tables. In Proceedings of the working conference on Advanced visual interfaces. Napoli, Italy: ACM.
2. Brandl, P., Forlines, C., Wigdor, D., Haller, M., & Shen, C. (2008). Combining and measuring the benefits of bimanual pen and direct-touch interaction on horizontal interfaces. In Proceedings of the Working Conference on Advanced Visual interfaces (Napoli, Italy, May 28 - 30, 2008). AVI '08. ACM, New York, NY, 154-161. Napoli, Italy: ACM.
3. Terrenghi, L., Kirk, D., Sellen, A., & Izadi, S. (2007). Affordances for manipulation of physical versus digital media on interactive surfaces. In Proceedings of ACM CHI 2007 Conference on Human Factors in Computing Systems (pp. 1157-1166). New York: ACM.
4. Klemmer, S. R., Hartmann, B., & Takayama, L. (2006). How bodies matter: Five themes for interaction design. In Proceedings of Designing Interactive Systems: DIS 2006 (pp.140-148). New York: ACM.
5. Agarawala, A., Balakrishnan, R.: Keepin'it real (2006), pushing the desktop metaphor with physics, piles and the pen. In Proceedings of ACM CHI 2006 Conference on Human Factors in Computing Systems 2006 (pp. 1283-1292). New York: ACM.
6. Apted, T., Sydney, A., Kay, J., Quigley, A., & Dublin, I. (2006). Tabletop sharing of digital photographs for the elderly. In Proceedings of ACM CHI 2006 Conference on Human Factors in Computing Systems 2006 (pp. 781–790). New York: ACM.
7. Scott, S., Carpendale, M., Habelski, S. (2005). Storage bins: Mobile storage for collaborative tabletop displays. IEEE Computer Graphics and Applications, 25(4), 58-65.
8. Mander, R., Salomon, G., & Wong, Y. Y. (1992). A 'pile'

metaphor for supporting casual organization of information. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 627-634). New York: ACM.
9. Guiard, Y. (1987). Asymmetric division of labor in human skilled bimanual action: The kinematic chain as a model. Journal of Motor Behavior, 19(4), 486-517.
10. Buxton, W., & Myers, B. (1986). A study in two-handed input. ACM SIGCHI Bulletin, 17(4), 321-326.
11. Carroll, J. M., & Thomas, J. C. (1982). Metaphor and the cognitive representation of computing systems. IEEE Transactions on Systems, Man and Cybernetics, 12(2), 107-116.

Chen-Hao Wuang and Yi-Shin Deng
Institute of Applied Arts, National Chiao Tung University, Hsinchu City, Taiwan

Dagmar Steffen
dagmar.steffen@hslu.ch

Categorizing product meaning: an investigation into the product language of clothing and fashion

Abstract

Product semantics is well anchored in design fields such as industrial and interface design on the one hand and on the other semiologists, sociologists, socio-psychologists and even anthropologists have been analyzing the semantics of clothing and fashion from the viewpoint of their own disciplines. Nonetheless textile and fashion designers are still educated to design in a rather artistic and intuitive manner. In order to provide a theoretical foundation, that can be applied in textile and fashion design practice and that reflects the concerns of professionals this paper presents a model for description and reflection of product meaning in the fields of clothing and fashion.

Keywords

Product Language, Product Meaning, Textile Design, Fashion Design, Design Education.

1 Introduction

Clothing and apparel fulfill practical functions and in this respect they are used for protecting the body against inhospitable climates as well as for reasons of modesty and attraction since ages. At least as important as protection and modesty are, of course, the semantic or communicative functions of clothing [1]. They serve as a non-verbal medium by which meanings and values are produced and exchanged. Already in the Middle Ages, the aristocracy used clothing as a means for demonstrating their social position. The increasing differentiation of town population required distinction and delimitation, and clothing was an appropriate medium for this purpose. Thus, the beginning of the idea of fashion was established [2]. Clearly, clothing, fashion, and accessories construct and communicate the identities and values of groups to members of other groups and also to the members of one's own group. Furthermore, they serve as self-portrayal and consolidate the self-perception of a person.

Since the dimension of communication and meaning is more pronounced in clothing and fashion than those of most other consumer goods, this field has been the subject of investigation by a number of disciplines. Currently, we can find publications by sociologists [3], socio-psychologists [4], anthropologists [5], and semioticians. [6] They approach the topic from the perspective of their disciplines, resulting in a theory of the social and psychological functions or in a study of semiological accounts and production of meaning in clothing and fashion. Barnard's book Fashion as communication is fairly comprehensive on these matters, we will come back to this later. Altogether, this body of literature has insights that are valuable for textile and fashion designers. Nonetheless it does not reflect the perspective and concerns of professional design practice, since guidance for design practice is not the original aim of the authors.

In contrast to other design fields, textile and fashion design did not develop a theoretical approach or a model that sheds light on the kind of information or meaning denoted and connoted by clothing and fashion and its interplay with the means of design such as material, form, shape, and color in a systematic manner. Without an appropriate theoretical concept that is applicable to design practice, textile and fashion designers are dependent on an intuitional comprehension of the messages and meanings of textiles. There are two arguments against the notion that this traditional approach to work, which is based on intuition and artistic creativity will be sufficient in future. First, the growing segment of smart textiles and smart clothes are a challenge for textile and fashion designers, since they offer additional functionality. This requires interdisciplinary teamwork with engineers, a methodological approach and substantial arguments for design decisions [7]. Second, an analytical approach to design has proven to be beneficial in other fields of design education, since it makes the teachable contents more comprehensive. Nevertheless, the aim should be to combine artistic and intuitive design methods on the one side and a theoretical model that reflects and supports design practice on the other.

1.1 Various semantic or semiotic concepts

In order to provide a theoretical foundation for textile and fashion design education, at the Lucerne School of Art and Design a research project has been conducted, that scrutinized various established concepts in the field of product semantics in regard to their applicability to design practice.

- The theory of product language was developed by Jochen Gros (Academy of Art and Design Offenbach, Germany) from the philosophical concept of sign and symbol by Susanne Langer as well as foundations of psychology of perception and Gestalt theory. In the design discourse as conditioned by science in the mid 1970s this disciplinary and humanistic approach to design theory was part of a paradigm shift [8].
- Product semantics represents a constructivist approach by Klaus Krippendorff (University of Pennsylvania, USA) and Reinhart Butter (Ohio State University, USA), developed from concepts of the philosophers Ludwig Wittgenstein and Giambattista Vico as well as psychological concepts by James J. Gibson [9].
- The design semiotics approach by Susann Vihma (University of Art and Design Helsinki, Taik, Finland) is based on semiotics by Charles S. Peirce and applies the representational concept of index, icon and symbol to design and visual culture [10].
- The product expression model by Josiena Gotzsch (Grenoble Ecole de Management, France) uses the theory of product language as a starting-point for a further analysis in product expressions of company identity, user identity and product identity [11].

Despite the different philosophical concepts and epistemologies the above-mentioned approaches share the objective to position communicative functions and the meaning of products in the center of reflection. All of them consider semantics or semiotics to be "a basic concern if not the basic concern of designers", as Klaus Krippendorff puts it. [9] Furthermore they make an effort to offer design professionals terms and models that are applicable and useful in design practice.

Being confronted with the need to make a choice between these distinct concepts, the Offenbach theory of product language and also its derivative, the product expression model were chosen. There are three reasonable arguments for this decision. First, the theory of product language uses a concept of symbol that takes a broad view. According to the conception of Langer, symbolic transformation is the essential activity of human minds and it penetrates all profound issues of a culture [12]. Symbols are meant to be "vehicles for the conception of objects", which are embodied in all kinds of cultural expression and refer to no specific category of content. The meaning of symbols is not fixed, but comprises the wide spectrum of connotations and associations, which come to someone's mind while looking at an object. Since in everyday life clothing and garments are an important bearer of meaning and communicate, among other things, current and short-lived topics and contents, Langer's concept of symbol meets these conditions quite well.

Second: as well as the higher-ranking level of abstract theoretical terms, which derive from Langer's philosophical concept, the theory of product language comprises a subordinated level of specifying terms, which give the various categories of product meaning a structure. They are directly applicable to the semantic analysis of specific products. Furthermore, new terms that reflect the latest development in practice can be added to the framework. In other words, this level of specifying terms represents the junction or intersection between "theory" (the realm of abstract terms and concepts) and "practice" (the realm of the embodiment of terms and concepts in the shape of physical objects). These specifying terms can be used for retrospective analysis of preliminary drafts and final products. They can equally be used in a prescriptive manner for design-briefings that define design criteria.

Third: the specifying terms help us to find, categorize and analyze the various kinds of information and messages, which clothing and fashion communicate. They can be used as a sort of taxonomy of the communicative functions of products. In this respect, the use of specifying terms supports design education, since they induce design students to reflect upon the possible dimensions of expression and meaning of products, including their own designs. In order to clarify how the theory of product language is adapted from the field of industrial and product design to the field of clothing and fashion, I will describe this in more detail.

2 Theory of Product Language

Basically, this conceptual model makes a distinction between the practical functions of a product on the one hand, and the formal and communicative aspects, the so-called product language functions, on the other. Analogous to the differentiation commonly deployed in a science of language between syntax and semantics, Gros subdivided the specific object of product language into formal aesthetic functions – i.e. those aspects that can be observed irrespective of content and meaning – and the semantic functions. He defines the latter as the bearers of meaning and follows Langer's distinction between sign (resp. signal) and symbol. Thus, he proceeded to differentiate between sign or indication functions and symbol functions. (Fig. 1)

As we have seen the formal aesthetic functions correspond to the syntax or "grammar" of the design concept. Based on the insights of perceptual and Gestalt psychology, the formal aesthetic functions distinguish between two antagonistic concepts: order and complexity. As is generally known, order emerges from the application of gestalt principles and reduction of stimuli in terms of shapes, colour, texture, material etc. while creation of complexity calls for the direct opposite.

Indication functions are directly related to the properties of a product, i.e. they are part of a condition of which they signify the remainder. Referring to

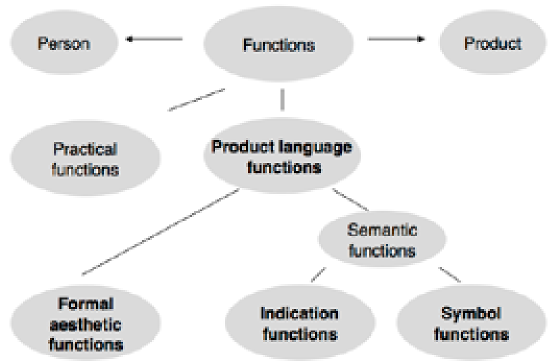


Fig. 1. Conceptual model of the Offenbach theory of product language (Gros 1976).

product language they enable the nature of a product or the product category to be identified. Furthermore, indication functions conciliate between technique and human beings: they visualise and explain the various practical functions of a product and how it should be used. Thus, they play an important role concerning recognition, usability and the self-explanation of products. If the user is not able to operate a product properly, this is often due to insufficient indication functions.

Compared to signs, symbols are associated with objects in the imagination of the recipient or user. Although there are various concepts and definitions of the term symbol in history, the theory of product language refers to the related concepts by Langer, Arnheim and the psychoanalyst Lorenzer. According to these writers, the meaning of symbols includes denotations as well as connotations. With regard to indication signs and symbols, Langer states: "The fundamental difference between signs and symbols is this difference of association, and consequently of their use by the third party to the meaning function, the subject; signs announce their objects to him, whereas symbols lead him to conceive their objects." [12] Thus, the symbol functions refer to conceptions and associations that come to a persons mind while contemplating an object: for example, historical, socio-cultural, societal, technological, economical and ecological aspects.

They convey, for example, conceptions of a period style or various partial styles. Since symbols are based on cultural and social conventions and traditions, knowledge of cultural norms and context is crucial for understanding the message and meaning of a product in the way it was intended. Furthermore, the symbolic functions evoke associations like cold or warm, male or female etc. It is the symbolic meaning first of all that provokes emotional reactions and on whose account we love, desire or dislike products [14].

3 Adaptation of the theory of product language to the field of clothing and fashion

The theory of product language took shape with a focus on product and industrial design. If the theory is to be applied to the field of textile and fashion design some categories and specifying terms need to be adapted, revised or added to. Clearly, abstract terms such as the formal aesthetic, indication and symbol functions as presented in Fig. 1 can be applied to various product fields, including clothing and fashion. Likewise, the criteria, which constitute order and complexity show no object specificity and can be applied in both cases. (Fig. 2a-d)

Fig. 2a-d: Formal aesthetic functions. Examples for fashion, showing a high degree of order (2a, b). Interestingly enough, in spite of high order, artful plication around the hips adds delicate refinement to the dress (2b). Stimuli as manifoldness, asymmetry, indistinctness and novelty create a high degree of complexity (2c, d).

3.1 Indication aspects of fabric and clothing

The matter is different in the case of those terms that specify the indication functions. Since they are directly connected with the nature and the practical functions of objects, they need some revision according to the product segment. (Fig. 3) First, an article of clothing indicates its garment category (coat, jacket, trousers, T-shirt, etc). Specific shapes, lines, typical proportions and sometimes certain details define these garments as a coat, a jacket, a dressing gown etc., even if proportions and details might show a wide spectrum of fashionable variation. (Fig. 4a-d) Analysing garment categories is not banal, since unfamiliar crossover or combinations of typical elements of two categories can be a source of inspiration in fashion design.

Concerning character, a fabric or a garment communicates its manufacturing technique (knitwear, warp-and-weft fabrics, felt etc.) as well as its decoration technique (screen print, inkjet print, tie-dye, embroidery etc.). Furthermore it might indicate its material, – but due to current use of blended fabrics, it is difficult even for experts, if possible at all, to identify materials apart from basic materials such as wool, cotton or silk. While the signs of manufacturing technique and decoration technique are almost unexceptionally natural signs – “a one-to-one correspondence of sign and object”, as Langer puts it, – in case of materials existence and appearance tend to diverge. This is also true for signs of usage, as brand-new juvenile fashion frequently uses artificially created patina. Thus, indication signs can

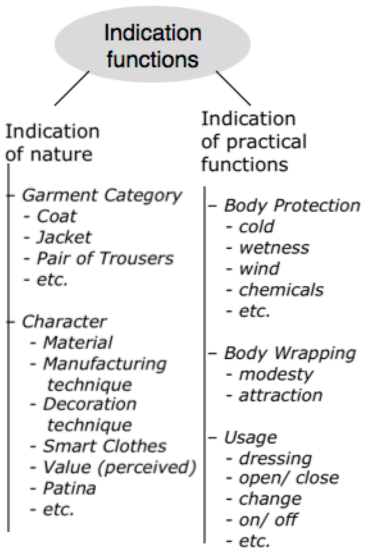


Fig. 3. Language of clothing and fashion: Subordinated level of indication functions.

Fig. 4a-d. Indication of nature. Garment category: Coat, parka, jacket, and blazer.

simulate or pretend to be something in order to achieve a certain effect with less cost. However, signs of value, such as high or low quality of material and workmanship, are easier to identify and in case a designer works in the premium and luxury products sector, he or she has to be familiar with this.

Regarding the indication of practical functions, it must be conceded that in the field of clothing and fashion these are much less relevant than in the field of technical appliances, tools etc. Everyone is familiar with the practical functions of clothing. Apart from smart clothes, which offer new functions and might require explanation, generally this is not the case. A deliberate design of indication signs is not necessary.

Nonetheless clothing and fashion designers should be aware of the interplay between indication and symbol functions. For example, buttons, zipper, outside attached pockets etc. not only indicate certain practical functions but also have an impact on the formal and symbolic functions. In general, certain wind- and water-proofed fabrics and details such as hooded zippers, numerous big pockets etc. connote outdoor clothing, while festive dresses avoid such signs of functionality. To mention another example, buttons do not only serve to close a jacket, but also they might add to complexity and sometimes they are solely a matter of ornamentation. In product design those signs which pretend to be functional elements but are employed to draw attention are called improper ornament [15].

3.2 Symbolic aspects of clothing and fashion

There is no doubt, that in respect to clothing and fashion, symbol functions are most important. Fashion is thoroughly a matter of symbolism and I will now describe what kind of information is communicated or what kind of connotations are evoked by clothing and fashion. As with the structuring of the symbol functions suggested by Gros and Steffen [13], the differentiation between styles, partial styles and associations is adapted to the field of clothing and fashion. Here it is argued that the concept of style comprises of first: period styles, which change in time; second: regional styles, which are closely associated with a particular place and change in time slowly or not at all; third: gender style and fourth concept style connected with activities and social roles (Fig. 5). They are defined as styles since they claim commitment. In other words – at a certain time or at a certain place, for both sexes or while performing a certain social role, these dress styles are binding and without much alternative for the individual.

Concerning period and regional styles, a court lady from Louis XIV, for example, would have to resign herself to the framework of a given fashion style. The same would apply to women from rural Black forest or India. Also the representation of sex is still pronounced in clothing. Even if in Western countries gender concepts have been in flux for about a century and so-called unisex clothing is available, most clothing and fashion connote male or female gender in some way. Without doubt, dress, bright colors, flower designs or laces connote female clothing. They represent femininity so definitely that it is still unthinkable that heterosexual men would wear such clothing in the West. The association between symbol and its mental concept is to such an extent obligatory that one might hesitate and wonder whether the signification of gender is a question of symbolism rather than indication. The concepts or male and female clothing are – like gender itself – socially constructed. There are no natural relations between dress, bright colors, right-hand button-facing and the female sex on the one side, and trousers, muted colors, left-hand button-facing and the male sex on the other. Thus, the gender concept of male and female clothing is doubtlessly a matter of symbolism.

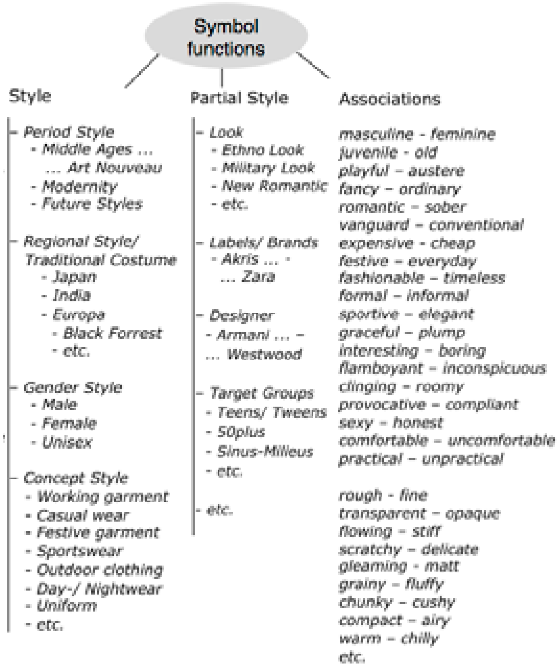


Fig. 5. Language of clothing and fashion: Subordinated level of symbol functions.

Last but not least, while performing certain activities and social roles at occupational or private occasions – for example playing golf or visiting the opera, taking on the role of a bank clerk, a policeman, a wedding couple, or mourners – people are, so to speak, obliged to clothe in a codified manner or at least in a way that society deems appropriate at that occasion. Thus, various concept styles of clothing announce the activity and social role of its wearer. (Fig. 6a-d) Apart from cases, where activities necessitate certain specific properties of clothing (i.e. safety attire or riot gear), the typical design of a working garment, casual wear, festive dress, sportswear, uniforms etc. is also based on symbolism. Although there are more or less strict rules as to what kind of clothing a judge or a policeman must wear, what someone should put on for swimming in a public pool or for visiting the opera, are the product of socially constructed codes. This becomes obvious because they vary in various cultures and because they are subject to change as times go by. As is generally known, Indian ladies wear their saris for swimming, and nowadays, even blue jeans are permitted for visiting the opera.

Thus the semiological account of "the arbitrary nature of the sign" [1] is appropriate and true. Nonetheless symbols are part of semantic networks, i.e. expanded circles of references and networks of meaning, which are specific for a certain culture and time and never fixed [16]. The meaning of symbols has far reaching roots and designers have to be familiar with them because the choice of materials, form, shapes and colors for clothing and fashion is not arbitrary but is meant to evoke particular associations within a certain culture and time.

Concerning partial styles, from the perspective of design practice, categorization in respect of various looks, labels or brands, fashion designers or couturiers and last but not least target groups seems to be relevant. Not only in product design, but also in fashion design, a broad spectrum of partial styles has developed. Unlike the binding character of styles, co-existing partial styles are a question of individual choice. They connote various meanings and messages, which can turn the balance in respect to the impulse to buy [13]. Looks, such as Ethno-Look, Retro-Look, New Romantic etc. distinguish themselves from style, since they exploit and adopt significant signs of another culture or epoch in a playful and not binding manner. In other words, they are not rooted in the values and conditions of the distant place or time, but might express a sort of admiration or imagination.

Fig. 6a-d. Symbol functions. Concept styles: Working clothes, casual wear, festive garment, and sportswear.

A further important partial style that in some cases overlaps with a distinct look concerns the use of labels or brands. From the perspective of customers, labels and brands serve as landmarks in the context of an over abundant array of products. Assisted by means of image cultivation, testimonials, product placement and storytelling in mass media, brands as for example Chanel, Benetton, Levis, Northface or Marimekko are strongly connected with their brand heritage, with definite values, a distinct way of life, and significant imagery (Fig. 7a-d). Thus, for textile and fashion designers it is essential to be familiar with the heritage and values of a company and, first of all, to be able to "translate" or transform them into a concise symbolism. The semantics of clothing and fashion has to reinforce the brand values and keep the heritage in the public mind. At the same time it should express continuity and also some sort of advancement.

In contrast to brands such as Benetton or Northface, where designers are anonymous, the concept of Haute-Couture fashion is based on famous couturiers or designers who distinguish themselves by a significant and unmistakable approach or designers style. Personalities such as Christian Dior, Vivienne Westwood, Jil Sander, Rosita and Ottavio Missoni or Yohji Yamamoto created characteristic partial styles that were noticeable and rather influential. Further development of the fashion industry needs such personalities, who introduce innovative and also relevant design ideas and character defining features. However, these distinguished fashion designers frequently become a brand themselves.

Last but not least target group specific design is an important source for categorization of partial styles. Designers have to take into account age groups, – kids, teens and tweens, young and older adults, seniors – on the one hand and on the other various lifestyle groups and subcultures – traditional and established milieus, modern mainstream, intellectuals, sensation oriented milieus, etc. – as identified by market research institutes for example Sinus Sociovision [17]. Clothing and fashion

Fig. 7a-d: Symbol functions. Partial style: The Finnish brand Marimekko

design for these diverse groups is not just a question of size and cost but first of all the (intended) message of the clothing has to meet the various values and "tastes". Beside styles and partial styles, associations and look-and-feel also have to be discussed. Gros called associations "the basis of every complex symbolism, to some extend the semantic vocabulary, which flows into the creation of styles and partial styles" [13]. Moving beyond the so-called literal or descriptive meanings, fashion designed by Jil Sander for example can thus be characterized as "pure", "minimalistic", "contemporary", "austere", "sober" and "elegant". However, clothing and fashion by Marimekko evokes opposed associations such as "cheerful", "young", "colorful", "straightforward", "easy-going" and "unsophisticated". Fig 6 sets out a preliminary scale of associations, which resulted from research into clothing and fashion. It comprises adjectives that might help to capture the character or "personality" of garments.

4 Comparisons and Application

As mentioned in the introduction, in many aspects Barnard's approach to the meaning of clothing and fashion is relevant and comprehensive from the clothing and fashion design point of view [1]. Interestingly enough, he separates the so-called material functions of fashion and dress, i.e. protection and modesty from their cultural, or communicative functions. This distinction coincides with the distinction between the practical functions and the product language functions introduced by Gros. On closer scrutiny, Barnard's conception of the communicative functions and meaning of clothing and fashion proposes a categorization that is heavily indebted to Roach and Eicher' essay The language of personal adornment (5), which covers the matter from an anthropological standpoint. Thus, Bernard describes eight kinds of information or meanings which clothing may be used to communicate. These are: Individualistic expression, social worth or status, definition of social role, economic worth or status, political symbol, magico-religious condition, social rituals and recreation. [1: 60-68]
Clearly, Bernards categorization of meanings is mostly concerned with the use of clothing and fashion to symbolize and communicate social roles and relationships and to regulate expectations and behavior between social classes, groups and individuals. In this respect he offers detailed categories, which indeed can be experienced in everyday life. Nevertheless I call into question, whether his concise differentiation between, for example social worth or status, social role and economic worth or status makes much difference in the design process of clothing and fashion. In comparison to the suggested categorization of meaning, based on the Offenbach theory of product language, Barnard totally ignores the various kinds of information and meanings of clothes and fashion, which are also relevant in everyday life, from companies point of view, and thus also from a design practice point of view. In particular this involves the communication of labels and brand images, which are closely connected with values, dreams, storytelling and lifestyles. This is also true with regard to the categories of looks, designer's style, associations evoked by look-and-feel and furthermore period and regional styles. Last not least, the categorization inspired by an anthropological point of view omits the information connoted by indication signs.

Another challenge for the above-presented categorization of product meaning is the approach suggested by Gotzsch. Partly, her model is based on the Offenbach theory of product language, but it differs in respect of the categorization of the semantic functions. Instead of splitting them into indication and symbol functions, she proposes to divide the semantic functions that give meaning to a product into three types of expressions: expressions about the product itself (product identity); expressions related to its user (user identity); and expressions related to the company (company identity). She argues that these three groups are in keeping with existing fields of literature, i.e. product identity relates to literature on product semantics and design research; user identity reflects consumer research and product attachment literature; and company identity draws from literature on brand identity. Furthermore, she defines the three main groups in the following way: Product's expressions about the product itself comprise "first of all expressions about the products intrinsic characteristics, such as its function and performance, second expressions positioning the product in its time and culture and thirdly those messages that arouse affection called affective signs". The second category, product's expressions related to its user reflects "the user's individual identity, the user's social achievements and future goals, roots and happy memories". The third category, product's expressions related to the company incorporates company's brand identity and a designer's personal style [11].

On closer inspection, the main and sub-groups of product's expression respectively product meaning identified by Gotzsch can also be found in the product language model. For example, intrinsic product characteristics (Gotzsch) overlap largely with indication of nature and indication of practical functions (Gros); product's place in time and culture (Gotzsch) are synonymic with period style and regional style (Gros); the expression of user identity (Gotzsch) includes the narrower category of target groups (Gros); last but not least brand identity and designer's style are listed in both models.

The main difference between both models lies in the fact that the product language model, developed by Gros is based on the two kinds of logical relations between signs and objects, – more precisely: the difference how an indication sign (signal) and its object relate to each other and a symbol and its object otherwise[1]. Gotzsch's model abandons the distinction between indication sign (signal) and symbol, but in the end she brings forward a similar categorization of product meanings.

In order to test and gain experience with the application of the framework of product language of clothing and fashion, the research group conducted various case studies, one of them a retrospective analysis of nightwear and lingerie by an international textile manufacturing company. To begin with, the team reviewed the company's history, brand heritage, self-image and future goals. Than we discussed spontaneous associations evoked by the garment, in this case pajamas, followed by an educated guess about the target group and the underlying gender concept. We inspected the pattern, material, ornaments and perceived value. Finally, we came to the conclusion that the meaning or message of the pajamas is in no accordance with the self-image and the future goals of the company, expressed by a costly advertising campaign. Discussions with company representatives resulted in the insight that there is a lack of acquaintance with the target group on company's side. Remedial actions were taken. On the part of the researchers, first the case study approved the applicability and use of the theoretical framework. Second, we have been learning that in a corporate context academic terms (i.e. indication functions, symbol functions) are difficult to place. The terminology introduced by Gotzsch lowered this language barrier. However, as has been said, her model takes the Offenbach approach as a starting point. Both models are not contradictory and the pros and cons deserve further research.

Acknowledgements

This research has been conducted at the Lucerne School of Art and Design, Competence Center Product & Textile. I have to thank Andrea Weber Marin, Isabel Rosa Müggler and Françoise Adler for creating ideal working conditions and fruitful discussions.

References

1. Barnard, M. (2001). Fashion as communication. New York: Routledge.
2. Waidenschlager, C. (1989). Schrittmacher des sozialen Wandels. In T. Böhm, B. Lock, & T. Streicher, (Eds), Die zweite haut, über mode. Reinbek bei Hamburg: Rowohlt.
3. König, R. (1971). Macht und reiz der mode. Düsseldorf, Wien: Econ.
   König, R. (1988). Menschheit auf dem laufsteg. Frankfurt/Main, Berlin: Ullstein.
4. Sommer, C. M., & Wind, T. (1986). Menschen, stile, kreationen. Frankfurt/Main: Ullstein.
   Sommer, C. M. (1989). Soziopsychologie der kleidermode. Regensburg: Roderer.
5. Sahlins, M. (1976). Culture and practical reason. Chicago: University of Chicago Press.
   Roach, M. F., & Eichler, J. B. (1979). The language of personal

[1] For more details see Langer [12, pp. 53-78]

adornment. In J. M. Cordwell, & R. A. Schwarz (Eds), The fabrics of culture. The Hague: Mouton.

6. Enninger, W. (1983, May). Kodewandel in der kleidung. Sechsundzwanzig hypothesenpaare. Zeitschrift für Semiotik, 5(1/2), 23-48.
   Barthes, R. (1983). The fashion system. Berkeley: University of California.
   Giannone, A. (2005). Kleidung als zeichen. Berlin: Weidler Buchverlag.
7. Kromer, R. (2007). Smart clothes. Wiesbaden: Gabler.
8. Gros, J. (1976). Sinn-liche Funktionen im design. Form, Zeitschrift für Gestaltung, 74, 6-9.
   Gros, J. (1976). Sinn-liche Funktionen im design. Form, Zeitschrift für Gestaltung, 75, 12-16.
   Gros, J. (1983). Grundlagen einer theorie der produktsprache. Einfürung. Heft 1. Hochschule für Gestaltung Offenbach an Main.
   Gros, J. (1984). Progress through product language in: innovation. The Journal of the Industrial Design Society of America, 3(2), 10-11.
9. Krippendorff, K. (2006). The semantic turn. A new foundation for design. London, New York: Boca Raton.
10. Vihma, S. (1995). Products as representations. A semiotic and aesthetic study of design products. Publication series of the University of Art and Design Helsinki UIAH, A 14.
11. Gotzsch, J. (2006). Product talk. The Design Journal, 9(2), 16-24.
12. Langer, S. K. (1957). Philosophy in a new key. A study in the symbolism of reason, rite, and art. Cambridge: Harvard University Press.
13. Gros, J. (2000). Der ‚Offenbacher. Ansatz' in Theorie und Praxis. In D. Steffen, Design als produktsprache. Frankfurt/Main: Form.
14. Ritterfeld, U. (1996). Psychologie der wohnästhetik: Wie es uns gefällt. Weinheim: Beltz.
15. Brandlhuber, J. (1992). Industrie-design und ornament. München: Akademie Verlag.
16. Du, Gay, P., Hall, S., & Janes, L. (1997). Doing cultural studies. London: Sage.
17. Sinus Sociovision.(n.d,). Retrieved September, 15, 2009, from, http://www.sinus-sociovision.de

Dagmar Steffen
Lucerne School of
Art and Design,
Competence Center
Product & Textile,
Lucerne, Switzerland

Rung-Huei Liang, Kuo-Chun Tseng, Meng-Yang Lee, Chih-Yun Cheng
liang@mail.ntust.edu.tw

Social radio: designing everyday objects for social interaction with ambient form

Abstract
With the popularity of electronic devices and the maturity of minimization in communication technology, more and more objects are created to improve miscellaneous interaction. However, they are often designed to engage users during limited time. Moreover, when overloaded information is shown on a computer screen, it not only occupies the visual sense and ignores the function of the other senses but also almost interrupts our work at hand in everyday life. In this thesis, we probe many rules of interaction design and draw the key elements from the interesting experience in our daily life. By this way, we redesign the prototype which is able to improve social interaction tenderly and spin out the group movements in ambient form. Furthermore, we consider sense of hearing and transform it to be more active and memorable social movements, opening a new way and direction to the interaction interface of communication. Finally, design principles of this type of ambient interaction are discussed and two prototypes, Social Radio and Social Clock, are presented with implementation detail.

Keywords
Social Interaction, Group Dynamics, Slow Technology, Second Sensory, Everyday Lives, Interaction Design, Ubiquitous Computing.

1. Introduction
The trend in technology development today is upgrading the requirement of software and hardware, to enable more information loading and ubiquitous computing. Consequently, there are more and more information and applications which can't be easily digested by humans within the limited time in our daily lives. In these applications, the social network application is surely a pervading genre with rapidly growing popularity. With powerful network technology, social software seems to promise a better future to connect people whenever and wherever they need. However, if we rethink computer mediation as well as social interaction, rather than taking current social software for granted, there is still much space to explore.
In this research, we first ask "what is the possible form and material of computer mediated social interaction?" By examining ways of communication and forms of everyday objects, we can gradually figure out that our target is to design everyday objects for social interaction with ambient form and networked media (Fig.1).
In the physical setting of our everyday life, social interaction happens not only with explicit form and real-time response, but also with implicit form such as written script, post-it stickers, footprints, and so on. In another words, people construct an understanding about others by using all types of senses in the physical environment. Moreover, to feel the atmosphere and

Fig. 1. Scenario of our household routine with an everyday object.

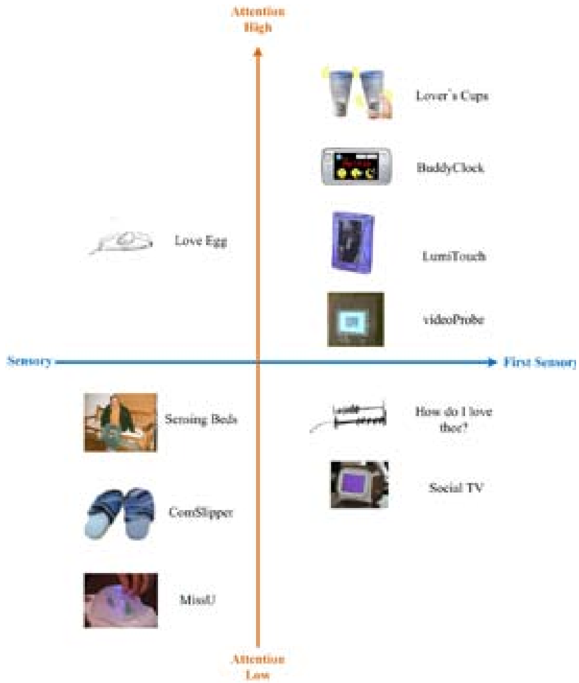


Fig. 2. Analysis of social applications over sensory and attention.

group dynamics of a team, visiting the workspace and observing all the physical settings there, is usually helpful to understand the underlying background of the whole team. For example, knowing what kind of music being listened in their workspace as well as what messages written on the whiteboard, all helps us to learn more about their group dynamics.

In addition to physicality, with the rapid expanding of Internet, the emerging types of social interaction become different from the traditional methods. This kind of computer mediated social interaction has broken the boundary of time and space, and tools like instant message (IM), internet-phone, and email, help us to keep in touch with people who live far away from us. In addition to convenient communication, computer mediated intimacy and the feeling of connectedness are becoming more a part of the overall theme.

Recently, there are many studies presenting new ways to improve the feeling of intimacy for remote couples [3][5][7][8][9][10][13] or to prolong the connectedness for families and groups [4][6][11][12]. We carefully analyzed these studies and surprisingly discovered that most of them used traditional first sensory, sight (Fig.2), to be the channel of communication, but few were mediated through second sensory, such as touch, hearing, smell, and taste (Fig.3). Compared with ordinary social software, the key points of these studies are the designing of the connected feeling rather than convenient communication.

Although computer-mediated relationships can be transmitted by different methods, the most used channel is sight. We are wondering whether there is another of the five senses better represents the characteristics of connected feeling. For example, lo-fi ambient sound from distant lovers might work better than real-time high resolution video. In other words, we are interested in what kind of material should be transmitted to facilitate computer-mediated intimacy and to evoke the feeling of connectedness. In addition to material, if information technology is not able to be concrete in human sense forms, it would be very difficult for us to benefit in everyday life from the existing experience, emotion, habit, faith, and ritual.

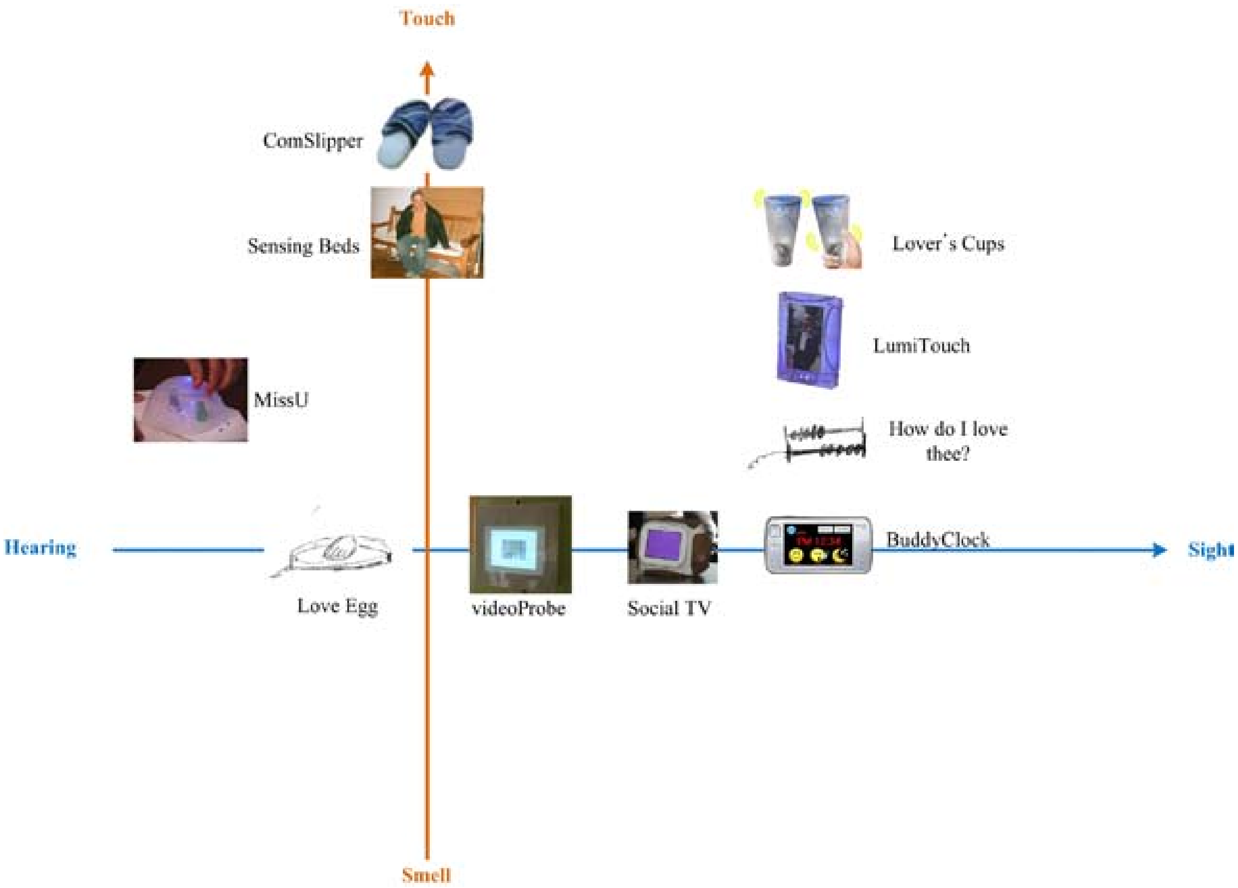


Fig. 3. Social applications and senses.

Instead of making people learn and engage in novel interaction behavior, this research proposes to return the elements of social interaction to the original material and the corresponding metaphor. Therefore, we explore every sense of the human body to be the new notion of information communication and probe the five key elements which can be employed for promoting social interaction. Transferring to the representation in space and time, we take repeated everyday habits and rituals of interaction into consideration and fulfill new design objects in the ambient form (Fig.4). The design principles of this type of ambient interaction are discussed and two prototypes Social Radio and Social Clock, which are everyday objects implicitly revealing group dynamics are presented with implementation detail.

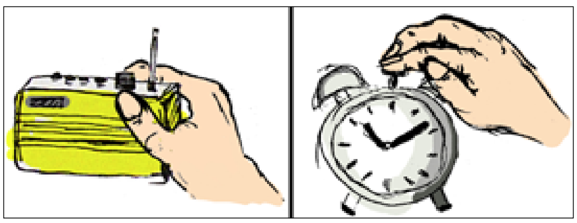


Fig. 4. Routine behaviors with everyday objects in daily life (a) Tuning in AM or FM (b) Turning off the clock alarm.

2. Analyzing the traditional ways of interaction

In general, the traditional ways of social interaction require that we maintain a focus on each other. It would be almost impossible to respond later or skip others' messages delivered to us without taking a break. However, the emerging technologies provide much more different ways of communication. For instance, users can tolerate answering with some delays on Internet. The distant interacting partner would think that you're typing, struggling with the lag of Internet, or away for a cup of coffee. As the phenomena show, the discontinuity either in space or time is one prominent feature in the digital age. Rather than thinking that the traditional ways vanish, we think that there are other ways to fill the gap.

Moreover, people are much busier than they were ten years ago. People are more occupied with learning, engaged in activities, and utilizing more software and electronic devices. Because of this busy-life-style, we sometimes neglect communication with our family and friends.

Therefore, in this chapter, we try to analyze the traditional methods of communication and interaction ways, emphasizing the importance of ambient and the use of everyday objects for improving social interaction.

2.1 Ways of the communication

The ways we communicate are limited to the senses of our human body. Generally speaking, there are five senses to communicate, including sight, hearing, taste, smell and touch.

However, not all of them are used to communicate directly with others. Sight, hearing and touch are more often used in combination to communicate. Still sight is the strongest and dominates the other senses. For example, we are used to using our eyes rather than ears, so that the first choice of communication tools are usually sight-related, such as face-to-face video conference and instant messaging (IM) etc. However, other communication tools, such as the telephone, have been developed to work with the remaining senses. In the case of the telephone, it is sound and hearing that is employed.

2.2 Ambient and everyday objects

When a new technology is invented initially, it will grab all of our focus [18], like computers and mobile phones do today. We usually engage in the new technology unconsciously, even though it interrupts the work in process. The following scenarios very often occur:

You are reading a newspaper and you have opened your RSS reader. You try to focus on the reading, but you will find that you can't stop peeking at the RSS reader.

The RSS reader is one example, but other types of new technology, such as instant messaging (IM), email, cell phone ring tones, could be substituted in its place.

All of these current technologies are still too primitive to be considered ambient communicators. The problem with the current technology is that many objects are designed with flashing, interrupting, and quick-responding, features. All of them are trying to grab our attention, which causes people to become distracted. Therefore, Weiser proposed that in the future, people will begin to design a calmer type of technology, which is less intrusive [18].

On the other hand, even though we design a special object for interaction, still, it is not ambient. The object is still very different from the others in our life so that we have to learn to adapt it. Therefore, the challenge would be how to design a lightweight everyday objects with lightweight interaction and ambient legibility [19] , in which group dynamics can be sensed as smell, sound, surrounding light, and other ambient media. Moreover, we will also introduce the concept of slow technology [2] to our interaction design agenda.

2.3 Analyzing sensory and attention of the communication

In our everyday lives, we may talk to our colleagues face to face saying good morning and exchanging a few pleasantries. After powering on the computer, Internet communication software such as msn and Google Talk are used to start connecting to the outside world. What we do almost every day includes logging into the email box to monitor and reply to email. During the break time, we also may call our friends or send a message to confirm the meeting time for an after work date. Sometimes, we post articles to our blog and visit a specific forum to express our opinions.

The communication method varies from traditional to contemporary at times. There are much computer-mediated commercial software packages which are able to enrich the interaction methods between people. Since the interaction between people is an essential part in our everyday lives, how can we make the communication to be more enjoyable and simple? Firstly, we classified these communication methods according to the human sense interface. They are divided into two parts: first sensory, sight, and second sensory by y axis, requiring attention high and low during every communication separated by x axis (Fig. 5). By this analysis, we discovered that both the traditional and current types of the communication methods and tools take advantage of the primary human sensory channels. In addition, widespread instant messaging tools on the Internet capture our attention to fulfill the goal of communication. This means that when users are engaging in communication with each other, they have to put down the work at hand to participate in that communication. It not only disrupts the fluency [1] of our everyday lives but also requires more of our attention. Due to this, sometimes disorientation of interaction and communication will occur.

For this reason, we think outside the box of the traditional communication interfaces and design new prototypes of Social Radio and Social Clock in which people are engaged through the sense of hearing. In other words, choosing hearing to be the communication channel will keep the fluency of our daily life. Additional key elements of improving social interaction are discussed in the next chapter, including the details for implementation.

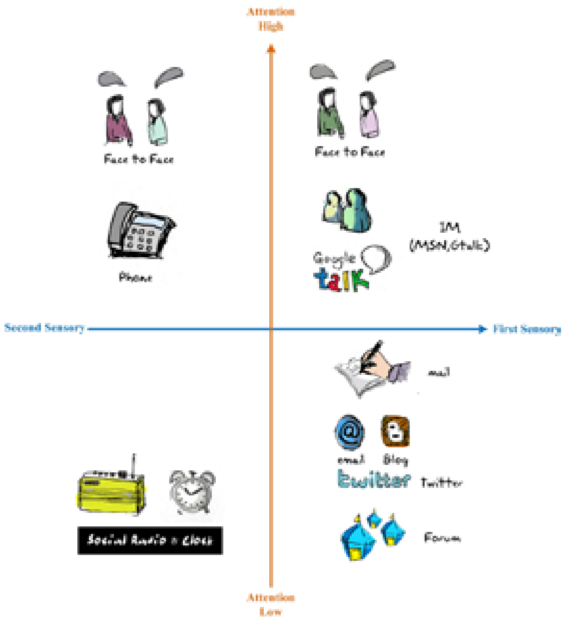


Fig. 5. Classification of the communication ways over the sense and attention.

3. Probing the elements of social interaction

In this section, we probe many rules of interaction design and draw key elements from the interesting experiences in our daily life. By these methods, we concluded five important factors for improving social interaction and merged all of them into our newly designed everyday objects in ambient form.

3.1 Second sensory

Our eyes furnish us with a lot of input information such as light, color, movement, location, and facial expressions. Sight is the primary sense to process this information.
Social interaction often occupies the primary senses to a degree that if we want to interact with others on the Internet, we need to stop doing things which we are working on, such as msn, twitter, and etc. Therefore, an alternative field we are interested in is to design a new object which reserves the primary senses to the user for doing the important activities and uses the second senses for social interaction.
Since the sight often becomes our primary sense for social interaction, we might consider using other senses such as hearing, smell, ambient light, vibration, as the method for communication. During our design process, we are interested in employing hearing as a second sense. Thus we set the condition that the design will based on sound.
In our daily lives, we use our ears to hear sounds of laughter, emotional voices, a variety of music, clock alarms and bell rings, as well as noise around us caused by electronic facilities, environment, and so on. We are able to sense danger, feel enjoyment through music and understand instructions when we receive the data interpreted by our brains through our ears. Hence, hearing is such a powerful sense and that's the reason why we choose hearing as the secondary sense.
When sitting in a clamorous party with noisy music, people talking, keys and glasses clinking, and dogs barking, we are still able to chat away with the friend sitting across the table. We usually refer to this process as sensory integration [20]. In our design consideration, we focus on this human ability and try to develop a new way to interact socially incorporating the property of sensory integration.

3.2 Random and shuffle

Randomness and uncertainty are keys to a challenging and enjoyable game. For example, poker takes advantage of shuffling cards to realize randomness. On account of the probability, the result of the dice always makes people eagerly anticipate the outcome. To make unexpected and joyful communication objects, we will take the element of randomness into consideration in our design project.

Playing music in a random order is much more interesting than predefined sequential order. A song played with uncertain proceeding and following songs will surely bring different and usually surprising hearing experience to listeners. This is one of the reasons why people like to listen to their familiar song played by a radio program. Moreover, if all the songs are contributed by our friends, the random playback would be much like a joyful jukebox. Therefore, rather than precisely representing media provided by social members, either in temporal sequence or user identification, we add randomness to our design as a key element.

3.3 Implicit form

As the Internet technology made great progress, the information communication with high resolution is able to be more concrete such as 2D flash, 3D models and videos. However, high definition media might not make people comfortable in communication.
When the expression and transmission of the information referred to the social interaction, explicit form is not always the best choice, but sometimes the utilization of the implicit form will have the better immense effect.

Design Research Method has mentioned that there is one broad category of unobtrusive measures of behavior known as physical trace measures. These measures make use of physical evidence of some behavior. For example, "if researchers want to discover attitudes toward racial integration of the school, they have studied graffiti in school restrooms. Other examples include smudges on pages of library books to see which pages are most read and grease prints on display cases in museums to see which displays are most interesting to children" [14]. Information could be in a very implicit form.
The team researched the topic of social immersive media discovered that using a silhouette or shadow of a user to be the projection has surprising advantages over a full-color representation. The reason is that people feel discomfort and self-consciousness with a color video representation of themselves. Therefore, the ambiguous form (silhouette) is not only socially liberating, but it also satisfies laws about privacy and alleviates these concerns [15].
It implies us that the implicit form (a shadow) may appear more "real" and have more power to the user than explicit form (a video image). Although it sounds paradoxical, we took the implicit form to convey the information of our Social Radio into consideration and discovered that there were absolutely more merits than the traditional way of information delivery, which were always used in explicit form.

Considering semantics, every motion and interaction with others in the physical world can be thought as explicit or implicit. Implicit methods are useful and expressive in our daily life. For example, roses for lovers usually express our love explicitly. However, if the number of roses is 101, the implicit meaning could be "my one and only one." Similarly, 365 roses would express the meaning of "loving you everyday." Common semantics bindings with flowers include "farewell and goodbye" for marigold, "great love" for oriental lily, "please remember me" for pansy, and so on.
Explicit attitude can transfer messages directly to others with the disadvantage that an instant response, either accepting or rejecting, should be made immediately. Moreover, the message receivers would have to be interrupted from their activity. On the other hand, a meaning with implicit expression is usually so ambiguous that people would feel like they are in an unlimited and imaginary space. A quick and instant response to implicit expression is unnecessary in general.
Therefore, if computer-mediated social interaction is performed with implicit expression, rather than explicit message in a traditional instant message system, the interactive user would experience much more soft, imaginary, and ambiguous space without pressure.

3.4 Ritual

Ritual usually functions as a tool of empowerment or emphasizes the meanings of some periodically repeated behavior. The power of ritual is usually adopted to create, remind, evoke, and amplify meanings of important events in our daily life.
Moreover, a regular pattern of daily practice can also be regarded as a ritual, through which we feel stability and satisfaction. The atmosphere and contextual detail during the process of a ritual would build up special memory, and enhance the intuition and certainty of our behavior manipulation of the object. In addition to individual daily practice, a ritual might also include periodical participation of group members and special dating.
We think that interactive social software would be better woven into our life if our design objects are to be practiced in a form of daily ritual. Instead of learning a novel and exciting interactive application, users can keep on practicing the daily ritual with calmly embedded computing technology.

3.5 Slow technology

"As computers are increasingly woven into the fabric of everyday life, interaction design may have to change." [2].

Slow technology differs from the task-oriented work which emphasizes performance efficiency and speed. It is eager to reserve a fertile land, which makes people think about the context of the produced information. Furthermore, slow technology could be thought of as inheriting its design from the concept of calm technology [18] and ambient computing. Furthermore, it cares about the perspective of affordance which depends on time and space, rather than consuming time, but more social and reflecting. The focus is on the long-term interactions between human beings and digital system. Hence, we know that designers must not only reform digital technology as visible forms and integrate them into our surrounding, but also immerse them into our everyday lives perfectly.

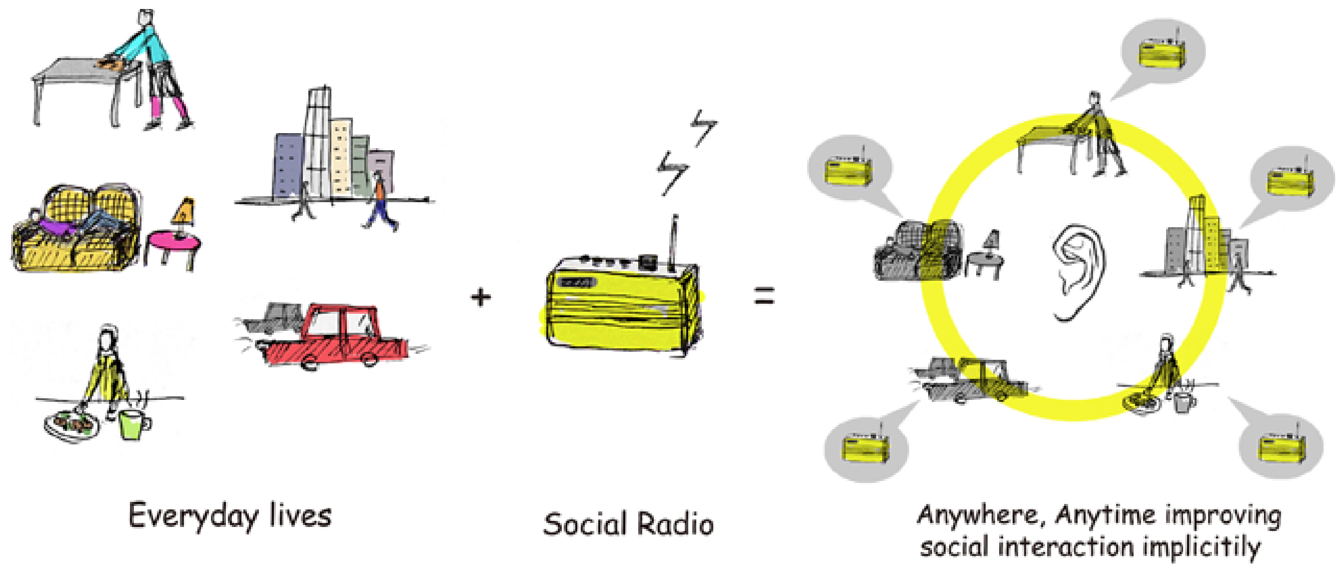


Fig. 6. Social Radio immersing in everyday lives.

Taking slow technology into consideration, we shape digital software into our everyday objects, radio and clock, through convenient Internet technology. Moreover, we choose music as the media to pass it on to every user. By making interaction through the sense of hearing, the information transmission is not so invasive and it allows users to feel the social context without being overburdened.
Delivering the information in ambient form instead of through a cold data display, we are eager for a warm representation. Certainly, the ambient orb [17] is a good design example to provide ambient information. Nevertheless, it only presents a data stream rather than a social relationship.

In the next section, we demonstrate in detail the new design objects, Social Radio and Clock which are the integration of the many important interaction concepts and social elements referred to above. They not only present the information in an ambient form, but also imply more of a relationship of social sharing and caring.

4. Designed everyday objects to improve social interaction

In the following paragraphs, we present the redesign of radio and clock with the concept of social function and ambient form discussed in the previous paragraphs. We also examine some basic design issues.

4.1 Social radio

We redesigned the radio and named it Social Radio. Listening to the radio is an ordinary behavior, while we usually do another job with it. For example, we can listen to the radio while painting or we can do reading and listening simultaneously. Listening to the radio doesn't always grab our full attention, but we can sense its presence by the sound it produces.

Social Radio takes the internet radio as its kernel concept, and mixes the music material and social elements in ambient form. The biggest difference between internet radio and Social Radio is that users can upload the music they like or recommend to the server. All music you are listening to from the Social Radio is uploaded by members of your group (Fig.7). When you are listening to a familiar style of music, you will know that someone shares the same musical taste with you. On the contrary, you will feel surprised if the music is not what you knew before. Broadcasting a same sequence of uploaded music from a group, this interaction is very implicit. Even though members are in different environment, they will listen to the same clips at the same time. Thus, similar flowing dynamics of music are experience in different contexts. Although we are not directly interacting with members of our group, we can still feel the group dynamic. We are also able to sense whether someone may be feeling happy or sad. Social Radio also supports a web interface. Users can upload and listen to music on it, chat on it, or leave comments about the music that is playing. Moreover, when some members find an interesting song playing, the background Social Radio will automatically shift to the foreground of their attention. If users have something to say, they can comment on the current music clip. The comments at that moment can explicitly help the social interaction of a group.

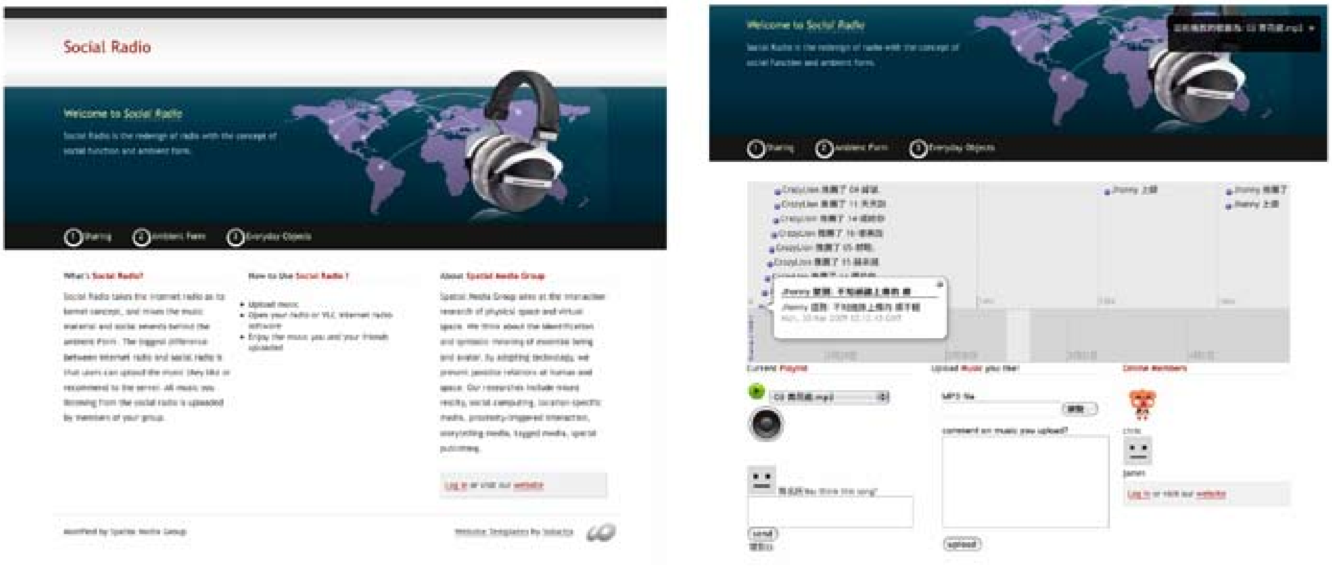


Fig. 7. Screenshot of Social Radio

Unlike other similar designs, this action is forced-free, meaning there is not any strong signal, such as a flashing light or sound to interrupt you.

The playlist of Social Radio is designed with the concept of aging and rating. A music clip will be played with less and less frequency if new music clips are uploaded or if it is rated lower. The playlist of the group represents the group dynamics. By noticing the changes in music style, members can get an impression about other members in this social group.

4.2 Implementation

Random and Shuffle

Although music in Social Radio is uploaded by members, the constant sequence still lets users get bored. Therefore, a random sequence of music play would be more effective in preventing users from becoming bored with the musical selections. Moreover, some music might have a special meaning. It could be a song which your friends used to celebrate your birthday, or has some special message in the lyrics. These attributes could improve the social interaction of the group in an implicit way.

Extremely strange or rarely heard music clips would become interesting topics to discuss when members meet. During our interview, most users confirmed and appreciate this phenomenon.

Explicit and Implicit

Improving social interaction by communicating in implicit ways is different from the way we usually communicate. The typical ways in which we interact are face to face, over the telephone or by written mail and email. These methods require that users respond in to the communication. It implores the receiver to reply. The concept of the Social Radio experiment is that all the interactions are designed to occur in an implicit way. You can upload a music clip for your friends and then they can in turn upload another clip based on their interpretation of the meaning of song you uploaded. However, the ambiguity of Social Radio makes listeners guess who uploaded a track and the possible semantics with a specific music clip. This implicit feature makes Social Radio different from other design objects.

The Power of Ritual

The concept of a ritual is that you repeat an action everyday or in a very specific order. The action of the ritual could become a part of one's everyday life. Twyla Tharp thinks that a ritual could also become a warm-up exercise to evoke the creative process [16].

Walking to your office could be a ritual, arbitrarily painting on the paper could be a ritual, and listening to the radio could be a ritual. Social Radio binds itself to this kind of behavior and thus listening to Social Radio could become a daily ritual to get the feeling of connectedness to a group. It could be seamlessly woven into daily life. In other words, Social Radio hides behind the ambient communication form.

As we reveal the design concept of Social Radio, we can see the advantages of the design principles when applied to designing an object for improved social interaction. Next, we will discuss another design concept, the Social Clock.

4.3 Social clock

The design of Social Clock is similar to that of the Social Radio. The Social Clock transforms the ordinary alarm into sociable material. With the concept of the community, users can upload any piece of sound or recorded voice to the clock. When the clock rings, it will pick a sound randomly. This design creates an interesting ritual and the unpredictability of the clock alarm sound can be a subject to initiate conversation and communication within the group. Users of the Social Clock will look forward to waking up to hear which alarm sound is played.

Imagine the following scenario of the random alarm ring. One of your friends would record their voice for you, but your clock doesn't select this sound initially. Nevertheless, others may hear it at a later time. Maybe they would upload additional voice recordings to your clock or they would send an email to you. This mismatch of communication will bring surprise to you, and evoke the social interaction of your group.

The Social Radio and Social Clock implement our design principles. You can see the advantage of using everyday objects as a way to transform the everyday behavior to a more sociable interaction. Moreover, both objects are unobtrusive. These two objects won't use any signal to interrupt your work and they hide behind ambient forms of communication rather than using an explicit form of communication annoy or distract you such as instant messaging.

4.4 Comments

The website of Social Radio is on the url below: http://www.dt.ntust.edu.tw/socialradio/. Our server runs on Ubuntu 7.04 and uses SHOUT as broadcasting server. The website of Social Radio is written by php and MySQL. When a music clip uploaded, we will re-generate the play list to make sure the randomness. The webpage embedded a VLC plug-in; therefore the user can listen to the radio without open another application like iTune .

Before collecting the user responses, group participants were exposed to the Social Radio and Social Clock for approximately one week.

All members indicated a difference between the Social Radio and the traditional radio (or internet radio). Members stated that the Social Radio has some interesting features and that the unpredictability of the objects is the most important one. The element of randomness and unpredictability will keep the interactions between the group members fresh and dynamic.

5. Conclusion

From the two examples of Social Radio and Social Clock, to begin with, we use the sense of hearing to substitute for the experience of seeing. This computer-mediated sound is often used in interaction and the members of the group are able to upload the songs which could imply their preference in privacy and help to realize unnoticed personality of other members. In this way, it changes the method of communication from a forcible one to a gentle one.

The newly designed objects will not replace the user's sight, but rather will use a softer method of communication through use of the other senses to avoid disturbing the user while they are engaged in an activity. Incorporating randomness and unpredictability into this softer method of communication helps to keep the communication fresh and enjoyable when it occurs.

Finally, by applying the principles of slow technology, we help users to relax and enjoy their time rather than feel hurried by passage of it. With the ambient form incorporated into the technology that pervades their daily activities, users of the technology can feel the freedom to enjoy their surroundings and the space which they occupy.

Reference

1. Lowgren, J. (2007). Fluency as an experiential quality in augmented apaces. International Journal of Design, 1(3), 1-10.
2. Hallnäs, L., & Redström, J. (2001). Slow technology –Designing for reflection. Journal of Personal and Ubiquitous Computing, 5(3), 201-212.
3. Strong, R., & Gaver, W.W. (1996).Feather, scent, and shaker: Supporting simple intimacy. In proceedings of computer supported cooperative work (pp.443-444). Boston :ACM Press.
4. Chang, A., Resner, B., Koerner B., Wang, X, & Ishii, H. (2001). LumiTouch: An emotional communication device (short paper). In extended abstracts on human factors in computing systems CHI2001 (pp.313—314). Seattle :ACM Press.
5. Chung, H., Lee, C.J., and Selker, T. (2006) . Lover's cups:

Drinking interfaces as new communication channels. Ext Abstracts CHI2006 (pp. 375-380). Seattle: ACM Press ..
6. Conversy, S., Roussel, N., Hansen, H., Evans, H., Beaudouin-Lafon, M., & Mackay, W. (2003). Sharing daily life images with videoProbe. In Proc.IHM2003 (pp.228-231), ACM Press, Seattle.
7. Dey, A., & De Guzman, E. (2006). From awareness to connectedness: the design and deployment of presence displays. In Proc. CHI2006 (pp.899-908). Seattle : ACM Press.
8. Goodman, E., & Misilim, M. (2003). The sensing beds. Workshop UBICOMP2003, ACM Press, 1-3.
9. Chen, C., Forlizzi, J., & Jennings, P. (2006). ComSlipper: An expressive design to support awareness and availability. Ext Abstracts CHI2006 (pp.369-374), ACM Press,.
10. Kaye, J., & Goulding, L. (2004). Intimate objects. Interactive Posters DIS2004 (pp.341-344), ACM Press.
11. Harboe, G., Metcalf, C. J., Bentley, F., Tullio, J., Massey, N., & Romano, G. (2008). Ambient social TV: Drawing people into a shared experience. In proceeding of the SIGCHI conference on human factors in computing systems (pp.1-10), ACM Press.
12. Kim, S., Kientz, J. A., Patel, S. N., & Abowd, G. D. (2008). Are you sleeping? Sharing portrayed sleeping status within a social network. In proceedings of the conference on Computer supported cooperative work (pp.619-628). San Diego : ACM Press.
13. Lottridge, D., Masson, N. & Mackay, W. (2009). Sharing empty moments: Design for remote couples. In proceedings of the 27th international conference on Human factors in computing systems (pp.2329-2338). Boston : ACM Press.
14. McBurney, D. H., & White, T. L. (2007). Research methods 7. Massachusetts: Thomson Wadsworth.
15. Snibbe, S. S., & Raffle, H. S. (2009). Social immersive media: Pursuing best practices for multi-user interactive camera/projector exhibits. In proceedings of the international conference on human factors in computing systems (pp.1447-1456). Boston: ACM Press.
16. Tharp, T. (2003). The creative habit: Learn it and use it for life. New York: Simon & Schuster .
17. Ambient Orb. Retrieved June 30 , 2009 , from http://www.ambientdevices.com/cat/orb/orborder.html
18. Wieser, M., & Brown, J. S. "Designing calm technology" c Xerox Parc 21 Dec 1995. Retrieved June 30 , 2009 from http://sandbox.xerox.com/hypertext/weiser/calmtech/calmtech.htm .
19. Morville, P. (2005). Ambient findability: What we find changes who we become. California: O'Reilly Media, Inc.
20. Laurel, A. H.(n.d.). Sensory integration. Retrieved June 30 , 2009 from http://www.thegraycenter.org/sensory_integration.htm.

Rung-Huei Liang, Kuo-Chun Tseng, Meng-Yang Lee, Chih-Yun Cheng
Dept. of Commercial and Industrial Design, National Taiwan University of Science and Technology, Taipei, Taiwan

Bart Hengeveld, Riny Voort, Caroline Hummels, Kees Overbeeke, Jan de Moor, Hans van Balkom
b.j.hengeveld@tue.nl

Bringing back real-world richness in interactive story reading: lessons from linguabytes

Abstract
This paper describes the iterative development of LinguaBytes, a play and learning system that stimulates the language development of toddlers (1 – 4 years old) with Cerebral Palsy. In particular this paper focuses on interactive story reading since collaborative parent-child story reading plays an important role in early language development. The authors have observed that interactive applications for children with Cerebral Palsy are hardly available or unsuitable. Usually, applications are PC-based or rely on menu structures that are cognitively too difficult for children in this age group, let alone children with a disability. This paper describes the iterative development process of a system that both benefits from interactive technologies and from the richness of the physical world. To achieve this, the authors use a Research-through-Design approach, which is an iterative process in which scientific knowledge is generated by designing, testing and evaluating experienceable prototypes in real-life settings. The prototypes are evaluated using formative evaluation techniques. This paper describes four consecutive designs of an interactive story-reading device and in doing so shows the value of physicality within an ever more virtual world.

Keywords
Interactive Story Reading, Social Interaction, Early Language Development, Cerebral Palsy, Tangible Interaction.

1 Introduction: story reading and early language development of pre-school children

Pre-school children (1 - 4 years old) learn mostly through play. They explore the possibilities and limitations of their environment and, based on their experiences, construct a mental representation of the world. In this age group, this process is highly interactive. By interacting with other, more experienced people (more capable peers or parents) the developing child is offered novel insights in the world. Also, these people can help the child with things he is still incapable of achieving independently. This process is commonly known as 'scaffolding' [1].

One area of child development that thrives on scaffolding is language development. When children start communicating they rely on others for correction, mostly their most frequent social partners: their parents. Therefore the basis for early language development is laid in parent-child communication.

A powerful platform for early language development is collaborative parent-child story reading [2, 3], which precedes and develops into conventional literacy.

By reading stories to and with pre-school children they are exposed to a huge amount of language in a comprehensive semantic context. It is shown that the presence of a parent or caregiver here is crucial here, with regard to the motivation of a child to engage in story reading [4]. Moreover, by involving children

in the process of 'reading' itself, they are stimulated to put their language skills into practice and start communicating.
This early communication is not limited to verbal information, but involves many bodily elements: children point at details in the book, grab the parent and make eye contact, make facial expressions to convey emotion, and use a variety of other expressive and communicative gestures and movements. Not in the last case due to the physicality of the book itself: children can flip through pages themselves, either backward or forward, prevent flipping pages or simply throw the book away if they're done. Also, the book conveys linguistic meta-information to the child outside the storyline: the length of the story is conveyed through the thickness of the book, the position in the story through the relative thickness of the book before and behind the current page, and thus the concept of story linearity. All this contributes to a child's early language development, forming an integral part of informal daily experiences.

2 Limitations in early language development of pre-school children with multiple disabilities

Although normal developing children acquire language skills seemingly effortlessly, this is not the case for non- or hardly speaking toddlers with multiple disabilities [5, 6]. For example, a major part of the non- or hardly speaking toddlers with multiple disabilities have a form of Cerebral Palsy (CP), which is an umbrella term encompassing a group of non-progressive damages of the immature brain, before, during or shortly after birth, with motor disabilities as a consequence. These children are confronted with considerable limitations in the developments of their language and communication skills. Factors that contribute to this are:

- Brain damage. Due to brain damage, a toddler with CP has trouble controlling the muscles of the body and might not be able to walk, talk, eat, or play the way most children do. If the part of the brain that controls speech is affected, a child with CP might have trouble talking clearly. Another child with CP might not be able to speak at all;
- Resulting motor problems. Because the arm- and hand functions are retarded, these toddlers have restricted access to their environment and therefore an impoverished experiential base for language development [6]. Another consequence of motor problems is that the facial, gestural and verbal expressions of toddlers with multiple disabilities can be hard to interpret by their caregivers, making it difficult to understand what the children are trying to communicate, especially since communication with non- or hardly speaking children is highly dependent on non-verbal expressions. As a consequence, these children receive less communicative reactions than normal developing children, or only reactions that are less rich in information. This leads to further impoverishment of the child's opportunities for language development;
- The requirement of much physical care. Because a lot of time is needed for physical care, less time and attention is leaving for caregivers to spend on play and communication. The toddlers miss opportunities for learning from their caregivers and surroundings, which leads to a restricted environment [7].

If we compare the children described here to those in the introduction, it should be clear that the limitations in language development do not only affect the linguistic prospects of the developing child. All developmental areas (social-emotional, cognitive and perceptual-motor) will progress significantly slower. To minimize these negative impacts it is essential to intervene as early as possible. Research has shown that the effectiveness of early intervention on language development can be reinforced by the use of multimedia technology [8]. One area that receives much attention lately is that of interactive story reading with integrated possibilities for augmented or alternative communication (AAC). Some applications have even already appeared on the market. However, despite their commercial success, we see many opportunities for improvement, which we will illustrate in the following section.

3 Novel technologies in interactive story reading; the gap with early intervention materials for disabled toddlers

The last two decades have seen a number of interactive story reading applications appear, both in research and on the commercial market. We have had ample time to get used to interactive CD-ROMs (in many incarnations) and more recently, to online storybooks and literacy adventure games. Also some interesting interactive toys for early language development have made it to market such as V-Tech® computers [9] and LeapFrog® Tag Junior Books [10], all specifically developed for pre-school children. The HCI research community has gone even further, exploring the possibilities of tangible interaction [11, e.g., 12] and augmented reality [e.g. 13]. However, not many of these appealing interactive story-reading materials are available or suitable for children with multiple disabilities, e.g. CP. Of course, one of the reasons is that many technologies mentioned above are difficult for children with CP. This can be due to both cognitive and perceptual-motor requirements; some are difficult to understand, others difficult to use. We believe that these are issues that can be solved though clever design. However, most designs of interactive applications for these children are based the combination PC – AAC-device. These applications seem to lose the richness of traditional story reading out of sight:

- Being PC-based, most applications don't reflect the way very young children think and interact with respect to navigation (menus and decision trees), input and output. The resulting cognitive load for these children to learn and use these devices is too high [14];
- Another disadvantage is that many applications have taken initiative possibilities away from the child. Where children used to be able to control the story through the physicality of a book, they now often have to wait until the computer allows them to act;
- Also, PC-based applications are often mainly suitable for individual use and makes social interaction difficult. The role of the parent or caregiver is thus being reduced, along with possibilities for scaffolding;
- Additionally, most AAC devices that these children rely on for communication aren't even appealing to young children with respect to their design [15] and interaction;
- Finally, current interactive language development applications mainly address the child's cognitive skills and only rarely their perceptual-motor skills. Only gradually some attempts to move away from the traditional PC interfaces start appearing on the market, e.g. TOM by Platus Learning Systems [16]. This system however does not support story reading.

These observations were confirmed by Van Balkom, De Moor and Voort in a study performed in the Netherlands in 2002 [17]. These findings showed that interactive story reading applications for children with multiple disabilities should significantly improve in order to be used effectively. The most important conclusions of Van Balkom, De Moor and Voort offer two valuable starting points:

1. The application should appear to be more toy than PC-based computer program;
2. The application should be adjustable to the skills of the child to optimize the interaction for each individual child. If the designed interaction doesn't fit the child's skills, the child will be less motivated to engage in the program and eventually stop using it.

In the following we will describe how we have tried to implement these insights in the LinguaBytes project, a three-year multi-disciplinary research project focused on early language development of young children with multiple disabilities.

4 LinguaBytes

4.1 Background and method

In 2006 we started developing LinguaBytes, a project defined as "developing and designing a tangible, adaptive, interactive play-and-learning system that stimulates the language development of toddlers between 1 and 4 years old (developmental age) with multiple disabilities". Some guidelines for the development of LinguaBytes were the following:

1. The LinguaBytes play-and-learning system should take interactive stories that stimulate parent-child interaction as a starting point and offer exercises and games related to these stories to deepen linguistic aspects such as phonological awareness, semantics and syntax;
2. Since LinguaBytes is aimed at a very heterogeneous group of children, the system should be highly flexible. It should be adaptable to the variety of needs, skills and preferences of individual children and ideally grow along with the developing child;
3. The interaction with LinguaBytes should correspond with the natural interaction style of toddlers: it should be playful, explorative and address all of the child's skills. Consequently, it should benefit from the richness of the physical world;
4. Finally, LinguaBytes should facilitate caregiver-child communication to enable scaffolding.

The development of such a product for this highly heterogeneous user group is a complex process, in which numerous choices that are impacted by factors related to the child (e.g. motor, cognitive and linguistic skills, interests and attractiveness), the parent or therapist (efficient to learn, maintain and develop) as well as factors related to the product itself (technology, material, costs) have to be made. In order to keep this process structured and efficient, we use a Constructive Research method – in our field of design research more commonly known as Research-through-Design (RtD). This a process in which scientific knowledge is generated through iterations of designing, building and testing experiential prototypes in real life settings [18]. The Research-through-Design process always moves through several iterations of designing, building and testing, each iteration yielding refined knowledge for the next. This means that early iterations are often more diverging in character (focused on mapping out all aspects involved in the project) and later iterations more converging (refining within these aspects). As a consequence, research activities such as e.g. literature search, are often repeated throughout the process, on different levels of detail: from global to specific knowledge. In our process, subsequent cycles were evaluated using formative evaluation [19, 20]. The aim of formative evaluation is to collect data with which the product can be improved. In our case, we made use of video analysis and questionnaires.

In the remaining part of this paper we will illustrate four RtD iterations. Within each iteration we will give a brief description of the complete LinguaBytes system before focusing on the part that supports interactive story reading. We will evaluate this part at the end of each iteration and draw conclusions on how to improve the design in the following iteration.

5 Four iterations of interactive story reading with LinguaBytes

5.1 Iteration 1: KLEEd

Overall system design

The aim of the first RtD iteration was to develop a first experienceable prototype, i.e. a physical prototype that people can interact with, not just act upon.

To gain insights our design space, we started off by building and testing several low-tech mock-ups (Fig. 1) that explored the possibilities of combining toys and interactivity, based on an extensive literature search. All mock-ups were made interactive using Wizard of Oz. A more elaborate, preliminary prototype was developed and tested, called the ExploraScope [21].

These preliminary designs made us decide to focus on: (1) offering the child many possibilities to take initiatives and to reward these clearly; (2) offering a variety of bodily experiences, since children with CP are usually limited to pushing plastic buttons.
The resulting prototype was called KLEEd (Kids Learn through Engaging Edutainment, see Fig. 2), a modular system consisting of four parts: (1) A central output module containing a 15” TFT monitor and speakers; (2) an interactive story reading module; (3) two exercise modules; (4) a collection of physical characters and verb cards, all tagged with RFID. All modules were covered in textile sleeves in bright colours. All modules contained material accents such as wood, string and coloured paper to offer a wider range of tactile sensations.
The physical characters were made of plywood.
The story and exercise modules could be magnetically connected to the output module, which would start either the accompanying functionality: either the interactive story, or one of the exercises. A hide and seek game focused more on semantics, the other exercise focused on syntactic awareness by challenging the child to combine different words into two-word sentences.

Interactive story reading in KLEEd

For the interactive story reading part we developed two stories based on three widely used Dutch word frequency lists [22, 23, 24]. Both stories started with the same opening scene: two children, Tom and Tess,

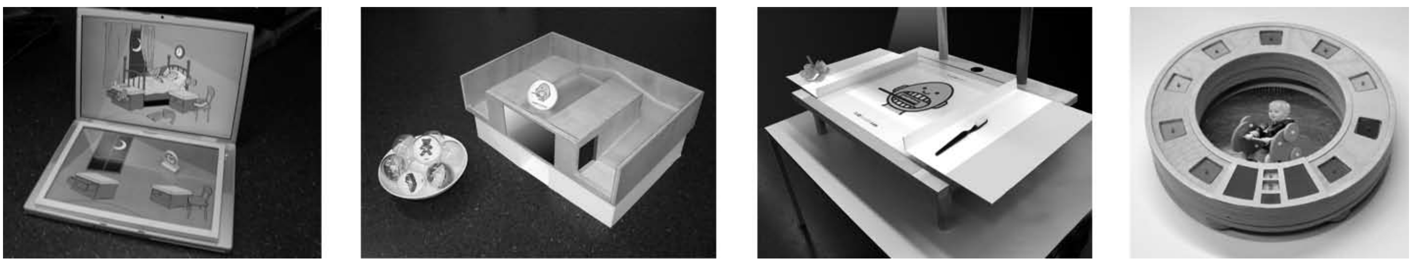


Fig. 1. Three explorative interactive mock-ups, and the ExploraScope (right)

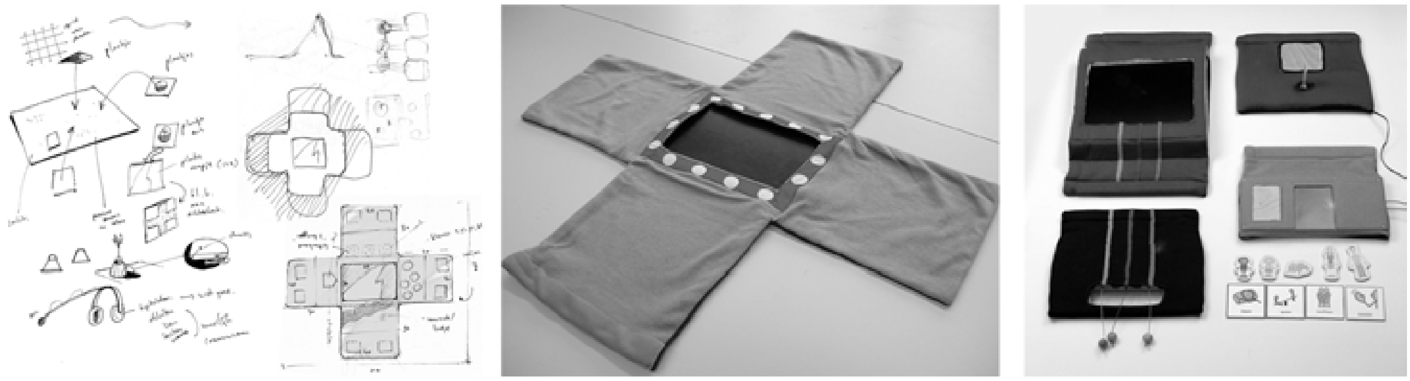


Fig. 2. Early sketches of the KLEEd prototype (left), the first model (middle) and the final, modular KLEEd prototype (right)

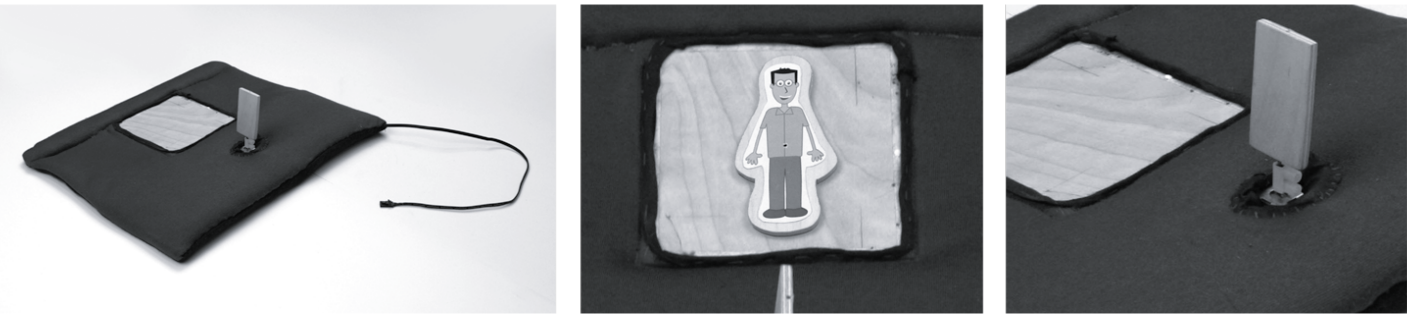


Fig. 3. The story-reading module (left), a tagged story character (middle) and the handle for moving through the story (right).

who are playing with a ball in the park. The opening scene would start automatically upon connecting the story module (Fig. 3, left) to the output module. At the end of the opening scene child and caregiver could choose which other character would join Tom and Tess by placing a tangible figure of that character on the story module, e.g. daddy (Fig. 3, middle). From that moment on, the story would continue in the daddy-branch. The child could flip through the story by moving a handle (Fig. 3, right) to the right for the next scene or the left for the previous scene. By replacing the tangible figure with another the story would change topic.
The story module contained a Phidgets joystick sensor and RFID reader [25], and was connected to an Apple MacBook Pro that ran Adobe Flash and MAX/MSP [26]. The character figures were tagged with 30 mm RFID discs.

Evaluation of the interactive story-reading functionality

Seven children with a developmental age between 3 years 1 month and 6 years 1 month took part in the evaluation study. The children were diagnosed with different multiple disabilities, mostly due to a form CP. The study was executed at two different locations: one school for special education and one centre for rehabilitation medicine. All children participated with their accustomed speech therapist.
All children enjoyed working with the prototype: they liked the stories and characters and kept interested in the story plot. However, some aspects of the design hampered the interaction. For example:

- Some children enjoyed moving the handle so much that it disrupted the continuation and concentration on the story and the requested tasks;
- Additionally, the handle did not provide the suitable feedforward or feedback: none of the children seemed to understand that moving the handle in different directions had different results in the story. The required cognitive mapping was regarded to be too complex;
- This was also the case with the role of the tangible story characters, though to a lesser extent. Mapping a 'branched story' in their minds was too difficult for the participating children;
- The physical interaction required for the placing of story characters encountered motor skill problems. This was due to the orientation of the pieces (horizontal) and the location of interaction space (behind the handle);
- The sensation of the textile sleeves was very much enjoyed by the children, but the material also hampered the interaction: due to their diminished motor control, children involuntary moved the module, frustrating the interaction. This significantly interfered with communicative initiatives;
- Finally, the therapists indicated that they wanted to make more choices with regard to content. One example is that they indicated the need for more stories aimed at different age groups.

Fig. 4. Click-It contains an output module (left), four input modules (middle), and a base module (right).

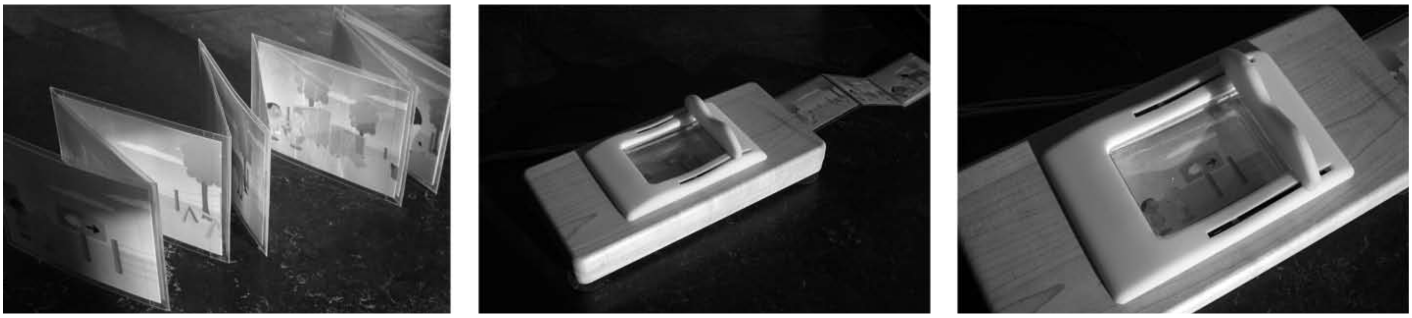


Fig. 5. The linear story booklet (left) can be inserted in the story-reading module (middle); the scene behind the viewer (right) is animated on the output module.

On the positive side, all therapists indicated that the number of both verbal and non-verbal language expressions increased, which they attributed to the physicality of the interaction. This strongly suggests that the device prompts communication skills as turn-taking, taking initiatives and cause-effect relations.
These and other findings were taken as guidelines for our second RtD iteration, which resulted in the Click-It prototype.

5.2 Iteration 2: Click-It

Overall system
Like KLEEd, Click-It is a modular system consisting of one output module (Fig. 4, left) and several input modules designed specifically for emphasizing the different language aspects: phonological awareness, semantics, syntax and story reading (Fig. 4, middle). In contrast with KLEEd all input modules are now connected onto a single base module that contains all reusable electronics (Fig. 4, right). The Click-It prototype comes with a small collection of tangible input materials comparable to those of the KLEEd prototype, with some changes and additions. The prototype worked with a combination of Phidgets sensors, MAX/MSP and Flash.

For this prototype we developed one linear story about Tom and Tess visiting the kiddy farm, and eight exercises and games.

Interactive story reading in Click-It
To tackle the main disadvantages of the interactive story reading functionality of KLEEd we redesigned the system thoroughly:

- To prevent the design from interfering with the interaction we replaced the textile with ash wood and added suction pads to the bottom of the base module to prevent it from sliding away;
- To reduce the cognitive load we made the whole story physical again: where in the previous prototype the child had to remember in which branch of the story it was, we now developed a simple linear story in the form of a foldable, RFID-tagged booklet (Fig. 5, left). This booklet can be inserted in the right side of the (redesigned) story-reading module and moved to the left by moving a slider accordingly (Fig. 5, middle). This will start a small motor that moves the booklet through the module. When a scene is located behind in the module's viewing window (Fig. 5, right), the motors stop and the scene is shown as an animation on the output module. Through these design changes we reintroduce several elements from traditional book reading:
  - By offering a physical booklet a child can literally see the 'length' of the story. Note that for this prototype we developed a linear story instead of a branched one;
  - Additionally, when being moved through the story-reading module the story is divided into three

- segments: one on the left of the module (past pages), the one behind the viewing window (the current page) and one on the right of the module (the remaining pages). This offers both clear feedback and feedforward, as well as valuable meta-information about story linearity and storyline causality;
- By being physical, the story booklet can be used both within the system as well as outside the system, e.g. for anticipating on the story or assessing the child understanding of the story in retrospect;
- Finally, by offering a physical booklet the child has an alternative communication means: children can handle the booklet similar to a traditional book, or point to details to convey specific words.

• We replaced the handle of the KLEEd prototype with a slider, for the following reasons:
  - To diminish distraction we reduced the handles degrees of freedom: the slider can only move from right to left and would slide back automatically;
  - The movement of the slider represents flipping a page: progressing through a book requires flipping a page from right to left, since the Western reading direction is from left to right. The slider and story booklet therefore also move from right to left.

Evaluation of the interactive story-reading functionality

We tested the Click-It prototype to date at a centre for rehabilitation medicine in the Netherlands, in 2 weekly sessions. Seven children with a developmental age between 1 year and 3 years 3 months participated. Most children were diagnosed with a form of CP. Each child would use our prototype during its regular weekly 30-minute speech therapy session, with his or her usual speech therapist. We used video analysis and questionnaires for the evaluation.
Some important conclusions from our observations and the feedback of the speech therapists were the following:

• The children generally showed a longer attention span than usual and took more initiatives. These observations were confirmed in the therapists' questionnaires. One child even returned for a double session, another child started crying when she had to leave for her next therapy;
• Children and therapists were very positive about the physical booklet. It was very clear that the physicality of all input material slowed down the interaction, subsequently giving both children and carers more control over the timing of the interaction. This was not due to the children's motor problems but to the fact that there were more moments between actions;
• As a result of this, there were more opportunities for facial, gestural and verbal expressions of the children, letting them evoke more communicative reactions of their surroundings;

However, despite these positive findings there were also aspects that needed further improvement, especially with respect to the story-reading module's single slider:

• Firstly, it was considered strange that it could only be moved from right to left to advance through the story, and not moved from left to right to go to a previous scene. Moreover, since the mechanism that automatically moved the slider back to its starting position rapidly broke down, the slider had to be moved back manually; intuitively this action should have resulted in going to the previous scene;
• Secondly, due to its construction the slider was not easy to manipulate: often it got stuck directly over the viewing, obscuring the view on the current scene.

Additionally, therapists expressed the wish for a wider variety of stories and exercises and for more control over the content, mainly within exercises. Based on these conclusions we redesigned the Click-It prototype, resulting in Click-It 2.0.

5.3 Iteration 3: Click-It 2.0

Overall system design

As the suffix suggests, the prototype developed in this iteration is largely an adjustment of the previous version. The most profound changes are: (1) adding a control module for the caregiver to the system (Fig. 6, left), to offer more control over the content and timing; (2) the extension of exercises and accompanying input materials; (3) a redesign of the base and story-reading modules.

Interactive story reading in Click-It 2.0

Some changes were made to the prototype to improve interactive story reading:

• Firstly, to emphasise the semantic context of the story a slot was added to the base module to hold a thematic background, e.g. the setting of a zoo for zoo-

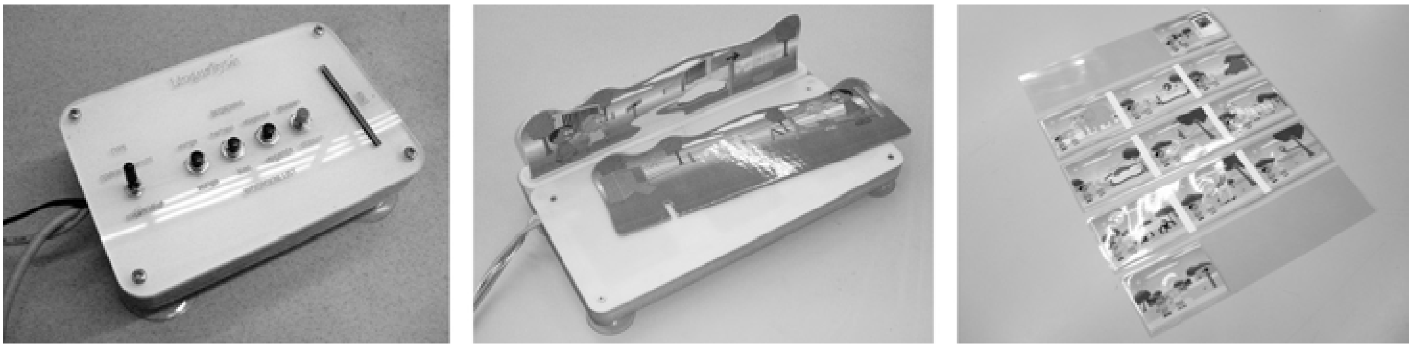


Fig. 6. The caregiver's control module (left), the new base module with a slot for thematic backgrounds (middle) and the branched story booklet (right).

related stories and exercises (Fig. 6, middle). By using the same background for all stories and accompanying exercises within a context their semantic connection is emphasised. Additionally, the backgrounds serve as a content filter: by placing a background the system automatically offered a menu with all related stories and exercises;

- Secondly, we developed a branched story. The branched story consists of a start and end scene and three clusters of three-scene sub-stories (Fig. 6, right). After the opening scene a child can choose the order of the sub-stories. Adding the possibility of branched stories has a few advantages:
  - Since there are more choice moments for the child, there are more opportunities for caregiver-child communication
  - Additionally, the child has more control over the story and is thus more involved and more concentrated;
  - Also, it allows for cutting up linear stories into parts. This opens up the possibility of training an additional linguistic skill: thinking about the right order of causally related scenes. This type of exercise is aimed at 4-year-olds;

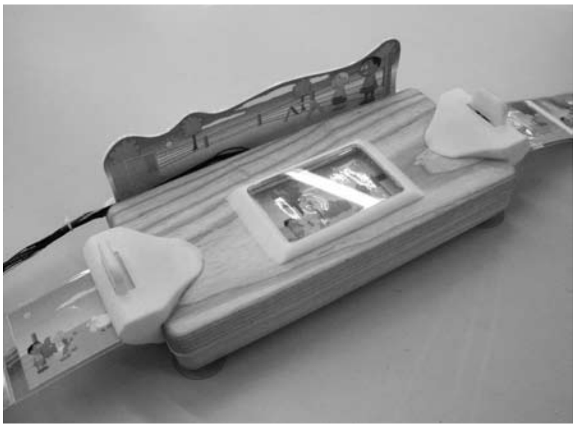


Fig. 7. The new story-reading module has two flippers on each side, instead of the earlier central slider.

- Thirdly, we replaced the single slider with two flippers (Fig. 7). The main reasons for this were the following:
  - It solved the inconsistency of the single slider with regard to moving the story forward and backward. Now each flipper had its own designated function: the flipper on the right moved the story forward, the other backward. Again, this corresponds to the motion of flipping book pages;
  - The single slider of the previous design obscured the view on the scene behind the viewing window. By putting the flippers to the side the view on the current scene improves;
  - Finally, locating the flippers where the story booklets had to be inserted made the connection between the child's action and the resulting reaction (a moving booklet) clearer.

Evaluation of the interactive story-reading functionality

We tested the prototype at the same two centres for rehabilitation medicine, in weekly sessions with 15 children over a period of 6 weeks. The children had a developmental age between 1 year 6 months and 4 years 6 months. All children had language retardations, mostly due to CP. Two children had the same developmental and calendar age, but were bilingual children from immigrant families.

Each participating child would use our prototype during his or her regular weekly 30-minute speech therapy session, with his or her usual speech therapist. Occasionally, other people were present, e.g. a parent, occupational therapists or physiotherapists. In one situation we tested the prototype with two children and one therapist.

The responses to the prototype were generally very enthusiastic:

- The branched story prolonged the children's attention span; often they would repeat sub-stories endlessly before going to another;

• Allowing children to go both forward and back in a story highly contributed to this.
• Additionally, therapists could repeat scenes using their new control module. This enabled them to dwell on particular aspects of the story, e.g. sounds, concepts or rhyming words;
• As a result, there were even more opportunities for communicative expressions of the children and interpersonal communication, compared to the previous iteration;
• The only situation in which these observations were harder to make was in the situation with two children simultaneously. A positive conclusion however is that our system was very suitable for collaborative use, mainly due the physical nature of the interaction.

Even though these findings are very positive, there were still some changes to be made in our final iteration, the most important being:
• Extending the content and accompanying input materials to cover a complete range of words for 1 – 4 year olds. Based on the word frequency lists mentioned earlier, we determined that our system should contain at least 560 words;
• Optimizing the design of the modules:
  - One remaining practical issue of the story reading module was that it was difficult for children to insert the story booklets;
  - Also, the output module should be changed to make it easier to position in different set-ups, e.g. when being used by two children;

In the final part of this section we will give an overview of the final design of the LinguaBytes product.

5.4 Iteration 4: Final LinguaBytes design
Overall system design
The final LinguaBytes prototype (Fig. 8) is a modular system consisting of (1) a redesigned output module ; (2) the base module; (3) the Combination Module, for doing exercises and games; (4) the BookBooster for reading interactive stories; (5) the Carer's Controller, the control module for the caregiver; (6) tangible input material: 8 thematic backgrounds, 16 story booklets, 236 input pieces and 31 verb cards, all tagged with RFID.

Additionally, 3 programmable RFID labels are included in the system which with custom input material can be

Fig. 8. The final LinguaBytes prototype

created. The system comes with a Mac Mini running MAX/MSP and Adobe Flash.
We have developed 16 interactive stories (6 linear, 10 branched) and 211 games and exercises, categorized in six themes: (1) animals; (2) people, family and parts of the body; (3) food and eating; (4) play, games and activities; (5) in and around the house; and (6) vehicles and traffic. In total, the system covers approximately 560 words, of which 236 are available as tangible input material. Some types of words are not suitable for making tangible (e.g. 'that' or 'to want'). We have tried to incorporate these words as much as possible in stories or as functional communication in exercises or between parent and child.

Interactive story reading in the final LinguaBytes design

To improve interaction with the story-reading module as well as the social interaction during story reading we made two main adjustments to the design:

- To increase the flexibility of the output module it was redesigned so that it can be used both horizontally and in a tilted position (Fig. 9, left & middle), and has a custom stand that contains wheels enabling a rapid adjustment of the module's orientation;
- To make it easier for the child to insert booklets in the BookBooster, the module now contains a freely accessible track in which the booklets can be easily placed (Fig. 9, right). The flippers are moved inwards to each side of the viewing window.

We have made three identical full prototypes and are currently arranging possibilities to test them longitudinally.

6 Future work

Although the development of the LinguaBytes system has already yielded a wealth of information, we acknowledge that longitudinal testing is demanded to measure the following:

1. Does the LinguaBytes prototype really stimulate language development? Data from our earlier evaluations strongly suggest this, but a longitudinal study will certainly enable us to make a stronger case of this. We wish to measure this by having our collaborating speech therapists evaluate the children's progress in a period using the LinguaBytes prototype, compared to a period without using the prototype. We understand that this may not be reliably possible, due to the fact that we depend fully on the therapists' interpretation, but we also acknowledge that within this specific context we have to rely on their professional judgements;
2. How do factors like the child's attention span, communicative initiative taking, etcetera change over time? Our past evaluation periods were never longer than 6 weeks, in which we submitted the toddlers to many 'first impressions'. We can imagine that once the children start familiarising with the prototype, some of the enthusiasm might diminish or change. We want to examine if this happens, and in what way. This will give us information about the proper way for the prototype to 'grow along' with the developing child;
3. Related to the previous point of attention, we want to determine whether the child's other skills improve as well. There are different techniques available for doing this, for example we can use the sensors in our prototype to monitor the 'aim' and strength of the child and visualise how these develop over time. Additionally, we can use questionnaires to determine the development of the child's social skills.

We are currently setting up arrangements to test two of our prototypes on a fixed location over a one-year period. We hope that the results these studies will help us determine how to implement adaptive behaviour in our design and, more importantly, which adaptive behaviour would be desired. Because, as we have

Fig. 9. The output module can be used horizontally (left), and tilted (middle). The booklets can be easily placed in a track (right)

pointed out in the second starting point in section 4.1, our ambition is to develop a system that could actually grow along with the developing child, not only as a product but also as a social partner for communication.

7 Discussion

In this paper we have described the development of an interactive story-reading device within LinguaBytes, a three-year research project aimed at developing and designing a tangible, adaptive, interactive play-and-learning system that stimulates the language development of toddlers between 1 and 4 years old (developmental age) with multiple disabilities. We have illustrated that most of the available applications don't seem to fit the natural interaction style of toddlers, nor their natural learning style. We have indicated that more attention should be given to caregiver-child interaction and that we should look for the optimal combination of the intelligence of novel technologies and the richness of the physical world. In particular we have focused on collaborate story reading. We have illustrated four consecutive stages in our iterative Research-through-Design process and highlighted the lessons learned with regard to interactive story reading, which we will illustrate in the conclusions. But first, we would like to discuss some interesting thoughts that arose the past three years.

One thought regards the primary target group: toddlers. In terms of interaction design one can say that this particular group of users is extremely young and highly unpredictable. This has had great repercussions on our research. For example, many of the interactions we (adults) have grown accustomed to are completely incomprehensible for toddlers. As can be seen in this paper, we have changed (parts of) the LinguaBytes interaction in all four iterations. This raises the question how many iterations are needed to reach the 'optimal design', if such a design exists. In the case of LinguaBytes, it can be seen that we spent the first two iterations on defining the interaction and the last two on refining. The most challenging activity during these two phases was to find the optimal tradeoff between the simplicity of the interaction and the richness of the functionality, especially because we were not simply dealing with unpredictable toddlers, but with toddlers with CP, who in terms of behavior are even more unpredictable. Children with CP have such a diversity in skills and needs that 'finding the optimal tradeoff' is inherently contradictory: when a user group is extremely heterogeneous, the optimal tradeoff varies with each individual user. There is not a single optimum.

This strengthens us in our conviction that the future LinguaBytes product should be able to adapt itself to individual users. Our current work has already given us insights in LinguaBytes' desired adaptive behaviour, but the longer we are in the process, the more we have to acknowledge that designing behaviour is a complex business. One reason is that it is quite complex to map out the guidelines, requirements and criteria for (developing) a complex product or system. A table or other static representation often does not suffice, due to the interdependencies of many guidelines: change one, and all related others change along, and those related with those, etcetera. We are still investigating ways to tackle this problem, which we feel most developers of complex products or systems have encountered.

A final related thought is that we have increasingly tried to develop a platform for behaviour: we have tried to design LinguaBytes in such a way that it would move into the background, serving more as an additional social partner offering communication opportunities between people, rather than as a dictatorial story reading machine. A repercussion of this changing approach is that much of the interaction we were aiming for was going to occur between people, not between people and the system. This is hard to combine with our ambitions to make LinguaBytes adaptive: if much of the interaction goes on outside the system, how is it supposed to learn? This will be one of the major challenges for a further development of the LinguaBytes system.

8 Conclusions

Over the past three years we have tried to bring back some of the real world richness in interactive story reading. We have seen time and again that offering tangible input materials hold great advantages in this, with regard to early language development:

- Using physical input material slowed down the interaction, which resulted in more opportunities for facial, gestural and verbal expressions of the children, letting them evoke more communicative reactions of their surroundings;
- Consequently, it allowed children and caregivers more control over the timing of the interaction, giving the children the sense of being in control;

- Additionally, it offered the non- and hardly talking children an alternative communication means: the children would grab, point to, show and hand over the input materials to communicate with their therapists or parents;
- By making using physical story booklets, we could benefit from the richness of traditional story reading: the physical booklet conveyed the length of the story, the relative position within the story, linearity, causality, and more;

More importantly, the physicality of our system redressed the balance between the role of the parent, the child and the medium. In most existing applications, the medium overshadowed the two participating communicators. By re-establishing the crucial role of the caregiver, all children showed a longer attention span than usual, took more initiatives and were showed a prolonged motivation.

Additionally, we have seen that by offering an interaction that is closer to their usual style of exploration clearly lowered the cognitive load for the disabled child, resulting in a longer attention span and motivation. All of the children understood the interaction with any of the prototypes intuitively.

Also, we have observed that using our prototypes offered all children more access to their environment: they showed more bodily activity and were seduced to explore using all their senses, thus acquiring a richer base for language development.

Concluding, we believe that the flexibility of the LinguaBytes system allows these – often severely handicapped – children to play and learn in their own way. We like to see these children not as children with 'special needs', but with unique needs: all have their own backgrounds, limitations, possibilities, needs, skills, preferences and desires. As designers we should respect this. It is not the trick to make these children 'normal', but to make their world normal. This calls not only for highly adaptable products and systems but also for intelligent, adaptive behavior of products and systems. We believe this holds not only for toddlers with multiple disabilities, but also for heterogeneous user groups in general. We hope that our work will enable us to contribute to this.

Acknowledgements

We thank the Dr. W.M. Phelps-Stichting voor Spastici and the consortium of additional sponsors for funding the LinguaBytes project. We also we thank the therapists of the two centers for rehabilitation medicine, Marjolijn Priest and Dominique de Backere at the Rijndam Revalidatiecentrum in Rotterdam, and Saskia Peek and Huguette de Roover at the St. Maartenskliniek in Nijmegen for their valuable feedback and for enabling us to test our prototypes. Finally, we thank the people of the /d.search-labs for helping us build the LinguaBytes prototypes.

References

1. Vygotsky, L. (1978). Mind in society. The development of higher psychological processes. Cambridge, MA: Harvard University Press.
2. Bedrosian, J. L. (1997). Language acquisition in young AAC system users: Issues and directions for future research. Augmentative and Alternative Communication, 13 (September), 179-185.
3. Snow, C. E., Ninio, A. (1986). The contracts of literacy: What children learn from learning to read books. In W. H. Teale, & Sulzby, E. (Eds.), Emergent literacy; writing and reading (pp. 116-138). Norwood, New Jersey: Ablex publishing corporation.
4. Bus, A. G., & van IJzendoorn, M. H. (1995). Mothers reading to their three-year-olds: The role of mother-child attachment security in becoming literate. Reading Research Quarterly, 30, 998–1015.
5. Falkman, K. W., Dahlgren Sandberg, A., & Hjelmquist, E. (2002). Preferred communication modes: Prelinguistic and linguistic communication in non-speaking preschool children with cerebral palsy. International Journal of Language & Communication Disorders, 37(1), 59-68.
6. Light, J. C. (1997). "Let's go star fishing": Reflections on the contexts of language learning for children who use aided AAC. Augmentative and Alternative Communication, 13(September), 158-171.
7. Basil, C. (1992). Social interaction and learned helplessness in severely disabled children. Augmentative and Alternative Communication, 8 (September 1992), 188-199.
8. Smith, M. (2005). Literacy and Augmentative and Alternative Communication. London, UK: Elsevier Academic Press.
9. V-Tech website. Retrieved June 23, 2009, from http://www.vtechkids.com/
10. LeapFrog website. Retrieved June 23, 2009, from http://www.leapfrog.com/tag/tag-jr.html
11. Ishii, H., & Ullmer, B. (1997). Tangible bits: Towards seamless interfaces between people, bits and atoms, CHI'97 conference on human factors in computing systems. Atlanta, GA, U.S.A.

12. Fontijn, W. & Mendels, P. (2005). Storytoy the interactive storytelling toy. In Proceedings 3rd International Conference on Pervasive Computing (pp. 37-42).
13. Billinghurst, M., Kato, H., & Poupyrev, I. (2001) The magic book—Moving seamlessly between reality and virtuality. IEEE Computer Graphics and Applications, 21(3), 2-4.
14. Plowman, L., & Stephen, C. (2003). A 'benign addition'? Research on ICT and pre-school children. Journal of Computer Assisted Learning, 19, 149-164.
15. Light, J., & Drager, K. (2002). Improving the design of augmentative and alternative technologies for young children. Assistive Technology, 14, 17-43.
16. Platus learning systems website. Retrieved June 23, 2009, from http://www.platus.at/index.php
17. Van Balkom, L. J. M., De Moor, J. M. H., & Voort, R. (2002). LinguaBytes. Een studie naar de ontwikkeling van een computerprogramma voor niet- of nauwelijks sprekende peuters met een motorische beperking. (First ed.). Nijmegen.: Universitair Expertisecentrum Atypische Communicatie(-ontwikkeling), EAC.
18. Archer, B. (1995). The nature of research. Co-Design, 2, 11.
19. Flagg, B. N. (1990). Formative evaluation for educational technologies. New Jersey: Lawrence Erlbaum Associates.
20. Sanders, J. R., & Cunningham, D. J. (1973). A structure for formative evaluation in product development. Review of educational research, 43(2).
21. Hummels, C, Van der Helm, A., Hengeveld, B., Luxen, R., Voort, R., Van Balkom, H. & De Moor, J. (2006). Explorascope: An interactive, adaptive educational toy to stimulate the language and communicative skills of multiple-handicapped children. In Proceedings of ArtAbilitation 2006 (pp. 16-24).
22. Zink, I., & Lejaegere, M. (2002). N-CDI's: Lijsten voor communicatieve ontwikkeling. Aanpassing en hernormering van de MacArthur CDI's van Fenson et al. Leuven (België)/ Leusden (Nederland): Acco.
23. Schlichting, J. E. P. T., Eldik, M. C. M. van, Lutje Spelberg, H. C., Van der Meulen, S., & Van der Meulen, B. F. (1995). Schlichting test voor taalproductie. Lisse: Swets & Zeitlinger.
24. Bacchini, S., Boland, T., Hulsbeek, M., & Smits, M. (2005). Duizend-en-een woorden. De allereerste Nederlandse woorden voor anderstalige peuters en kleuters. (1-ste editie ed.). Enschede: SLO, Stichting Leerplanontwikkeling.
25. Phidgets website. Retrieved June 23, 2009, from http://www.phidgets.com/
26. Cycling'74 website. Retrieved June 23, 2009, from http://www.cycling74.com/products/max5

Bart Hengeveld[1], Riny Voort[2,3], Caroline Hummels[1], Kees Overbeeke[1], Jan de Moor[2], Hans van Balkom[3]

[1] Designing Quality in Interaction Group, Department of Industrial Design, Eindhoven University of Technology, Eindhoven, The Netherlands
[2] Faculty of Pedagogical and Educational Sciences, Radboud University Nijmegen, Nijmegen, The Netherlands
[3] PoNTeM, Nijmegen, The Netherlands

Fang-Wu Tung and Yung-Ping Chou
fwtung@gmail.com

Designing for persuasion in everyday activities

Abstract
Modern technology enables products to be sensitive and responsive to people and are changing the way we interact with everyday objects, by which it is possible that objects can shape human behaviors unobtrusively and unconsciously. In this paper, we propose augmented aesthetic interactions as a better way to embody calm, persuasive technology. To illuminate the idea, we propose the three designs with the intention of exploring possibilities of behaviors shaping for user desired lifestyles. The three conceptual designs are respectively merged into three daily activities: dining, working and driving. The objectives of persuasions are slowing down, sitting right and saving fuel. The design principles, including implicit interaction, aesthetic feedback, and emotional engagement, are proposed by us for developing designs that are consistent with the theme. In the design process, designers are led to prescribing feedback as well as technology for creating human-object interaction in calm and aesthetic manners. To attain different attempts of persuasion, provoking users' emotional responses at various levels by interaction design works as a design strategy and also brings us issues remaining to be studied.

Keywords
Persuasive Technology, Calm Technology, Interaction Design, Everyday Aesthetic Experience.

1 Introduction
Widespread computer applications have been woven into the fabric of our world. As a result, people are accustomed to interacting with computers in various occasions and accept them as a part of our lives. The pervasive functions of computers provide us with new ideas of new systems or products in the regard of human-computer interaction which integrate computer technology into everyday lives seamlessly. Weiser and Brown [1] argue that information load should be reduced for bettering user experiences, particularly in the information age, and propose "calm technology". The concept of calm technology is to make the information that users need or are interested in accessible yet unobtrusive. The instrumentality that processes information is embedded into our environment, working silently until it is needed by us. Similar concepts, such as ambient intelligence and ubicomp, are developed for building smart environments, in which chips are found not only in personal computers but also everywhere for augmenting everyday objects so that they can process and display information for teaming up with people to create desired experiences.

As intelligent computation is distributed to the physical environment, we can envision a significant change in roles objects play in our everyday life, and extend human-object relationship beyond utility or usability. In addition to enriching user experiences and offering emotional attachments, applications of calm technology create persuasive interactions between humans and objects that may influence and then change users' behaviors. In commenting the ever-different role of computer technology, Fogg [2] has proposed the term "persuasive technology" to describe the fifth wave of computer technology. Persuasive technology is a new concept for designers to create influential human-computer interactions (HCI, hereafter) aimed at changing users' behaviors and attitudes. In this sector of HCI, people are attracted to close contact with applications of persuasive technology; the latter become more influential by creating social interactions to attain designers' intentions of persuasion

Several examples related to persuasive technology have been demonstrated, which show the beneficial potential by shaping users' behaviors, motivating desirable lifestyle, or encouraging people to change their attitudes regarding certain issues such as saving energy [3][4]. Some of those cases are embodiments of the concept of calm technology attempting to change the behaviors of their users. Everyday objects augmented by calm technology can interact with people in more sensitive ways, because the objects can easily keep track of users' behaviors or states without intrusion and, further, can display suggestive information through "subtle changes in form, movement, sound, color, smell, temperature or light" [5]. This provides designers with a new perspective to rethink human-object relationships and allows them to explore new possibilities of persuasive interactions in everyday life.

Calm technology is a principle of designing the way by which products engage people's attention; the main concept is reducing users' information load by mainly arousing the periphery of our attention. Less intrusive ways to remind people is particularly important when the design comes to changing users' behaviors over time. Many designs have been explored since Fogg first proposed the term persuasive technology [6]. A problem of calm, persuasive technology is to make user addictive to the system before persuasion eventually takes effect. People in the field have tackled the problem by enhancing social interactions [7] and prescribing proper emotional feedbacks [8].

To explore the value and possibilities of calm, persuasive technology being integrated into everyday activities, we approach the study through three design projects in which design concepts are developed for illuminating the idea. The designs are respectively embedded into three daily activities: dining, working and driving. The objectives of persuasions are slowing down, sitting right and saving fuel, each carrying a current value. From our perspective, enhancing aesthetic experiences of the activities people engage everyday is essential. We think the calm and the persuasive technologies can be integrated to form a new set of design principles for designing everyday objects, which in turn suggests new design issues for us. In the following sections, we explain the design principles for respective projects and then elaborate them by three conceptual designs.

2 Design Principles

Based on the concept of calm and persuasive technology, devices or applications can interact with people in unobtrusive yet pleasant manners, and can be designed to change people's behaviors or attitudes in a prescribed way. To reach the persuasive goals, it is challenging for designers to design human-computer interactions and the media for conveying information to create effective or seductive user experiences. Three design principles listed below are proposed for shaping conceptual designs.

Implicit interaction

How to apply calm, persuasive technology for an unobtrusive and seamless integration of our designs into our life is a key issue. A system of our interest can track users' activities without interrupting them. To this end, the idea of implicit interaction provides us with a feasible solution. According to Schmidt [9], implicit interaction is defined as "an action, performed by the user that is not primarily aimed to interact with a computerized system but which such a system understands as input." In this way, data characterizing the user's activities and postures can be obtained by passive observation without relying on user's input. With the developments of sensors and wireless networking, interaction designers now are more flexible to realize the concept of implicit interaction, by which users are influenced by embedded computer technologies without noticing changes in their environments.

Aesthetic feedback

With calm technology, people could experience the stimuli from their surroundings via a wide variety of data presentations on objects other than computer screens. Those objects could be our personal stuffs at home, office, or in other personal areas [10][11]. Thus, people's willingness to accept the presence of information in their environments would be a decisive factor for its success. In the regard of persuasive technology, criteria for usability are not so critical in evaluating the design like they are in other HCI-related designs [12]. From a designer's standpoint, it is essential to emphasize aesthetic aspects in designing ambient displays which lead to a better acceptance of calm, persuasive technology in real environments. Accordingly, we tried to embody the concept of calm technology in everyday objects imbued with aesthetic qualities for presenting people with pleasant peripheral information.

Emotional engagement

In this study we explore possible uses of modern technologies by proposing designs associated with daily activities in modern life, in the attempt to motivate changes in behaviors for a desirable lifestyle. Different emotional responses can be provoked by manipulating the content of feedbacks [13]. Conventionally, building an emotionally engaging feedback mechanism serves as an effective design strategy, yet, in the framework of calm and persuasive technology, emotional engagement should be balanced against by the longevity problem [14]. This poses a challenge of designing emotional feedback for the problems we are attacking. The ambient display used in the study is not just used to deliver visceral information that is imbued with aesthetic qualities, but, further, it should be readable and interpretable for creating meanings for users in their socio-culture contexts. A good design will so evokes emotional responses that it will reward the user a meaningful experience which may in turn supports behavior change.

3 Design and technology

3.1 Simple Joy

The principle, "The faster, the better", has influenced the way metropolitan Taiwanese engage with daily activities. We are always in a hurry to get everything done and then wait for the next task; the pleasure of experiencing the process is largely ignored in catching up with the rhythm of modern time, a crazy rhythm without a cause. It is reflected by many that the fast speed at which daily activities are carried has deprived us of aesthetic experiences of daily life, making us anxious and even ill. As a consequence, a movement of slowing down against speed has emerged. Those who participate depart themselves from the dictatorial metropolitan rhythm and do things at much lower speeds so as to enjoy every moment in daily life. This design "Simple Joy" is attempted to propose a design concept by augmenting cutlery and table clothes which may enhance the relationship and communication between family members by slowing down and synchronizing dining motions.

Implicit interaction

To observe people dining on two sides of a table, a set of sensors is embedded in the environment, not interfering with diners' movements. The sensing technology can be a wide-angle camera hidden in a vase on the table or multi-axis sensors each having an identification code and embedded in a piece of dining ware (Fig. 1). The former takes dynamic images of the diners and analyzes them at the same time for their respective rhythms. The latter sense respective motions of the diners and analyze for respective rhythms. The motion analysis is carried out by a micro-computer, a single-chip microcomputer embedded with associated computer algorithms, which is also merged into the environment. The data and control commands are transmitted among the devices wirelessly.

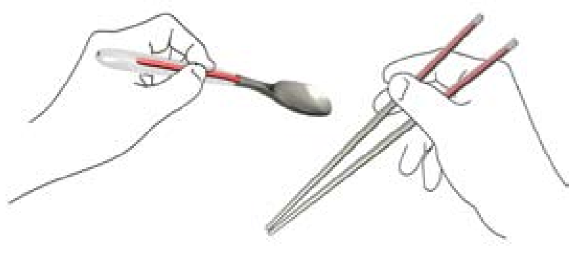


Fig. 1. Dining ware embedded with motion sensors

The differences of pattern presented on the tablecloth are designed to be subtle and poetic, which bring diners a pleasant surprise not easy to get tired of. To follow the guidelines of implanting calm technology[15][16], the ambient display of this design is chosen to be a tablecloth made of a soft, flexible smart textile, capable of displaying varying colorful patterns. The pattern on the tablecloth is shown via the reflection of surrounding lights for reducing eye fatigue, which varies as dining rhythms of people around the table change. The display on the tablecloth provides visual aesthetic experience while dining and makes people feel connected to others. It also creates a relaxed environment for interpersonal interactions, because family or friends having meal together is the best moment for communication and sharing.

Emotional engagement

We enhance the aesthetic experiences of dining so that people would like to slow down not only for enjoy the food but also for communication. The aesthetic effects are mainly visual. When a diner keeps her dinning speed lower than a preset value, the portion of the tablecloth close to her side starts to blossom and expand. When two dinners keep their speeds low and close, respective tablecloth portions not only blossom but also start to connect (Fig. 2(c)). There will be a pleasant visual effect when the dining motions of the diners are sufficiently slow and synchronized. If the dinners increase their dining speeds or depart from synchronization, the flower pattern starts to wither. It is conjectured by us that two people dining at different speeds communicate less efficiently. We therefore encourage speed synchronization in this design. That is, people who slow down will be rewarded with a visually appealing effect. Since by slowing down they give themselves more room to appreciate the details of the process, the visual appeals shown on the tablecloth would effectively enhance their aesthetic experience.

3.2 Forest on the Way

Driving to work has become a routine in our daily life. With the problems of climbing gas price and global climate change getting worse, it is important to find a way to better fuel economy and reduce carbon emission. Is it possible to make drivers believe they are alleviating the problems and experience daily life aesthetics at the same time? This system is our response to the situation. In the light of calm persuasion, we design a system that is installed in a car and may change a driver's habits gradually so that better fuel economy can be attained.

Implicit interaction

The information of instantaneous fuel consumption rate (mileage, in unit of distance per unit of gas) can be easily acquired by combining the signals of fuel injection rate and speed. Those signals can be taken from modern cars, without a slight influence on driving. The average mileage over a time period indicates driving efficiency, which is a mix of driver's driving habits and road conditions. The continuous signals from observation are recorded in either a built-in car computer or a small wireless control box carried by the driver; the latter device can be a 3G mobile phone.

Aesthetic feedback

An ambient feedback, visual or acoustic, should be non-intrusive to the driver, or the driver will be so distracted to shut down the system. When it comes to driving, this effect is especially sensitive. Therefore, the feedback should be calm, bring no burden to the already tense driver. Given that driving is a daily activity, we intend to design feedback not only on the level of psychological conditioning but also on the level of enhancing drivers' aesthetic experiences of driving. In a larger sense, we would like to replace the behavioral notion of control and conditioning by aesthetic interactions. In other words, we want to associate saving gas with creating something beautiful. The emotion connecting the two is a driver's commitment to environment protection.

To achieve an aesthetic ambient display, a long strip of e-paper powered by sunlight extended across a wind shield as a sun block provides a driver with feedback (see fig. 3). We use the concept of planting a forest to

Fig. 2. User scenario of Simple Joy: (a) having a meal alone; (b) having a meal with others; and (c) the dynamic pattern on a table cloth.

attract drivers to stay with good driving habits. Also, the image of forest serves as a metaphor to allow people to associate it with eco-friendly issues. In this way, users may be motivated to plant a forest in hope of making our earth greener. The short-term reward is designed to be a sudden rain fall on the forest, accompanied by the sound of rain drops falling on tree leaves (Figure 4). When it stops, the trees grow appreciably. The long-term reward is a more substantial change in the landscape, more trees and more tree species (Figure 5). After a long period of time, perhaps a couple of months, a complete forest landscape is finished, and drivers may start a new game, in which a different landscape is to be created.

Fig. 3. A long strip of e-paper powered by sunlight provides a driver with feedback

Emotional engagement

Nakajima et al. [17] applied the rules of punishment and reward in computer game design to persuasive technology, because they maintained user emotions should be provoked properly so as to make them addictive (to the product). Without such an addiction, users will not use the product continuously, and a change in behaviors will never come true. Behavior change needs a longer time to develop, and therefore driver's addiction to the system is essential. Particularly in the design context, drivers should not be punished for things they cannot control, such as bad mileage due to bad road conditions. Therefore, in this design, only rewards are considered. There is a short-term reward when a driver has maintained average mileage below a preset value in a short time, say, 15 minutes. There is a long-term reward when a driver has reduced average mileage of a day below a preset value. Since Forest on the Way is about the value of environment protection, we regard it an emotional design that arouses reflection. By installing the system in their cars, drivers feel committed to that value, because saving gas is linked to reducing carbon emission.

3.3 Hey Buddy, Take a Break!

The situation that we are confined in a small, cubicle workspace everyday working for a long time, particularly in front of computers, causes injuries. Many people eventually develop problems of sore back, neck, and wrist, which are the result of being frozen in prolonged sitting postures. Taking breaks constantly from repetitious daily office work will help reduce body fatigue, as well as stress, and thus prevent us from

Fig. 4. Short-term reward, Forest on the Way

Fig. 5. Long-term reward, Forest on the Way

injuries. The design "Hey buddy, take a break" is devised to track users' sitting postures in the workplace and interrupt them to take a break.

Implicit interaction

Subject to the design principles of calm persuasion, the sensors for tracking sitters' postures on office chairs should be integrated into the environment, without causing too much attention. In our design, either a pair of cameras or a matrix of pressure sensors is utilized. As shown in Fig. 6, two cameras are respectively attached to two ends of a pillow-like hanger, capable of continuously measuring the location of a sitter's spinal column. A matrix of pressure sensors are embedded within a chair pad for continuously measuring the weight center of a sitter. Either of the sensor combinations can be used for tracking sitting posture. A sitting posture, expressed by either spinal column location or weight center, is further classified into one of three states: normal, forward and crooked. The data sequence of sitting posture classifications is transmitted wirelessly to a device of ambient display.

Fig. 6. The sensing technology of Hey Buddy, Take a Break!

Emotional engagement

The design tries to propose a humorous and effective way to induce users to change sitting postures while working and further care about their stressful bodies. Rules of punishment and reward are used in designing feedback that activates a user-object interactive relationship. The object is a doll, as shown in Fig. 7. The human-figure doll used here is intended to induce users' social responses because anthropomorphic forms can be persuasive [18]. The doll is not only functional in reminding sitters to change their postures but also a healing toy in stressful workplace. If a user on a chair in a working state for a long time or in a crooked state for a shorter time, the doll will show some ailing signs and look unhappy. The user is expected to sympathize with the condition of the doll and to try to do something for relieving its pains. Inspired by ancient Chinese medical treatments of acupuncture and acupressure for relieving a variety of symptoms and pains, the ailing signs on the doll will disappear after the user touch it with a pen or a finger, mimicking an acupressure therapy. Unconsciously, the user changes her sitting posture by doing so and thus takes a break from work. As the ailing signs on the doll disappear, it looks happy again. In regard of a game, the punishment is the disappearance of a happy face and the appearance of ailing signs, and reward is the disappearance of ailing signs and a resurfacing happy face.

Fig. 7. The display device and user scenario of Hey Buddy, Take a Break!

Aesthetic Experience

As shown in Fig. 8, the doll is designed to take the shape of a cute, plump human body. Its skin is made of a soft, flexible, partially transparent material, under which a pattern of a tree-like structure of body channels in Chinese medicine, called Jing Mai, is provided. The icons of main body organs connected to the body channels are shown as well. As the system is activated, the doll continuously receives signals of sitting posture from the sensor setting. In the normal condition, the doll will show a smiling face, and the pattern underneath its skin is vaguely seen. If the sitting posture is kept in a crooked posture for a period of time, some parts of the channels are lighted up. If the crooked posture continues, the ailing signs will propagate to a main body organ, twinkling in a warning color. Not being taking care for a longer period of time, the doll will show an unhappy face. If the sitting posture is kept in a forward posture, most likely indicating working on a computer, similar signs will appear on the doll but with a longer waiting time, because this situation is not as hazardous as sitting askew. The ailing condition of the doll exhibits a calm display that will not distract users from working and at the same time still arouse their peripheral attention. The users do not relieve the doll by an anxious emotional impulse but by sympathy for the doll and eventually for themselves. When the users practice treatments on the doll, they actually take a break from work and heal themselves as well.

Fig. 8. The display design of the healing doll of Hey Buddy, Take a Break!

4 Discussion

Emotional engagement as motivator

Calm, persuasive technology cultivates a new design sector where designers can explore. Our search for valid design principles for this sector is through design approach, making products with the goal of changing users' behaviors. The design principles guide designers to properly apply clam, persuasive technology to tackle a problem. The main focus here is how to change users' behaviors through their interactions with a product. We attempt to create interaction design for arousing users' persistent emotional responses necessary to behavior change. Norman argues that human emotion can be affected by objects at various levels [19]. The different levels of emotion we intend to elicit for supporting motivation of lifestyle/behavior change are discussed below.

In Simple Joy, blossoms or a connecting trail appear on the tablecloth when a user is slowing down a little bit or interacting with others while dining. The subtle, poetic visual effect serves as a positive reinforcement in the context and brings users aesthetic experiences at the same time. According to Norman's three levels of emotional design, Simple Joy is visceral which can be pursued through a design focus on aesthetics. Actually, aesthetics does matter in design of ambient display because the information is going to be presented in our personal area. It should be able to reflect individual's lifestyle. In addition to visual perception of graphic design, the notion of aesthetic experience while interacting with surroundings augmented with ambient intelligence will pose a new topic remained to be studied further.

Forest on the Way is designed for reducing fuel consumption through changing driving habits, arousing in users an echo of sustainability. The feedback that a forest is forming gradually as a driver has kept an eco-friendly driving behavior over time is provided to enchantingly remind the driver of a progress being made. As the awareness of such eco-friendly driving is rising, the process of planting a forest through maintaining eco-driving is meaningful in the socio-cultural context. Meanings emerge through performing activities may trigger our emotion at reflective level [20] where beauty comes from conscious reflection influenced by knowledge and cultural background of users, what we call reflection of self-image. As presentation of self in everyday life proposed by Goffman [21] has argued, people attempt to manage their impressions they want others to have. Taking the emotional response into account, feedback that allows users to move closer to their idealized images of self may help the designers attain the goal of persuasion.

To encourage office workers to sit in a healthful posture or takes regular breaks at work, Hey Buddy, Take a Break is designed to convey peripheral awareness to users via a human-figure doll. When an individual sits incorrectly or has worked for a long time, an organ icon will appear on the doll's surface to ask a touch from the user so as to make the icon fade. The interaction design might be humorous and intuitive for users because it is associated with acupressure, an ancient Chinese medical treatment. By doing the action, the user could change her posture accordingly and might further care about her health while seeing the organ icon on the doll's surface. As suggested by Fogg [22], the fact that people respond socially to computer products has significant implications for persuasion. In the sense, social cues such as physical cues through physical human attributes can create opportunities to persuade. Indeed, attributing human characteristics to objects is a way of changing the values we place on them and the way we can interact with them [23]. Our anthropomorphic perceptions may reflect the social nature of humans. Thus, that people may yield social responses toward objects with human characteristics and further generate empathic feelings can be used as an effective way for behavior change.

Design inspiring technology

Modern technologies that support calm technology and ambient intelligence enable our environments to be sensitive and responsive to people and at the same time free designers from prescribing explicit ways for people-object interaction. Moreover, the design thereby created may in turn inspire technological development. For ambient sensing, the current sensor technologies are good enough to carry out tracking the users in the physical contexts of our design. However, since the sensors are to be hidden in the environment, they have to be made small and in many occasions self-powered. For example, multi-axis acceleration sensors can be attached to the dining ware of Simple Joy so that the rhythm of dining motions can be analyzed; but the sensors may not be too big to make the user burdened. For ambient computing, there are software and hardware solutions for carrying out the computations. The software solution should be carried by a computer, which is not easy to hide and expansive to install and maintain. The firmware solution, namely the ambient computing encoded in a versatile computer chip, is cheap and durable and therefore probably the best current option to date. To materialize ambient intelligence, media for providing feedback may be obtained in a variety of new materials in the future. We think in the near future the interaction design will become smarter and more human, and therefore the ambient computing will include mechanisms of machine learning. At that time, the hardware solution, namely computer chips for specific purposes, capable of accommodating fast, large-scale computations, would be a better solution. Since design thinking [24] has become a major driving force for technological innovation, we promote that designers not only are informed by engineers the current technologies but also should inform engineers the future technologies.

Conclusion

We live in a world where cues can be found everywhere. A leaf turning red suggests that autumn is on the way. We have no difficulty receiving and interpreting such information beyond language. Nowadays, the advance of technology and materials will expand the role of daily objects to convey a variety of information in many ways. Objects can be sensitive and responsive, and interact with people in more engaging way, with which people might get the information naturally and be affected unconsciously during interaction. In the current paper three design concepts are made with the intention of exploring possibilities that behaviors may be shaped for desirable lifestyle while performing routines in everyday life. To continue the study issue, some prototypes will be proposed to help us to obtain users' responses and experiences in real situations.

Acknowledgments

This material is based upon work supported by the National Science Council of the Republic of China under grant NSC 096-2917-I-009-005. The authors thank Lee, H.S., Lee, P.H., Liou, Y.S., Yang, J.L., and Wu, Y.J. for their contribution to this project.

References

1. Weiser, M., & Brown, J. (1995). Designing calm technology, Xerox PARC, December 21. Retrieved June 21st,2009, from http://www.ubiq.com/hypertext/weiser/calmtech/calmtech.htm
2. Fogg, B. J. (2003). Persuasive technology: Using computers to change what we think and do. San Francisco: Morgan-Kaufmann.
3. Jafarinaimi, N., Forlizzi, J., Hurst, A., & Zimmerman, J. (2005). Breakaway: An ambient display designed to change human behavior. CHI '05 Extended Abstracts (pp. 1945-1948). New York: ACM.
4. Nawyn, J., Intille, S. S., & Larson, K. (2006). Embedding behavior modification strategies into a consumer electronic device: A case study. In Proceedings of UbiComp'06 (pp. 297-314). Orange county.
5. Wisneski, C., Ishii, H., Dahley, A., Gorbet, M., Brave, S., Ullmer, B., & Yarin, P. (1998). Ambient displays: Turning architectural space into an interface between people and digital information. In Proceedings of the 1st International Workshop on Cooperative Buildings, Integrating Information, Organization, and Architecture (pp. 22–32). Heidelberg: Springer.

6. Ham, J., Midden, C., & Beute F. (2009) Can ambient persuasive technology persuade unconsciously? using subliminal feedback to influence energy consumption ratings of household appliances. In Proceedings of the 4th International Conference on Persuasive Technology 2009, Claremont, California.
7. Midden, C. J. H. & Ham, J. (2008). The persuasive effects of positive and negative social feedback from an embodied agent on energy conservation behavior. AISB 2008 Proceedings - Convention of the Society for the Study of Artificial Intelligence and Simulation of Behaviour, Aberdeen.
8. Nakajima T., Lehdonvirta V., Tokunaga E., & Kimura H. (2008). Reflecting human behavior to motivate desirable lifestyle. In Proceedings of the 7th ACM conference on Designing interactive systems. (pp. 405-414). New York: ACM.
9. Schmidt, A. (2000) Implicit human computer interaction through context. Personal Technologies, 4(2), 191-199.
10. Fogarty, J., Forlizzi, J., & Hudson SE. (2001) Aesthetic information collages: generating decorative displays that contain information. In Proceedings of the 14th annual ACM symposium on User interface software and technology. New York: ACM.
11. Hallnäs, L., & Redström, J., (2001). Slow Technology – Designing for reflection. Personal and Ubiquitous Computing, 5 (3), 201-212.
12. Mankoff, J., Dey, AK., Hsieh, G., Kientz, J., Lederer, S., & Ames, M. (2003) Heuristic evaluation of ambient displays. In Proceedings of the SIGCHI conference on Human factors in computing systems. New York: ACM.
13. Nakajima, T., Lehdonvirta, V., Tokunaga, E., Ayabe, M., Kimura, H., & Okuda, Y., (2007) Lifestyle Ubiquitous Gaming: Making Daily Lives More Pleasurable. In Proceedings of the 13th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (pp. 257-266).
14. Löwgren, J. (2007) Fluency as an experiential quality in augmented spaces. International Journal of Design, 1 (3), 1-10.
15. Redström, J., Skog, T., & Hallnäs, L. (2000). Informative art: Using amplified artworks as information displays. In Proceedings of DARE 2000 on Designing Augmented Reality Environments (pp. 103-114). New York: ACM Press.
16. Weiser, M., & Brown, J. S. (1997). The coming age of calm technology. In P. Denning & R. Metcalfe (Eds.), Beyond calculation: The next fifty years (pp. 75-85). New York: Copernicus.
17. Nakajima T., Lehdonvirta V., Tokunaga E., & Kimura H. (2008) Reflecting human behavior to motivate desirable lifestyle. In Proceedings of the 7th ACM conference on Designing Interactive Systems (pp. 407). New York: ACM.
18. Tung, F. W., & Deng, Y. S., (2007). Increasing social presence of social actors in e-learning environments: Effects of dynamic and static emoticons on children. Displays, 28 (4-5), 174-180.
19. Norman, D. A. (2004). Emotional Design: why we love (or hate) everyday things. New York: Basic Books. (pp. 63-69)
20. Norman, D. A. (2004). Emotional Design: why we love (or hate) everyday things. New York: Basic Books. (pp. 83-89)
21. Goffman, E. (1959). The presentation of self in everyday life. Garden City, NY: Doubleday.
22. Fogg, B. J. (2003). Persuasive technology: Using computers to change what we think and do. San Francisco: Morgan-Kaufmann.
23. Caporael, L.R., & Heyes, C. M., (1997). Why anthropomorphize? Folk psychology and other Stories. In R.W. Mitchell, N. S. Thompson, & H. L. Miles (Eds.), Anthropomorphism, anecdotes, and animals (pp. 59-73). New York: State University of New York Press.
24. Brown, T. (2008), Design thinking. Harvard Business Review, 86(6),

Fang-Wu Tung
Yung-Ping Chou
Department of Industrial Design, National United University, Miaoli, Taiwan

Martijn ten Bhömer, Kirstin van der Aalst, Emilia Barakova, Philip Ross
m.t.bhomer@tue.nl

Product adaptivity through movement analysis: the case of the intelligent walk-in closet

Abstract
In this paper we investigate the use of human movement qualities and the design of intelligent products. Our future products and systems are envisioned to become context-aware and adaptive. The design of these adaptive products brings new opportunities to the design of interactive products. Self-adaptivity of products depends on their ability to learn through interaction with the user. We explored a research-through-design process that revolves around a product which is able to interpret human movement qualities. In our approach we integrated three fields: Laban Movement Analysis, neural learning and interactive product design. In this paper, we explain our approach to design adaptive interactive products, and describe the resulting walk-in closet research platform. We present the choices and findings, show results of initial user-testing of the prototype, discuss the open questions that this innovative design approach raised, and further research possibilities.

Keywords
Ambient Intelligence, Adaptive Products, Human Movement Qualities, Neural Learning.

1 Introduction

The integration of technology in our environment and in physical objects is envisioned to lead to ambient environments which are context aware, personalized and able to adapt and even anticipate our wishes, needs and behaviors [1]. This vision of Ambient Intelligence (AmI) leads to new opportunities in industrial design. Aarts and Marzano [1] noticed that self-adaptability of systems depends on how well the system can understand context and learn through interaction with the user. Our challenge was to integrate such ability into a product/system design process and to explore the design implications raised by this process. Several ways to analyze human behavior, based on non-intrusive sensors and wearable computers have been proposed [2,3,4,5,6]. They are based on the analysis of different modalities, such as, tactile modality [7] visual modality carrying information about facial expressions and body gestures [5,8], voice [9], facial, and head movements [10].

We explored an approach in which we recognize human movement qualities related to the whole body instead of facial expressions and gestures because of the inherent expressiveness of the human body. Exploitation of the rich perceptual motor skills of the user has been used before to derive mood or emotional state from the way people interact with a product [11,12].

Tracking and analysis of human body movement has yielded a large body of research on computer vision, for use in entertainment, sports, medical applications and in film making (see for instance [13]). Aiming at implementation of a body motion detection and analysis system within an everyday product, we need a system

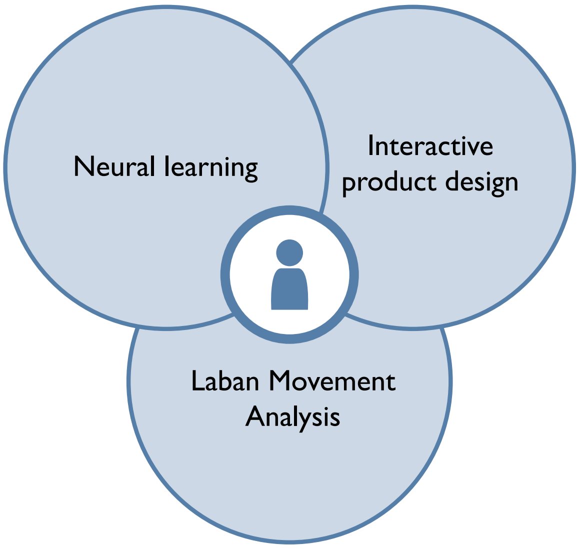


Fig. 1. Visual representation of the novel combination of the three fields we integrated: LMA, neural learning and interactive product design.

that uses basic sensing technology, but is still able to recognize human movement qualities from simple movement measurements.
We use Laban Movement Analysis (LMA) to analyze the physical movement of the user because it combines a set of definitions which can help to distinguish different human states. LMA is a framework which can be used to describe and notate movement. Other research has shown that LMA can provide insight in human behavior and attempts have been made to implement this into product design [14,15]. LMA has also been used to describe frameworks which can be used to design dynamic product behavior, for example in the Choreography of Interaction design approach [16] and in the Interaction Quality Framework [17].
We explored the integration of a learning method in an interactive product/system in an everyday context. Our goal is to contribute to field of AmI from an industrial design perspective. We created a product that learns to categorize movement qualities of a person interacting with it. The designed adaptive product functions as research platform, creating the opportunity to further explore adaptivity in the design of AmI systems. For this purpose we integrated Laban movement analysis, neural learning and interactive product design (represented in figure one) into a product which is able to interpret the state of the user on a dimension which is useful in everyday practice.

A research platform was created (figure 2) using a research through design approach [18]. The goal of the research platform is to investigate how the combination of movement analysis, neural learning and interactive product design can contribute to meaningful product behavior.
We worked in close collaboration with a Certified LMA specialist [19] who helped us to become sensitive for the subtleties in LMA and was involved with important choices during the process regarding movement analysis. For neural learning we relied on unsupervised learning because of its ability to exploit the underlying structure of input data without any teaching [20].
The choice to design a walk-in closet platform was made, because a private space with a lot of movement is a good starting point to explore intelligence in the home environment. This platform follows a project at the Carnegie Mellon University School of Design [21], where a walk-in closet with lighting behavior was created. We extended this idea further by adding the interpretation of human movement qualities by the walk-in closet.
The paper is organized following important phases of our research-through-design process. Section 2 describes how LMA theory was used to study the physical layout of the closet and how relevant movement qualities can be abstracted. In section 3 we describe how sensor data can be interpreted as movement qualities by the neural learning algorithm. In section 4 we will describe a preliminary experiment to test the implementation of the design. In section 5 we will elaborate on the design of the research platform. Section 6 is dedicated to the discussion which this study evoked and in section 7 will give our insights about where to take this research in the future.

Fig. 2. The finished walk-in closet which was designed based on the findings of the research through design process.

2 Integrating Laban Movement Analysis in the design

LMA is composed of five major components: Body, Space, Effort, Shape, and Relationship. Together these components constitute a qualitative language for describing movement [22]. We focused on the Effort factors since these are strong indications of human expression. For example, Quick movements point towards a hasty mindset of a person, whereas a Sustained movement relates to a relaxed mindset of a person.
Effort consists of four movement qualities: Space, Weight, Time, and Flow. Every movement quality is a continuum between two extremes which are: indulging in the quality and fighting against the quality. In LMA these Effort elements are seen as the smallest units needed in describing an observed movement. These Effort elements with their two extremes are: Space (Indirect/Direct), Weight (Light/Strong), Time (Sustained/Quick), Flow (Free/Bound) [23]. In LMA the combination of two movement qualities from the Effort factors is called a State.

2.1 Influence of physical form on movement

Physical surrounding is one of the attributes which contributes to how people move and where attention is placed. This notion is deeply connected to LMA through for example the Space Effort [23]. To find out how the physical design of a walk in closet would change the movement of a person in the closet in terms of LMA Efforts and States we built two closets with different layout. The goal of this experiment was to find balance between the amount of movement which could be elicited from participants while maintaining efficiency in choosing garments.

Within the first closet set-up (figure 3) the closet area is smaller and placed in one line, parallel to the walking area in the closet. In set-up two (figure 4) the closet has a corner in it, and the garments are placed with more space between them.

The participants acted out scenarios in the two different closet set-ups. For example a scenario was: you are in a hurry, get your tennis clothes. The scenarios used in the test were specifically developed, in cooperation with the LMA specialist, to elicit a variety of movement qualities from the participants.
After the experiment the video recordings of the scenarios were analyzed and coded in terms of movement qualities by two people trained during a one-day workshop in LMA and the LMA specialist herself. Based on these observations we concluded that closet set-up one gives a more consistent result in terms of movement qualities, while closet set-up two elicited more expressive human qualities. It was too early to find why this difference occurred. A conclusion for further development was that the physical design of the closet should be easy to modify to enable further testing of the influence of physical form on movement. A second conclusion from the test was to focus on the Space, Flow and Time Efforts. The Weigh Effort was not relevant for the proposed scenarios.

2.2 Abstracting and sensing relevant movement qualities

To interpret the human movement qualities of the user on a dimension which is useful in everyday practice, we aimed at abstracting parameters from movement which

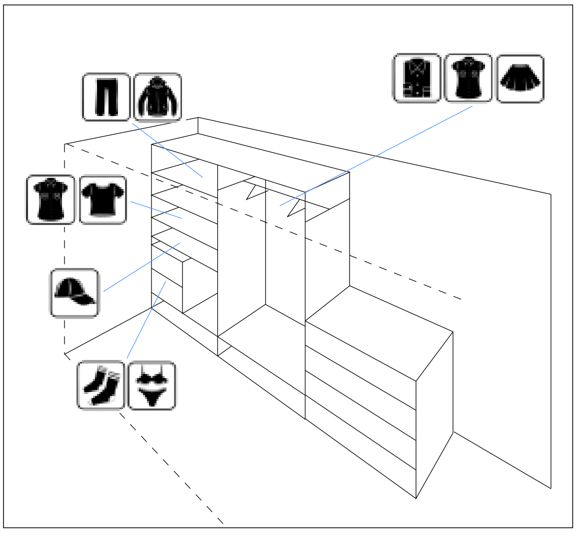


Fig. 3. Set-up one within the test. The closet is placed in a line parallel to the walking area and the garments are placed concentrated.

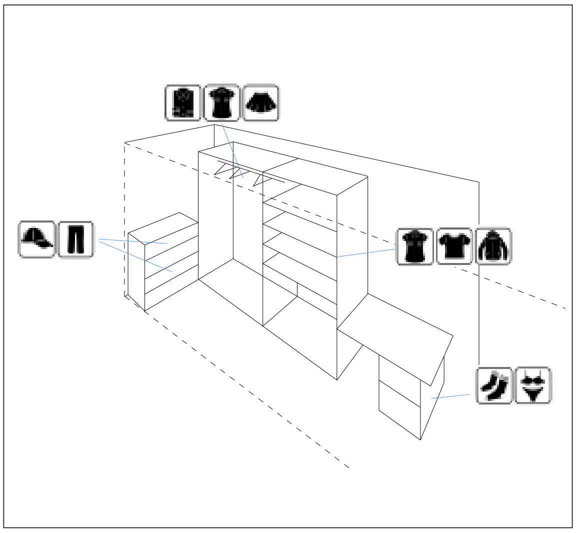


Fig. 4. The second closet set-up used in the test. The closet is built around a corner and the garments are placed more spatially.

		Time	
		Sustained	Quick
Space	Direct	1	2
	Indirect	3	4

Fig. 5. The four combinations possible in the Awake state.

were unique enough to distinguish different behaviors of the user.

With sensors placed in the floor, in the shelves and in the vertical space in the walk-in closet we asked participants again to act-out several scenarios. From the analysis of the sensor data it became apparent that the walking movements and the movements of the participants in the shelves were most informative. These two movements related to two kinds of movement analysis: micro analysis of the movements in the kinesphere of the user (personal space surrounding a person) and macro analysis to describe the larger movements in the space.

We narrowed down the analysis of movement qualities to Space and Time Efforts to reduce complexity and because qualitative observation by the LMA specialist of the video recording showed that and sensor recordings were most distinguishable for these two Efforts.

A combination of the Space and Time effort can be described as the Awake State. Because every Effort consists of two extremes it possible to create four different combinations of the Awake State (figure 5).

2.3 Scenarios to elicit Awake state variations

For every combination of two movement qualities of the Awake state one scenario was created which could be used to elicit these specific movement qualities from a person. All the scenarios had as main context a selection of clothes for different occasions, but the feeling (for example stressed or relaxed) was varied.

1. Sustained/Direct: It is a Sunday evening; you had a nice and easy day. Tonight you will have a drink with a friend. You have the time to prepare your clothes, you are very relaxed. You already know what to wear, you want to wear your favorite party clothes tonight to feel comfortable. Take your favorite party clothes, you have all the time in the world.
2. Quick/Direct: It is Friday evening. You had a long day at school, and you just returned home. You receive a phone call: "hey, do you want to join us for a drink tonight?" You quickly finish dinner, and rush to your walk-in closet. You are going to party tonight and you will be picked up in 10 minutes. You will take your favorite party clothes tonight, hurry!
3. Sustained/Indirect: It is a Saturday evening. You had a quite relaxed day and you are looking forward to tonight. Last week you and your friends decided to go partying tonight. You are going to your walk-in closet and take your time to choose clothes. It is a special occasion to be together with so many friends, so take your time to choose nice clothes.
4. Quick/Indirect: It is Saturday evening. Today you worked at your part-time job, it was a long day but you still feel full of energy. You call your friend in Amsterdam and ask if she wants to party tonight.

She agrees to join, and you decide to go to Amsterdam. You will have to leave in 10 minutes to catch the train! You want special clothes for this special occasion, so you decide not to wear your favorite clothes. Choose a set of clothes, but hurry!

3 Integrating neural learning in the design

Martinetz and Schulten [24] have devised an algorithm which is able to reduce dimensionality and reveal the structure from a dynamically changing input set of data, the so called Growing Neural Gas algorithm. We used the simpler Neural Gas algorithm to analyze the abstraction of movement data from our sensors, in a way similar to [20] and to find data structure which can be linked back to movement qualities in Laban terminology.

To enable the neural gas algorithm to find relevant structures in the input data we need to record data which has a relation with the movement qualities that we want to discover. First these recordings function as training data for the algorithm to divide them on classes and secondly the algorithm uses these classes to cluster the new coming data.
The layered conceptual framework for expressive gesture applications of Camurri et al. [25] describes different layers which can be used to analyze movements (illustrated in figure 6). We used this framework as guidance to process raw data to a meaningful interpretation about the state of the user on a dimension useful in everyday practice.

3.1 Interpreting movement patterns

In the framework of Camurri et al. (figure 6) the first layer is the acquisition of physical signals. Our approach to interpret human physical movement was to use relatively simple sensors, which placed on appropriate positions in the closet are able to capture unique information to distinguish the intended movement qualities. To capture macro movement we placed 12 sensor mats (595mm x 170mm) in the floor which are able to capture the walking movement on one axis.
In the shelves we placed six passive infrared sensors which measure activity, which we linked back as micro movement. An illustration of the set-up can be found in figure 7.
This raw data can be considered as physical signals, but the parameters which can be calculated from this data as for example speed can also be considered as a layer 1 variable. The sensors were connected through three Arduino microcontrollers [26] to a PC. Calculations were made with Cycling '74 Max/MSP [27].
Layer 2 of the framework explains how statistical parameters are calculated to create specific motion cues. We implemented this, for example, by calculating the percentage of movement with high acceleration during the total interaction with the closet. In our system we use the 3rd layer of the framework as a step where the training set for the learning algorithm is created. These training sets can be composed from any combination of parameters from the first and second layer. We found out that the quality of the interpretation by the neural gas network depends on how the training sets are composed.
The interpretation of the Laban States takes place in the 4th layer. The neural gas algorithm is able to find structures from the training sets after a training session

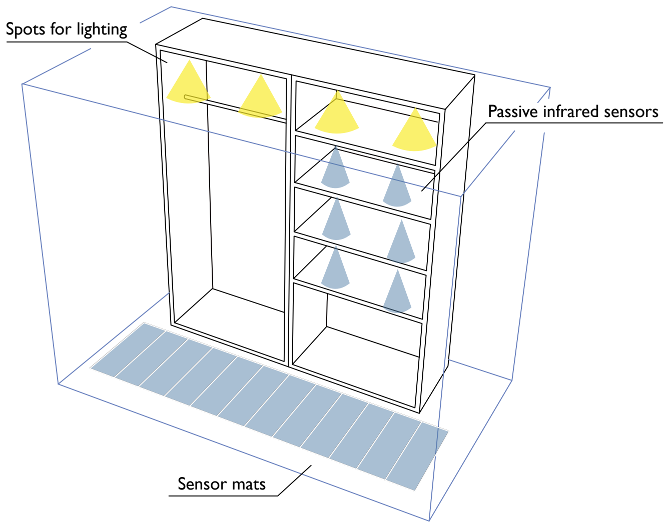


Fig. 7. The prototype set-up: in the shelves six passive infrared sensors. On the floor 12 sensor mats which can switch between on and off state.

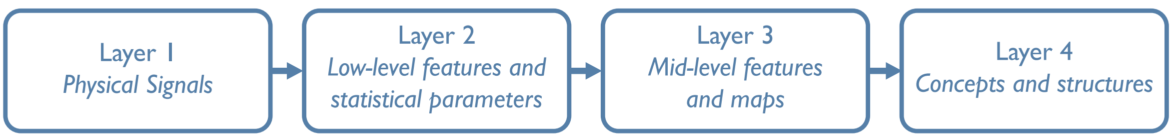


Fig. 6. The layered conceptual framework for expressive gesture applications, adapted from Camurri et al. [25].

of 10 times 5 seconds and can cluster training sets based on these structures. When the sensor sources are chosen well, the clustering information can be related back to Laban movement qualities. The algorithm was implemented in Java within a Max/MSP object.

4 Experiment to test the interpretation of movements

With a user test we were aiming to find out if the prototype we developed in the preceding iterative process was indeed able to interpret the human movement qualities of the Awake state. In figure 8 the closet prototype as described in section 3 is pictured. The system was trained with training data compiled from 2 people who were trained in LMA during a one day LMA workshop, the same training set was used during the whole test. The test consisted of 10 male participants, chosen using convenience sampling, who acted out the scenarios to elicit different extremes of the Awake State Efforts as explained in section 2.3. The scenarios were read to the participants, after which the participants were asked to act out the scenario as good as possible. Video was recorded of the participants, while the interpretation data of the algorithm was also recorded.

Fig. 8. The closet set-up with all the sensors integrated.

4.1 Discussing the results of the experiment

We compared video recordings with the interpretation data of the algorithm. Analysis by the LMA specialist indicated that the interpretation of the Space Effort of the closet is reasonably in line with the observation from the video. We tentatively conclude from this that the most informative movement quality was the Space Effort.

There was a difference in interpretation of the system for different user test participants. Some participants used more Indirect movement throughout the entire scenario, while others used more Direct movement.
A possible explanation for this outcome is that the system was able to interpret the difference in specific movement styles of the participants. Another explanation is that the initial training session by the two persons was not personalized enough and worked for some participants, but failed for those with a different movement style. Further study is needed to be able to explain this phenomenon.

5 Towards a research platform

The experiment described in previous section raised many questions and it is difficult to draw strong conclusions. However, the process leading to the walk-in closet prototype and the experiment lead us to believe that further research can unveil interesting results.
We have chosen to create a research platform which will enable us to conduct further research on the integration of the fields of LMA, neural learning and product design. Such a platform should communicate the intelligence and adaptivity through its form and behavior.

5.1 Physical design of the closet

The prototype we used for the experiment (pictured in figure 8) looked like a very traditional closet. However, when interacting with it, the closet's behavior is not traditional at all, it is intelligent.
Therefore, the embodiment of the closet needed a drastic change, and was designed to be perceived as intelligent, and communicate the nature of the closet through the physical form. The shelves of the closet communicate this through the body line, adaptivity, complexity, dynamics, and cleanness of form. These aspects were influenced by the movements made by the users, resulting in the final prototype which is pictured in figure 2.
In order to study the relation between adaptivity of the product behavior and its physical constitution, the closet was designed as modular system. We ensured that the sensors and actuators could easily change their position and different sensors and actuators could be added. The set-up of the closet (the embodiment) was also modular as each shelve can easily be attached and detached to the wall. Different set-ups can therefore be easily created and tested. For example the set-up picture in figure 2.

6 Conclusion

In this paper we described the research-driven design of a platform for investigating different aspects of the interaction between an intelligent interactive product and a person. We integrated three separated fields, and this combination triggered many questions, points of discussion and new research opportunities.
It was deliberately chosen to stay on the level of Laban Movement Analysis and to create scenarios which were linked to movement qualities. We focused on the analysis of Space and Time Efforts to reduce the complexity of the analysis. This limited our system in the ability to interpret more complex human movement behaviors. Based on the initial and the ongoing user tests we concluded that interpretation of movement qualities can be one of the factors which an AmI system can take into account to adapt better to its user. The better the system can understand LMA and interpret movement qualities, the better adaptation to the user will take place.

There is still room for further optimization of the current analysis of the Space and Time Efforts. In the third layer of our implementation of the Camuri et al. [25] framework the training set data for the learning algorithm is created. This training set is composed from a combination of parameters from the first and second layer during a specific time frame. Finding an optimal combination of parameters will improve the effectiveness of the learning algorithm further.
We have implemented unsupervised learning in the system. The benefits of unsupervised learning are the robustness and flexibility of the algorithm; structures which cannot be known a priory can be found. However, this method requires a human to add meaning to the system clusters. We now added this meaning to the clusters manually after the training was completed and clusters were found. Supervised learning could be considered as alternative, because this method can interpret training set data following learned information. The interpretation is based on predefined structures.

7 Discussion

The research platform we developed triggered a myriad of new research directions for the field of product design, adaptive products and AmI.
Specifically aimed at the context of choosing clothing new opportunities arise. The openness and changeability of the research platform leaves room for further explorations and experiments within this field of design. A design possibility could be to help the user to reflect on the choice of garment by providing a "light trail" of movement history. Besides the home-context a translation could also be made to a shopping context. The information from movement qualities of the customer could be used by shops to more purposefully present products to their customers.
A value of human movement analysis by a system is the consistence of interpretation. This could be used when a product needs to be evaluated though user validation. Instead of relying on questionnaires, the categorization of the system can be used to measure the effects of a design on the user in terms of movement qualities. Being able to interpret the human movement qualities is an useful step towards designing product adaptivity. This new knowledge of the user can be used by the product to react with more meaningful behavior. The behavior can be purposely designed to adapt on specific movement qualities (for example reacting on a hasty user with more efficient task lighting). We think that LMA can also have potential to when designing dynamic product behavior. The interaction with a product which behaves using movement qualities derived from LMA could be perceived as more natural for example.
LMA specialists are able to use movement qualities to elicit reactions from people on subconscious level, for example when training politicians. The possibility to design an intelligent product which is able to purposefully influence the behavior of a person presents new research opportunities. Many questions arise when we think about implementing this into intelligent products. What happens when we design an intelligent closet which is able to elicit more relax movement when the user is behaving hasty for example? Besides new research opportunities this new ability of intelligent products also raises many ethical questions.

8 Acknowledgements

We would like to thank Roos van Berkel for her expertise about LMA and enthusiasm during the project. Also we would like to thank the students from Carnegie Mellon University: Ellie Choi, Johanna Ham, Megan Langdon, Scott Smith and Koo ho Shin for the inspiration which their walk-in closet has given. Finally we would like to thank all the supporting staff of Industrial Design for their expertise and facilities.

9 References

1. Aarts, E. & Marzano, S. (2003). The new everyday: Views on ambient intelligence. Amsterdam: Uitgeverij 010 Publishers.
2. Pantic, M. & Rothkrantz, L. J. M. (2003). Towards an affect-sensitive multimodal human-computer interaction. In Proceedings of the IEEE, 91(9) (pp 1370-1390).
3. Song, M., Bu, J., Chen, C. & Li, N. (2004). Audio-visual based emotion recognition: A new approach. In Proceedings of the 2004 Computer Society Conference on Computer Vision and Pattern Recognition (pp. 1020-1025).
4. Starner, T. (2001). The challenges of wearable computing: Part 1. IEEE Micro, 21(4), 44-52.
5. Lourens, T. & Barakova, E.I. (2009). My sparring partner is a humanoid robot. In International Work-Conference on the Interplay Between Natural and Artificial Computation (pp. 344-352).
6. Kanade, T., Cohn, J. F. & Tian, Y. (2000). Comprehensive database for facial expression analysis. In Proceedings 4th IEEE International Conference on Automatic Face and Gesture Recognition (pp. 46-53).
7. Pentland, A. (2005). Socially aware computation and communication. Computer,38(3), 33-40.
8. Ambady, N. and Rosenthal, R. (1992). Thin slices of expressive behavior as predictors of interpersonal consequences: A meta-analysis. Psychological Bulletin, 111(2),256-274.
9. Dong, W. & Pentland, A. (2007). Modeling influence between experts. Artificial Intelligence for Human Computing, 4451, 170-189.
10. El Kaliouby, R. & Robinson, P. (2004). Real time interference of complex mental states from facial expressions and head gestures. In Computer Vision and Pattern Recognition Workshop (pp. 154-154).
11. Wensveen, S. A. G., Overbeeke, C. J. & Djajadiningrat, J. P. (2002). Push me, shove me and I show you how you feel. In Proceedings of the Conference on Designing Interactive Systems Processes, Practices, Methods and Techniques (pp. 335-340).
12. Barakova, E. I. & Lourens, T. (2009). Analyzing and modeling emotional movements: A framework for social games with robots. Personal and Ubiquitous Computing, in press.
13. Cheung, K., Baker, S. & Kanade, T. (2003). Shape-from-silhouette of articulated objects and its use for human body kinematics estimation and motion capture. In IEEE Computer Society Conference on Computer Vision and Pattern Recognition (pp. 177-184).
14. Chi, D., Costa, M., Zhao, L. & Badler, N. (2000). The EMOTE model for effort and shape. In Proceedings of the 27th Annual Conference on Computer Graphics and Interactive Techniques (pp. 173-182).
15. Fagerberg, P., Ståhl, A. & Höök, K. (2003). Designing gestures for affective input: an analysis of shape, effort and valence. In Proceedings of Mobile Ubiquitous and Multimedia (pp. 57-65).
16. Hummels, C. C. M., Overbeeke, C. J. & Klooster, C. (2007). Move to get moved: A search for methods, tools and knowledge to design for expressive and rich movement-based interaction. Personal and Ubiquitous Computing, 11(8), 677-690.
17. Ross, P. R. (2008). Ethics and aesthetics in intelligent product and system design. Eindhoven: Eindhoven University of Technology.
18. Hummels, C. C. M. & Frens, J. W. (2008). Designing for the unknown: A design process for the future generation of highly interactive systems and products. In Proceedings Conference on EPDE (pp. 204-209).
19. Van Berkel, R. E. (2008). Laban workshop. Eindhoven: Eindhoven University of Technology.
20. Barakova, E. I. & Lourens, T. (2005). Event based self-supervised temporal integration for multimodal sensor data. Journal of Integrative Neuroscience, 4(2), 265-282.
21 .Choi, E., Ham, M., Langdon, S., & Shin, K. (2006). Carnegie Mellon University School of Design Project. Retrieved Month date, year, from http://projects.domusacademy.net/retailtherapy08/?p=166.
22. Zhao, L. (2001). Synthesis and acquisition of laban movement analysis: Qualitative parameters for communicative gestures. Pennsylvania: CIS, University of Pennsylvania.
23. Newlove, J. (2003). Laban for all. New York: Theatre Arts Book.
24. Martinetz, T. & Schulten, K. (1991). A neural-gas network learns topologies. Artificial Neural Networks, 1, 397-402.
25. Camurri, A., Trocca, R. & Volpe, G. (2002). Interactive systems design: A KANSEI-based approach. In Proceedings of the 2002 conference on New interfaces for musical expression (pp. 1-8).
26. Arduino. (n.d.). Arduino – HomePage. Retrieved March 3, 2009, from http://www.arduino.cc
27. Welcome to Max 5: Max for the next 20 years (n.d.). Max 5. Retrieved March 3, 2009, from http://www.cycling74.com/pr

Martijn ten Bhömer,
Kirstin van der Aalst,
Emilia Barakova,
Philip Ross
Department of Industrial Design, Eindhoven University of Technology, Eindhoven, The Netherlands

Yi-Heng Lee and Chao-Ming Wang
s966402@mail.yzu.edu.tw

Using light, sound, and ripple motion to design the ambient display environment

Abstract
According to the concept of ambient display and tangible interaction, we design three works and use light as material to generate the essential affordance of each demonstrator. Because human follow the light with human perception, light is appropriate for being an ambient trigger. Then, the works build with other ambient media like sounds and the animation of ripple motion. These materials (light, sound and ripple motion) are constructed ambient displays as the media between virtual information and human. These demonstrators also design with tangible interaction to make the more strength of information-manipulating. Ambient display and tangible interaction will trigger the interactive behavior of human for virtual information and make the Human-Computer interface more interesting and friendly.

Keywords
Ambient Display, Tangible User Interfaces, Ubiquitous Computing, Interaction Design.

1 Introduction

This is the age of implicit human-computer interaction. Only a few years back, technology pundits spoke of the computer as a device that would cease to exist as soon as its functions become accessible in an ubiquitous and intangible manner. Now, the need for an increasingly amicable human-computer interface has been made possible by ambient display, which aims to make users feel the human-centered spirit of computing. Ambient display allows users to adjust the computer environment to fit their needs, bringing computers to the center of everyday life.

2 From ubiquitous computing to ambient intelligence

The concept of ubiquitous computing was first introduced by Marc Weiser in the early 1990s [1]. Since then, the computer has become an almost pervasive yet indispensable tool in our lives, as Weiser envisioned. In this study, the author posited that ubiquitous computing is geared towards "enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user" [2]. Here, the computer is invisible to the user, who pays little attention as computing carries on in the background.

To reinforce the concept of ubiquitous computing, Weiser upped the ante and introduced "calm technology" [3], which describes the relationship between background computing and the user's concentration. It encourages people to view their environment with their peripheral attention, which may then shift to the central attention when needed. This concept had a profound influence on the development of ambient display.

In a related development, Prof. Hiroshi Ishii of the MIT Media Lab, Massachusetts Institute of Technology advanced the notion of tangible bits, a concept which describes the relationship between the tangible and the virtual worlds [4] based on Weiser's concepts of ubiquitous computing and calm technology. Ishii used atoms as a metaphor for the tangible world and bits for the virtual information sea; within such a system, one can operate digital information in the virtual world from the seashore. Generally, the concept of tangible bits represent the body of the digital information in the tangible world [4].

To achieve true ubiquity, Ishii designed a human-computer interface called tangible user interface (TUI) which expands the graphical user interface (GUI) into the tangible environment. Widely accepted by the PC operating system, GUI was first developed by Dr. Douglas C. Engelbart and his research team at the Stanford Research Institute [5]. It features the windows, menus, and icons whose elements can be displayed with the smallest unit pixels on the screen, which are usually matched with sounds. However, it can only be operated with the use of a keyboard or mouse.

On the other hand, TUI allows the user to grasp or control information directly by touch, making virtual information more real. As illustrated in Figure 1, TUI enhances one's perception and experience by managing information intuitively and conveniently through information amplification technology, such as projecting an image on an object together with its intangible representation.

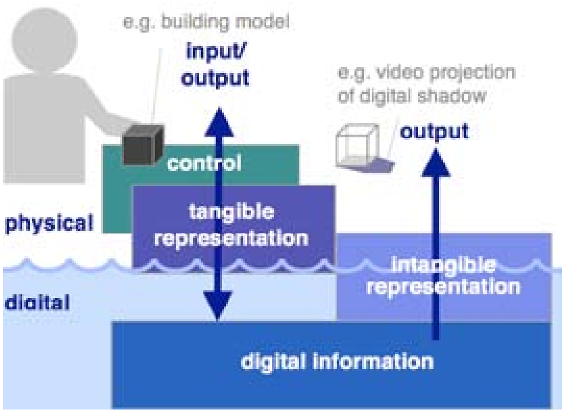


Fig. 1. Sketch Map of the Tangible User Interface [4,6]

In recent years, "ambient intelligence" has been the focus of global research institutions. The term first appeared in an article entitled, "Ambient Intelligence: Thuisomgevingen Van de Toekomst," published by Aarts and Appelo in IT Monitor [7]. On example is the Intelligence Housing Experimental Plan jointly developed by Philips Research and MIT Oxygen Project focuses on ambient intelligence. Dedicated to developing 21st century computing technology, this project seeks to bring popular, transparent, and intelligence technology to our homes through natural interfaces that control various electrical equipment. This is based on the wireless family network and voice design that run on broadband communication network and radio-frequency communication technology, combined with the individualized environment [8].

With the vision of ambient intelligence put forward by Philips, Europe is expected to be at the forefront of information and communication technology (ICT). According to the Information Society Technologies Advisory Group (ISTAG), the ICT advisory body to the European Commission, people will be surrounded by intelligence computing and network interfaces anywhere or in any given application, such as in furniture, clothing, automobiles and roads, to name a few.

In principle, ambient intelligence exists everywhere yet vanishes into the background. It cannot be perceived by the user except when being used [9]. The vision for ambient intelligence complements that of ubiquitous computing. Through invisible and ubiquitous computing, users can tap into the embedded system to achieve their target outcomes. Aarts [10] simplified the five technical elements of ambient intelligence as follows:

Embedded. Many network fittings are integrated in the environment.

Context-aware. The system can discern the user and the actual situation.

Personalized. The system can adjust itself according to the user's requirement as first set in the beginning.

Adaptive. The system can observe the user's behavior pattern after an observation period and make a proper adjustment.

Anticipatory. The system will anticipate what the user wants and help make some choices.

Based on these elements, ambient intelligence evidently focuses on context-aware, personalization and ubiquity. Besides intelligence technology, the character of ambient intelligence is natural human computer interface. The natural interface is like gestures recognize, voice recognize, facial expression analysis, etc [11]. Although these human presentations are easy for us, the visual design of the interface needs to use the concept of ambient display and visual perception.

3 Ambient display

The concept of ambient display was first presented by Wisneski [12]. Ambient interfaces display digital information through subtle changes in the user's physical environment, such as in the form of colorful lights, sounds, and movements. Serving as a human-computer interface, ambient display has a wider vision than traditional GUI as it can transform the tangible environment into the display interface of digital information [12,13].

Through ambient display, one can know time passed by feeling the light of the sky or someone is close to someplace by hearing footsteps. Here, peripheral attention is used to perceive. Peripheral attention is a natural ability that human is born with and the important theory in ambient display. In ambient display, people use perception that human is born with to perceive contents of the virtual information. It is almost related to the concept of affordance, created by Gibson [14] in his work on The Ecological Approach to Visual Perception: "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or for ill". In other words, the design of ambient display will generate the affordances that be explore by human perception, that is what Gibson meant. Based on this, the present study aims to design an environment interface that can be embedded into everyday life according to one's perceptions, experiences, and impressions of objects' texture. The concept of ambient display will not only be explained but demonstrated through aesthetic design; it also aims to improve the users' acceptability and allow them to connect to the digital information seamlessly. The study likewise intends to promote affection communication among various users based on their common experiences in ambient display.

4 Experiments

The following three demonstrators will be applied to daily life with the aim of connecting digital information seamlessly with the tangible environment. The computer will be relegated to the background by combining it with tangible user interface. According to the concept of ambient display and tangible interaction, we design three demonstrators and use light as material to generate the essential affordance of each demonstrator. Because human follow the light with human perception, light is appropriate for being an ambient trigger. Then, the demonstrators work with other ambient media like sounds and the animation of ripple motion. These materials (light, sound and ripple motion) are constructed ambient displays as the media between virtual information and human. These demonstrators also design with tangible interaction to make the more strength of information manipulating. Ambient display and tangible interaction will trigger the interactive behavior of human for virtual information and make the Human-Computer interface more interesting and friendly. They reinforce social interaction between people and people, as a result, people don't focus their eyes just on the cold screen.

4.1 Ripple motion

This refers to the earlier design of ambient interaction that was originally intended for public spaces. It aims to reflect subtle changes in affection between people, viewers and space, and vice versa through rippling motion and light (see Figure 2). Dynamic ripples and changing color in Ripple motion environment will trigger social interaction by moving bodies. Ripple is a type of diffused or stretched image, where a familiar texture is disturbed and a kind of subtle overlapping affection is produced. For example, passers-by will see the superimposition of a ripple diffused into the texture of an object when they pass by. In nature, the reflection of light varies according to the time, year, and weather. Viewers may be astonished by the dynamic quality and possibly become happy upon seeing the beauty of the light. Therefore, the viewer's feeling or perception of the whole space may be enhanced by light variation design and the presence of ripple motion, which may mimic the viewer's body motion.

Fig. 2. Interaction between Human and Ripple Motion

The ripple will move as the viewer passes by, and its up- and down movement will gradually fade through time. When a more tempestuous movement is detected, a more furious disturbance of the ripple will be produced, together with a continuous variation of color to respond to the viewer's body motion. This type of "feedback" from the image will encourage the viewer to interact with the ripple again. Meanwhile, in the absence of motion, the ripple will be still and a placid blue image will be shown.

4.2 Cheers!

The term "cheers" is used to express well wishes before downing an alcoholic drink. It is usually followed by clinking glasses. In this design, an interactive feedback is created with the aid of an ambient display of light, sound, and motion. The structure of the Cheers! system is composed mainly of embedded infrared-aware glasses, a projector, IR camera, and a four-channel speaker (see Figure 3).

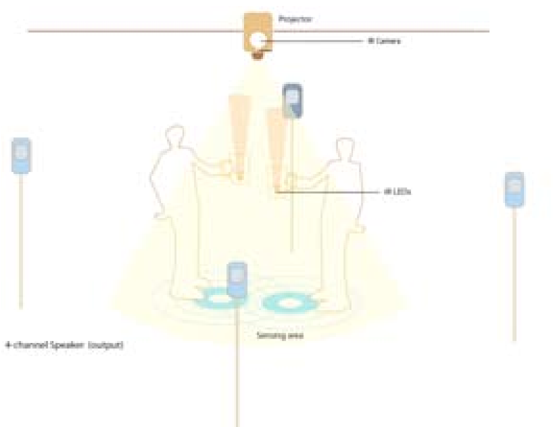


Fig. 3. Configuration of the Cheers! System

The relationship between social places and sound is important. Music is indispensable in certain social situations and provides identity so that one can perceive one's self and others in a party [15]. Additionally, like a mirror, music can make one recall past experiences. However, people's feelings toward music vary. In Cheers!, spot music will play continuously in the space and change subtly as the social state varies. The ambient music will generate the affordance in musical fluctuations to affect the participants unconsciously and improve their interaction.

In Cheers!, the glass is used as a metaphor for one's personal role, and ambient media connects the information. When the glass moves in space, it mimics people's motion in space as well. The position of the glass will influence the direction of the musical flow. When the distance between two glasses is less than a certain degree, an "online relationship" will occur between the two glasses, indicating the distance between two people (see Figure 4). When the glasses clink with each other, ambient music will feed back the sound immediately, implying that the feelings of people are resonated in the situation. Apart from the echoing sound, different rays of light will be flashed when the glasses clink(see Figure 5). The flash light will trigger people to interact with each other again, and as if electricity was flowing through them, ignite the hearts of their holders and set sparks.

Fig. 4. The line between two glasses indicates the distance between two persons

Fig. 5. Light-rendering effect produced when glasses clink.

The Cheers! system can identify the number of glasses present in the current context. The number of glasses will affect the projected colors and patterns, indicating the number of participants present. Figure 6 is the prototype for the actual testing of the Cheers! System, while Figure 7 demonstrates the interaction that occurs when people say, "Cheers!"

Fig. 6. Prototype for the actual testing of the Cheers! System

Fig. 7. Interaction when people say, "Cheers!"

4.3 Rainbow Recorder

The concept of the Rainbow Recorder is derived from the gramophone invented by Thomas Edison. It redefines and re-interprets the device's sound-recording function. Voice can express one's affection and thoughts, but it is intangible and invisible. The traditional concept of the gramophone is combined with ambient display and tangible user interface in the Rainbow Recorder, in which voice is stored as a tangible object in the physical space and not merely a portion of an image. Each unit of the Rainbow Recorder can store a variety of voices. When touched by hand, it will record or release sound, producing lifelike speech. Figure 8 illustrates the conceptual design of the rainbow recorder. Beyond being just a sound-recording device, it can serve as a notepad which records information

Fig. 8. Conceptual Design of the Rainbow Recorder

Fig. 9. Each person can have his own exclusive voice pattern and color in the Rainbow Recorder

through words. Thus, upon listening to the voice recording, one can recollect one's feeling at a given moment.
To predigest the interface, input and output are placed on the same interface. Aside from the input function, the button controls ambient display as well as displays the color of the voice. The button with dynamic light changing will trigger user to touch it and make user interact easily with the artifact. Apart from displaying color with a single button, one can design an exclusive

voice pattern when recording, making the voice record more lifelike (see Figure 9).

Further, the rainbow recorder can serve as an indoor ambient light. Multi-color LED is embedded in each button. When rotated, the Rainbow Recorder will display the color variation of more than 16KK (16777216). Users can then select their favorite color and light depending on their mood.

When the Rainbow Recorder's prototype was first tested, it was discovered that children and the elderly showed greater appreciation for the interface because it uses fewer functional keys and does not have complicated menu options. The integral interface controls information through the use of natural human haptic perception. Thus, visual perception is achieved through the light pattern guided by the user's finger.

5 Conclusion

This paper combines with ambient display and tangible interaction to design ambient technology environment. The experimental space and product designs of devices using the ambient display concept have taken into account both the public place and individual application. Through observation, the affordance serves as the first step in promoting interaction between the participant and the device. For example, when a ripple emerges, the participant can sway his body to produce more rippling effects. As the distance between participants and glasses decreases in Cheers!, clinking sounds are produced. Moreover, light produced by touching one button in the Rainbow Recorder system will naturally guide one's finger to touch the other buttons. All of these are interactions between users and devices triggered by affordances of ambient display. Once this is achieved, digital information are absorbed easily by participants. Among the various designs, the most effective are the light ray's motion and variation of color, perhaps owing to people's partiality towards images and the fact that light is found to trigger one's affections.

Furthermore, when the user perceives information through an ambient interface, seamless network connection and information transmission are achieved. The Rainbow Recorder will connect with the network database in a later design which, apart from the local message interface, can transfer messages from a farther distance as well as download real-time information such as the weather forecast, stock updates, and so on. The button will be transformed into a simple and clear LED display which can naturally blend into the natural environment and aim to the true Ambient Intelligence environment.

Yi-Heng Lee
The Department of Information Communication, Yuan Ze University, Taiwan

Chao-Ming Wang
The Department of Digital Media Design, National Yunlin University of Science and Technology, Taiwan

References

1. Weiser, M. (1991). The computer for the twenty-first century. Scientific American, 265(3), 94-104.
2. Weiser, M. (1993). Ubiquitouscomputing. IEEE Computer, 26(10), 71-72.
3. Weiser, M., & Brown, J. S. (1996). Designing calm technology. PowerGrid Journal, 1(1). http://www.powergrid.electriciti.com/1.01
4. Ishii, H., & Ullmer, B. (1997). Tangible bits: Towards seamless interfaces between people, bits and atoms. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. New York: ACM.
5. Moggridge, B. (2006). Designing interactions. New York: MIT Press.
6. Ishii, H. (2008). Tangible bits: Beyond pixels. Proceedings of the 2nd International Conference on Tangible and Embedded Interaction. New York: ACM.
7. Aarts, E. and L. Appelo (1999). Ambient intelligence: Thuisomgevingen van de toekomst. IT Monitor, 9(99) , 7-11.
8. Aarts, E. (2003). Ambient intelligence: Building the vision. In 365 days' ambient intelligence research in HomeLab (pp. 2-5). Eindoven: Neroc Publishers.
9. ISTAG (1999). Orientations for work programme 2000 and beyond. Retrieved Feburary 10, 2009, from http://www.cordis.lu/ist/istag.htm
10. Aarts, E. (2004). Ambient intelligence: A multimedia perspective. IEEE Multimedia, 11(1), 12-19.
11. Alcañiz, M., & Rey, B. (2005). New technologies for ambient intelligence. In Riva et al. (Eds.), Ambient intelligence: The evolution of technology, communication, and cognition towards the future of human-computer interaction. Fairfax, VA: IOS Press.
12. Wisneski, C., & H. Ishii. (eds.) (1998). Ambient displays: Turning architectural space into an interface between people and digital information. In Proceedings of the First International Workshop on Cooperative Buildings, Integrating Information, Organization, and Architecture (pp. 22-23). Springer-Verlag.
13. Gross, T. (2003). Ambient interfaces: Design challenges and recommendations. In Proceedings of the 10th International Conference on Human-Computer Interaction (p. 2). Heraklion, Greece.
14. Gibson, J. J. (1979). The ecological approach to visual perception. Cambridge: Lawrence Erlbaum Associates.
15. Frith, S. (1996). Music and identity. In S. Hall & P. D. Gay (Eds.), Questions of cultural identity (pp. 108-127). London: Sage.

Kai-Hsiang Liang
rexkai@arch.nctu.edu.tw

The relationship between architectural media and elements: the emerging undefined digital architectural elements

Abstract
In the process of design, architects arrange the architectural functions and concepts with architectural elements. At the same time, design media act as helping roles between the designers' concept and the composition. Today, there are many architectural media. Architectures designed by different media have different outcomes. This study discusses the relationship between architectural elements and design media, and treats whether digital media impact the existing architectural elements. To study, there are 10 cases by five architects. These cases are analyzed by three traditional architectural element factors, which include "basic geometry", "interface", and "function". This study compares new architectural elements with the traditional ones to find the differences, similarities and the reasons to generalize the definition of new architectural elements created by digital media. In conclusion, define three digital architectural elements, "curvy-surface", "multiple-functions" and "slit-open."

Keywords
Digital Architecture, Design Media, Architectural Element.

1 Introduction

1.1 Previous Studies
Architecture includes multiple systems, and this study focuses on the architectural elements. There are two level meanings of architectural elements, both independent "whole" but also a "part" of larger scale context. In the element-defining process, there are a few principles as follows. First, according to the element-defining, people can clearly understand the whole architecture. Second, architectural elements can be combined to the whole architecture without missing. Third, every element should be the most essential [1]. Architectural elements have variety of different definitions by different times or field. This study divides them into the nonmaterial and the material. The reviews of nonmaterial elements include the follows, the geometry [2], solid and void and surface [1], the relationship between environment and nature and architecture [3], the user's viewpoint [4] and the architect's viewpoint [5]. The reviews of material elements include the follows, the ontological and representation [6], the relative height [2], the functions and usability of objects [7], the systematic classification by spatial dimensions [8]. This study analyzes the previous classification of architectural elements, and concludes three basic and main factors, "basic geometry", "interface" and "function."

Design media act as helping roles between the designers' abstract concept and the concrete composition [11]. The earliest design media in architecture is simply as a tool to record. Then architects started to make physical models to aid design

The concluded architectural factors	The architectural factors of previous studies
Basic geometry	The geometry [2]
	The relative height [2]
	Relative positioning and the dimensioning [9] [10]
	The systematic classification by spatial dimensions [8]
Interface	Solid and void and surface [1]
	The relationship between environment, nature, and architecture [3]
	The ontological and representation [6]
Function	The user's viewpoint [4]
	The architect's viewpoint [5]
	The functions and usability of objects [7]

Table 1. The concluded architectural factors and their reference

thinking of 3D space [12]. In the twentieth century, in order to create new forms, some architects, such as Antoni Gaudi, used home-made media. In the twenty-first century, digital media are used by architects to not only record but also aid design of 2D and 3D, and are much precise than media in the past [13]. Today, architects just give computer enough design rules, and computer will feed back design possibilities.
From precious studies, the architectural elements are never given new explanations or definitions because of the different media, while the digital media has already become one of the effective and inspiring media to designers [14] [15] [16] [17]. This study hopes to discuss the latest media of architecture, digital media, to understand whether the digital media will affect the existing architecture elements or not? Compared with the physical media, the precious studies about discussing the relation between architecture elements and design media are rare. This study tries to find out that whether architects' usage of different media, digital media and non-digital media, would create the physical architectural elements that couldn't defined by the existing ones, and compares the differences between these elements, the existing ones and the defined ones. And then induce and define appropriate architecture element to the era of digital architecture.

1.2 Methodology and Steps

An architecture element is a well-defined unit, and it can be combined to the whole without missing [1]. Hence, in order to study architecture elements, architecture itself should be also studied. Case study is a valid method to study architecture. This study analyses the architectural elements of cases, and aims at the elements which created by digital and non-digital media. Because of the numerous factors of architectural element-creating in design process [11] [13], cases are separated into five groups, every group has two cases of one architect who uses digital and non-digital media, to avoid personal factors influencing the outcome. Simultaneously, simplify all results are because of different media. In addition, with the diversity of the cases, this study lasted the discussion of the precious studies and chosen cases are the finished physical architecture. In order to take a big amount of sampling and be as objective as possible, this study takes the cases in magazine a+u (Architecture and Urbanism). I take 30-years magazine a+u from 1977 to 2007, with the top five published-times of architects who use digital media, and select their two cases, one designed by non-digital media and the other one is by digital media. The definition of "digital architects" is that the architect who mainly develops his design by digital media. This study analyses the related graphs, such as pictures, and the data, including words and related information, and compares the architectural designs with non-digital media and digital media by the same architect.

1.3 Analytic Factors

This study concludes three factors from the previous studies, which are "basic geometry", "interface", and "function."

(1) Basic geometry

Basic geometric forms are circle, triangle and rectangle [2]. The factor basic geometry, can be modify to generate sub-factors, which are "addition", "penetration", "bending" and "intercept" [8]. There are three steps of analyzing the factor. First, trace every line of architectural drawings. Second, extend the traced-line to be reference lines, and make each intersected. Third, analyze the forms shaped by the reference lines' intersection, and compare the forms with the sub-factors of basic geometric.

(2) Interface

The interface of architectural elements is indispensable [3]. The sub-factors of interface include "corner", "surface", "opening" and "site planning". The main analysis of interface is based on photos. There are four steps of analyzing factor interface. First, analyze corners of the architecture, and measure the angle of corner. Second, analyze the architectural surface. This study divides the sub-factor, surface, into three levels: plane, fold and curved surface. Third, analyze the architectural openings. This study bases on the position of openings and divides the sub-factor, opening, into three levels: entrance, window and skylight. Fourth, analyze site planning focused on the relationship between the site and the architecture.

(3) Function

Definitions of architectural elements are generally classified by their functions [7]. Every architectural element has its unique and one function. The sub-factors of function include "door", "window", "column", "beam", "slab", and "wall." The main analysis of function is based on architectural drawings, plan and section. There are two steps of analyzing the factor interface. First, mark every category with colors, "door" as blue; "window" as green; "column" as orange; "beam" as purple; "slab" as yellow; "wall" as red. Second, compare functional elements with the whole architecture.

Main factors	Sub-factors
Basic geometry	Addition
	Penetration
	Bending
	Intercept
Interface	Corner
	Surface
	Opening
	Site planning
Function	Door
	Window
	Column
	Beam
	Slab
	Wall

Table 2. The main factors and sub-factors

2 Non-digital architecture

2.1. Gemini G.E.L

The name of this project is "Gemini G.E.L", and the architect is Frank O. Gehry. It is finished in 1979. This case is a combination of the basic geometric forms. The layout of first-floor-plan drawing is based on rectangles, and it is applied the sub-factor, intercept, to change rectangular layout into the L-shaped. The layout of third-floor-plan drawing is applied the sub-factor, penetration, to place the skylight. The included angle of the skylight's and the site's reference lines is because the skylight- placed is applied sub-factor, bending. Other sub-factors are not applied, and this case can be fully deconstructed by basic geometry. According to the photos, the sub-factor, corner, of this case is fully orthogonal. The sub-factor, surface, is fully plane. The sub-factor, opening, has three, entrance, window and skylight. The sub-factor, site planning, is vertical line and the included angle of ground line and the walls is right angle. This case can be fully deconstructed by interface. Mark every category with colors. This case can be fully deconstructed by function (Fig. 1).

2.2. House VI

The name of this project is "House VI", and the architect is Peter Eisenman. It is finished in 1975.This case is a combination of the basic geometric forms. The layout of plan drawing is based on rectangles, and it is applied the sub-factor, addition, to form the layout of plan, section and elevation drawings. Other sub-factors are not applied, and this case can be fully deconstructed by basic geometry. According to the photos, the sub-factor, corner, of this case is fully orthogonal. The sub-factor, surface, is fully plane. The sub-factor, opening, has two, entrance and window. The sub-factor, site planning, is vertical line and the included angle of ground line and the walls is right angle. This case can be fully deconstructed by interface.

Fig. 1. The element analysis of Gemini G.E.L

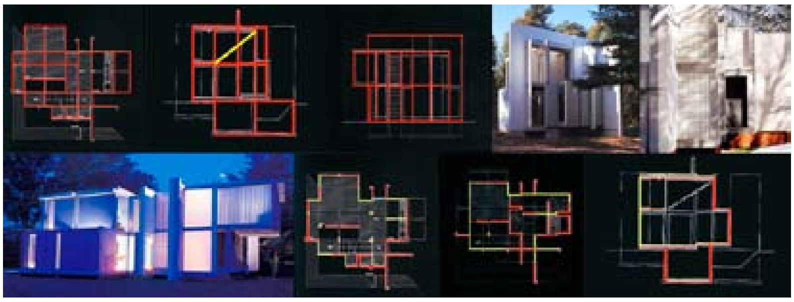


Fig. 2. The element analysis of House VI

Mark every category with colors. The peculiarity of this case is the sub-factor, column because the columns of this case are not independent. The columns look like parts of the walls. This case can be fully deconstructed by function (Fig. 2).

2.3. Two Patio Villas

The name of this project is "Two Patio Villas", and the architect is Rem Koolhaas. It is finished in 1988.This case is a combination of the basic geometric forms. The layout of plan drawing is based on rectangles, and it is applied the sub-factors, addition and penetration, to form the layout of plan, section and elevation drawings. Other sub-factors are not applied, and this case can be fully deconstructed by basic geometry. According to the photos, the sub-factor, corner, of this case is fully orthogonal. The sub-factor, surface, is fully plane. The sub-factor, opening, has three, entrance, window and skylight, and there are two entrance of different heights because of the landforms. The sub-factor, site planning, is vertical line and the included angle of ground line and the walls is right angle. This case can be fully deconstructed by interface. Mark every category with colors. This case can be fully deconstructed by function (Fig. 3).

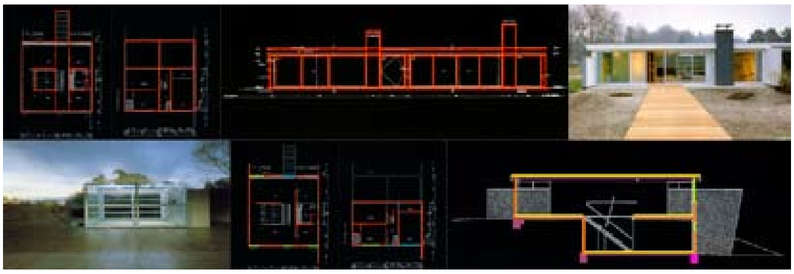


Fig. 3. The element analysis of Two Patio Villas

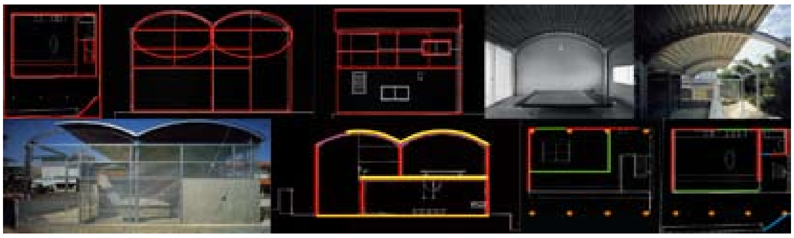


Fig. 4. The element analysis of House in Magomezawa

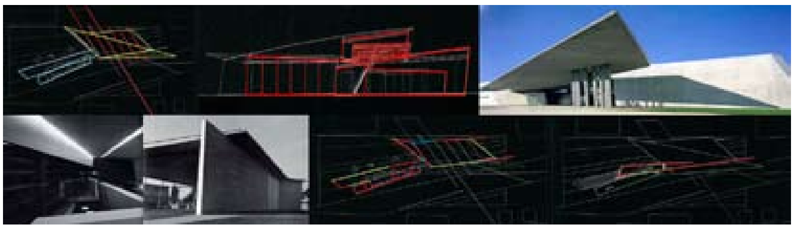


Fig. 5. The element analysis of Vitra Fire Station

2.4. House in Magomezawa

The name of this project is "House in Magomezawa", and the architect is Toyo Ito. It is finished in 1986. This case is a combination of the basic geometric forms, circle and rectangle. The layout of plan drawing is based on rectangles, and it is applied the sub-factors, intercept, to form the layout of plan. It is applied the sub-factors, addition, to form the layout of section and elevation drawings. Other sub-factors are not applied, and this case can be fully deconstructed by basic geometry. According to the photos, the sub-factor, corner, is fully orthogonal. The sub-factor, surface, is fully plane besides the roof. The sub-factor, opening, has two, entrance and window. The sub-factor, site planning, is vertical line. This case can be fully deconstructed by interface. Mark every category with colors. This case can be fully deconstructed by function (Fig. 4).

2.5. Vitra Fire Station

The name of this project is "Vitra Fire Station", and the architect is Zaha Hadid. It is finished in 1990. This case is a combination of the basic geometric forms. The layout of plan drawing is based on triangles and rectangles which are transformed into quadrangles, and it is applied the sub-factors, addition, to form the layout of plan, section and elevation drawings. Other sub-factors are not applied, and this case can be fully deconstructed by basic geometry. According to the photos, the sub-factor, corner, is bias. The sub-factor, surface, is fully plane. The sub-factor, opening, has two, entrance and window. The sub-factor, site planning, is bias line. This case can be fully deconstructed by interface. Mark every category with colours. This case can be fully deconstructed by function (Fig. 5).

3. Digital architecture

3.1. Nationale-Nederlanden Office Building

The name of this project is "Nationale-Nederlanden Office Building", and the architect is Frank O. Gehry. It is finished in 1995. This case is formed by free forms and rectangles. The layout of plan is based on free forms, especially the elevations. All sub-factors are not applied, and this case can not be deconstructed by basic geometry. According to the photos and isometric drawings, the sub-factor, corner, is curved. The sub-factor, surface, is curved, too. The sub-factor, opening, has three, entrance, window and skylight, but the columns on the ground floor are slit to form the gates which are not defined of openings. The sub-factor, site planning, is bias line. This case can be deconstructed by factor, interface. Mark every category with colours. This study finds out some elements with multiple functions, such as column and door. This case cannot be deconstructed by function, and sub-factors, column and door, should be redefined (Fig. 6).

3.2. The Aronoff Center for Design and Art at the University of Cincinnati

The name of this project is "The Aronoff Center for Design and Art at the University of Cincinnati", and the architect is Peter Eisenman. It is finished in 1996. Because this case is to extend the old buildings, it is formed by two forms, free forms and the shape from the old building. The two forms are processed by computer-aided design to create new forms which architect can select. So, all sub-factors are not applied, and this case can be not deconstructed by basic geometry. According to the photos, the sub-factor, corner, is bias. The sub-factor, surface, is folding. The sub-factor, opening, has three, entrance, window and skylight. The sub-factor, site planning, is bias line. This case can be fully deconstructed by interface. Mark every category with colours. Because the space is formed by the computer, there are many elements which are not defined, such as column and slab. This case can not be deconstructed by function (Fig. 7).

3.3. Casa Da Musica

The name of this project is "Casa da Musica", and the architect is Rem Koolhaas. It is finished in 2005. This case is formed by quadrangles and rectangles, and the four angles of every quadrangle are different. It is applied to plans, sections and elevations by the same way. All sub-factors are not applied, and this case can not be deconstructed by basic geometry. According to the photos, the sub-factor, corner, is bias. The sub-factor, surface, is plane. The sub-factor, opening, has three, entrance, window and skylight. The sub-factor, site planning, is bias line. This case can be fully deconstructed by interface. Mark every category with colors. Because the continued form from slab to wall, or wall to slab, there are elements which are not defined. This case cannot be deconstructed by function (Fig. 8).

3.4. Serpentine Gallery Pavilion 2002

The name of this project is "Serpentine Gallery Pavilion 2002", and the architect is Toyo Ito. It is finished in 2002. This case is a combination of the basic geometric forms. The layout of plan drawing is based on triangle and rectangular frames, and it is applied the sub-factors, addition, penetration and Intercept, to form the layout of plan, section and elevation drawings. Other sub-factors are not applied, and this case can be fully deconstructed by basic geometry. According to the photos, the sub-factor, corner, is fully orthogonal. The sub-factor, surface, is a double-wall which is a combination of several triangles and quadrangles. The sub-factor, opening, has one from, triangles. The sub-

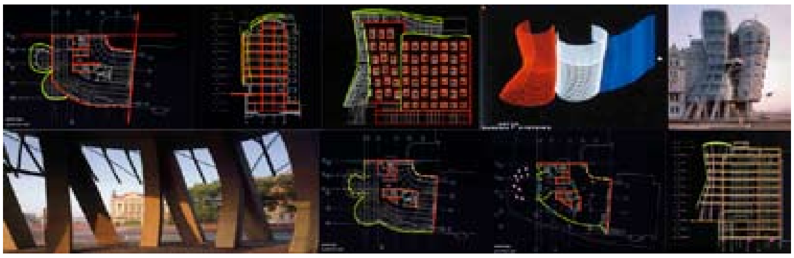


Fig. 6. The element analysis of Nationale-Nederlanden Office Building

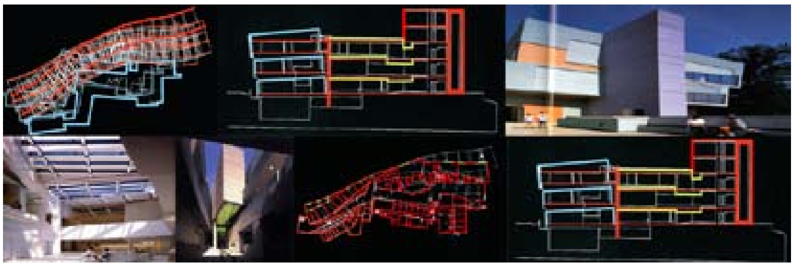


Fig. 7. The element analysis of The Aronoff Center for Design and Art at the University of Cincinnati

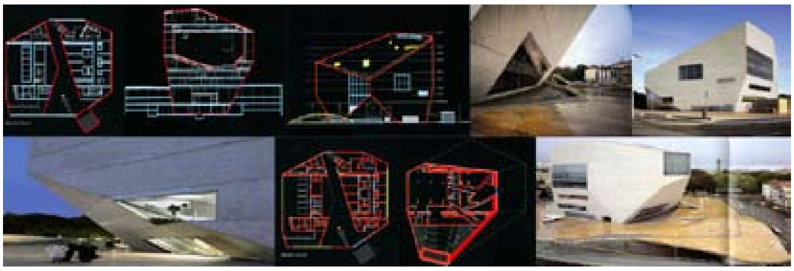


Fig. 8. The element analysis of Casa da Musica

factor, site planning, is vertical line and the included angle of ground line and the walls is right angle. This case can be fully deconstructed by interface. Mark every category with colors. Because of the structural system, there are no column and beam. This case can be fully deconstructed by function (Fig. 9).

3.5. Ordrupgaard Museum Extension

The name of this project is "Ordrupgaard Museum Extension", and the architect is Zaha Hadid. It is finished in 2005. This case is formed by two systems, free forms and parallelograms. This study marks free forms as green, and parallelograms as red. The colors show the outer elements are free forms, and the inners are parallelogram. All sub-factors are not applied, and this case can not be deconstructed by basic geometry. According to the photos, the sub-factor, corner, is curved. The sub-factor,

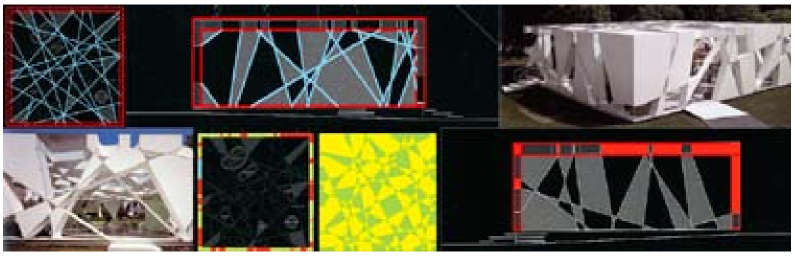


Fig. 9. The element analysis of Serpentine Gallery Pavilion 2002

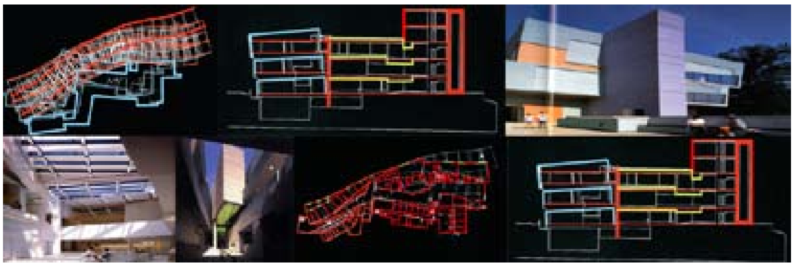


Fig. 10. The element analysis of Ordrupgaard Museum Extension

surface, is curved, too. The sub-factor, opening, has two, entrance and window. The sub-factor, site planning, is curved line and the case appears to be suspended. This case can be fully deconstructed by interface. Mark every category with colors. There are elements which cannot be defined by all sub-factors because they have multiple functions, such as wall and door. This case can not be deconstructed by function (Fig. 10).

4. Conclusions

Through the foregoing analysis, this study draws conclusions. In terms of Factor Basic geometry: non-digital architectural cases are primarily composed of basic geometries; digital architectural cases are difficult to disassemble using basic geometries. Non-digital architectural cases are made up mostly of rectangles, with few cases of round and triangular shapes, while digital architectural cases are mostly made up of free forms; any free lines intersect with each other at free angles. In terms of Factor Interface: the contact interfaces between surfaces in non-digital architectural cases are clear; the contact interfaces between surfaces in digital architectural cases are unclear. Surface-to-surface contacts in non-digital architectural cases are mostly at 90 degree angles, while those in digital architectural cases have varying angles. In terms of Factor Function: the architectural

Architect	The concept with non-digital media	The concept with digital media
Frank Gehry	(1978)	(1995)
Peter Eisenman	(1975)	(1996)

Table 3. Digital media stimulate architects to create new combination of architectural elements.

element units in non-digital cases are clear, while those in digital architectural cases are not. The architecture in non-digital architectural cases can be completely disassembled based on every function; the architectural elements analyzed in digital architectural cases can be disassembled according to the factor function, and it is because there are multiple functions not fit original definitions. This study also found that because of digital media, even the same one designer, he would create new way to arrange architectural elements. In other words, digital media also gave him a new stimulus resulting in a new combination of architectural elements (Table 3). This study also found out some components which can not be included in the existing architectural elements' definition, and redefine and called them: Digital architectural elements. Digital architectural elements include the following: curvy surface, multiple functions, and slit opening (Table 4).

(1) Curvy Surface

This study finds some features which cannot be defined by two existing architectural element factors, "basic geometry" and "interface." According to the result of case studies, the architectural element of most digital cases is curve not straight line of basic geometry, and this study named them "curvy surface."

(2) Multiple Functions

This study also finds some features which cannot be defined by the existing architectural element factor, "function." According to the functional architectural elements in digital case studies are curvy, the architects have chance to merge the functions of existing elements to one element with multiple functions, such as the combination of "floors and walls", "beams and columns" and "windows and doors," and this study named them "multiple functions."

(3) Slit Opening

There are some features which cannot be defined by three existing architectural element factors, "basic geometry", "interface" and "function." According to the result of case studies, this study found digital architects set up the spatial function in slit of surface to create new formal entrances and windows, and named them "slit opening."

This study finds out that using digital media can not only create existing architectural elements but also the new elements that could not be defined yet. The limitation is because of the case-choosing in the international magazine a+u. If the architects who never been posted in the magazine will be the blind spot of this research. My future study will choose other domains to recertify.

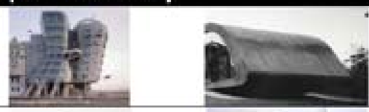
Digital architectural elements	Examples of case-study
Curvy Surface	
Multiple Functions	
Slit Opening	

Table 4. The examples of digital architectural elements

References

1. Norberg-Schulz, C. (1963). Intentions in architecture. Cambridge, Mass: MIT Press.
2. Ching, F. D. (1979). Architecture: Form, space and order. New York: Van Nostrand Reinhold.
3. Unwin, S. (1997). Analysing architecture. New York: Routledge Press.
4. Tschumi, B. (1987). Cin gramme folie: Le Parc de La Villette, Paris. Dix-neuvi me arrondissement, Princeton University Press.
5. Kalay, Y., & Marx, J. (2003). Changing the metaphor: Cyberspace as a place, CAAD Future 2003, Taiwan, 18-28.
6. Semper, G. (1851). Die vier elemente der baukunst. Ein Beitrag zur vergleichenden Baukunde. Brunswick: Smith.
7. Atkinson, R., & Banegal, H. (1926). Theory and elements of architecture. London: Benn.
8. Krier, R. (1988). Elements of architecture. London: AD publications.
9. De Luca, L., Florenzano, M., & Veron, P. (2007). A generic formalism for the semantic modeling and representation of architectural elements. Visual Computer, 23(3), 181-205.
10. Chevrier, C., & Perrin, J. P. (2008). Laser range data, photographs and architectural components. ISPRS conference, Beijing, 1113-1118.
11. Liu, Y. T. (1996). Understanding architecture in the computer era. Taipei: Hu's Press.
12. Smith, A. C. (2004). Architectural model as machine: A new view of models from antiquity to the present day. Oxford: Architectural Press.
13. Lim, C. K. (2007). A better digital design and construction process using CAD/CAM media, Ph. D. Thesis. National Chiao Tung University, Taiwan.
14. Boden, M. A. (1998). Creativity and artificial intelligence. Artificial Intelligence, 103, 347-356.
15. Manolya, K., Stephen, A. R., & Linden, J. (1998). Structure in idea sketching behavior. Design Studies 19(4), 485-517.
16. Verstijnen, I. M., Hennessey, J. M., Leeuwen, C., van Hamel, R., & Goldschmidt, G. (1998). Sketching and creative discovery. Design studies, 19(4), 519-546.
17. Chen, S. C. (2001). The role of design creativity in computer media, the 19th eCAADe conference, Helsinki, Finland, 226-231.

Kai-Hsiang Liang
Graduate Institute of Architecture, National Chiao Tung University, Hsinchu City, Taiwan

Shuo-Hsiu Hsu, Pierre Cubaud, Sylvie Jumpertz
shuohsiu.hsu@orange-ftgroup.com

Phorigami: visualization of digital photo collections by origami arts

Abstract
Issues about navigation of large photo collections have been studied for years. Associated interfaces tend to provide a single usage to deal with all kinds of photos and an integrated interface is rarely addressed. As the everyman photo collection consists of photos of various contexts, we advocate browsing different types of photos by different interaction techniques and presentation models. We present Phorigami, a photo browser based on proposed meta-categorization to enable searching by browsing. We describe the mapping between the six categories and the origami arts in terms of examining paper models with different levels of folding and the potential benefits for end-user experience is discussed in the end.

Keywords
Visualization, Origami Arts, Personal Photo Collections, Photo Browsing.

1 Introduction
For people in this age of digital explosion, building digital personal photo collections becomes indispensable due to the availability of image capturing devices, storage equipments and various internet services. The drastic growth of personal digital photos published on the online sharing services, i.e., flickr, Google Picassa or saved in personal storage devices becomes a "black hole" from the viewpoint of management. Such growth of digital contents has consequently stressed the conventional, WIMP-based, management interfaces. Organizing the digital collections through categories or themes is an evident way of reducing or filtering the information flux for users. A posteriori categorization via content analysis techniques is a very promising approach, since the production of metadata is time consuming and inefficient for large public applications. As we have described from the work of Rodden [8], one of the interface requirements is to apply task-free techniques to facilitate the photo browsing. Therefore, the task-free management techniques such as the automatic photo clustering are heavily applied to the system tools. Such techniques exploit the add-on camera metadata to support different photo clustering strategies.

2 State of the art
Information visualization systems help users to understand data by presenting the results of data analysis. The core manner of organizing digital photo collections relies on the mechanism of categorization. A categorized content can facilitate browsing, especially when users have a clear target. Automatic algorithms for photo management are known as time-based [3] [4], location-based [5], content-based [6],[7] and multiple-clustering algorithms. These algorithms focus either on visual content of photos or on its metadata to perform clustering tasks according to the user's demand. As

Rodden [8] indicates that a task-free management technique such as automatic photo clustering is one of the requirements for photo management system, researchers make the effort to explore more complex algorithms to satisfy varied demand from users. Rodden et. al [6] apply the low level content-based analysis to conduct the image clustering by similarity; however, photo clustering by similarity may not enhance the efficiency in browsing when users do not have a clear idea about the target for their search browsing. PhotoTOC [20] is integrated with time-based and content-based clustering to automatically organize digital photos according to their events. The result of their experiment confirms positive feedback about using an automatic organization technique for the management of digital photo collection. Besides, FotoFile [19] and EasyAlbum [21] are applied with an annotation and content-based analysis technique to manage people by face recognition. Schaffalitzky et al. [17] investigate with content-based image analysis to establish a relative viewpoint from unordered digital photos. In addition, Jaimes et al. [15] raise the issue of detecting non-identical duplicate photos in consumer photo collections. They propose a content-based analysis algorithm and conduct an experiment by manual classification to observe the performance of proposed algorithm; however no concrete interface is addressed in their study. All in all, the conventional management tools with automatic clustering techniques for the end user, to this day, are only used to deal with the demand in a specific situation. The relevance of these specific situations with respect to "everyman" photo collection is rarely addressed in the literature.
Photowares [16] based on content analysis techniques mainly focus on enhancing its performance of specifying queries: however their visualization and interaction techniques still rely on the traditional WIMP interface. The deficiency of traditional WIMP interface for those InfoVis tools is their limited and fixed visualization techniques that may not sufficiently support various tasks of browsing large collections. Although certain interface studies such as PhotoMesa [1], Photo tourism [18], Face Bubble [7] and the work of Porta [14] have tried to make up for this shortcoming by integrating unconventional visualization and interaction techniques into experimental photo browsers, however the visualization and interaction techniques beneficial for specific usages are still in search.

2.1 Overview of visualization techniques

The objective of visualization techniques is to feature the prominent part of the analyzed data. For years, several techniques have been proposed for different problematics of visualizing large data. The most common visualization technique for large content data is the thumbnail display that resized data units providing users with a full view of the content. However, for visual contents such as images, the drawback of a thumbnail display is the loss of informativity and visibility with the resized thumbnail presentation. The zooming techniques are therefore developed to improve the informativity and visibility of the content. Certain context+focus techniques such as fisheye, sphere visualization [9] and hypertree browser [2] allow users to keep both foreground and sideward information when zooming into a focused part. However, both fisheye and sphere effects may cause the loss of partial visual information due to image distortion. Another advanced version of the zooming technique is the zoomable interface integrated with a treemap such as PhotoMesa [1]. With the same context-focused technique, a zoomable browsing interface allows users to be less disoriented when browsing categorized data. Other context+focus techniques applied in visualizing large data can be found as perspective wall [10] and melange [11] which both apply the folding technique to make the focused part stand out. Moreover, development of visualization techniques also goes to another way of different presentation modes. The Rapid Serial Visual Presentation, RSVP [12] aims to provide an automatic presentation so that users can browse more content within a short time. The study of [13] compares different RSVP modes for photo presentation, and Porta [14] proposed varied artistic visualization techniques based on RSVP for presenting large image collections. In spite of the advantage of automatic presentation, the crucial drawback is that the fixed presentation speed (no matter fast or slow) fails to satisfy the realistic human behavior of browsing.

3 Categorization of photo collections

The drawback of current studies in automatic categorization techniques is the lack of an integrated interface to deal with varied types of photos for our everyman albums. Thus we present Phorigami, a photo browser based on the meta-categorization and origami visualization. This categorization approach encompasses

Target of photographer \ Camera	Fixed	Mobile
Fixed	A	B
Mobile	C	D
Groups(subject replacement)	E	F

Table 1. Movement of camera and focused targets.

Type	Intention of Photographer	Photo Context	Interaction Technique
A	Simple static view	Panorama	Panoramic Presentation
B	Multi-view		
C	Motion capturing	Action	Animated Photo Presentation
D	Motion capturing		
E	Groups	Social Relation	Simple Folding Presentation
F	Groups in motion and subject replacement		

Table 2. Classifications with associated contexts and interaction techniques.

the scope of current or expected recognition technologies. Our goal is not only to propose a categorization approach, but also to outline different interaction and presentation models toward different categories. Concerning the meta-categorization, the details about the experiments and the discussion of findings are presented in the associated article [25]. We then outline our meta-interface by applying different interaction techniques and origami visualization to feature each photo group.

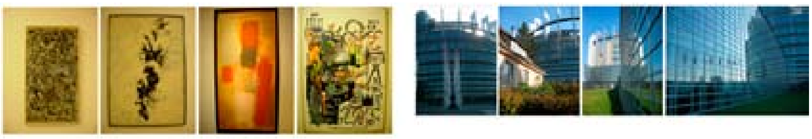


Fig. 1. Type A: Simple static view(left), Type B: Multi-view (right)

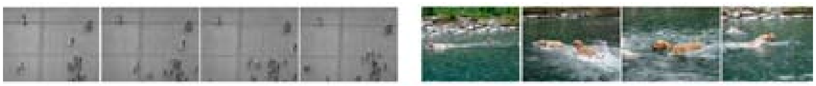


Fig. 2. Type C: Motion capturing with fixed camera (left), Type D: Motion capturing with mobile camera (right)

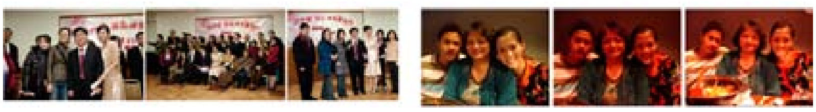


Fig. 3. Type E: Groups (left), Type F: Groups in motion(right)

3.1 Meta-categorization for everyman photo collections

We propose a meta-categorization method based on the analysis of the relative status between the camera and the focused targets. The objective of categorization is to perform an automatic organization of photo contents and to highlight different contexts in the photo collection. This proposed approach can potentially be implemented by the state of the art of content-based image analysis algorithm and camera metadata. We analyze the photo shooting in terms of two parameters: the movement of the camera and the focused targets in two states (static and mobile). A similar idea of analyzing photos by camera and photographer has been used in Jaimes et al. [15] in terms of camera, scene and image parameters to detect duplicate digital photos. In our definition, we add a third dimension called "groups" for targets, in order to include the user experience in taking group photos of reunion. The Table 1 presents the distribution of parameters and associated dimensions and six classifications are generated as A, B, C, D, E, F. We explain each classification with associated photo scenarios in Table 3. Type A refers to a scenario of a simple static view point where each single photo is focused on a static object from the same environment; for example, a user takes photos of several artworks on an exhibition and the scenario of "multi-view" in type B describes how the photographer changes the position to take a photo of each face of a static object, especially for buildings. Associated examples are illustrated in Fig. 1. Types C and D belong to the motion-capturing scenario where the photographer takes photos of a moving object. The difference between C and D depends on the status of the camera. An example of type C is presented in Fig. 2 where the photographer stays motionless to take photos of walking pedestrians with a bird's-eye view. Type D shows where the photographer moves the camera to trace an object in motion. Likewise, types E and F in Fig. 3 are the group photos of reunion. It is to be noted that type E refers to photos of a static group while photos concerning the subject replacement [15] or changes in movement are classified as type F. In addition, the double-shot or multi-shot of a digital camera on the same target are what have caused the problems in managing digital photo collections [15]. In our categorization, such double-shot photos in the same context will be possibly categorized in type B, C, D, F while the intention of the photographer is merely to take a "better" photo.

3.2 Origami visualization based on meta-categorization

We explore appropriate metaphorical mappings for our interaction techniques in terms of two directions: human experience in interacting with paper-based documents and the art of origami. When browsing a large photo collection, it is important to provide a global view of the entire content and at the same time allow users to be information-conscious toward each category. The conventional thumbnail display succeeds at providing a global view for browsing the large content; however it is space-consuming and may cause visual overloads. As we aim to feature the photo context by applying our categorization approach, each photo context is supposed to be presented by a specific visualization technique. Such visualization technique requires the visual capacity to embody the photo context via the appropriate metaphorical mapping and also requires the interaction capacity to provide users an intuitive manipulative technique.

The principle of the folding technique in origami art is to reconstruct an object via a minimal presentation. The folding technique is implemented from an everyday use to an artistic presentation. The brochure is one of the practical usages of the folding technique in the daily life (see Fig.4). The law of folding in origami art has been applied to solve problems in engineering, industrial design and scientific work [22]. The commercial products implemented with folding techniques can also be found in Rovi Liquid media guide interface launched in 2009 [23] and Scentsory-Nokia mobile phone concept [24]. The folding visualization in Rovi Liquid media guide interface tends to give users a continuous presentation for associated TV programs and multimedia contents. For the concept design of Nokia mobile phone, the objective is to enhance the mobility of the device by the folding mechanism and also to provide an innovative user interface. In the literature, the folding technique is firstly applied as a context-focus technique in Perspective wall [10] that a simple folding technique helps to feature the focused information. Similarly, the folding technique is proposed in "mélange" [11] for multi-focus interaction in a complex InfoVis system.

The goal of this folding model is to examine the capacity of the folding presentation to convey photos. We aim at the fast prototyping paper models to acquire appropriate mapping between the folding function and the photo visualization of our six categories in three contexts. Prototypes are done with folding in three levels of complexity: low, medium and high.

In Fig.5, we present certain snapshots about the development of folding ideas. We build a 4x4 block square with two themes of photos (theme of a cat and theme of trips) printed on the different side. This folding mechanism expands photos from the centre of the object and its presentation may probably correspond to the metaphor of "groups getting together". We make another folding model whose feature is minimizing the object by a vertically-extended folding mechanisms.

The original model and the photo-printed model are shown in Fig.6. We find that printed photos on the folded paper are distorted and less visible for two reasons. First, photos are less informative because they are distorted by complex folds. Second, the vertically extended folding fails to present the photo contexts in a consistent way. We consider simplifying this folding mechanism and apply it to present a series of snapshot photos in our meta-interface. Another trial of the folding paper model is shown in Fig.7 where the surface of the paper is entirely folded so that the folded presentation can be more freely manipulated. However, this folding idea fails to contribute to one of our three photo contexts due to its high freedom in folding.

For the photo context of "action", the best way to browse such kind of photos is to allow them to play as a filmstrip. The filmstrip view is broadly implemented in conventional software interfaces especially for audiovisual software. The feature of the filmstrip view is to provide a browsing window for the ongoing displayed content and a linear window to present the entire image frames; however its drawback is the requirement of sufficient space for two window displays. We trace back to the early invention used to project motion pictures. One of the early devices for displaying motion pictures is Zoopraxiscope created by Eadwear Muybridge in 1879. The image frames are printed on a glass disk, which is equal to the function of videotape. For our meta-interface, the round layout may be space consuming so that an appropriate layout for displaying the motion pictures requires to be taken into account.

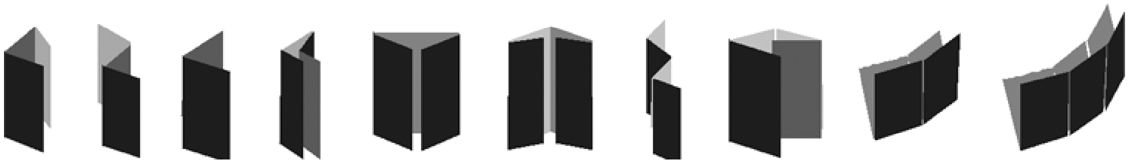


Fig.4. Different type of brochures.

Fig.5. Folding in low complexity. Unfolded (left), half-folded (middle) and folded (right).

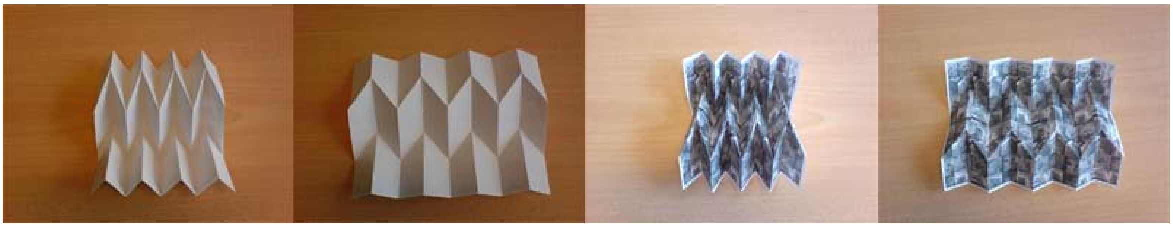


Fig.6. Folding in medium complexity: original paper model (left two), paper model with printed photos (right two).

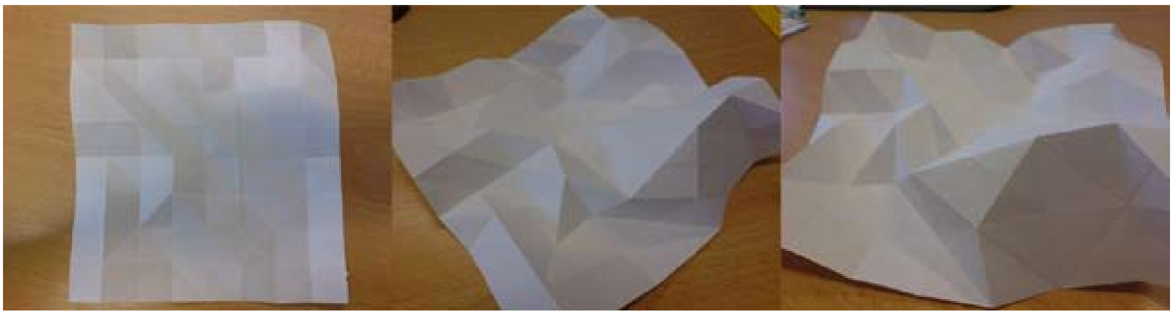


Fig.7. Folding in high complexity.

3.3 Phorigami meta-interface

Based on the idea development described above, we outline our interface, Phorigami, with different origami visualization: Accordion folding display, Rolodex display and a simple folding display, as illustrated in Fig.8.
For photos of Category A and B, we use an accordion-like folding technique to compress the space of panoramic photos into a folding mode to present an entire panoramic photo by a horizontal photo extension. The mechanism of accordion fold corresponds to the continuous photo snapshots toward a panoramic scene. For motion frames in Category C and D, the potential mechanism is supposed to manipulate motion frames like a GIF animation. Same as the automatic presentation, the related technique such as RSVP specializes in presenting images with a specific

speed; however, such preset browsing speed fails to be adapted in different contexts and may counteract the user behavior in browsing images. Therefore, we propose a "manual" Rolodex technique that users can customize the browsing speed to render the original scenario via motion photos. In addition, we simplify and refine the previously-developed idea of 4x4 block square. Due to the consideration of the layout, a center-expanded presentation may be difficult to unfold when its position is near the boundary layout. Thus a poker pile presentation is used to visualize photos of Category E and F.

It is to be noted, for a folded status, the size of each presentation model except the accordion presentation is maintained within a single square size as a thumbnail image. For poker pile and Rolodex presentation, users can learn to understand their visual representation both from the thumbnail image and the shape of presentation; however the accordion presentation fails to provide clear thumbnail image because its image content is folded. Therefore, the basic size of the folded accordion presentation is defined as two squares in order to reveal more visual messages for users to understand the photo content from the folded presentation.

We develop our interface prototype by using the Processing environment to simulate the visualization and associated interaction techniques. The three visualization models are supposed to be implemented with tactile technology to enhance the sense of manipulation toward virtual objects. As illustrated in Fig.8, users are allowed to interact with three presentation models by finger dragging or nudging. In Fig.9, we present the snapshot of Phorigami visualizing 561 photos. As illustrated, the screen space used by Phorigami is more than three times less than that used by a conventional thumbnail interface. In general, photo albums presented by Phorigami potentially present rich visualization results, which are both information-conscious and space-saving.

The potential benefits of Phorigami to the end-user experience can be supposed in two aspects: first, it may trigger the visual clues beneficial to conduct different levels of browsing, i.e., general browsing, search browsing and serendipitous browsing . Second, the meta-interface may enhance the pleasure of browsing due to providing different interaction techniques.

This prototype has been presented informally to obtain the preliminary user feedback. In general, users confirm the coherence between the categorized photos and presented visualization techniques. The accordion and Rolodex presentation are much more fascinated than the poker pile one. However, the view of folded content seems to be somehow disordered that the three presentation models fail to be highlighted and visually interfered by other uncategorized photos. The prototype may require the application of a further visual effect to rectify this deficiency. The potential solution may be to assign the categorized and uncategorized photos in different layers in order to distinguish the difference. As the formal process, the usability of the different interaction techniques and related metaphor mapping require an integral test plan to execute associated tasks to examine our interface prototype.

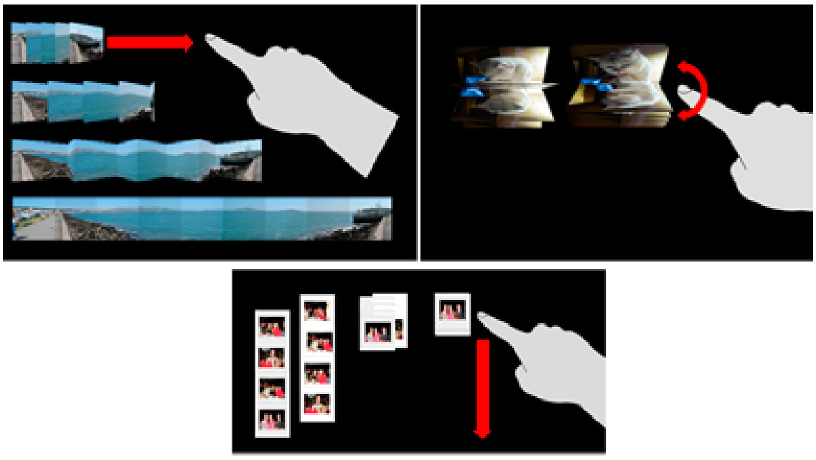


Fig.8. Accordion presentation (top left), Poker pile presentation (bottom), Rolodex presentation (top right) with dragging and nudging.

4 Conclusion

For years, the photo management system tools have evolved into more powerful algorithms that enhance the efficiency in dealing with the visual content of digital images. Different from the development based on a technology-oriented viewpoint, we come to deal with the management of digital photos from a more user-centered standpoint, envisioning a potential interface by proposing a framework for the future system. For the digital photo management, our original idea is evoked from the user experience on daily practice of photo shooting. This idea is enriched and expanded into a categorization approach based on the state of art technology.

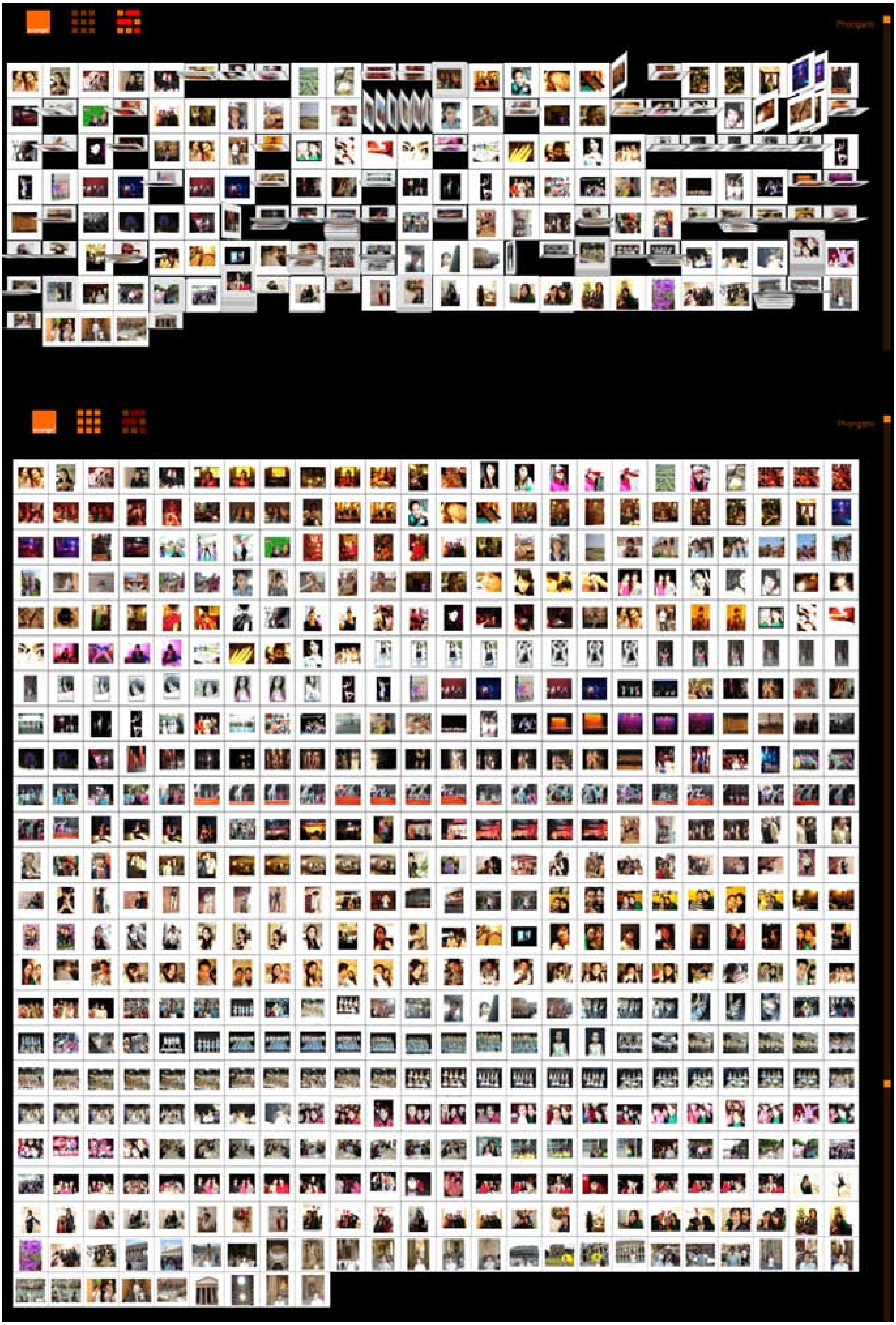


Fig.9. Visualization of 561 photos by Phorigami. The folded content view(Top) and the original content view (Bottom).

Our goal is far from a simple categorization solution but opens a vision with a user-centered interface design to facilitate the organization of digital photos. While conventional approaches are used to working on add-on techniques to facilitate photo categorization, we aim to stand out different photo contexts for photo categorization from a more user-centered viewpoint. Although nowaday system tools support photo categorization by providing diverse techniques, i.e. text tagging, time clustering and content-based analysis, we advocate conducting photo categorization via their contexts. The photo categorization data generated by clustering algorithms is entirely a posteriori while the photo context can be discerned at a glance without any added-on processing. The photo context as the complex information can be narrated in various ways by textual description but can easily be understood by visual presentations. Moreover, the photo context representing a variety of emotional clues can visually recall user's memory to render associated scenarios and stories. All in all, we confirm the importance of state of the art development in clustering algorithms and consider our user-centered interface proposal to be a potential framework to develop a future system for digital photo management. The future work will aim at the user studies on comparing Phorigami with conventional thumbnail browser, especially on the issue of serendipitous browsing.

Acknowledgments

We would like to thank Rodrigo A. B. Almeida for his opinions and the help on the development of the prototype in Processing programming. We are grateful to the anonymous referee for her/his time and efforts in providing the constructive suggestions. Thanks also go to Chia-yi Shy for the sharing of her digital photo albums as the sample collection for the demonstration of our interface design.

References

1. Bederson, B. B. (2001). PhotoMesa: a zoomable image browser using quantum treemaps and bubblemaps. Proceedings of the 14th Annual ACM Symposium on User interface Software and Technology. (pp.71-80), New York: ACM Press,
2. Lamping, J., Rao, R., & Pirolli, P. (1995). A focus+context technique based on hyperbolic geometry for visualizing large hierarchies. In I. R. Katz, R. Mack, L. Marks, M. B. Rosson, & J. Nielsen.(Eds).Proceedings of the ACM CHI Conference . (pp.401-408.) New York: ACM Press.
3. Graham, A., Garcia-Molina, H., Paepcke, A., & Winograd, T. (2002). Time as essence for photo browsing through personal digital libraries. Proceedings of the 2nd ACM/IEEE-CS Joint Conference on Digital Libraries (pp. 326-335). New York: ACM Press.
4. Harada, S., Naaman, M., Song, Y. J., Wang, Q., & Paepcke, A.(2004). Lost in memories: interacting with photo collections on PDAs. Proceedings of the 4th ACM/IEEE-CS Joint Conference on Digital Libraries (pp. 325-333). New York: ACM Press.
5. Toyama, K., Logan, R., and Roseway, A.(2003). Geographic location tags on digital images. Proceedings of the Eleventh ACM international Conference on Multimedia (pp. 156-166). New York: ACM Press.
6. Rodden, K., Basalaj, W., Sinclair, D., & Wood, K.(2001). Does organisation by similarity assist image browsing? Proceedings of the ACMCHI Conference (pp.190-197). New York: ACM Press.
7. Xiao, J. & Zhang, T. (2008). Face bubble: Photo browsing by faces. Proceedings of the Working Conference on Advanced Visual interfaces (pp.343-346). New York: ACM Press.
8. Rodden, K. (1999). How do people organise their photographs? Proceedings of BCS-IRSG Annual Colloquium on IR Research
9. Christmann, O. & Carbonell, N. (2006). Browsing through 3D representations of unstructured picture collections: an empirical study. Proceedings of the Working Conference on Advanced Visual interfaces (pp.445-448). New York: ACM Press.
10. Mackinlay, J. D., Robertson, G. G., & Card, S. K. (1991). The perspective wall: Detail and context smoothly integrated. In S. P. Robertson, G. M. Olson, & J. S. Olson, (Eds). Proceedings of the ACM CHI Conference (pp.173-176). New York: ACM Press.
11. Elmqvist, N., Henry, N., Riche, Y., & Fekete, J.(2008). Melange: Space folding for multi-focus interaction. Proceeding of ACM CHI Conference (pp.1333-1342). New York: ACM Press.
12. Spence, R. (2002). Rapid, serial and visual: A presentation technique with potential. Information Visualization, 1(1),13-19.
13. Cooper, K., de Bruijn, O., Spence, R., & Witkowski, M. (2006). A comparison of static and moving presentation modes for image collections. Proceedings of the Working Conference on Advanced Visual interfaces (pp.381-388). New York: ACM Press.
14. Porta, M. (2006). Browsing large collections of images through unconventional visualization techniques. Proceedings

of the Working Conference on Advanced Visual interfaces (pp.440-444). New York: ACM Press.
15. Jaimes, A., Chang, S. F., & Loui, A. (2003). Detection of non-identical duplicate consumer photographs. Proceedings of the Fourth Joint Conference Pacific Rim conference on Multimedia (pp.16-20). Singapore: IEEE Press.
16. Kirk, D., Sellen, A., Rother, C., & Wood, K. (2006). Understanding photowork. In R. Grinter, T. Rodden, P. Aoki, E. Cutrell, R. Jeffries, & G. Olson (Eds). Proceedings of the ACM CHI Conference (pp.761-770). NewYork: ACM Press.
17. Schaffalitzky, F., & Zisserman, A. (2002). Multi-view matching for unordered image sets, or "How do I organize my holiday snaps?". In A. Heyden, G. Sparr, M. Nielsen, & P. Johansen (Eds.), Proceedings of the 7th European Conference on Computer Vision-Part I (pp.414-431). London: Springer-Verlag.
18. Snavely, N., Seitz, S. M., & Szeliski, R. (2006). Photo tourism: Exploring photo collections in 3D. ACM SIGGRAPH 2006 Papers (pp.835-846). New York: ACM Press.
19. Kuchinsky, A., Pering, C., Creech, M. L., Freeze, D., Serra, B., & Gwizdka, J. (1999). FotoFile: A consumer multimedia organization and retrieval system. Proceedings of the ACM CHI Conference (pp.496-503). New York: ACM Press.
20. Platt, J., Czerwinski, M., & Field, B. (2003). PhotoTOC: Automatic clustering for browsing personal photographs, Proceedings of the Fourth Joint Conference Pacific Rim conference on Multimedia (pp.6-10). Singapore: IEEE Press
21. Cui, J., Wen, F., Xiao, R., Tian, Y., & Tang, X. (2007). EasyAlbum: An interactive photo annotation system based on face clustering and re-ranking. Proceedings of the ACM CHI Conference (pp.367-376). NewYork: ACM PRess.
22. Robert Lang. Idea + Square = Orgami.(n.d.). Retrieved November 20, 2008, from http://www.ted.com/index.php/talks/robert_lang_folds_way_new_origami.html
23. Rovi Liquid media guide interface. (n.d.). Retrieved July 16, 2009, from http://content.techrepublic.com.com/2346-1035_11-321318.html
24. Nokia scentsory. (n.d.). Retrieved October 10, 2008, from http://www.intomobile.com/2007/05/21/nokia-scentsory-cellphone-concept.html
25. Hsu, S. H., Cubaud, P., & Jumpertz, S. (2009). Phorigami: A Photo browser based on meta-categorization and origami visualization. International conference on human-computer interaction (pp.801-810). Berlin Heidelberg: Springer-Verlag.

Shuo-Hsiu Hsu,
Sylvie Jumpertz,
Orange Labs, Cesson Sévigné Cedex, France

Pierre Cubaud
CNAM-CEDRIC,
Paris, France

Andre Liem, Shahriman Zainal Abidin, Anders Warell
Andre.Liem@ntnu.no

Designers' perceptions of typical characteristics of form treatment in automobile styling

Abstract
Automobile styling is a complex discipline where the designers' recognition is determined by visual elements of the car and characteristics that establishes the expressive properties of the overall form. The objective of this study is three-fold. The first objective is to find out how recognition is formed by visual elements of the car. The second objective is to determine what form characteristics are important for creating expressive properties of product form. The third objective is to find out what words are generally used by designers to describe expressions of car designs, specifically based on a word list and images of cars. This has led to the following implications:

1. The identification of general perceptions of car designers, which are most relevant for automobile styling.
2. The development of an understanding on how these perceptions, expressed as adjectives, influences or can be used as a basis for selecting a range of factors and characteristics typically used in car design, such as form features, form elements, and form principles.
3. The exploration of applying selected bi-polar adjectives as spectra for morphing.

The study has shown that there are valid correlations between selected designers' perceptions and form elements/car components of an automobile. This justifies the search on how these selected designers' perceptions can be used as a foundation for automobile styling.

Keywords
Automobile Styling, Car Components, Designer Perceptions, Form Elements, Form Features.

1 Introduction
Because of Modernism's paradigm about functional problem solving and "form follows function", styling has been relegated to an unnecessary evil. However, styling plays a strategic, communicative role in design, especially for product differentiation when an industry moves into its mature phase [1, 2].
In the matured automobile market, designers are challenged by differentiating car models based on a common platform; the task is usually two fold: at corporate brand level, the designer needs to continue and strengthen a specific brand image; and, at the product brand level, the designer seeks to create novel and distinct characters for a car model. The brand and model image can be manipulated by design via the use of visual elements, which consists of design features to identify a brand and design features for specific models to emphasize individuality [3, 4].
Karjalainen's work [4], noted that explicit visual references are embedded in the design features designers implement with the intention to be immediately perceived and recognized. For example, Volvo has defined explicit design cues that are used consistently over their entire product portfolio.
These include the strong 'shoulder' line, the V-shaped

bonnet, the characteristic front with soft nose and diagonal Volvo logo, the rear with its distinctively carved backlight, the flowing line from roof to boot-lid, and the third side window. Previously, Warell [5] developed qualitative methods to identify and assess such characteristic elements, which may have syntactic or semantic roles in product design.

In daily life, people like to use image words based on the aesthetic features such as 'beautiful' and 'ugly' [6] to invoke moods in an object or a product. However, the psychological problem focused on the fact that image perceptions or mental feelings for a product are full of fuzziness and uncertainties. Traditionally, this mental recognition problem with high fuzziness is usually solved by the designer based on his/her intuitive feeling, experience, inspiration from artistic works, and habit. Later these intuitive feelings were formalized and structured through Kansei Engineering where consumer feelings and demands were used to design a new product [7].

Within the field of automobile design, fuzzy set theories and consumer-oriented Kansei engineering techniques were applied to analyze the results of consumer surveys and determine the relationships between image and shape-regulating words and car styles [8]. Also, fuzzy set theories in conjunction with weighted mean and weighted generalized mean methods have been used to merge multiple beta-spline models of automobiles [9]. A weakness of these techniques is that they can only produce forms that are a combination of prior forms i.e., they are interpolative rather than creative [10].

2 Automobile styling based on designers' perceptions and morphing

According to Tovey, the design of motor cars is almost always evolutionary, where designs do not change radically from one model to the next. The basic elements and components, such as wheels, seating position, engine, etc. remain the same [11]. This has allowed the industry to structure its design to manufacturing processes in a very compartmentalized and sequential way, with a number of specialist inputs being involved. More particularly than in any other product area the industrial design activities have also become highly specialized and focused towards determining the appearance and identity of the product. Until quite recently they were generally referred to as automobile stylists.

According to Kimura (1997), in the near future, innovation may happen through styling based on technological trends, inevitably changing product development processes. For automobile styling the following very clear trends of evolution can be identified [12]:

(a) Total time period required for design has been steadily reduced. However, the most important difference between past and future is not the reduction of time, but the change of the relative importance of each design process phase. In the past, design detailing and final drawing took a major portion of the design work, whereas, in future, planning and concept design will take most of the time, and especially drawing work can be eliminated due to the complete shape modeling in detailed design phase.

(b) The usage of Computer Aided Design (CAD) systems will be expanded up to the planning phase, and the total design process will be integrated by CAD-based digital models. Nowadays, much repeated data input is necessary, because each phase is supported by different CAD systems.

(c) Manufacturing consideration will be initiated from the phase of planning. This activity will be very effective for reducing the total time required for quality of body engineering.

According to Edson, automotive designers, in order to have control of the complex sculptural forms, imagine shapes in a mental space while they conceive them [13]. This simulation by visualization of the imagined real space establishes the field in which the conceptualization takes place. It can be said that the mental process goes back and forth in this space, as if the designer was trying to grasp it mentally as well as physically. It also appears that the space itself seems to undergo a distortion, a blur, as if ideas oscillated through themselves.

In embodying the concept of connecting the relationship between products and their images, several methods such as fuzzy theory, multidimensional scaling (MDS) methods were proposed [14, 15]. Although they can be used to design a product with a given image, they cannot yet be used to predict the image of a new shape generated with original shapes.

Form can be generated by analyzing human responses to shapes and thereby defining the transformations between descriptive words and shape. For example, assessment of what a product is (semantic interpretation), may influence judgments on the elegance of a design (aesthetics impression) and the social values it may connote (symbolic association) [16]. In a sense, words are the ultimate high-level form operators and constitute a common language for all of the participants of the conceptual design phase: designers, engineers, marketers and test consumers. Unfortunately, the compactness of verbal expression also leads to ambiguity.

3 Automobile Representation

As stated in the previous section, there has been a lack of discussion related to automobile representation. No clear explanation concerning intentions emerges from literature studies. However aesthetics, semantic and symbolic aspects as well as the uses of sketches as means of representation are important to be defined. According to Crilly [16], designers' tacit understanding of perception and visual composition often guide their intuitive judgements [17, 18]. In car design, the designers use their skills, training and experience to design automobiles that induce a positive aesthetic impression. Indeed, there are those who feel and perceive that intuitive creativity is all that is required for the production of visually attractive products contrary to a scientific approach, which is not relevant for understanding the problem. This view may be reinforced by the discovery that very few of the scientific studies have led to generalisations which are useful for students or practitioners of design [19]. However, designers and consumers often interpret products differently and express different aesthetics preferences [20]. Thus, although styling is the 'artistic' part of product design, it must still be directed towards opportunities and held within constraints [21]. As such, Coates suggests that correlating consumer perceptions with product features may align product designs better with consumers' aesthetic preferences [22].

In the automobile industry, a semantic approach to design emphasises on the opportunity for consumers to interpret a product's utility and associated qualities. Krippendorff [23] thus proposes that "design is making sense (of things)" and that designers should facilitate the user in correctly interpreting the product. To assist designers in this mission, Butter [24] has suggested a sequence of activities that integrate semantic considerations into the design process.

The key stages of the process are: firstly, to establish the overall semantic character that the product should communicate; secondly, to list the desired attributes which should be expressed; and thirdly, to search for tangible manifestations capable of projecting the desired attributes through the use of shape, material, texture and colour [24]. Not only has knowledge of semantic principles been shown to improve the clarity of students' designs [25, 26], but commercially successful products have also been produced with explicit consideration given to their semantic character [27]. For designing a new product, Opperud states that "it is the designer's job is to decode the common values and opinions that exist in a culture, and reproduce them into forms that embody the appropriate symbolic meaning [28]."

Once the form is defined, curves characterizing and structuring the car embodiment are considered most important. In the profile view, these curves are for example the roof line; the waist (or belt) line and the front and rear panel overhangs. By definition, the waist line is the curve dividing the side windows and the body side, while the overhang is the distance between the front/rear part of the car and the centre of the wheel. In practice, rather than the waist line, a curve (the accent line) just below is considered for the character evaluation. Actually, the accent line may be a light line; a curve only perceived when light is reflected. In fact, it is a common habit for stylists to work with all of these characters.

4 Research Objective

The purpose of this research is to study the designers' perceptions of characteristics of form treatment in automobile styling. Research objectives are three-fold:

1. To find out how recognition is formed by visual elements of the car.
2. To determine what form characteristics are important for creating expressive properties of product form.
3. To find out what words are generally used by designers to describe expressions of car designs, specifically based on a word list and images of cars.

5 Research Method

According to Patton [29] the purpose, use, credibility and available resources also dictated the size of sample. Representatives rather than scale were primary

Figure 1. Five Views of a Sedan Car: Proton Waja

concerns as indicated by Oppenheim [30] and Erdos [31]. The structure of questionnaire depends on different aspects such as purpose, respondent group [31]. In this research a survey questionnaire was used to better understand designers' perceptions of characteristics of form design in automobile styling. Type of respondents and survey questions will be further elaborated in this chapter.

5.1 Type of Respondents

In this study, 46 practicing vehicle designers, vehicle design students and educators participated by responding to a survey questionnaire. A majority of the practicing designers were from Malaysian vehicle manufacturers, such as Proton, Perodua, NAZA Automotive Manufacturing, Modenas, Proreka (M) Sdn. Bhd., and Norwegian company Inocean AS. Students and educators were from United Kingdom (Coventry University, Royal college of Art), Sweden (Umeå University), Norway (Norwegian University of Science and Technology) and Malaysia (Universiti Teknologi MARA).

Several studies have classified respondents based on their expertise. For example Popovic has categorized expertise of design students engaged in a five year program according to three levels: Novice, Intermediate and Expert [33]. Bouchard considered experts professionals currently working in the branch, intermediate experts the students having acquired a concrete skill in car styling by the participation in several industrial projects, and the novice students those who have not yet acquired concrete experience in the field [34]. In this study, respondents were classified in four categories according to their level of experience and occupation (Table 1):

a. Novice: student, educator or practitioner with less than 5 years working experience in industry.
b. Intermediate: educator or practitioner with 5 to 10 years working experience in industry.
c. Senior: educator or practitioner 8/10 to 15/18 years working experience in industry.
d. Expert: educator or practitioner with more than 18 years working experience in industry.

		Experience in design				
		Novice (Less than 5 yrs)	Inter-mediate (5 - 10 yrs)	Senior (8/10 – 15/18 yrs)	Expert (above 18 yrs)	Total
Occupation	Student	14	0	0	0	14
	Academic	0	0	0	1	1
	Practitioner	21	1	7	1	30
	Others	0	1	0	0	1
Total		35	2	7	2	46

Table 1. Level of design experience and number of occupation among the respondents

5.2 Survey Method

A standard questionnaire of nine questions were presented and grouped into 3 sections, each section comprising of 3 questions. The questionnaire employed a combination of qualitative and quantitative questions, including categorical multi choice questions, open ended questions and a combination of these, as well as Visual Analogue Scales (VAS). If required, respondents were guided through the questionnaire by the interviewer, who clarified the meaning if any uncertainties occurred. The first section aims to study the common characteristics of a car [35]. Because of practical and popular reasons, the image of a Malaysian Sedan car model of Proton Waja has been selected. According to the Automobile Magazine (2009, April 27), Sedan reviews, sedan cars are still the majority worldwide [36].

In the first question, respondents were asked to indicate which view they consider as most important for car recognition (see Figure 1). In the second question respondents were asked to indicate, according to Figures 2A and 2B, which components were considered to be essential in determining the recognition of a car.

With reference to question three, it has been found that many researchers studying form totality, whether art-based or science-based, have adopted the properties of Point, Line, Plane or surface and Volume as basic form elements [6, 37, 38]. Respondents were encouraged to rate the importance of each form element according to its ability to convey a certain perception. In order

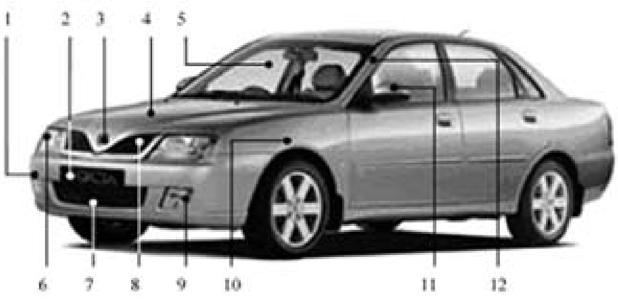


Figure 2A. Selected Car Components on 3 quarter front view. Note: (1) Front bumper; (2) Front plate number; (3) Emblem; (4) Hood panel; (5) Windscreen; (6) Head lamp; (7) Air intake; (8) Radiator grill; (9) Fog lamp; (10) Fender; (11) Side mirror; (12) A-pillar.

Figure 2B. Selected Car Components on 3 quarter rear view: Note: (13) Tail lamp; (14) Trunk lid; (15) Rear emblem; (16) 3rd brake light; (17) C-pillar; (18) B-pillar; (19) Rear bumper; (20) Exhaust; (21) Rear plate number; (22) Body trim; (23) Side signal; and (24) Wheel.

to make the respondents understand the terminology, a geometrical explanation for each form element was provided.

In section 2 of the questionnaire, emphasis was placed on how features, as a tool to verbalize the perception of a car, are used in the understanding of form principles and form elements. In question six, a Semantic Differential Style has been used. We explored the words based on adjectives. In addition, the words are not necessarily 'contradictive' in meaning. The questions supporting this section were formulated as follows:

Question 4: How do you rate the following principles of form in association to the perception of a car, according to a five point scale (not important – extremely important)?

Question 5: How do you rate expressive value of specific form features in design, supported by form elements, such as curve, line, and surface?

Question 6: To what extent do you disagree or agree that the following bi-polar adjectives can be used in the design of the car and its form elements?

In section 3, Question 7 respondents were asked to indicate a perception when presented with the front, side and rear view of 36 images of different types of cars, sub-divided into 12 front view, 12 side view and 12 rear view images. The cars were heuristically selected by the researchers.

6 Data Analysis

Data was statistically analyzed directly as well as indirectly using a Statistical Package for the Social Sciences (SPSS) version 15 for Windows. Frequency distribution tests were conducted for the direct analysis of each individual question. In addition Chi-Square tests were run for section 3. For the indirect analysis, mainly correlation tests based on bi-variate statistics were conducted to evaluate the relationship among the five views, among selected car components, between form elements and perceptions based on pre-selected car models, between form features and bi-polar adjectives, between car components and form features, and between car components and bi-polar adjectives (Table 2). In order to test the reliability of this questionnaire, the reliability statistics model of Cronbach's Alpha have been used [39]. Cronbach's Alpha is a reliability coefficient that indicates how well the internal consistencies of items in a set are positively correlated to one another. It shows that the analysis results for this questionnaire are high at 0.862.

Base software	Test	Descriptions
Descriptive statistics	Frequency distributions	A frequency distribution is a display of the frequency of occurrence of each score value.
Bivariate statistics	Correlations	A Pearson product-moment correlation coefficient describes the strength and direction of a linear relationship between two continuous variables.
	Chi-Square test (non-parametric test)	The best-known situations in which the chi-square distributions are used are the common chi-square tests for goodness of fit of an observed distribution to a theoretical one, and of the independence of two criteria of classification of qualitative data.

Table 2. Statistical Test conducted for this research

6.1 Findings

The first section shows that 63% of the respondents consider the three quarter front view as providing the strongest recognition of a car (i.e., brand, type of car, category, properties, country of origin, or other characteristics). However out of the selected 24 components for the car, five components were considered essential in determining the car recognition.

These components are Front emblem (50%), Head lamp (80%), Radiator grill (80%), Tail lamp (89%), and Rear bumper (58%).

Form Elements	Important	Very important	Extremely important
Point	45.7	13.0	6.5
Line	8.7	34.8	54.3
Plane or Surface	26.1	37.0	32.6
Volume	26.1	19.6	52.2

Table 3. Frequency distribution of importance ratings of Form Elements

When considering the ability of each form element to convey a certain perceptions. It shows that all form elements were rated between "important" to "extremely important" (see Table 3). However the relative percentage of frequency distributions indicate that Line (97.8%) and Volume (97.9%) followed by Plane/ surface (95.7%) are most important in determining the perceptions of a car.

Many automotive designers use form elements and the manipulation of principles of form when developing and communicating the main form of the vehicle or its components [40, 5].

Principles of Form	Important	Very important	Extremely important
Unity and variety	37.0	41.3	10.9
Balance	10.9	45.7	41.3
Emphasis v. subordination	52.2	30.4	13.0
Directional forces	30.4	41.3	21.7
Contrast	39.1	30.4	10.9
Repetition and rhythm	34.8	37.0	17.4
Scale and proportion	4.3	21.7	73.9

Table 4. Percentage of Principles of Form rated by designers

In section 2, it was found that the use of form elements needs to be added with the understanding of the principles of form. Based on a rating between "important" to "extremely important" (see Table 4), a percentage of frequency distributions indicate that balance, directional forces, and scale and proportion are the most important principles of form of a car. This finding is important as it provides evidence to principles that car designers colloquially mention as essential. It is also interesting to note that all principles rate very high in accumulated score; however it is not unexpected, because all form principles used by designers would probably be rated as at least "important," or other wise they would not be used by designers.

Form Features	Important	Very important	Extremely important
Accelerate (curve, line, surface)	26.1	37.0	34.8
Arc	34.8	34.8	17.4
Bevel	41.3	28.3	17.4
Bone	41.3	34.8	17.4
Chamfer	34.8	39.1	10.9
Crease	43.5	37.0	13.0
Cut-line	37.0	34.8	17.4
Edge	43.5	34.8	13.0
Fillet	34.8	41.3	10.9
Flush	37.0	30.4	23.9
Radius	32.6	26.1	32.6
Taut	39.1	30.4	15.2

Table 5. Percentage of Selected Form Features rated by designers

To assess the expressive value of "form features", twenty eight form descriptive terms were selected and adopted from Saunders [41]. Of course, the types of form features which are more frequently or consistently used depends on the type of design format/style (given by brand identity, expression, form language, etc) employed in a particular car design. The ratings given only provide an understanding of perceptions of car designers regarding general (across typical car designs on the market) or possibly individual (given by the style of each designer) tendencies for the use of certain form features in car design. All form features were considered "important" to "extremely important" (see Table 5). However a selected number of form features show a high cumulative percentage and above 10% score on "extremely important." It seems that the form feature "accelerate" is highly rated compared to the others, as it denotes a behavior of compositions of form features, rather than being a form features itself.

To find out whether bi-polar adjectives can be used in the design of the car and its form elements, forty eight of them were heuristically selected or derived from other sources such as Semantic Differential [42, 43]. The findings indicate that 38 bi-polar adjectives are commonly being used by car designers when expressing their feeling about the car. Out of these 38, the following 15 bi-polar adjectives with accumulative score above 80% or above 30% score for "strongly agree" are being favored (see Table 6). It is interesting to note that dynamic – static, feminine – masculine, and aggressive – submissive are the strongest rating bi-polar adjectives, which seem to correspond to common perceptions of modern cars. The designers' response to this question may be interpreted as indicating that a continuum of perceptions of form characteristics, as described by the

extreme bi-polar endpoints given by the adjectives, are commonly used in car design.
Three bi-polar adjectives were considered neutral among the respondents. They are charming – displeasing, cheerful – sad, and intelligent – stupid.
However, the following adjectives have been rejected by the respondents: cheeky – backward, contempt – not contempt, disgusted – not disgusted, gorgeous – plain, happy – unhappy, pleasant – annoyed, sleepy – alert, stupid – smart, truthful – exaggerated and worried – assured.

Bi-polar Adjectives	Agree	Strongly agree
Aggressive – submissive	37.0	52.2
Avant-garde – conservative	41.3	39.1
Contemporary - traditional	43.5	37.0
Dynamic – static	39.1	56.5
Elegant – not elegant	39.1	45.7
Excited – bored	52.2	28.3
Exclusive – inclusive	34.8	45.7
Feminine – masculine	39.1	56.5
Futuristic – nostalgic	39.1	47.8
Heavy – light	54.3	32.6
Innovative – imitative	50.0	37.0
Simple – complex	58.7	34.8
Streamlined – rugged	34.8	50.0
Strong – weak	52.2	34.8
Soft – hard	43.5	41.3

Table 6. Percentage of Set of Bi-polar Adjectives for car perceptions rated between "strongly agree" to "agree"

With regard to section 3, where adjectives, representing designer perceptions, were correlated to specific car models and their respective images from the front, side and rear view, it can be concluded that all 36 images evoke certain perceptions. For all three views a high standard deviation and broad range between minimum and maximum is noticed, which means that the perceptions of each designer are highly variable.
In order to study the perception of individual designer with an image of the car, we have made an open-end question with provided images of the car randomly. Since the answers by the designers' are varied, the best test for the analysis is using the Chi-square test, the test uses to analyze abnormal data based on individual interpretations or non-consistencies of individual answer. The verbs expressed by the respondents were analyzed using descriptive statistics based on percentage of frequency distributions and bi-variate statistics based on Chi-Square test for goodness of fit (non-parametric techniques). An example of the test results is shown in Table 7.

To verify whether the 3 quarter front view is the only significant view for the recognition of a car, a correlation was conducted among all views. Based on a negative 2-tailed correlation (Pearson -0.419(**)) it can be specifically noted that there is no relationship at all between the three quarter front view and front view in determining the recognition of a car, which means the designer did not reflect or respond on that view. We have assumed that the recognition would refer to one brand (recognition as an identity mode is based on the iconic sign, i.e. recognition through similarity/likeness to something seen before), while the other view would to some other brand, or not to any brand at all. It may also refer to identification of (other) characteristics of cars. It seems reasonable to assume that recognition of type (of product), i.e. categorization in terms of e.g. type of car such as sedan, family, or micro car, would not be dependent on the view, as car designers are familiar with design characteristics for different types of cars.

Image	Model	N	Mean	Std. Dev.	Min	Max
	Volkswagen New Beetle	38	71.29	43.724	5	157
	Citroën DS	41	69.80	54.292	3	160
	BMW 3 Series	39	80.82	51.573	3	156
	Smart Fortwo	39	64.23	33.736	24	111
	Mini Cooper S	40	79.58	36.309	4	122
	Mitsubishi Galant Fortis	41	77.15	41.314	2	120
	Volvo S80	40	99.75	37.955	1	142
	Audi TT	37	85.00	44.487	2	125
	Volkswagen New Beetle	39	65.38	42.874	6	132

Table 7. Example of test results where images of cars in front, side and rear view are assessed on their expressive qualities.

The study revealed that "front emblem", "head lamp", "radiator grill", "tail lamp", and "rear bumper" are significant components for determining the recognition of a car. A positive 2 tailed correlation test shows that head lamp, radiator grill and tail lamp have strong relationships in jointly determining the recognition of a car (see Table 8). It should be noted that this result might reflect the general opinion of designers regarding which components are typically important for (brand) recognition. However, it is easy to imagine car design where other form features, such as bone lines or characteristic curves, may be used to create the same references to brand characteristics.

The correlation test between the form elements and the perceptions of the car based on specifically provided images has led to the following findings. Reference to the front view (see Table 9), Chevrolet Camaro and Line are positive 2-tailed correlation (Pearson 0.524(**)) based on the perceptions of aggressive,

		Head lamp	Radiator grill	Tail lamp
Head lamp	Pearson Correlation	1	.171	.356(*)
	Sig. (2-tailed)		.255	.015
	N	46	46	46
Radiator grill	Pearson Correlation	.171	1	.708(**)
	Sig. (2-tailed)	.255		.000
	N	46	46	46
Tail lamp	Pearson Correlation	.356(*)	.708(**)	1
	Sig. (2-tailed)	.015	.000	
	N	46	46	46

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 8. Correlations among Significant Components

		Point	Line	Plane or surface	Volume
Chevrolet Camaro (Aggressive, confidence, cheerful, futuristic)	Pearson Correlation	,213	,524(**)	,312(*)	-,018
	Sig. (2-tailed)	,193	,001	,050	,910
	N	39	39	40	40
Aston Martin DB9 (Aggressive, confidence, elegant, speed)	Pearson Correlation	-,123	,361(*)	-,014	-,070
	Sig. (2-tailed)	,475	,030	,935	,680
	N	36	36	37	37
Ford Cougar (Aggressive, dynamic, happy, odd, ordinary)	Pearson Correlation	,133	,405(*)	-,106	-,054
	Sig. (2-tailed)	,441	,014	,531	,753
	N	36	36	37	37
Mitsubishi Lancer (Aggressive, anger, confidence, brave)	Pearson Correlation	-,435(**)	,261	-,067	-,125
	Sig. (2-tailed)	,006	,113	,683	,448
	N	38	38	39	39

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 9. Correlations between the Form Elements and the Expressions of Car Front View

confidence, cheerful, and futuristic, whereas the same car and Plane or Surface indicate a positive 2-tailed correlation (Pearson 0.312(*)) based on the perceptions of aggressive, confidence, cheerful, and futuristic. Aston Martin DB9 and Line are positive 2-tailed correlated (Pearson 0.361(*)) based the perceptions of aggressive, confidence, elegant, speed; whereas Ford Cougar and Line show a positive 2-tailed correlation (Pearson 0.405(*)) based on the perceptions of aggressive, dynamic, happy, odd, and ordinary.

Reference to the side view (see Table 10), Lotus Elise and Line are positive 2-tailed correlated (Pearson 0.460(**)) based on the perceptions of dynamic, sporty, fast, and streamlined; Jaguar XK Coupe and Line are positive 2-tailed correlated (Pearson 0.405(**)) based on the perceptions of sleek, aerodynamic, classy, contemporary, streamlined. Toyota Yaris and Line are positive 2-tailed correlated (Pearson 0.398(*)) based on the perceptions of cute, cheeky, compact, contemporary, smart. This means that "Lotus Elise and Line," "Jaguar XK coupe and Line," and "Toyota Yaris" show strong relationships between the form elements and perceptions based on specific car models.

A negative 2-tailed correlation has been found between Jaguar S-type and Point based on the perceptions of elegant, exclusive, formal, traditional; between Mercedes E-class Wagon and Volume based on the perceptions of elegant, bulky, exclusive, family, and long; between BMW 1 Series and Volume, and between Smart Fortwo and Point based on the perceptions of dynamic, aerodynamic, and smart. This means that "Jaguar S-type and Point," "Mercedes E-class Wagon and Volume," "BMW 1 Series and Volume," and "Smart Fortwo and Point" show no relationships between the form elements and perceptions based on specific car models.

For the Rear view (see Table 11), only a positive 2-tailed correlation (Pearson 0.327(*)) can be found between Lotus Elise and Line based on the perceptions of dynamic, sporty, fast, and streamlined, indicating a strong relationship between the form elements and perceptions. This means that reference to the front, side and rear views strong relationships can be found between certain form elements and car perceptions based on selected car images.

When analyzing the relationship between 28 form features and all 48 bi-polar adjectives, a positive 2-tailed correlation can be found between 11 bi-polar adjectives and 17 form features. The pairing between the respective bi-polar adjectives and form features is shown in Table 12.

Correlation tests were conducted between all 24 car components and 28 form features (see Table 13). A positive 2 tailed correlation is found for "Rear bumper and Blister" and "Head lamp and Radius", indicating strong relationships between these components and form features. A negative 2 tailed correlation is found for "Front emblem and Coke-bottle/wasp-waist", "Front emblem and Cut-line", "Tail lamp and hollow", and "Front emblem and Taut", indicating that there is no relationship at all between these form features and car components.

Chen et al. have applied Conceptmorph and Conjoint Analysis to explore a large number of shapes by modifying the entire car or its components on spectra of bi-polar adjectives [44]. However, components and bi-polar adjectives were randomly selected. In this study, an attempt to correlate 24 car components with the 48 bi-polar adjectives has only a surfaced a positive 2 tailed correlation between "Front emblem and Intelligent-stupid" (Pearson 0.306(*)). However, "Intelligent-stupid" is not part of the list of popular bi-polar adjectives.

7 Discussion

It is a common practice in car design as well as other product categories to "borrow" characteristic features from already existing products, in order to emphasize design heritage, product and brand identity, and recognition, thus providing a visually characteristic form and a consistent design format [5]. These tendencies has evoked the interest of the researchers to conduct a more fundamental study on how designer perceptions can be used as a basis for automobile styling by correlating selected adjectives with form elements and car components.

According to Tovey, Porter, and Newman who undertook an analysis of the content of a number of automotive sketches with the intention of categorizing the visual components, and determining which are the most important in communicating 3D form,

		Point	Line	Plane or surface	Volume
Lotus Elise (Dynamic, sporty, fast, streamlined)	Pearson Correlation	,080	,460(**)	,135	-,256
	Sig. (2-tailed)	,637	,004	,419	,121
	N	37	37	38	38
BMW 1 Series (Dynamic, Aerodynamic, smart)	Pearson Correlation	-,061	-,086	-,075	-,382(*)
	Sig. (2-tailed)	,717	,606	,651	,016
	N	38	38	39	39
Jaguar XK coupe (Sleek, aerodynamic, classy, contemporary, streamlined)	Pearson Correlation	,099	,405(**)	,154	-,027
	Sig. (2-tailed)	,542	,010	,336	,868
	N	40	40	41	41
Smart Fortwo (Cute, compact, fun, static, intelligent)	Pearson Correlation	-,337(*)	,137	-,027	-,196
	Sig. (2-tailed)	,039	,411	,871	,232
	N	38	38	39	39
Toyota Yaris (Cute, cheeky, compact, contemporary, smart)	Pearson Correlation	,009	,398(*)	,238	-,228
	Sig. (2-tailed)	,955	,011	,133	,152
	N	40	40	41	41
Jaguar S-type (Elegant, exclusive, formal, traditional)	Pearson Correlation	-,450(**)	,029	-,036	-,289
	Sig. (2-tailed)	,004	,859	,825	,067
	N	40	40	41	41
Mercedes E-class Wagon (Elegant, bulky, exclusive, family, long)	Pearson Correlation	-,188	,087	-,034	-,399(**)
	Sig. (2-tailed)	,238	,590	,833	,009
	N	41	41	42	42

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 10. Correlations between the Form Elements and the Expressions of Car Side View

		Point	Line	Plane or surface	Volume
Lotus Elise (Dynamic, sporty, fast, streamlined)	Pearson Correlation	-,092	,327(*)	,192	,011
	Sig. (2-tailed)	,577	,042	,236	,945
	N	39	39	40	40

* Correlation is significant at the 0.05 level (2-tailed).

Table 11. Correlations between the Form Elements and the Expressions of Car Rear View

Bi-polar adjectives	Form features
Anger - calm	Cut-line (.323*)
Charming - displeasing	Coning (.328*), Radius (.296*)
Cheeky - backward	Bulge (.339*)
Cheerful - sad	Arc (.309*), Hollow (.347*)
Comfortable - uncomfortable	Arc (.424**), Extrusion (.362*), Hollow (.393**), Lathe (.314*), Pooches (.328*)
Consistent - inconsistent	Concave (.309*)
Contemporary - traditional	Concave (.330*)
Contempt - not contempt	Blister (.386*), Concave (.333*), Dimple (.455**), Hollow (.397**)
Disgust - not disgust	Coke-bottle/wasp-waist (.342*)
Excited - bored	Arc (.359*)
Fear - brave	Bulge (.300*), Extrusion (.293*), Hollow (.4.19**), Lathe (.312*), Sheer (.390**)

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 12. Positive Correlations between Form Features and Bi-polar Adjectives

		Front emblem	Head lamp	Radiator grill	Tail lamp	Rear bumper
Blister	Pearson Correlation	.075	.175	-.065	.037	334(*)
	Sig. (2-tailed)	.630	257	673	814	.026
	N	44	44	44	44	44
Coke-bottle/wasp-waist	Pearson Correlation	-.318(*)	.071	.009	-.063	.039
	Sig. (2-tailed)	.031	639	951	677	.799
	N	46	46	46	46	46
Cut-line	Pearson Correlation	-.371(*)	-.279	.131	.044	-.112
	Sig. (2-tailed)	.012	.064	391	.776	.465
	N	45	45	45	45	45
Hollow	Pearson Correlation	.027	.093	-.247	-.367(*)	-.052
	Sig. (2-tailed)	.859	539	.098	.012	.731
	N	46	46	46	46	46
Radius	Pearson Correlation	-.135	.333(*)	-.153	-.136	.203
	Sig. (2-tailed)	.371	.024	309	367	.176
	N	46	46	46	46	46
Taut	Pearson Correlation	-.379(*)	269	.024	.035	-.109
	Sig. (2-tailed)	.010	.074	873	822	.475
	N	45	45	45	45	45

* Correlation is significant at the 0.05 level(2-tailed).

Table 13. Correlations between Car Components and Form Features

components, such as headlamps, tires, mirror, etc. are essential in giving meaning and identity to the overall design [45].

In this study, Front emblem, Head lamp, Radiator grill, Tail lamp, and Rear bumper have been found to be significant components for determining the recognition of a car, both as an individual component and coherently.

Tovey and Porter described that "emotional characteristics" such as friendly and aggressive, are most easily described by the 'face' or front view of the vehicle [46]. However, in this study it is found that the three-quarter front view provides the strongest recognition of a car. We believe our comparison is possible to make, as Tovey discusses emotional response and a tendency for the creation of such perceptions in the front view of the car, while we discuss recognition (which we interpret as identification of brand), which is a characteristically different experiential aspect [47].

In terms of form elements, the relative percentage of total frequency distributions indicates that Volume and Line, followed by Plane/Surface are considered most important in determining the perception of a car. With respect to the rating of these elements as "extremely important", the frequency distributions of Line (54.3%) and Volume (52.2%) followed by Plane or Surface (32.6%) are not unexpected. Because points are used only to a limited extent as an explicit design element in car design, it is as expected considered less essential (6.5% "extremely important"). Balance, directional forces, and scale and proportion are being considered as the most important form principles of a car.

According to Table 6, 15 out of the 38 sets of bi-polar adjectives presented to designers were considered to be expressed in car design. However, alternative expressions, such as bi-polar scales, that describe designers' perceptions of cars need to be further investigated. Furthermore, the use of word pairs does not tell us anything specific about what types of perceptions designers actually have, or whether they perceive the word pairs used as being opposites. However, we found that there are two styles of structured questionnaires where words pairs (bi-polar adjectives) are employed on a Semantic Differential scale. The first style is a direct contradiction of word pairs. This contradiction means that the word selected has an "explicit" representation of the meaning like "beautiful" versus "ugly". For example, Hsiao and Liu uses the image of a specific product by adjectival images words like traditional-modern, complex-simple, cheap-expensive, cold-warm, soft-hard, etc [48]. The second style is an indirect contradiction of word pairs. This contradiction means that the word selected has an "implicit" representation of the meaning such as "beautiful" versus "not beautiful". For example, Ishihara, Ishihara and Nagamachi uses the list of adjectives randomly like pretty-not pretty, intellectual-not intellectual, elegant-not elegant, derived form from sources such as magazines, mail-order catalogs, recordings of conversation, etc [49].

A clear relationship can be found between a wide range of bi-polar adjectives and form features. As form features represent certain form elements, such as lines, surfaces and shapes, these may be developed according related bi-polar adjectives. Complementary, with reference to the front, side and rear views, strong relationships can be found between certain form elements and car perceptions based on selected car images. Popular perceptions, with reference to the front view, are aggressive, confidence, cheerful, futuristic, elegant, speed, dynamic, happy, odd, and ordinary. Popular perceptions based on the side view are dynamic, sporty, fast, streamlined, aerodynamic, sleek, classy, contemporary, cute, cheeky, compact, and smart. Frequent perceptions for the car rear view are dynamic, sporty, fast, and streamlined. A comparison across the three views shows that the adjectives aggressive, cute, and dynamic are important.

8 Conclusion and Further Research

This study has shown that there are valid correlations between selected designers' perceptions and form elements/car components of an automobile. This justifies the search on how these selected designers' perceptions can be used as a foundation for automobile styling.

Further research will test the applicability of designers' perceptions in hands-on automobile sketching. In terms of methods, video observations will be conducted to better understand how designers visualize automobiles during sketching as well as its components along selected bi-polar spectra, represented with a car image on either extreme. The visualization process will be supported by the recognition of visual characteristics, elements and components of a car, expressed through words generally used by designers.

Acknowledgment

This research was financially supported by the Ministry of Higher Education, Malaysia; and the Universiti Teknologi MARA, Malaysia.

References

1. Wang, H. (1995). An approach to computer aided styling. Design Studies, 16, 50-61.
2. Walsh, V., Roy, R., Bruce, M., & Potter, S. (1992). Winning by design: Technology, product design and international competitiveness. Oxford: Blackwell.
3. Bouchenoire, J. L. (2003). Steering the brand in the auto industry: An interview with Anne Asensio. Design Management Journal, 14(1), 10-18.
4. Karjalainen, T. M. (2007). It looks like a Toyota: Educational approaches to designing for visual brand recognition. International Journal of Design, 1(1), 67-81.
5. Warell, A. (2001). Design Syntactics: A functional approach to visual product form. Unpublished doctoral dissertation. ISBN 91-7291-101-8. Gothenburg: Chalmers University of Technology.
6. Abidin, S. Z., Sigurjonsson, J., Liem, A., & Keitsch, M. (2008). On the role of formgiving in design, Proceedings of New Perspective in Design Education (pp. 365-370). Barcelona: Artyplan Global Printers Ltd.
7. Nagamachi, M. (1999). Kansei engineering: the implication and applications to product development. IEEE International Conference on Systems, Man and Cybernatics, 6, 273-278.
8. Hsiao, S. W., & Wang, H. P. (1998). Applying the semantic transformation method to product form design. Design Studies, 19(3), 309-330.
9. Hsiao, S. W., & Cheng, M. S. (1996). Form Creation for Automobile Design. International Journal of Vehicle Design, 17(4), 360-363.
10. Smyth, S. N., & Wallace, D. R. (2000). Towards the synthesis of aesthetic product form. In ASME 2000 Design Engineering Technical Conferences and Computers and Information in Engineering Conference (DETC'00). Baltimore, Maryland.
11. Tovey, M. (1992). Intuitive and Objective Processes in Automotive Design. Design Studies, 13(1), 23-41.
12. Kimura, F. (1997). Issues in Styling and Engineering Design. Annals of the CIRP, 46/2: 527-534.
13. Edson, A. C. (1991). The art of american car design. In M. C., Kim. Et al.(Eds.), The Profession and Personalities: 'Not Simple Like Simon'. Trace Analysis Based on Formal Specifications, FORTE 1991, pp. 393-408.
14. Hsiao, S. W., & Chen, C. H. (1997). A semantic and shape grammar based approach for product design. Design Studies, 18(3), 275-296.
15. Hsiao, S. W., & Chang, M. S. (1997). A semantic recognition-based approach for car's concept design. International Journal of Vehicle Design, 18, 53-82.
16. Crilly, N. (2005). Product aesthetics: Representing designer intent and consumer response, Unpublised doctoral dissertation. Cambridge: University of Cambridge,.
17. Schmitt, B., & Simonson, A. (1997). Marketing aesthetics: The strategic management of brands, identity and image. London: The Free Press.
18. Liu, Y. (2003). Engineering aesthetics and aesthetic ergonomics: Theoretical foundations and a dual-process research methodology. Ergonomics, 46 (13/14), 1273-1292.
19. Crozier, W. R. (1994). Manufactured pleasures: Psychological response to design. Manchester: Manchester University Press.
20. Hsu, S. H., Chuang, M. C., & Chang, C. C. (2000). A semantic differential study of designers' and users' product form perception. International Journal of Industrial Ergonomics, 25(4), 375-391.
21. Baxter, M. (1995). Product design: A practical guide to systematic methods of new product development. London: Chapman & Hall.
22. Coates, D. (2003). Watches tell more than time: Product design, information and the quest for elegance. London: McGraw-Hill.
23. Krippendorff, K. (1989). On the essential contexts of artifacts or on the proposition that design is making sense (of things). Design Issues, 5 (2), 9-38.
24. Butter, R. (1989). The practical side of a theory: An approach to the application of product semantics, section b. In S.

Vakena (ed.), Product semantics '89 conference. Helsinki: University of Industrial Arts Helsinki.
25. Langrish, J., & Lin, S. H. (1992). Product Semantics - Any Use? In S. Vihma (ed.), Objects and images: Studies in design and advertising (pp. 132-135). Helsinki: University of Industrial Arts Helsinki.
26. Huang, C. (1996). Design for ease of use: Product semantics and design education. Unpublised doctoral dissertation, The Manchester Metropolitan University, Manchester, United Kingdom.
27. Blaich, R. (1989). Forms of Design, section d. In S. Vakena (Ed.), Product semantics '89 conference. Helsinki: University of Industrial Arts Helsinki.
28. Opperud, A. (2002). Semiotic product analysis. In Design and Emotion Conference (pp. 137-141). Loughborough, UK: Loughborough University.
29. Patton, M. Q. (2002). Qualitative Evaluation and Research Methods (3rd ed.). California: Sage Publications.
30. Oppenheim, A. N. (1992). Questionnaire design, interviewing and attitude measurement. London: Pinter.
31. Erdos, P. L. (1972). Professional mail surveys. New York: McGraw-Hill.
31. Roscoe, J. T. (1975). Fundamental research statistics for the behavioural sciences (2nd ed.).. New York: Holt, Rinehart and Winston.
33. Popovic, V. (2004). Expertise development in product design-strategic and domain-specific knowledge connections. Design Studies, 25(5), 527-545.
34. Bouchard, C., Aoussat, A., & Duchamp, R. (2005). Role of sketching in conceptual design of car styling. The Journal of Design Research, 1(1), 116-148.
35. Chen, L. L., Kang, H. C., & Hung W. K. (2007). Effects of design features on automobiles styling perceptions. Hong Kong: IASDR97 (International Association of Societies of Design Research.
36. Automobile Magazine (2009, April 27), Sedan reviews. Retrieved April 27, 2009, from http://www.automobilemag.com/reviews/02/sedans/index.html
37. Akner-Koler, C. (2000). Three-dimensional visual analysis. Stockholm: Reproprint.
38. Muller, W. (2001). Order and meaning in design. Utrecht: Lemma Publishers.
39. Sekaran, U. (2003). Research methods for business: A skill building approach (4nd ed.). Singapore: John Wiley & Sons.
40. Preble, D., Preble, S., & Frank, P. (2002). Artforms: An introduction to the visual arts (7th ed.).. NJ: Prentice Hall.
41. Saunders, P. (2001, November 28). Conceptual design: Understanding and communicating form. Retrieved April 27, 2009, from http://www.carbodydesign.com/tutorials/?id=4
42. Osgood, C., Suci, G., & Tannenbaum, P. (1957). The measurement of meaning. Urbana, IL: University of Illinois Press.
43. Nagamachi, M. (1999). Kansei engineering and its application in automotive design, in Kansei Engineering Workshop at the eleventh symposium on Quality Function Deployment. Novi, Michigan: QFD Institute.
44. Chen, L. L., Kang, H. C., & Hung, W. K. (2007). Effects of design features on automobiles styling perceptions. Hong Kong: IASDR07 (International Association of Societies of Design Research, 2007).
45. Tovey, M., Porter, S., & Newman, R. (2003). Sketching, concept development and automotive design. Design Studies, 24(2), 135-153.
46. Tovey, M., & Porter, S. (2002, April 24). Aesthetic design: Methods, tools and practices. Symposium conducted at the meeting of the 4th International Symposium on Tools and methods of competitive engineering (TMCE), Wuhan, China.
47. Warell, A. V. (2008). Modelling perceptual product experience – Towards a cohesive framework of presentation and representation in design. Proceedings of the 6th Design & Emotion Conference, 6-9 Oct 2008. Hong Kong: Hong Kong Polytechnic.
48. Hsiao, S. W., Liu, M. C. (2002). A morphing method for shape generation and image prediction on product design. Design Studies, 23 (5), 533-556.
49. Ishihara, S., Ishihara, K., & Nagamachi, M. (2001). Kansei engineering analysis on car instrument panel. Proceedings of the International Conference on Affective Human Factors Design, Asean Academic Press, Singapore.

Andre Liem, Shahriman Zainal Abidin
Department of Product Design, Faculty of Engineering Science and Technology, Norwegian university of Science and Technology, Trondheim, Norway

Anders Warell
Division of Industrial Design, Department of Design Sciences, Lund University, Lund, Sweden

Yaliang Chuang, Po-Hsuan Chuang, Huang-Shiu Shi, Kun-An Hsiao, Lin-Lin Chen
yaliang.chuang@gmail.com

Computer morphing as an effective approach to develop successful products half a step ahead of the market

Abstract
In this study, both qualitative and quantitative approaches were employed to examine the usage of morphing technology in new product development. First, a comparison survey of the car design was carried out. The morphing stimuli mixed with the older car and the concept car of specific car models were generated. A participant compared the latest car with the morphing stimuli and chose the most similar one. Second, an observation experiment was conducted to investigate the process designers employ in generating design concepts with morphing stimuli. It was found that the usage of morphing stimuli could help the designers to catch the design problems and concentrate their focus on the related directions. Moreover, the morphing stimuli with the mixture degree between 50%~70% were not only thought to be the most useful one to develop tangible ideas, but also chosen as the most similar stimuli to the real commercial cars in the first survey. Based on the results, the computer morphing method could facilitate designers to create successful products half a step ahead of the market.

Keywords
Car Design, Concept Design, Concept Cars, Morphing Technology.

1 Introduction

In recent years, creativity and innovation are becoming the most important strategy in many industries [1]. Many companies have devoted lots of resources in developing new products. And they hope the results can catch consumers' attentions and obtain great success on the market. Among all kinds of goods and products, the car design is one of the most challenge fields.
The annual auto shows of Tokyo, Frankfurt, Geneva, and Detroit are the most important evens in car industry. Most of the world-wide manufacturers are exhausted to unveil their new designs to the public in the shows. Every year, millions of people attend the exhibitions to shop for their next vehicle [2]. Every automobile company invests incredible time and money to investigate market trends, develop concept cars, and reveal the models in the annual auto shows.
However, among the thousands of new products released each year, it was found that more than half of the products were failed on the market [3]. Most of them even created financial deficits for the company.
In addition, by analyzing several fail cases, Norman [4] concluded that the key points were not related to the deficiency of functions or technology. Instead, they provided great innovations in technology. Why they were failed is because their innovation is too advantage to beyond consumers' perceptions.
To address this issue, Masafumi Matsumoto, the executive vice president of Sharp corporation,

Fig. 1. Lotus Elise, Lotus M250 concept car and the morphing stimuli (65%). Image source: www.dieselstation.com.

proposed a new strategy named "half a step ahead" [5]. Matsumoto thought that designers could create surprising product concepts with leading technologies. However, when it is realized to the commercial products, due to the deficiency of infrastructures, users would not be able to fully enjoy the advantages of the product. If the product concept is only leading half a step ahead the competitors, the consumers are much like to perceive its value. Within Sharp, this strategy was applied in various kinds of product development process and led to many marketing successes. This kind of principle is also employed in other industries, for example, the Pontiac Aztec was unveiled as a concept vehicle at Detroit motor show 1999. A year later, a commercial version of half adaption was ready to hit the dealers' showrooms and created marketing successes [2]. In a previous study [6], the "half a step ahead" strategy in new product development was investigated with 8 car models unveiled between 2000 and 2006. For each model, we collected the images of the latest commercial car and the concept car. Then, the computer morphing technology was used to generate artificial stimuli blended between the pairs of images. One of the results is shown in Fig.1. By analyzing and comparing the stimuli with the commercial car released later (i.e. the 2001 Lotus Elise shown in Fig.1), it was found that the design of the concept car was not fully embedded into the commercial model. In contrast, it is the blended stimuli between 60% and 70% that was the most similar to the new car. This finding is similar to the "half a step ahead" strategy mentioned earlier. It is also found that this kind of strategy not only can help designers to express new concepts in the commercial model, but also makes it retain the existing characteristic that consumers could easily perceived and recognized.

In this study, the "half a step ahead" strategy in new product development was investigated further. Both quantitative and qualitative approaches were employed to examine its applications in computer-aided design. The computer morphing technique was employed to generate blended stimuli with the product images collected. First, a comparison experiment of the morphing stimuli and the real car released later was carried out. A participant compared and chose the most similar stimuli to represent the characteristics of the real car. In this reversed-engineering-like approach, it was found that the "half a step ahead" strategy is somehow embedded in the products and the morphing technique could be a useful application for designers. To inspect this finding, an observation experiment was conducted to investigate the process designers employ in generating design concepts with morphing stimuli. A designer was provided 9 sofa stimuli and was asked to generate a new design concept based on his/her inspiration.

2 Image morphing technique

As the computing technology getting more and more powerful, the morphing techniques are widely used to create new shapes or investigate academic research issues. We will introduce some examples that use morphing method as a tool for different fields.

2.1 Shape averaging

Chen and Parent [7] proposed a shape creation method called shape averaging for product design. Shape averaging could produce a series of novel shapes between two typical shapes representing different meanings. It is hypothesized that the average results could preserve the characteristics of the original shapes and these results are useful for predicting trends in form, or for extracting stereotypes from a group of related shapes. The technique can be used to create new forms by blending global features of existing unrelated shapes. The algorithms of shape averaging could extract the mean, median and mode forms from the average shapes. Fig.2 shows the blending results between car shape and teardrop shape at different weighted averaging ratios.

2.2 Shape morphing and image prediction method for product design

Hsiao and Liu [8] constructed an affective shape creation model. Feature-based method is applied to build three-dimensional (3-D) CAD models for products, and new shapes are generated by shape morphing method (see Fig. 3). New product shapes can be created by inputting two different shapes and setting the morphing ratio or image value. However, this 3-D approach is nevertheless limited in its scope of shapes, because, in order to facilitate 3-D shape morphing, product shapes must be parameterized with identical number of vertices, edges, and surfaces, an extremely restrictive constraint. On the contrary, the 2-D morphing method offers certain degree of freedom in selecting the input of shapes. In this study, the 2-D morphing method is employed to generate morphing stimuli.

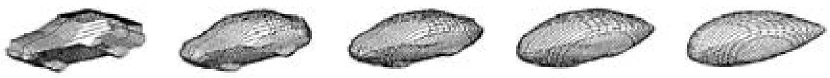


Fig. 2. Weighted averaging shapes from a car and the teardrop shape under ratios of (a) 70/30, (b) 50/50 and (c) 30/70. (Source: [7])

Fig. 3. Intermediate shapes obtained with shapes S1 and S5 (Source: [8]).

3 Experiment 1: comparing the morphing stimuli with the commercial car models

3.1 Materials

In this study, there were 6 models of cars selected from several car design magazines and web resources. The 6 models includes BMW Z, AUDI TT, AUDI 4 series, FORD MUSTANG, MAZDA MX-5 series, and LEXUS IS series. For each model, two products released in different time and a concept car revealed in the year between the two products were collected. Using the LEXUS IS series as an example, the 3 samples (shown in Fig. 4) includes the two Lexus IS released on the market in 2001 and 2005 and the related LF-C concept car unveiled in the 2004 motor show.

Then, Elastic Reality, a warping and morphing software application produced by Avid, was employed to generate the morphing stimuli for each model. Using the LEXUS IS series as an example again, the old Lexus IS (2001) and the LF-C concept car (2004) were paired as the bipolar input images to generate the blended stimuli in-between. And the latest Lexus IS (2005) was used for comparison in the user survey. In order to investigate the benefit of morphing approach, the stimuli was created and represented as two different forms. First, a dynamic morphing sequence of movie clip was output and saved. A user could drag the slider to see the specific frame of blended result. Second, there were 9 static images with different blending percentage (5%, 15%, …, 85%, 95%). Based on the previous study [6], we only focused on the middle sequence and chose the 5 stimuli (45%~85%) for conducting the comparison experiment. An example of the Audi S4 series is shown in Fig. 5.

Fig. 4. The 3 samples of Lexus IS series collected (source: http://www.dieselstation.com).

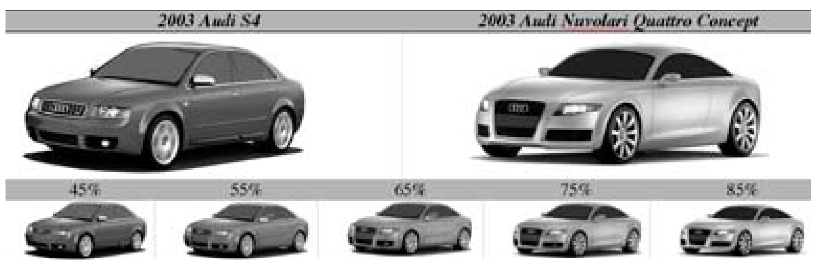


Fig. 5. Some of the static morphing stimuli of the Audi S4 series and the concept car.

3.2 Experiment Process

This experiment included two sections. First, the continuous morphing sequences of quicktime movie clips were used for investigation. A user controlled the slider to browse the blended stimuli. Then, he/she was asked to pick the frame which is most similar to the image of the latest car shown on the right. An example of the experiment is shown in Fig. 6.

Fig. 6. An example of the 1st section of the comparison experiment.

In the second section (see Fig. 7), the static morphing stimuli were employed. A participant moved the mouse over the labels (ABCDE) to browse and analyzed the blended stimuli. Then, he/she was asked to compare the morphing stimuli (shown on left screen) with the latest car (shown on right screen) and pick the one which is most similar to the car. In order to facilitate the participants easily compare the cars, the images were shown with 1024x768 pixels in two 19" LCD monitors arranged side by side. The stimuli were also shown randomly to reduce the potential effects. In addition, before doing the real survey, a participant was asked to complete two rounds of test to understand the usage of system. This would help to reduce the survey errors to an extent.

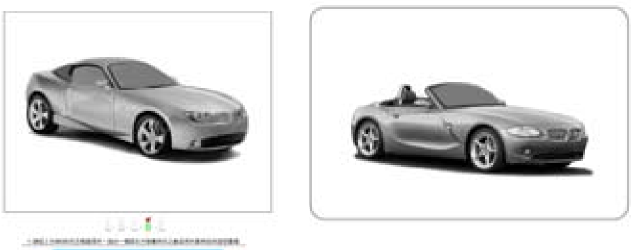


Fig. 7. An example of the 2nd section of the comparison experiment.

3.3 Participants

There are 30 graduate students from the first author's department participated in this experiment. They are age 20-29. The average age is 24.

3.4 Results

The results of the two different kinds of morphing stimuli investigated are similar. Among the 6 models of car, there are 3 models (Audi S4, BMW Z, and Lexus IS) which the participants felt the stimuli of 65% blended value are most similar to that of the latest commercial car. For Ford Mustang and Audi TT, the participants thought the newest cars were much represented in the morphing stimuli around 75% (slightly close to the concept car). And for the Mazda MX-5, the stimulus in the middle (50%) of the morphing sequence was chosen.

3.4.1 Audi S4, BMW Z, Lexus IS

For these 3 models, the sample mode is located around the 65% morphing stimulus (as shown in Fig. 8). The average blended value for these three models are 66.87% (Audi S4), 64.47%(BMW Z), and 59.70%(Lexus IS). Based on the result, it is suggested that the latest commercial car seems to be developed with the mixture consisted of the previous model (65%) and the concept car (35%). This approach helps to increase its innovation and retain the original chrematistics at the same time.

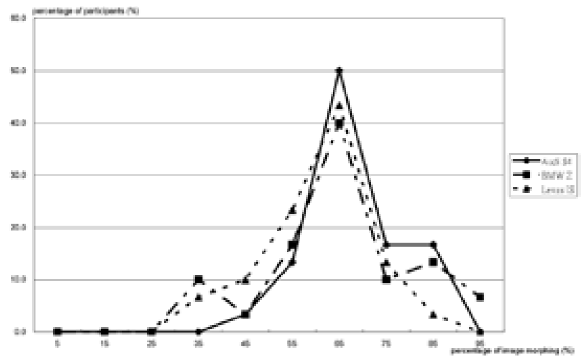


Fig. 8. The result of the stimuli of the Audi S4, BMW Z and Lexus IS model.

3.4.2 Audi TT

The Audi TT is the most extreme case among the 6 models investigated. Because the designers embedded strong future image, most of the participants thought the morphing stimulus at 75% point is most similar to the latest commercial car (AUDI Le Mans TT, as shown in Fig. 9). The average blended values are 71.67% (for image stimuli) and 79.57% (for movie stimuli). In this case, it is found that if the designers want the consumers feel much surprised or innovative with the late commercial model, they can increase the degree of composition of the concept car in the mixture.

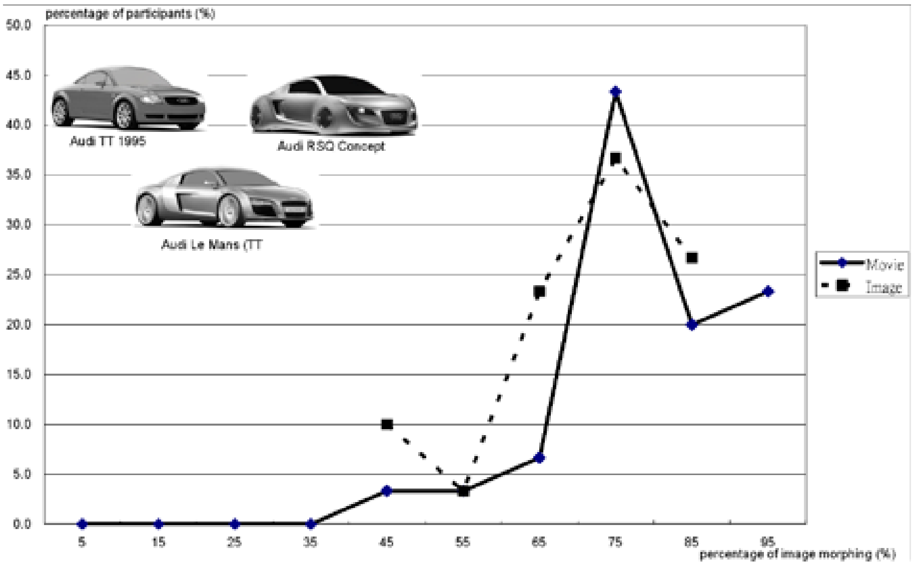


Fig. 9. The result of the stimuli of the Audi TT model.

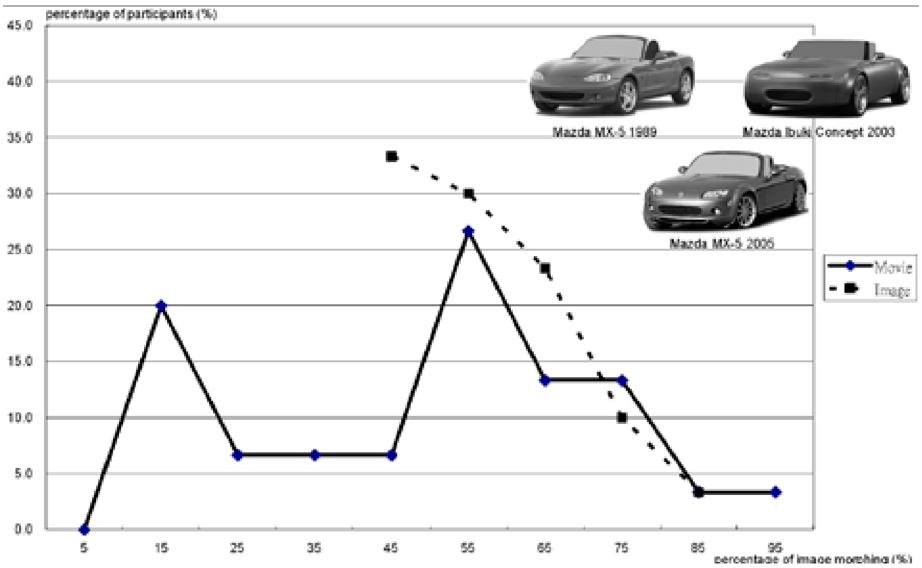


Fig. 10. The result of the stimuli of the Mazda MX-5 model.

3.4.3 Ford Mustang

The result of the Ford Mustang is slightly close to the concept car, too. The average values of the blended stimuli are 75.67% (for image stimuli) and 76.43% (for movie stimuli). Although the result is similar to that of the Audi TT, the story is somehow different. In this case, the older commercial model chosen is sold in 1965, the design philosophy is disimilar to that embedded in the concept car unveiled in 2005. For example, the forms of the hood scoop & the spoiler, and the proportion of the entire vehicle are quite different. From the result of this case, it is found that when the designers want to create a late car based on a classical model, they can integrate more elements of the concept car. Then, a car retained the classical image would be able to fit the consumers' tastes in a new generation.

3.4.4 Mazda MX-5

Comparing to the other cases, the result of the Mazda MX-5 is located between 45% and 55% (as shown in Fig. 10). The average values are 57.0% (for image stimuli) and 49.2% (for movie stimuli). In this case, it was found that the difference between the older car and the concept car is not obvious, and the latest car is thought as a mixture of the older model and the concept car with similar degree. It is also suggested that the Japanese manufactures are more likely to take conservative strategy in car design.

4 Experiment II: Concept design with morphing stimuli

To evaluate the findings concluded from the 1st comparison experiment, this 2nd experiment was

Fig. 11. One of the morphing stimuli of the sofa investigated.

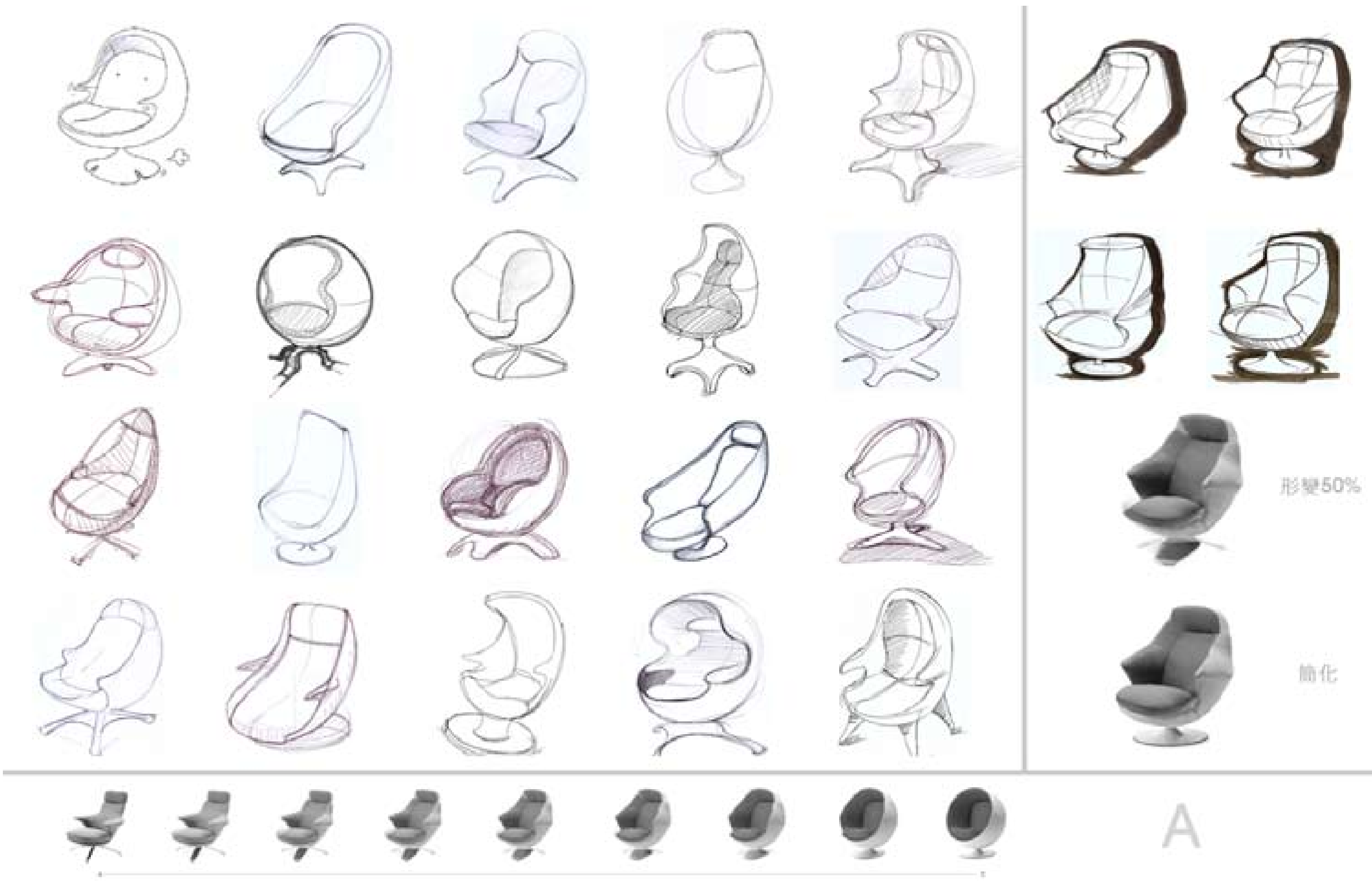


Fig. 12. One of the results of the concept design experiment.

conducted to investigate the assistance of morphing technique in design practice. The images of sofa product were employed and the same morphing software application was used to generate morphing stimuli. Then, 20 designers were recruited and asked to generate ideas with the inspiration of those stimuli.

4.1 Materials

The images of 10 sofas were chosen in pairs from the multidimensional results of 100 sofas concluded in a previous study [9]. In each pair, the 2 stimuli embedded opposite semantic images, such as traditional and modern. Then, the morphing technique was employed to generate a sequence of blended stimuli in between. One of the samples is shown in Fig. 11.

4.2 Experiment Process

Participants were invited and asked to do a concept design of sofa. A participant was given 5 to 10 minutes to develop ideas with the sequence of morphing images provided. Then, he/she chose an idea and finalized the concept on a paper. In the end, each participant generated 5 concepts with the 5 sequence of morphing sofas presented.

4.3 Participants

There were 20 graduate students major in industrial design participated in this experiment. They are aged 21-29, and the average age is 24.5.

4.4 Results

The concepts for one of the morphing sequence is shown in Fig. 12. By observing the design process and analyzing the results, it was found that:

- The usage of morphing stimuli could help the designers to catch the design problems quickly in the very beginning.

- At the same time, those materials could also guide the designers to concentrate their focus on the related direction, and inspire new ideas.
- Comparing to the abstract line stimuli used in some study (such as [10]), the realistic morphing stimuli are much useful to facilitate designers' thinking and creation.
- A high percentage (around 60%) of the final concepts was developed based on the morphing stimuli which were the blended result between 50% and 70% of the input sofas. This finding is similar to the 1st comparison survey with the cars mention previously.

5 Conclusions

Based on the results of the comparison survey of the car design and the concept design with morphing sofa stimuli, the effectiveness of the computer morphing method in product development is demonstrated. In the comparison experiment, it was also found that most of the latest cars were developed based on the mixture of the older model and the concept car with 60% to 70% degree. This approach made the latest car retain the original characteristics and also reveal innovative features. By this way, the consumers are more likely to perceive and appreciate the designs which are half a step ahead in the market. This kind of strategy is also observed in the 2nd concept design experiment with sofas. The morphing stimuli of blended with 50% to 70% degree were largely chosen as inspiration materials. They help the designer to focus on the design problems, and generate tangible ideas in a short period of time. Based on the results of this study, a practical approach for the new product development is proposed. The companies could invest much more resources in the research of marketing trends in new product development. Then, they can visualize the results with the developments of concept products and demonstrate them in the shows or exhibitions. Once those concept designs passed the evaluation of the leading consumers, the designer could easily generate realistic morphing stimuli with the old product and new concept model. Based on the inspirations, the designer can even decide whether to increase the mixture degree to enhance the feeling of surprise or to take a conservative strategy with less than 50% degree of mixture. In the end, while the public is still immersed in the atmosphere of the concept design, the company could release the commercial model half a step ahead in the market.

References

1. Kelley, T., & Littman, J. (2001). The art of innovation: Lessons in creativity from IDEO, America's leading design firm. New York: Currency/Doubleday.
2. Krebs, M. (2000). An introduction to the NAIAS 2000: Welcoming the world. In M. Bevolo, Z. Skalska, & C. Lieshout (Eds.), Detroit motor show: American car design trends analysis (p. 3). Eindhoven, The Netherlands: Philips Design.
3. Sivadas, E., & Dwyer, F. R. (2000). An examination of organizational factors influencing new product success in internal and alliance-based process. Journal of Marketing, 64(1), 31-49.
4. Norman, D. A. (2000). The invisible computer. New York: Basic Books.
5. Rowley, I., & Tashiro, H. (2004, December 13). Japan's phones are the coolest -- And have the skimpiest profits. Businessweek. Retrieved May 15, 2007, from http://www.businessweek.com/magazine/content/04_50/b3912070.htm
6. Shih, H. H. (2005). Study of style evolution in car model series.. Unpublished master thesis, National Taiwan University of Science and Technology, Taipei, Taiwan.
7. Chen, S. E., & R. E. Parent. (1989). Shape averaging and its application to industrial design. IEEE Computer Graphics and Applications, 9(1), 47-54.
8. Hsiao, S. W., & Liu, M. C. (2002). A morphing method for shape generation and image prediction in product design. Design Studies, 23(5), 533-556.
9. Chuang, Y., & Chen, L. L. (2008). How to rate 100 visual stimuli efficiently. International Journal of Design, 2(1), 31-43.
10. Chang, Y. -M., & Chen, H. -Y. (2007). A neural network-based computer aided design tool for automotive form design. International Journal of Vehicle Design, 43(1-4), 136-150.

Yaliang Chuang, Po-Hsuan Chuang, Huang-Shiu Shi, Lin-Lin Chen
Graduate School of Design, National Taiwan University of Science and Technology, Taipei, Taiwan

Kun-An Hsiao
Graduate Institute and Department of Industrial Design, Chang Gung University, Tao-Yuan,Taiwan

Wei-chen Chang and Shih-huei Huang
xz016071@gmail.com

A study on the application of story mapping to the innovative product design model

Abstract

This study aims at the investigation on story design and storytelling. By means of the industry-academy cooperation cases of bag design, this study brings up a design model based on story mapping to develop product concepts. It is suggested by this study that designers should construct the product ideas by story reading and design accordingly the strategies and procedures to make the designed products tell the stories, which may result in more resonating effects. This design model employs two dimensions, namely story concept and concept development, to define the innovative thinking matrix of product design model. In addition, the procedures of story concept include the elements of setting, problem, goal, action, and outcome. The procedures of design concept thinking include the design steps of context, problem, feature, and value. This paper first investigates relevant theories and the use principles and procedures for product design model. Secondly, three cases of concept product development are used to test and verify the applicability and announce it accordingly through the industry-academy cooperation experience. It is initially confirmed, through the verification, that this kind of model is helpful for designers to compose design. Consequently, based on story design thinking and use types, this study has established a set of developing model for product design. Regarding the establishment of proper activities for product development in order to correspond to the user group, there are three conclusions induced by this study: (1) by story reading, designers can try to reexamine the core product value and increase the competitiveness among the overlapping products; (2) there should be a sensitive 'story mapping' product design model to generate consumers' consumption emotions on a product; (3) story knowledge is collected to integrate design development, and stories are further interpreted to generate information, which is then value-added to be bestowed with meaning and thus to become useful design information for creating the aesthetic experience and economic value of product.

Keywords

Story Design, Storytelling, Cultural Value, Design Model.

1 Research Background and Motive

In the process of product design, designers, by new techniques, bestow new meaning and value upon products; they create touching products to enable the products to speak on their own, namely expressing the concepts and thoughts the designers would like to communicate. Therefore, the core value of product lies in increasing the emotional energy of a product through innovation, collecting the context and emotional values by means of story, and eventually using the values to communicate the touching feeling resulted from people and things. A lot of arguments have been resulted from the research relevant to human creativity.

According to Lawson [1], the creative process of human beings is: (1) discovering the existence of a problem and hence determining to solve it; (2) intending to understand problems and thus finding the solutions; (3) the subconscious activating and thinking in the relaxing mood; (4) suddenly obtaining the inspiration for solutions; (5) internal thinking and evaluations specifying inspiration. Jocelyn Wyatt[2]brings up the concept that through the three behaviors of empathy, prototyping and storytelling, designers achieve the ultimate goal of product development. Through the approach of storytelling, designers can design a simple and affecting story while designing, by which the essence of the value and opinions can be sufficiently communicated. However, except the thinking model of designers, it is important how to guide designers, through the considerate, creative idea of story reading, which generates humanity in products, to interpret a story, to generate information accordingly, and to add value to the information for bestowing meaning upon it and making it become useful design information. At this time, the story plays the pivot in design, in which developing a product that moves people is emphasized, and the product is used to tell the pictures, which ever happened, as well as imagination. To go a step further, a story is the best communication medium between designer and user, the imagination resulted from which constructs the developing structure of a design idea. Therefore, based on reading text stories, this study discovers key vocabulary and the problems generated to construct the story plot, investigate the problem resolutions for story mapping and design concept, enable designers to carry out the 5W thinking, and communicate the story spirit to the product design in a planned way, namely telling the story by designing products. This study plans to establish a story mapping design model understandable for designer and user.

2 Literature Review

The story mapping strategy is one of the story grammar strategies[3]. The story grammar, in a broad sense, indicates the article structure of narration or exposition [4]. Generally, the structure of narration includes setting, topic, plot and resolution while the structure of exposition includes description, enumeration, cause and effect, comparison, and problem resolution[5]. The research relevant to story mapping strategies is as follows:

(1) Short and Ryan[6]teach the students receiving story grammar training to ask themselves five questions while reading: a. Who is/are the leading character(s) of the story? b. When and where did the story happen? c. What did the leading character(s) do? d. What is the ending of the story? e. What did the leading character(s) feel? These five questions are the five constructive elements of story map.

(2) The study of Carnine and Kinder [7]teaches story grammar strategies: Who is/are the leading character(s) in the story? What did the leading character(s) do? What happened to the leading character(s)? What was the final outcome? These four questions are included in the constructive elements of story map.

(3) Folwer and Davis[8] argue that story framework is similar to the approach of story mapping. All the information related to the article content includes problem, event sequence, methods to solve problems, and the outcome of the story.

(4) Idol and Croll[9]deem that the five comprehensive elements for reading, namely setting, problem, goal, action, and outcome, can assist the metacognition, including planning, motoring, and checking, in a reading process and thus improve one's comprehension on the article content.

(5) The research of Newby, Caldwell, and Rech[10] employs story grammar training cards and index, in which the cards using the five constructive elements of story map help establish the content and concepts of an article.

2.1 Interpreting design texts through the story mapping strategy

Story mapping is an approach to help students learn how to make reading meaningful, and it is also a tool to evaluate literal comprehension[11]. According to the current literature, story mapping can be divided into two categories, general story mapping and visual story mapping.

General story mapping indicates the tool which can be used to keep track of the story grammar elements. Since Beck and McKoewn[12]regard a story as an article consisting of setting, problem, goal, and resolution, what is inserted between problems and solutions is the critical event to achieve the goal or the resolution for the problems. Consequently, they develop a story mapping procedure to ascertain each element, and they regard it as the method to develop a story or categorize the problems. Pearson[13]further develops the story mapping approach into a method expressed by image to show the correlation between the story elements. Therefore, general story mapping is the earlier story mapping.

Visual story mapping indicates the superficial characteristics of image for the correlation between all the elements in a story. Hence, some story mappings are resulted from the revisions of traditional plot structure or story grammar[14]while some investigate the structures of other articles and possess the forms similar to a structural outline. Story mapping integrates the superficial and hidden information relevant to the leading characters, events, and concepts in the story. The story mapping strategy belongs to the metacognition strategy, which teaches readers to aim at the key points of the article content to monitor one's own reading progress. Meanwhile, research [15]also indicates that the story mapping strategy is indeed helpful to improve cognitive skills and reading comprehension. Through story mapping, the story mapping strategy establishes schemas in order to help learners understand reading materials more to enhance the reading comprehension of articles. The constructive elements of story map include setting, problem, goal, action, and outcome[16]. Thus, through users' description of the reading content, the content of the event can be interpreted, by which the meaning and spirit that the story would like to communicate can be depicted, and the previous experience and perception can be infused into design ideas. The story mapping strategy employs the visual display of story map to structure the content of reading materials, and it can help readers understand reading materials more easily. What context would a story setting like to communicate? First, while reading a story, how does one make a prompt decision to find out the context that the story would like to communicate? While reading written words, one visualizes images on his or her minds through interpretation. Relative to the provoked imagination, the written words unceasingly stimulate one's brain simultaneously and increase new imagination through the repeatedly changes of sentence patterns. By means of written words, reading constructs images, temples, temperature, and touch, which make us sad as well as joyful. At this time, the imagination space for reading can be expanded infinitely.

Learning things through reading is the easiest and most usual learning mode for human beings in thousands of years. Now, in the era of global knowledge economy, reading is, to a greater degree, a crucial pivot to enter diverse knowledge fields. Through reading, one can further express the grievances, sorrow, happiness, and gains in life. Reading transforms written words into images, uses pictures to express the correlation between relevant things, makes abstract content become more specific and easier to understand in order to achieve the goal of comprehension and communication.

2.2 Developing a composing procedure of product design by means of visual story mapping

Procedure 1:

brainstorming and listing possibly useful story elements to construct event mapping. This precise list includes purpose, setting, character, event, action, outcome, and response.

Procedure 2:

establishing a list for major concepts, major events, and major characters. The list needs some order to arrange the elements in the story, including setting, time, place, characters, problem, plot/events, and resolution.

Procedure 3:

according to designers' needs, choosing one sort of story mapping to keep track (e.g. literal, inferential or graphic).

Procedure 4:

centering the major concept in story mapping.

Procedure 5:

placing the information relevant to settings, major characters, events into the circle surrounding the major concepts to ascertain product use types, including introducing who, why, when, where, how (5W), and ending

Procedure 6:

finally, studying the story mapping to determine how it guides and generates attention and make proper adjustments accordingly.

Story mapping should structure product use context in terms of problem, and the problem developed should be reflected in the story mapping information. Meanwhile, the links between events and concepts should be established to integrate the content of a story and deduce the connectivity of the story. After reading the story, one should make sure if the analysis carried out

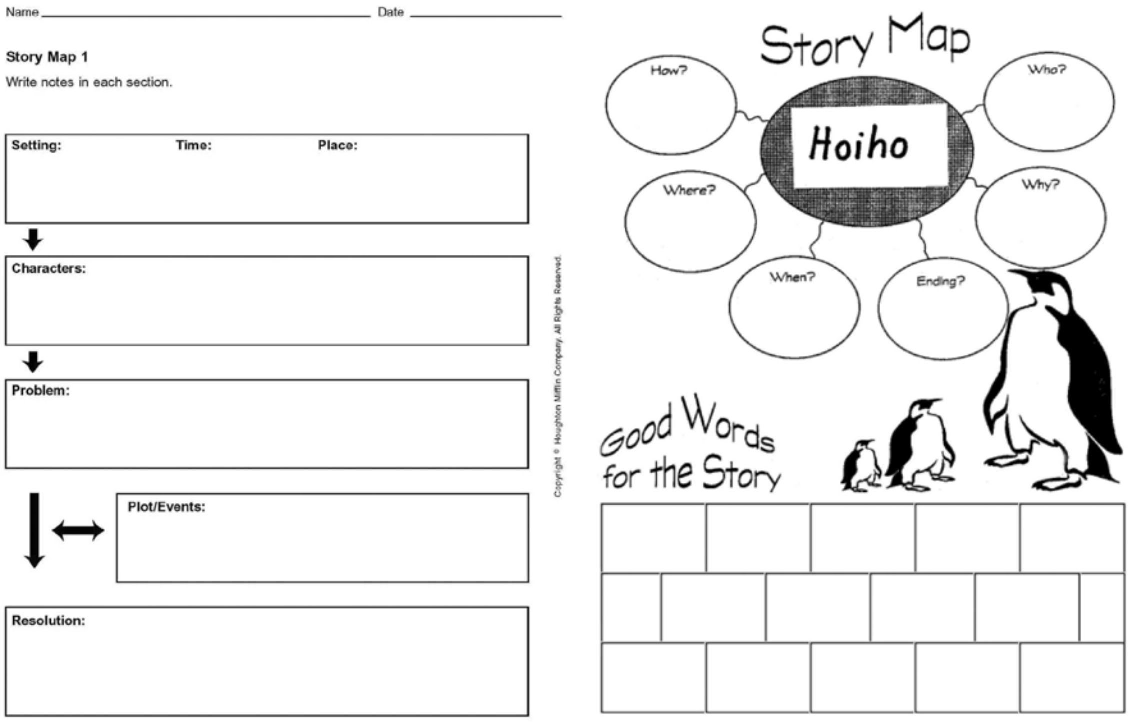


Figure 1. List for story mapping elements (source: compiled from [16])

by himself or herself is correct, appropriately revise accordingly, check, and summarize.

2.3 Deriving a product design mode through the constructive elements of story mapping

According to this study, the product design mode derived from the constructive elements of story mapping can be listed as follows:
Context: Which characters are there in the story? Where did the story happen? When did it happen? How did it happen? (who, where, how, when, and why (5W))
Feature: What was the setting when the story began? (setting, time, place)
Problem: What important information did you find from the story? Can you perceive the methods to solve some problems? (characters, problem, plot/events, resolution)
Value: After finishing reading the story, what conclusion have you obtained about life? What about the values stated by the author by means of the story? How do you describe these values? (ending, value)
In the stage of design, based on the story mapping constructive elements, four product design modes are brought up, including context, what a product would like to express -- feature, what a product would like to communicate -- problem, what a product would like to solve -- value, what a product would like to display. The application of these modes can be effectively imported into the design elements through the sensitive side of a product. For example, the spiritual characteristics of telling the story, the Archer and the Suns, are used to develop innovative products. It indicates that the design mode developed by the story mapping strategy is helpful for designers to create design ideas more diversely, understand the features and problems of a story, and communicate the value of a product through stories.

3 The practical creation method of story mapping

According the storytelling model of Gerrit Muller[17][18], based on the CAFCR model, storytelling values customers' needs for a product. The CAFCR model consists of five elements, respectively C, or Customer objectives, namely the objectives of customers, A, or Application, namely how customers practically apply the goal, F, or Functional, namely the functions of a product, C, or Conceptual, namely the concepts of a product, and R, or Realization, namely the realization of a product. Stories are added to market observation and the CAFCR model for investigating how to solve problems by means of the CAFCR model, and storytelling is used to analyze, design, and practice. Integrating the thinking approach of product design, this study brings up one design procedure and method, which is beneficial for introducing story emotions and design, as indicated in Figure 2.
When designers emphasize that the effects of the story demanded by a product is to communicate emotional features and attractions, and, through story

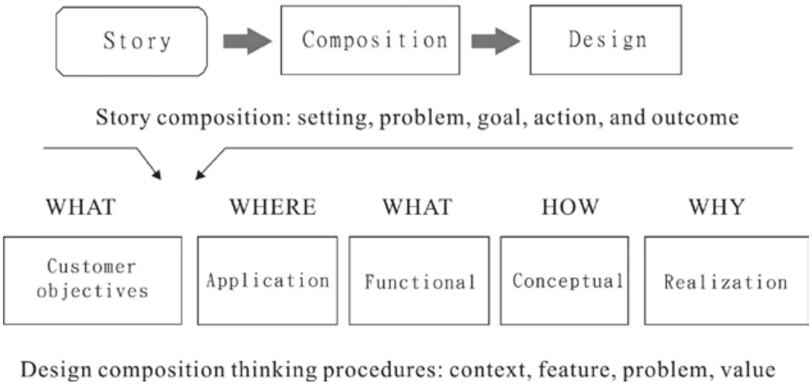


Figure 2. Design procedures and methods for story concept and design (compiled by this study)

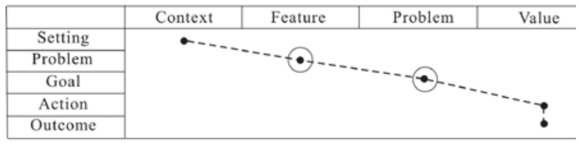


Table 1. The innovative thinking matrix of cross matching for story concept and concept development

emotions, they fasten fixedly the attention of customers upon the product or even put them into a state of hypnosis, the customers will be deeply attracted by the wonderful image of the product imagined by themselves, not able to turn away their attention until they purchase it. This effect can not be accomplished by other sales tools, and it is also the emotional demand that stories want to communicate.

3.1 Seeking for critical elements from story mapping

In order to effectively use the strategy of story mapping, designers should know how to identify story syntactic elements. First of all, one should try to explain the content of story syntax and collect the meaning of some elements from most stories. All the stories have a starting point, including that the story time is its happening tense, from which the key words of the story content are analyzed. Without exception, the story is possibly set up in a problem or conflict, which is in action, from trying to achieving the goal or solving the conflicts. When critical words are transferred into applicable elements, the words are repeatedly used to correspond to the outcome whether or not for achieving the goal or solving the conflict.

3.2 A creative thinking matrix for cross matching story concept and concept development

In an ordinary design process, in order to seeking for a theme, the concept is often caught through any pattern, which can not be understood or interpreted though. Under such kind of circumstances, designers frequently can not express their emotions through the products, and usually, they do not have a foothold to explain what the product's concept is. Consequently, by means of the two dimensions of story concept and concept development, this study defines a creative thinking matrix for product design model. The procedures of story concept include the constructive elements of setting, problem, goal, action, and outcome; the procedures of design concept thinking include the design steps of context, problem, feature, and value. To make it easy for designers to understand and analyze promptly the information communicated by a story, this paper tries to cross match story concept and design concept, the table of which is compiled as follows:

3.3 Importing the creative procedures of story concept and concept development

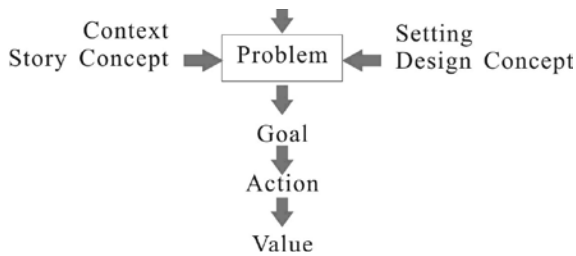


Figure 3. The creative procedures of story concept and concept development

Problem is the key element jointly formed by design concept and story concept. Therefore, when implementing a design concept, one can solve and analyze the problems of each event one by one to find the core value of the story no matter from the features inside the story or from the goal that the story expects to communicate.

4 The applications of design cases

The creative thinking matrix and creative procedure of story mapping developed by the author can be suitable for not only independent designers but also the application to design teaching. Thereinafter, this model is respectively applied to the instruction on the design works by three different groups of students, aged 20, from the design department in the college. Through this model, the students respectively think about thematic design and create three pieces of works. Each case is a regular design case in which the creative time is six weeks, the conceptualizing time is three weeks, and discussions are carried out weekly. The three chosen cases can be used to investigate the linking progresses between products and human beings, such as the design performances of story concept generated by instinctive thinking, interactive stages, long-term experience, etc. In terms of the creative thinking matrix approach of story mapping, the implementing processes and achievements of these three cases are illustrated as follows:

4.1 Design case 1: a traveler's autumn thoughts

Story Origin: Autumn Thoughts, Sky Clear Sand: The withered vine, the weathered tree, and the crow on the bough; the little bridge, the streaming brook, and the country dwellings; the ancient way, the westward wind, and the scraggy horse; the sun is setting in the west, and at the end of the world is a woeful soul with a broken heart [19].

Design Concept: The lonesome scenes seen and felt by the traveler are imported to the bag design, natural scenery is integrated with the bag decorations, and the natural features of leather are brought into full practice to generate a bold and unconstrained style. Based on travelers' needs traveling faraway and convenience, a bag design with great capacity combines with plenty of hidden segmenting bags, in which functionality and practicability are integrated with design. The connectivity of additional metal materials, such as zipper, is employed to alter the bag shapes and combinative structures to create multiple use types.

4.2 Design case 2: the secret garden

Story Origin: The story is written by Burnett, an English author. It describes that an orphan girl found a secret garden in her uncle's home. In that story, the girl turned from a pampered girl to an accommodating one, like an imprisoned soul was released. In the dark, mysterious manor, Mary, guided by a robin, found a key, and opened a secret garden fallen into disuse for ten years. As the garden reopened and revived, the gentle side of Mary was also awaken, and the fate of the entire manor was gradually changed[20].

Design Concept: The bag design is used to overturn the structure. When the external brown leather is overturned, a lively bag with flower patterns is showed. Thus, the bag pattern can be altered according to different occasions. By means of different contrasts, namely colors and materials, the image of garden is displayed.

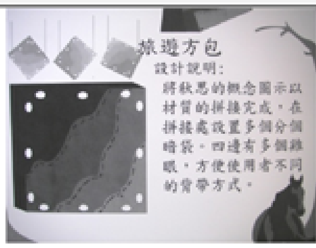
Setting	Autumn scenes	Time	Autumn
Place	Ancient way	Characters	withered vine, weathered tree, crow, little bridge, streaming brook, ancient way, scraggy horse, unset
Problem	Autumn thoughts	Plot/events	Travelers' needs
Resolution	Plenty of hidden segmenting bags, great capacity	Expressing travelers' needs, bold and unconstrained style with a brown autumn feel	
Design draft		Model	
			

Table 2. Design case 1: table compilation, analysis, and graphic draft (compiled by this study)

Setting	Secret garden	Time	Unidentifiable
Place	England	Characters	Garden, girl, robin, key
Problem	A imprisoned soul	Plot/events	Yearning for the garden, the girl's moods
Resolution	The setting of garden is represented by the direct lines of imprisoning.	After the window is opened, Mary appears.	
Design draft		Model	
			

Table 3. Design case 2: table compilation, analysis, and graphic draft (compiled by this study)

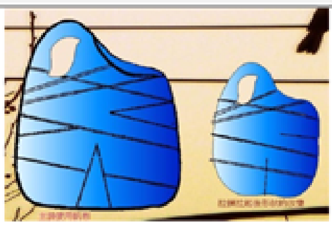
Setting	The setting sun, blue sky	Time	Dusk
Place	Woods	Characters	Little bird, branch, wind, flying
Problem	The expansion of self capability	Plot/events	Context
Resolution	Zippers are used to indicate the movement of branches.	Performing by interlacing; a bird-shape bag opening; dying the bags in blue and yellow	
Design draft		Model	
			

Table 4. Design case 3: table compilation, analysis, and graphic draft (compiled by this study)

4.3 Design case 3: Silhouette

Story Origin: A little bird is tightly grabbing a branch. Wind comes and blows the leaves to sway, but the bird's thin claws still tightly grab the thin branch. Wind becomes stronger, and the entire tree shakes, but the bird still grabs the branch desperately. Eventually, the bird can not fight the power of wind. At the instant it looses the claws from the branch, it thinks it would fall, but he flies instead. As it turns out, the bird has already known how to fly. It was his fear that made him limit himself previously. My darling, you are similar to this little bird sometimes, grabbing tightly affection, a position, and a past and forgetting your own capability of flying. However, one day, just like this little bird, you will find that you own the entire sky after you leave the branch [21].

Design Concept: Snap buttons, zippers, and eyelets are interlaced in the bag design, overlapped and arranged in order, like tree branches and sprouts, to generate multiple changes in shape.

4.4 The analysis results of the implementations of the three design cases

The analysis of the aforesaid design cases discovers: (1) Problem is the expressive element jointly formed by design concept and story concept, so design composition and the function of a part of a item can be employed to represent the design elements that one looks for. (2) The design elements formed by story composition can be used to develop design concepts, and they can be deduced and changed into the constructive elements of product whether or not they are expressed in terms of spot, line, or surface. (3) The connecting ingredients formed by reading on one's mind are the key elements of design composition, which are then associated and selected according to product use and functions to obtain the optimum innovative integration between emotional design and functional design. (4) Story is made abstract in an appropriate degree to form imaginary space, and in consideration of the atmospheric performance of context, designers further make flexible alterations according to the different needs of the objects.

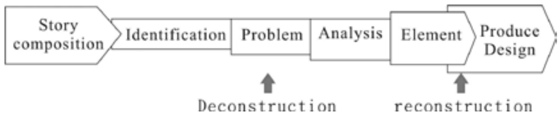


Figure 4. The model for applying story mapping to innovative product design (compiled by this study)

Through ingredients identification, problems are drawn up from a story, and each superficial feature is deconstructed and analyzed. These features are the key to form the problems. Meanwhile, through design techniques, the elements are reconstructed, such as the objects of material, texture, and color, and a kind of new description is provided for the objects, the purpose of which is to determine how a visual object is formed and constructed to confirm the constructive elements that it includes. In addition, another critical element of description is to decide which kind of information of an object possesses the important features which stride across story frameworks but remain constant. That is to say, people's identification of story elements only needs to be based on some important key ingredients of an object, the featured ingredients are kept, and the connectivity with the resolutions of problems is thus formed.

5 Conclusion

This study applies story mapping and brings up an innovative product design model. In addition to analyzing systematic story composition, this sort of integrated visual image intends to think outside the box of ordinary thoughts, which is an application of feature collecting techniques in the product design and development procedures nowadays. Therefore, the value of this study lies in the suggestion of the activation in innovative products.

The discovery of this study can be divided into four forms for discussion in terms of story collection:

1) Narration composition: Narration is one kind of storied narrative and speaking form, which is a mode of not only cognition/expression but also life/behavior.
2) Ingredient composition: It is a set connected according to the logic and time order, and it is organized in accordance with the constructive ingredients.
3) Action composition: It is the action resulted from a future or past event caused or experience by a behavior agent.
4) Media composition: It is represented by media, such as language, touch material, voice, image, or the mixture.

The aforesaid forms enable everyone to bring into full practice the imagination and creativity to narrate. Even if in the plots seemingly without order and connection, a meaningful story can still be connected and created to construct the world of meaning. In addition, element interpretation can not be neglected, either. The use of feature elements will make a story more valuable. Regarding to the application of story mapping to the product design cases, this study sums up the following principles:

1) The fundamental purpose of element application lies in advancing designers' capability of integrating knowledge, but in the application, it should be particularly careful to achieve a mutually compatible result.
2) Generating attractive plots indicates applying various elements to make other people notice the features. Consequently, comprehensive element features have to be collected to avoid the occurrence of extreme forms.
3) Each element has its characteristics or forms, and it also has several changes, which are the optimum tools for designers to employ for creating any possible effect.
4) All the elements are equipped with the functions of physical communication and psychological communication which can not be completely limited to a physical approach of expressing perception. Instead, this kind of function depends on the communication of designers' analysis and interpretation of cultural symbols.
5) Adequately making use of elements as well as creating and applying the visual guidelines of clothes, including (1) the principles of object oriented design: duplication, parallel, sequence, alteration, gradient, transposition, radiation, and rhythm; (2) the principles of emphasis design: concentricity, contrast, and emphasis; (3) the principles of synthetic design: proportion, specification, balance, harmony, and unification.
6) The interpretation of the same element may include the topics from different sources or the combination of multiple topics, in which the methods of interpretation, including realistic, modeling, abstract, and geometric ones, are fully employed.

A story is the object and content described by narration, and it includes a narrative structure and dramatic ingredients. Narrative discourse is a method to describe a series of events, and narrative behavior is the specific action of storytelling. Designers can create products corresponding to cultural features by means of storytelling and further make the products more acceptable and touching. Therefore, the emotional factor is also the most important ingredient to make product communication salient. Different stories contain different applications of feature elements, which, meanwhile, indicate the differentiated values of those story meanings. In other words, feature elements imply that story mapping can sufficiently represent product styles, and they begin to absorb cultural and sensitive factors. Furthermore, story mapping starts to possess the intention of expressing cultural meanings. Hence, the full demonstration of cultural meanings exists in the construction of innovative product design features.

The product development of story mapping design mainly communicates four characteristics:

1) Ordinary product designs should be able to express the cultural characteristics belonging to us, such as aboriginal cultures, instead of only blindly pursuing modeling lines.
2) Settings featuring scenery often appear in the story mapping, including dusk and flowing water. Not constrained by time and space, abstract designs can form the so-called fashion.
3) Designers can use story elements and composition principles to create a unique personal image and generate effects along with the changes of elements and principles, which is also one kind of expression power.

4) Story mapping can also be regarded as the symbolic signification of individual features. Sometimes, it is not only about decorating the original meaning of a story but expressing personal characteristics. Designers should understand these elements and principles in order to create and master diversified effects under the conditions resulted from any combination of time and place.

In addition to the values of exhibition and symbolic communication, story mapping is also capable of cultural communication which is, by nature, relevant to people's desire for expression as well as the exhibitive characteristics of story mapping. Through innovative product design, story mapping can be conceptualized to accomplish element application and establish unique styles. In the research process, by means of the planning and application of story mapping features, all the ideas on cultural symbolization are fully expressed. Hence, bolder and more innovative attempts on the use of design teaching resources can be carried out to provoke students to bring in more imagination and creativity. This study is expected to provide the following researchers and students the continuity in the inspiration of learning and creative thinking.

Now, when it enters the 21st century, story design does not communicate simply cultural nature but that how to adequately integrate the resources of cultural styles with innovative product design to create the modern cultural features of the new generation. Consequently, designers also play the role of cultural reclamation, in which design is not only for them to express themselves, but they should further be obligatory to promote cultural ideas and expand the creativity development by means of story.

References

1. Lawson, B. (1990). How designers think. London: Butterworth Architecture.
2. Jocelyn, W. (2008). Design for social impact: What does it mean and why should we care. San Francisco: IDEO.
3. Mastropieri, M. A., & Scruggs, T. E. (1997). Best practices in promoting reading comprehension in students with learning disabilities 1976 to 1996. Remedial and Special Education, 18(4), 197-220.
4. Pressley, M., Johnson, C. J., Symons, S., McGoldrick, J. A., & Kurita, J. A. (1989). Strategies that improve children's memory and comprehension of text. The Elementary School Journal, 90(1), 3-32.
5. Lin, C. P. (1997). Learning consultation – Theory and practice. Taipei: Wunan.
6. Short, E. J., & Ryan, E. B. (1984). Metacognitive difference between skilled and less skilled readers : Remediating deficits through story grammar and attribution training. Journal of Educational Psychology, 76(2), 225-235.
7. Carnine, D., & Kinder, B. D. (1985). Teaching low performing students to apply generative and schema strategies to narrative and expository material. Remedial and Special Education, 6(1), 20-30.
8. Fowler, G. L., & Davies, M. (1985). The story frame approach: A tool for improving reading comprehension of EMR children. The Exceptional Children, 17, 296-298.
9. Idol, L., & Croll, V. J. (1987). Story-mapping training as a means of improving reading comprehension. Learning Disability Quarterly, 10, 214-229.
10. Newby, R. F., Caldwell, J., & Rech, D. R. (1989). Improving the reading comprehension of children with dysphonetic and dysedetic dyslexia using story grammar. Journal of Learning Disabilities, 22, 373-380.
11. Choate, J.S., & Rakes, T.A. (1997). Reading comprehension: Process, skills, and strategies. In J.Choate (Ed.), Successful inclusive teaching: Proven ways to detect and correct special needs(pp. 82-125). Needham Heights, MA: Allyn and Bacon.
12. Beck, I. L., & Mckoewn, M. G. (1981). Developing Questions The Promote Comprehension: The Story Map. Language Arts, 58(8), 913-918.
13. Pearson, P. D., & Dole, J. A. (1988). Explicit comprehension instruction: A review of research and a new conceptualization of instruction (ERIC Document Reproduction Service No. ED294152) .
14. Stein, N., & Glenn, C. (1979). An analysis of story comprehension in elementary school children. In R. O. Freedle (Ed.), Advances in discourse processing (Vol. 2). Norwood, NJ: Ablex.
15. Cardill, M. C., & Jitendra, A. (1999). Advanced story map instruction: Effects on the reading comprehension of students with learning disabilities. The Journal of Special Education, 33(1), 2-18.
16. Idol, L. (1987). Group story mapping: A comprehension strategy for both skilled and unskilled readers. Journal of Learning Disabilities, 20, 196-205.
17. Gerrit, M. (2003). Architectural reasoning; balancing genericity and Specificity Embedded Systems Institute, Eindhoven.

18 Gerrit, M. (2004). CAFCR: A multi-view method for embedded systems architecting; balancing genericity and specificity. Retrieved August 1, 2009, from http://www.gaudisite.nl/ThesisBook.pdf.

19 Ma, C. Y. (n.d.). Sky clear sand. Autumn thoughts, Retrieved July 18, 2009, from http://www.epochtimes.com/b5/3/4/30/c12609.htm
20 Nancy, F. (2008). My secret garden. New York: Simon & Schuster.
21 Inspiration from the bird. (n.d.). Retrieved May 18, 2009, from http://blog.pchome.com.tw/a700906200/post/1270846552

Wei-chen Chang,
Shih-huei Huang
Graduate School of Design, National Yunlin University of Science & Technology, Douliou, Taiwan

Elif Özcan and Marieke Sonneveld
e.ozcan@tudelft.nl

Embodied explorations of sound and touch in conceptual design

Abstract

In conceptual design, abstract features of a new product (e.g. adventurous, elegant) are explored and mapped to concrete physical product properties. Sketching as an exploratory activity is usually restricted to the visual product properties. However, rich and consistent product concepts involve all the senses. This paper explores conceptualization and sketching for two non-visual senses: sound and touch. How can designers audiolize and tactualize in the conceptual phase of designing? How do they go from the abstract to the concrete for sound and touch? This paper tackles the topic both from a theoretical and a practical perspective by analyzing design students' exploration processes for conceptual design. We conclude that auditory and tactual experiences are events, grounded in physical interactions, and therefore ask for embodied exploration during sketching. Furthermore, role-playing is suggested as a strategy that supports embodied explorations for sound and touch.

Keywords

Abstract Concept, Concrete Concept, Conceptual Design, Sound, Touch, Sketching.

1 Introduction

In the beginning of a design process, strategy developers often provide a design brief that summarizes the vision for the new product in order for designers understand the expected outcome of the global design project. In the design brief designers receive information about the product function and the core concept envisioned for the new product expression. First implementations of the design brief take place in the conceptual design phase. At this stage, designers need to tackle two types of conceptual design: design of the abstract product features which refer to the differentiation of the product by means of emotional impact (e.g., elegant, motherly, adventurous) and the concrete product features which define the prototypical form of the product and its supporting objects (e.g., a car, a coffee maker, a website). In the end, it is the designers' task to interpret abstract concepts and map them onto concrete product features, such as form, colour, texture, weight and sound. As a result, a coffee machine can be designed to be homey, friendly, and yet elegant, or a car can be designed to be adventurous, sportive and luxurious (see Figure 1). Abstract and concrete concepts seem to be fundamentally different: concrete concepts being tangible, whereas abstract concepts having a more intangible nature. Thus, the question designers are facing is: how to go from the abstract to the concrete?

When looking at the design practice, first explorations of this abstract-to-concrete conceptual mapping (i.e., the initial phase of 'sketching') seem to address mainly the visual sense. For example, sketches in the form of drawings or mock-ups occur while designers seek for

the appropriate product expression [1], [2]. However, product expression is a result of the combined physical product features, which inherently address all our senses [3]. Users prefer objects with a consistent relation among the different sensory features [4], [5]. For example, if the visual product property implies elegance, auditory and tactile product properties should also express elegance. However, despite the importance of a consistent multi-sensory expression, not much is known concerning the conceptual design for the auditory and tactual expression of products. How does a designer 'sketch' combining the abstract and the concrete in the auditory and the tactual domain? In other words: how does a designer audiolize and tactualize a product, next to visualizing it?
The main goal of the paper is to provide insights into the nature of exploratory sketching for these two neglected non-visual physical properties of products: sound and touch. In this paper, we will tackle the first explorations during non-visual sketching from two different perspectives. We will first have theoretical discussions regarding the fundamental differences (i.e., mental representations and structural compositions) between abstract and concrete concepts. Then, from the practical perspective, we will gain insight into conceptual design for different senses and observe design students' exploration of the auditory and tactual qualities of a new product during the sketching phase of a multi-sensory design exercise. Finally, we will conclude with recommendations for new strategies to support this auditory and tactual sketching in designing.

2 Conceptual representation

What is the nature of concepts? Murphy [6] describes concepts as the glue that holds our mental world together. Imagine a chair. The chair concept represents knowledge about the primary function of the chair (i.e., sitting on it), its physical disposition (e.g., image, sound, tactility), actions that take place with it, and the context of use (e.g., the location of use, other relevant products such as cushions, or potential users). Any given chair will be able to activate these conceptual associations. Furthermore, the concept of a particular chair can evoke abstract associations such as luxury, freshness, or playfulness. These associations depend on the subtleties in the product's physical disposition, on the user, and on the context of use. For example, the interpretation of playfulness can vary for a chair, a corkscrew or a car as

Fig 1. Left: Senseo, coffee machine by Philips; right: Sports car by BMW.

can be seen in Figure 2. This implies that designers face different types of physical interpretations for the same abstract conceptual design of a product. Presumably, they have to define first what, e.g., a prototypical chair should look like, and then determine how to apply more abstract concepts such as playfulness. As can be seen in the examples, perhaps playfulness has more obvious physical implications. However, when it comes to an subtle abstract concept such as sobriety, it is even more difficult to link sobriety to physical product properties. Are there any fundamental and representational differences between abstract and concrete concepts? If there are, this implies that designers need to bridge the gap between abstract and concrete concepts. If there are no differences, designers could use a common ground for their explorations of abstract and concrete concepts.

2.1 Abstract concepts vs. Concrete concepts

Cognitive psychologists argue that representation of (abstract or concrete) concepts in memory cannot be reduced to one modality (e.g., semantic, auditory, motor-action). That is, a concept encompasses physical and spatial object features. According to Paivio [7], a concept is the common space for sensory and semantic memories; therefore, it is via concepts that multi-modal interactions occur. Barsolou [8] takes this view further and suggests that the formation of concepts is embodied with all sensory, motor, emotional, and spatial experience. Therefore, a concept becomes linked to sensory and motor-action memories and can automatically re-enact all relevant sensory, semantic, and contextual representations. Accordingly, a collection of relevant living or inanimate objects, activities, situations, and locations underlie a conceptual network. Moreover, a concept can contain both core and peripheral information (i.e., direct and indirect

Fig 2. Products (a chair, a corkscrew, and a car) that express playfulness in their own way.

representations, respectively). Therefore, the structure of activated conceptual network can be dynamic as it adapts itself to the actual situations with the core and peripheral representations. Finally, a label (i.e., lexical representation) is the shortest semantic link to access a concept.
Psychologists and linguists discern two main types of concepts that differ in the representational structure: concrete and abstract concepts [9], [10], [11]. Roughly speaking, concrete concepts relate to physical entities such as objects, places, and activities that surround us (e.g., cars, apples, birds, bathroom, running). Abstract concepts are those entities that cannot be quantified by physical, spatial, and temporal object properties (e.g., truth, democracy, invention, adventure). Paivio [12] has shown that concrete concepts have an overall advantage to abstract concepts in terms of memory storage, speed of lexical access, and word comprehension. One of the main reasons for this is that abstract concepts lack sensory references, which makes their sensory memory coding weaker and presumably the direct categorical semantic associations weaker. According to the recent study of Dunabeita et al. [13] an activated conceptual network for abstract words is greater than concrete words. That is because, the primary organization of concrete words is based on categorical similarity (e.g., apples are compared to bananas and oranges), whereas, abstract words are organized by their semantic association to other words (e.g., theft relates to punishment, court, jail) and fail to provide categorical associations (e.g., theft is not compared to burglary).
Although abstract and concrete concepts seem to differ in cognitive processing and organizational structure, there is converging evidence that suggest that abstract concepts are formed by perceptual processes [14] and are grounded in perceptual representations [15]. Furthermore, Barsalou and Wiemer-Hastings [16] have shown that abstract concepts can even hold situational information (e.g., location). These findings imply that abstract concepts are rather part of a sensory-cognitive network. Furthermore, considering that any conceptual representation is amodal but have links to the sensory information, perhaps it is the synthesis of sensory inputs that constitute the representation of concepts. Assuming that abstract concepts also have sensory representations, designers may simultaneously explore such concepts directly with their senses. This suggests that designers adopt a more embodied approach for the search of the physical correlates of abstract concepts.

2.2 Metaphors

Surfacing the sensory representation of abstract concepts is a difficult task for designers. In the search for the interpretation of product expression, and the subsequent mapping on physical product properties, designers need supporting tools and design methods. One of the methods employed often is the use of metaphors. Gibbs [10] defines metaphors as a specific mental mapping that influences much of how people think, reason and imagine in everyday life. Metaphor, by definition, is a linguistic style that is used to simplify and also embody abstract thoughts and ideas in order to make them relatively more imaginable [11], [17].
Abstract ideas cannot be understood through their own representation, because they lack clear physical references. For example, life (an abstract concept) is not an easy concept to understand and explain without any apparent physical features. However, if we resemble life to a rollercoaster (a concrete concept that supports imagery), then, the physical features of a rollercoaster will be mapped on to life, making life materialized. That is because, both life and a rollercoaster share common features such as continuity, time, variations in speed, changes in the altitude that causes emotional fluctuations, and so on. Murphy [9] explains this as the following: All concepts are a result of embodied cognition and are represented in their own way, even the abstract ones. Consequently, the semantic / sensory structure of abstract or concrete concepts may share similarities. Such similarities can be exploited by the application of metaphors.
In design, metaphors are often used for the same purpose: visual poetry. Stylistic, formal, and structural properties of a product can be used to apply a metaphor in order to enhance the function as well as the meaning of the product [18], [19], [20]. For example, the photo

Fig 3. Flee camera by Hakan Bogazpinar. The camera is designed to take several photos at different time intervals when airborne.

camera (named as flee camera) in Figure 3 resembles a badminton shuttlecock which makes it easier for users to associate the correct usage of this photo camera: Toss it and it will drop back safely like a badminton shuttlecock. Metaphors in design can decrease the cognitive load users might have in the interpretation of the abstract thoughts which designers materialized into physical product features. In the case of the flee camera, the users can understand the use of the camera via the physical and functional properties. That is, especially the form of the camera is inspired by a shuttlecock. Hekkert [20] classifies five reasons to exploit metaphorical expression in design: (1) identification (e.g., the first cars referred to a horse and carriage), (2) use / operation (e.g., trash can on our desktop), (3) figurative meaning (e.g., Senseo Crema expresses 'servitude' because its bended shape refers to a butler or waiter), (4) fun / wit (Alessi's Anna G corkscrew), and (5) ideology (designing a chair that looks like a flower to bring in the nature into homes). Because all senses can be used for the application of metaphors, we expect to encounter the use of metaphors during the exploration of abstract ideas for sound and touch design.

3 Conceptual Design

Within the product development phase, conceptual design starts with the interpretation of the design brief. This phase gives designers freedom to explore possibilities for the aesthetic, ergonomic, functional, and emotional aspects of a product. It is a creative process and designers are ready to be inspired. Many ideas are generated and assessed. More than one conceptual design is created and discussed among the design team members. The outcome of this phase is taken further in the materialization phase.

Typically, in a design brief, the function of the product is known and also the type of expression that needs to be explored. It is a challenge for designers to establish a conceptual space for the design of a product that fits both their designerly intentions and the semantic associations that the consumers will eventually have with the product. Accordingly, designers face two different types of conceptual associations during the conceptual design of a product: (i) concrete concepts that often are or relate to the prototypical product features and therefore that are easy to imagine and implement; (ii) abstract concepts that do not have direct links to product features or have changing featural presentation depending on the product and therefore that are difficult to imagine and to implement. Therefore, during conceptual design the physical properties of a product needs to be determined and consequently translation of the abstract to concrete takes place.

The most typical activity during conceptual design is sketching. Through sketching, designers think, reason, create, share, and discuss (see Ferguson's thinking, talking and prescriptive sketches, [21]). Sketching can occur in the form of drawings, making mock-ups, annotations, small-size working models, etc. According to Buxton [1] sketches should be evocative, suggestive, explorative, questioning, provoking, and tentative. Although conceptual design inherently tackles all physical aspects of a product, in practice auditory and tactile properties of a product are often neglected during this phase. Activities such as sketching or communication have often been studied in the form of visual form of the product. However, Buxton [1] and Ferguson' [21] suggestions do not explicitly exclude auditory and tactile sketching. Not much is known, how tactile and auditory sketching happens. The main aim of this paper is to investigate designer's exploration process during only auditory and tactile sketching.

3.1 Visualization

Purcell and Gero [22] have discussed that drawings that occur in the early stage of conceptual design (i.e., sketches) embody abstract and high-level design ideas, and furthermore, such activities involve thinking through imagery, reinterpretation, and the use of knowledge in the long-term memory. In other words, imagery and reproduction of concepts seem to be the key cognitive activities that designers incorporate during sketching. Such cognitive activity also involves sensory processes and requires the activation of information stored in sensory memories. Furthermore, Kavakli and Gero [23] have suggested that mental imagery of objects and their structures (mental synthesis) could be equivalent to seeing real objects and (physical synthesis). Oxman [24] has stated that shapes that emerge during sketching are not only the result of perceptual processes but also e result of thinking with shapes. According to Oxman, emergent shapes are the first signs of conceptualization, which is the connection between semantic content and structural form; and also, the function of images in design is to link semantic content to complex perceptual content.

These findings imply that with imagery designers are able to reproduce sensory properties of a product and initiate the first conceptualization of a product and its features. Thus, visual sketches can be considered as the outcome of a series of mental activities that involve sensory, motor-action, and semantic memories. Moreover, a network of abstract and concrete concepts must be active during sketching. Do similar mental activities apply for auditory and tactile sketching?

3.2 Audiolization

Designing the sound of products is a new field (excluding the automotive industry which have gained expertise on sound design over the years). In existing practice, designers encounter product sounds only in the prototyping phase when all the ideas are embodied in the form a working model. That is, establishing the design requirements for a product sound often starts late in the design process at the point in which sound exists. Özcan [25] suggests that sound design should be a part of the main design process and should go parallel to it in order to avoid time loss and interruptions for mechanical alterations. Nevertheless, tools and methods lack that support designers in their attempt to design product sounds in each phase of the design process [26]. Existing methods (e.g., questionnaires with sound) help designers evaluate the sound quality of the product and position their product among the competitors. However, in order to get to the point of sound evaluation, a proper conduct of sound design should take place (i.e., problem analysis, conceptual design, materialization, prototyping, and evaluation). Accordingly, the first crucial step is the conceptual design. At this early stage of designing only the ideas exist but not their physical components. As done with visual sketching, explorations are needed to determine salient auditory features of a sound. For example, what physical features of a product could evoke, e.g., friendliness? Designers could use rounded shapes, bright colours that do not hurt the eyes, or softer materials in order to evoke friendliness. Similarly, for sound Özcan and van Egmond [26] has suggested a method that prompts designers collect objects that may emit a friendly sound. Accordingly, designers with their idiosyncratic approach could search for a bath-duck for its squeaky sound, silver bangles or cat bells for their jingling sound, or a wooden windcharm for its chiming sound. Then, they can analyze the spectral-temporal content of the material collected and come up with a common physical sound description: friendliness for sound means overlapping repetitive sound events with a rather high-pitched sound that has a short round envelope. This sketching activity for sound is called audiolization.

Furthermore, a graduation student at Delft University of Technology [27] is investigating how sound sketching takes places within an interdisciplinary design team which are not experts on sound design. Jansen, adopting Ferguson's terminology [21], suggests thinking sketches for the first explorations of product sound, talking sketches for communication among the team members, and storing sketches for further alterations. Jansen's approach covers a full sketching activity and in this paper we only tackle the initial explorative phase of sketching (i.e., thinking sketches). Upon this explorative phase, designers translate their discoveries into physical product properties.

3.2 Tactualization

Touch is a tacit experience [28]. This tacit aspect of tactual experience makes it a difficult topic to address during the design phase: we do not have the means to get access to it and to explore it. Sonneveld [29] developed a conceptual framework for designers to get insights in the nature of the tactual experience, describing five domains of touch: the movements involved, the bodily sensations, the tactual properties, their affective expression and the experienced feelings people have. Overall, the tactual experience of an object can be described by the body language of that object. The sketching of tactual aspects of touch (i.e., tactualization) can be seen as a designer's explorations of the body language of objects. In the course Tactility [29], students try out different techniques to support this tactualization process. First, words and images are used to explore the abstract aspects of the tactual experience. For example, an object can be described as stubborn because it does not want to open (e.g., a cookie jar) or as aggressive because it actually hurts you. An image of two acrobats can be used to illustrate a specific type of working together that is experienced between a user and a tool. To describe tactual properties of designs in a conceptual phase, tactility students create 3D-collages: they build a collection of materials and objects each illustrating a specific tactual aspect (such as texture, shape, flexibility, hardness, weight, balance, and so on) thereby tactualizing the product as a whole. The next step in tactualization is to model the design, in clay, foam, or other materials that allow designers to explore the nuances in of tactual properties.

In the virtual world, tactualization is still in a pioneer stage. For example, Free form is a virtual design system that offers the designer a experience of virtually claying, supported by visual images (http://www.sensable.com/industries-design-model.htm, seen on 30-06-09). But so far 'materiality' in the virtual world is mainly approached from a mere visual perspective.

4 The practice of audiolization and tactualization

At the Delft University of Technology, the course Multi Sensory Design offers a platform for students to explore the multi-sensory aspects of products, and to design for an integrated multi-sensory experience [30]. The course provides workshops for each sense modality, and asks students to collect sensory stimuli for a specific expression. For example, students are provided with the concept 'naïve' and collect images, sounds, tangible objects, and smells that express the 'naïve'. After an individual collecting phase, the students bring their stimuli to the class, during which they are discussed for each sense modality. In this course, the authors of this paper provided the workshops on sound and touch, and supported the collecting and discussing of the auditory and tactual stimuli.

After collection and discussing, the students fill out a questionnaire for each sense modality to describe the stimuli they collected and the conclusions on their sensory aspects, and to describe the process strategies they adopted to collect and analyze these stimuli. In discussing the results on sound and touch, we found fascinating similarities in the strategies the students developed to go from the abstract to the concrete, which led to the initial ideas to this paper.

The following section presents the different strategies reported during the course, held in the third quarter of 2008/2009. The course was attended by 24 students, divided in groups of 6, each group exploring a specific product expression (fickle, determined, reserved, or involved).

4.1. Open-mind searching

Students start with an open mind: touching and listening to sensory phenomena in their environment, asking themselves how they experience these stimuli: "I just looked around and touched things. However, not everything. I only tried things that looked like they might feel fickle to touch, so who knows what I have missed?'. Students with this approach have built a collection of concrete descriptions that broaden their insights of the abstract concept. Several students report that finding the first object is the most difficult stage. Once they have a starting point it is easier to elaborate on it: "The first thing that felt determined was a mortar and from that as a starting point I found the other objects".

On the other hand, some students start with elaborating on a deeper understanding of the abstract concept. For example by generating a list of keywords that define the desired experience. These insights allow them to generate a list of possible sensory properties that might express the experience they are exploring. Once they have this preliminary list of possible sensory properties, they look for objects with such properties in their environment. This approach might limit the exploration phase: "At first, I was limited by the properties 'soft' and ' loose'. So, the materials I linked with involved are all soft things".

4.2 Physical explorations

Students differ in the environment in which they start looking for examples. Some look in their direct surroundings (home, school, shops and street) for these objects: "I went to many different shops and started touching, feeling and playing with different objects that could give the experience of involvement". Some students report that they go to a specific environment where they expect to encounter the experiences they are exploring. For example, they go to the workshop of the faculty to find determined sounds and touch, because they assume that these experiences actually happen in that environment. These exploration involve physical interaction: the students explore the sensory properties of the object by exploring what they can do with them: "I explored my belongings first and kept adjusting the way to interact with the objects to find the most proper sound matching 'involved'". Students seem to be aware of this active aspect of exploration: "for touch, I took a more active searching stance, by manipulating any kind of objects'.

Most students report that it is only through active exploration of an object (grabbing it, playing with it, exploring its different possible interactions) that they can explore the appropriate sensory properties, for sound as well as for touch. The same object may differ in its expressions, depending on the type of interaction. For example, a gentle rubbing of a texture may give an impression of involvedness, but squeezing the same object might not. Thus, stimuli are not collected per se, the appropriate interaction needs to be described as well.

Instead of exploring the real world, some students start searching their own memories of past experiences in order to come up with examples of objects that express the desired experience. Other students start to look for sounds on the Internet to get a first impression of what they are looking for. Nevertheless, the students starting in a virtual setting report that they eventually turn to the material world to look for examples, because they need to experience 'the real thing' to get the 'real feeling', whether it is to explore touch or sound: "I started to look at findsounds.com, but I realized very quick that I need an object to be able to listen to the expression of the sound". Because, as another student stated: "the real experience of interaction with a product is just better than just the recorded sound on the internet".

4.3 Acting out

Because the exploration of sound and touch involves an active physical exploration of the interactions with objects, thus of events, some students developed 'acting out' as third strategy to explore an abstract experience. Some students reported that they first try to put themselves in the mood of the experience they are exploring and then, interact with their environment to search for stimuli that resonate with their own mood: "I explored everything in my environment while being in a 'determined' mood, This allows me to connect with the object itself and find out if the object feels like me or not". Furthermore, some students explore themselves, how they feel when they are in a specific mood: "I tried to put myself in a sound experience that would make me feel involved".

4.4 Simultaneous explorations of the concrete and the abstract

Students deepen their insights simultaneously on the abstract level and on the concrete sensory level. The students start out with just one word describing the experience they are exploring (e.g. involved), but in the end they have a list of several other abstract descriptions of this experience (e.g. gentle, peaceful, familiar, towards you, surrounding, and so on). There seems to be a going back and forth between the abstract and the concrete. The discovery of a specific sensory property (e.g., the smooth properties of a material gliding between the fingers), gives the insight that involvedness is the experience of being surrounded with care. This is illustrated by the interaction with a glove or a wool slipper. This in turn leads to the insight that involvedness is expressed through the concrete property of warmth.

This going back and forth between the abstract and the concrete is an important aspect of the exploration strategies; it allows students to build a deep understanding of both worlds. Moreover, the results of the collected stimuli and their descriptions show that the understanding of an abstract concept might differ for sound and for touch. For example, in sound, involvedness is described as something "that attracts you to join", and as something "that keeps you fascinated". Whereas in touch, this auditory attraction of involvedness translated into the experience of "being one, of melting together". In addition, in touch involvedness is experienced when something '"will stay in contact with you in a gentle way, when it will not let you go". This suggests that exploring all the senses separately actually enriches the overall understanding of the abstract experience.

4.5 Metaphors

In the previous section, metaphors were identified as fruitful means to explore the experience of objects. This is confirmed by the descriptions provided by the students: many of them are based on the use of a metaphor. For example, "I think being reserved has to do with opening and closing. So I listened to the sounds when opening and closing different products in my room". The descriptions of the students show many metaphors that describe a specific action such as hugging, surrounding, melting together, pushing, attracting, and so on. This underscores that exploring the auditory and the tactual is grounded in bodily action, and can be researched by mimicking these actions.

4.6 Increasing awareness for the sensory experience

Students report that throughout the exploration phase of the assignment, their sensory experience of their surroundings is increased. They start to hear the objects around them, to actually 'listen to what they are saying', rather than taking the sounds for granted as "just functional background noise". This increased awareness eventually allows them to go through the searching process with more ease and sensitivity than when they first start.

4.7 Conclusion: embodied exploration for sound and touch

The observation of student exercises has shown us that translating the abstract to the concrete in sound and touch is an embodied exploration process. Sound and touch are events, to be explored by doing something. This embodied exploration underscores that sound and touch are time dependant and therefore need action to be experienced and explored. Furthermore, we can conclude from the observations that the interpretation and translation process is not a one-way reasoning from the abstract to the concrete. Both the abstract and the concrete are explored and developed simultaneously in a back and forth process. Interestingly, these two types of explorations do not occur separate from each other. We observed an inter-dependant and embodied process for the explorations of the concrete and abstract concepts. The use of metaphors has emerged in student's conceptualization activities. They use metaphors to explore and understand the abstract concepts and also to communicate their approaches to define the abstract concept.

5 Discussion and future explorations

The previous section emphasized on action, acting out, being involved, being aware of the body, and experiencing the real world as the strategies used by design students in exploring sound and touch. These aspects all together lead to the notion of role-playing as a potential exploration strategy to explore the sensorial aspects of abstract experiential concept. This implies that only asking designers to collect auditory and tactual stimuli does not seem to be the right approach. We should rather ask designers to look for physical (inter)actions that produce auditory and tactual experiences. Role-playing allows designers to imagine events and to experience their sensory implications as an outcome. The value of role-playing was already extensively described by Boess [31] and Boess, Saakes, and Hummels [32]. They emphasize the fact that role playing is a bodily experience, therefore an inspiring technique to enrich the design experience and to enhance empathy for the users. The findings in this paper confirm these insights, developing them with the insight that in role playing, one can explore the auditory and tangible aspects of human-product interaction.
To achieve this, the findings of our students suggest that role-playing as an exploration technique in design should involve different objects that offer a broad pallet of auditory and tactual experiences. Role-playing will therefore be further explored in future workshops in design courses at the Delft University of Technology.
In Section 2 we discussed the nature of abstract and concrete concepts and have concluded that although there are functional and representational differences, both type of concepts can be grounded in the sensory systems. Our observations and findings regarding how designers explore abstract concepts for certain sensorial expression provide support for this conclusion. That is, abstract concepts can have sensorial links and it is possible for designers to surface the sensorial representations of abstract concepts. Combining this finding with Murphy's discussion [33] that there is lack of empirical evidence to demonstrate sensorial representations of abstract concepts, we suggest that designing products with their multi-sensory character make a good platform to investigate this phenomenon. Conceptual design seems to be the most suited design phase for this purpose as designers are bound to use abstract concepts and translate them onto physical product properties.
Furthermore, in this study we only tackled the initial explorative phase of sketching for sound and touch and excluded the actual audiolization and tactualization of the abstract concepts into a material object. Future

empirical studies could investigate this actual translation from the abstract to the concrete and thereby give deeper understanding of the semantic and sensorial representations of abstract concepts.

References

1. Buxton, W. (2007). Sketching user experiences: Getting the design right and right design. San Fransisco: Morgan Kaufmann.
2. Van der Lugt, R. (2001). Sketching in design idea generation meetings. Unpublished doctoral dissertation, Delft University of Technology.
3. Schifferstein, H. N. J. & Hekkert, P. (2008). Product experience. Amsterdam: Elsevier.
4. Ludden, G. (2008). Sensory incongruity and surprise in product design. Unpublished doctoral dissertation, Delft University of Technology.
5. Schifferstein, H. N. J & Desmet, P. M. A. (2008). Tools facilitating multisensory design. The Design Journal. 11(2), 137-158.
6. Murphy, G. L. (2002). The big book of concepts. Massachusetts: MIT Press.
7. Paivio, A. (1991). Dual coding theory: Retrospect and current status. Canadian Journal of Psyhcology – Revue Canadienne de Psychologie, 45(3), 255-287.
8. Barsalou, L. W. (2003). Grounding conceptual knowledge in modality-specific systems. Trends in Cognitive Sciences, 7(2), 84-91.
9. Murphy, G. L. (1996). On metaphoric representation. Cognition, 60, 173-204.
10. Gibbs, R. W. (1996). Why many concepts are metaphorical. Cognition, 61, 309-319.
11. Lakoff, G. & Johnson, M. (1980). Metaphors we live by. Chicago: University of Chicago Press.
12. Paivio, A. (1986). Mental representations: A dual coding approach. Oxford: Oxford University Press.
13. Dunabeitia, J. A., Aviles, A., Afonso, O., Scheefers, C., & Carreiras, M. (2009). Qualitative differences in the representation of abstract versus con concrete words: Evidence from the visual-world paradigm. Cognition, 110, 284-292.
14. Goldstone, R. L. & Barsalou, L. W. (1998). Reuniting perception and cognition. Cognition, 65, 231-262.
15. Mahon, B. Z. & Caramazza, A. (2008). A critical look at the embodied cognition hypothesis and a new proposal for grounding conceptual content. Journal of Physiology – Paris, 102, 59-70.
16. Barsalou, L. W. & Wiemer-Hastings, K. (2005). Situating abstract concepts. In D. Pecher & R. Zwaan (Eds.), Grounding cognition: The role of perception and action in memory, language, and thinking (pp. 129-163). New York: Cambridge University Press.
17. Steen, G. (1994). Understanding metaphor in literature. New York: Longman.
18. Cupchik, G. C. (2003). The 'interanimation' of words: Creative metaphors in art and design. The design Journal, 6(2), 14-28.
19. Van Rompay, T., Hekkert, P., Saakes, D., & Russo, B. (2005). Grounding abstract object characteristics in embodied interactions. Acta Psychologica, 119(3), 315-351.
20. Hekkert, P. (2007). Metaphorical communication and appreciation in product design. Paper presented in the Workshop MultiModal Metaphor – Driebergen.
21. Ferguson, E. S. (1992). Engineering and the mind's eye. Cambridge: MIT Press.
22. Purcell, T. & Gero, J. S. (1998). Drawings and the design process. Design Studies, 19(4), 389-430.
23. Kavakli, M. & Gero, J. S. (2001). Sketching as mental imagery processing. Design Studies, 22(4), 347-364.
24. Oxman, R. (2002). The thinking eye: Visual re-cognition in design emergence. Design Studies, 23(2), 135-164.
25. Özcan, E. (2008). Product sounds: Fundamentals and application. Unpublished doctoral dissertation, Delft University of Technology.
26. Özcan, E. & van Egmond, R. (2006). Product Sound Design and Application: An Overview. In P. M. A. Desmet, M. A. Karlsson, & J. van Erp (Eds.), Proceedings of the 5th International Conference on Design and Emotion. Gothenburg: Chalmers University of Technology.
27. Jansen, R. (2009). Sketching product sounds. Internal report, Delft University of Technology.
28. Polyani, M. (1967). The tacit dimensions. New York: Doubleday.
29. Sonneveld, M. H. (2007). Aesthetics of tactual experience. Unpublished doctoral dissertation, Delft University of Technology.
30. Sonneveld, M. H., Ludden, G. D. S., & Schifferstein, H. N. J. (2008). Multi sensory design in education. In Proceedings of the 5th International Conference on Design and Emotion, Hong Kong.
31. Boess, S. U. (2008): First steps in role playing. In: Proceedings of ACM CHI 2008 Conference on Human Factors in Computing Systems (pp. 2017-2024). S.l.: ACM.
32. Boess, S. U., Saakes, D., & Hummels, C. (2007). When is role playing really experiential?: Case studies. In: Proceedings of the 1st International Conference on Tangible and Embedded Interaction (pp. 279-282).
33. Murphy, G. (1996). Reasons to doubt the present evidence for metaphoric representation. Cognition, 62(1), 99-108.

Elif Özcan and
Marieke Sonneveld
Faculty of Industrial Design Engineering, Delft University of Technology, Delft, The Netherlands

Stella Boess
s.u.boess@tudelft.nl

For future use: an initial categorization of designers' speech-accompanying gestures

Abstract
This paper is about the problem that designers do not always design successfully for product meaning in use. Tools to alleviate this problem, such as the presentation of usability data or role-playing exercises, have drawbacks. They may be difficult for the designers to use or may not be easily available and accessible at the moment that design decisions are being made. A pilot study is presented that seeks to find starting points in the designers' own talk for a tool that could improve this situation. A categorization of the designers' speech-accompanying gestures is adopted and applied to a pilot sample of data. An initial finding is that the designer used few emotive expressions when demonstrating presumed product use. A future tool could take its point of departure from this finding if further corroborated, helping designers engage with product use better during designing.

Keywords
Product Meaning, Product Use, Anticipation, Speech-accompanying Gestures, Gesticulations.

1 Introduction
This paper presents a pilot analysis of product meaning in use as talked about by designers. The paper is part of a research effort to develop tools for designers that they can use to anticipate on future product meaning in use. What is meant by product meaning here? The focus is on the mainly functional meaning that users make of products in an interaction, and the ways designers can design to accommodate for this meaning. To give an example of functional meaning: how a user will know how a hatch on a product can be opened, or whether a user is able to find a red stop button when the user wants to shut down a product quickly. The author found previously (as others have, as well) that it is not always easy for designers to anticipate on functional product meaning in use at those moments when they are making concrete design decisions. Often, neither users nor information about them are (easily) accessible at those very moments. This difficulty for the designers contributes to usability problems for the users of the finished products [1, 2]. Many attempts have been made to address this problem. For example, the specialized field of usability research seeks to provide information to designers on how users interact with products. However, Cooper [3] argued that usability research sometimes slowed down design processes so much that designers did not want to be bound by it anymore. Furthermore, Black [4] found from extensive consulting experience that designers need data about product use to be transformed and communicated in such a way that they can use it. "Many professionals, particularly designers, are not great readers. They need key points, vividly and memorably presented, to carry the user perspective forward from observation right through product development." From the basic realization

that designers need information about product usage, we next realize that the designers need it in such a form and at those moments that they can use it during designing. Reports and requirements are not enough.

1.1 A double gap between designing and using products

Any human activity is dynamic, situated and involves human decisions, emotions, movements, and interactions [5]. At the moment that a designer makes a decision about a product, the product can appear to be a static entity or configuration. The designer decides, for example, on the colour or shape of a casing, or on a protocol that later regulates a certain data transmission. At that moment, the designer's activity is that of designing, not of using. However, the apparently static configuration on which a decision is being made, will later be used and experienced as part of a dynamic use situation. There is a gap here, not just between mental models of the designer and the user about what the system is and does [6], but also between the kind of activity of the designer carries out and the kind of activity that the user carries out. The gap relates to time (design=now, use=future) and space (design office versus use situation). A tool should be of help to the designers in bridging this double gap between now and later and between here and there, just like, for example, scenario approaches do. My previous conclusions [1, 2] were that the designers found it difficult to move across this double gap. For example, they often did not distinguish between their design intentions ("then the user has to do that…") and their ideas about what users might actually do of their own accord. They tended to talk about the former.

1.2 Testing, enactment and communication

The study that was conducted previously also showed that the formalised and specialised usability testing that is part of the development processes e.g. at large companies, can create a distance for the designers from access to testing [2]. Possibly as a result of this, but perhaps also because of their own inclination, some designers conducted testing informally themselves, with colleagues or relatives [2]. They also demonstrated the use of a product to each other during design meetings [2]; so the designers' knowledge about product use derives partly from looking at their own product use. They furthermore communicate about their design decisions with others and sometimes have to try to persuade those others [1]. So it can be presupposed that the designers have a need to see the use of their products being enacted, either by themselves or by others. A tool to be offered to them should connect with this need to see the use of their products. If a tool were also of help to the designers in communicating about their design decisions to others, this would also conceivably make such a tool more accept able to them. Particularly in the field of interaction design, the problem of anticipating on later product use has been addressed, for example, through actively working with use scenarios and/or stories during design processes. While scenarios present an abstracted, normal view of interactions related to a certain design challenge or task, stories are more concrete and personal and with that, offer more opportunity for emotional engagement and identification with a protagonist [7]. Scenarios and stories bring the users' later actions into the design process to some degree. Enacting these scenarios can be of further help in anticipating on user actions. For roughly the last twenty years, researchers have explored how the dynamics of interaction can be included in the design process by introducing role playing techniques that exaggerate and make explicit the users' anticipated later actions (for brief reviews of the literature, see e.g. [8, 9, 10]). While these efforts aim to improve the designers' capability of empathizing with users and of imagining the use situation, it has also been found that designers do not always find it easy and self-evident to engage in role playing activities [8]. Even designers who are familiar and proficient with these activities caution that such activities are not always suitable during designing, because they can over-simplify or even caricature the users' actions and situation. The use of video prototyping has increased as a way to present (anticipated) use situations engagingly [e.g. 11]. While these turn out to have particularly strategic and vision-building value, they tend to be work-intensive to make. There is still a lack of small methods and tools that designers can use and interact with in making the small decisions where information is lacking. The purpose of the paper is to identify starting points for a tool that can be provided to designers in order to integrate product meaning in use more in an engaged way, and consequently more user-centred, in their designing activity.

2 The study

In order to lower the barrier for designers to have access to product meaning, this study takes a different approach than the dramatization of user actions. The overall aim of the study is to find out whether there are starting points for a tool to be found in the designers' own talk and behaviour. Such a tool might then feel more natural to designers and thus present fewer barriers to its adoption.

Previously, the author conducted an interview study with designers and asked about the terms that the designers use when they talk about meaning in product use [1]. The designers were also asked about the activities that they carry out in order to ensure that users can make sense of products [2]. The video data from the ten interviews showed designers using gestures copiously while they described intended, presumed or anticipated interactions with the products they had designed. This initial observation prompted the step to focus on gestures in a new analysis. This study is a re-analysis of the same video data, with a specific focus on the designers' gestures. A pilot analysis of the data is presented here.

2.1 Speech-accompanying gestures

The focus in this study is on the gestures that accompany the designers' talk. Most verbal communication between people includes gestures through which the speakers indicate or emphasize their intentions and meanings: speech-accompanying gestures or gesticulations [12]. They are investigated here for their role in making future use present for the designers. In order to understand this role, it is necessary to assess whether and how designers were engaged with the anticipated use of the products they had designed. How can different ways of expressing by designers, to let users recognize the function meaning of the product, be categorized?

2.2 Data

The material from the previously mentioned interview study is used as data here. As a caveat, the data that is used is not completely representative of the designers' normal talk. The data derives from ten in-depth, semi-structured interviews the author conducted with the designers [1]. In the interviews, the designers had been asked to discuss their design decisions on products they had designed, with those products at hand. This interview situation may differ from the work situations the designers are usually in. Still, it is part of designing to have to present one's results and ideas to others verbally and physically. So while the situation itself is probably out of the normal realm of the designers' work, the data derives from a quasi-conversational situation and probably reflects the designers' normal vocabulary and ways of talking about usage aspects of the products they designed fairly well.

2.3 Analysis approach

Almost all of the data from the ten interviews were potentially useful for an analysis because it showed the designers gesturing and reasoning about use. However, it was not clear yet how the material could be categorized. Since the topic of gestures is a complex research area and other authors have previously investigated it, it was decided to adopt an existing categorization to work from in analyzing the data. It was difficult to find existing categorizations that were focused on the content and the meaning of a gesture. Hummels and Stappers' [13] categorization stood out in this.

Adopting a Categorisation. Hummels and Stappers [13] presented a categorization of designers' gesticulations that they had developed in order to then develop a gesturing sketch tool for designers. Hummels' work [14] was focused on the design of actual objects in its investigation of gestures. It was not focused on the verbal communication of designers, but on their sketching situation. As Hummels and Stappers [13] note: "When the designers sketched forms by gestures they rarely made use of speech". Nonetheless, the categorisation of gestures that Hummels and Stappers [13] propose, was found to be valuable here in that it investigates what the gestures can be taken to mean, rather than just recording patterns of the gestures themselves (Figure 1). Hummels and Stappers [13] present a definition of gestures that is meaning-focused: "a gesture is a movement of one's body that conveys meaning to oneself or to a partner in communication". These meanings, it was supposed, could also provide insights into the designers' view on anticipated product use in the study presented here.

Marking a pilot segment of the data using the categorization scheme. A segment in which the designers' hand movements with a product were shown

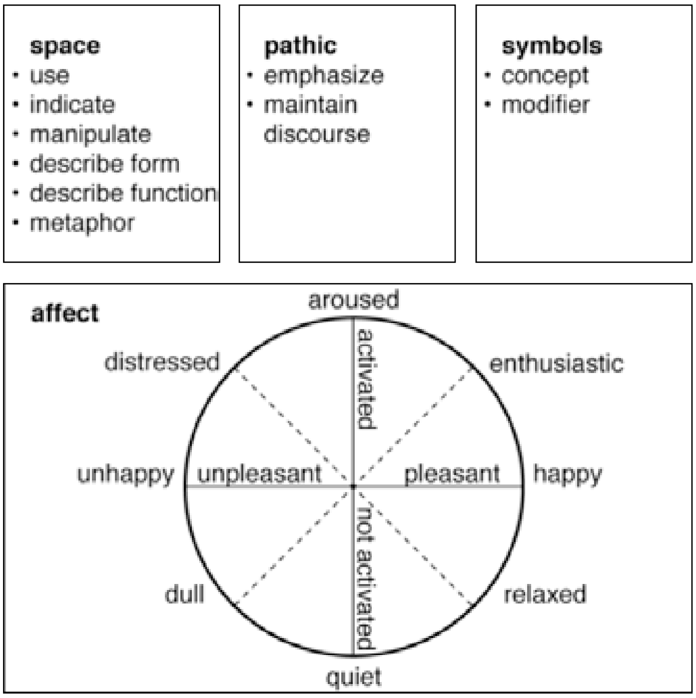


Fig. 1. The categorisation of gestures proposed by Hummels and Stappers [13]

B: Dit is dit is rond dat duidt dat je hieraan kan draaien	SIU
toch zie je niet dat die hele cirkel niet dit is eigenlijk	SID
een rechthoek maar omdat hier dat toch dat kromme	SIU
oppervlak bovenaan hebt in combinatie met de	
ribbeltjes hebt begrijpen mensen in combinatie met de	SIU
ribbeltjes toch oja dat je daaraan kan draaien. Nu als je	SIU
kijkt naar de conventie die hier is gebruikt dan zie je	SII + SID
ook bijvoorbeeld de dominantheid of de	PEF
ondergeschiktheid van een grafiek doordat zoals je	SII
deze knoppen ziet. Hoewel dat grafiek echt in de	SCF
knoppen vastzit, maakt dat ze ook meteen met elkaar	PMF + SII

Fig. 2. Coded interview text, with codes corresponding to Hummels and Stappers' categorization [13]. A translation is provided in Table 2.

Category	Sub-category	Gesture, movement or emotion	Code
Space	Interaction with a 3D object	Using Indicating Manipulating Describing the form	SIU SII SIM SID
	Functionality without a direct relation with form	Describing its functionality Metaphor (being the object)	SFD SFM
Pathic	Emphasize aspect	Formless gesture (hand) to support the process	PEF
	Maintain discourse	Formless gesture (hand) to improve the process	PMF
Symbols	Specified concept	Manual expression Finger expression Body expression	SCM SCF SCB
	Specified modifier	Manual expression Finger expression Body expression	SMM SMF SMB
Affect	Pleasantness & Activation	Aroused Enthusiastic Happy Relaxed Quiet Dull Unhappy Distressed	APA APE APH APR APQ APD APU API

Table 1. The original categorization scheme, based on Hummels and Stappers [13]

quite clearly, was selected for pilot analysis. Hummels' and Stappers [13] categorisation was applied (Figure 1). Codes were assigned to the gestures found. Below is an example of the relationship between what is being said and the accompanying gestures (Figure 2). The running text is marked in colour where accompanying gestures occur. The codes on the right hand side correspond to the codes shown in the categorisation scheme in Table 1. This video data fragment is shown in pictures in Figures 3 and 4. The utterances being made are presented Table 2.

2.4 Findings

In the pilot segment, it was found that the recorded data did not allow for a categorisation according to affect, as the face of the designer was not visible in this recording nor in most of the recordings from the interview study. Yet just as Hummels and Stappers [13] had included the affect category in order to estimate rather than to determine the emotional expression of gestures, it was still possible to interpret some emotional content in the data. This related to the amount of expressiveness per se: whether it was largely absent and the gestures were basically 'sober', or whether the gestures had an emotional loading.

It was also found that there was a relationship between the type of gesture and the amount of emotional loading that could be interpreted in the gesture. Interaction-related and symbolic gestures were found to be less emotionally charged, yet partly highly expressive in themselves. On the other hand, the more commonly known speech-accompanying gestures such as place holders and contextual gestures tended to betray a greater emotional investment, although in themselves they were not the most elaborate as gestures. (Figure 5).

2.5 Adapted categorization

An adapted categorisation was created that reflected these findings. This categorisation can be used in a future, more extensive, analysis to investigate more of the data for the relation between gestures, their expressiveness, and the content of wat is spoken about. The new categorisation is shown in Table 3. Instead of affect, a category 'context' is created in which the designer was not interacting with an object particularly but with the context, the interview situation and the topics being discussed.

3 Discussion and conclusions

The most interesting finding from this pilot analysis in terms of the long-term aim of developing a tool, is that the interaction-descriptive gestures related to objects were the least emotive. Should they be? Conceivably, this finding indicates that designers may not be in a user-oriented mode of thinking when they are demonstrating the presumed meaning of their objects in use. This supposition is strengthened by statements the designers frequently made like "This is round, that shows that you can turn it". Such a statement is not made from the user perspective but from the designer's perspective. Likewise, it was found many times throughout the interviews that demonstrations of use by the designers were not made from the user perspective. In continuing to develop a more full analysis of the data in search of starting points for a tool, this will be a point of attention. The initial finding indicates that there might be a need for ways to designers to learn to demonstrate the presumed meaning of objects they design from a user perspective. The demonstration of user actions could be supported by a personalized scenario, or story as Erickson [7] distinguishes it. That is, a designer's attention would be drawn to the possibility of presenting use in the form of "I am a user of this product. When I tried yesterday to look for a way to adjust this …" etc. The usual parts of stories such as a protagonist, a setting, a motivation, possibly trouble, etc, could be presented and exercised to a degree that is useful. The story structure would provide an invitation to the designer to play through the users' actions in an empathic and engaged way.

A further aspect that can inform future steps in this analysis, is what is known about language in the available research on gesture. For example, Kendon [12] has shown that there is a relationship between gestures that people make during their daily lives and interactions, and between the formalized sign language used by people who cannot rely on auditory information. Formalized sign languages arise out of more general gesturing. This process starts when people establish gestures as a common language when they need to refer repeatedly to a phenomenon. For example, reference to a particular person can become reduced to a hand movement indicating, for example, that person's conspicuous haircut. Kendon [12, p. 309] identifies three aspects of this process: first, a particular movement sequence gets selected and comes

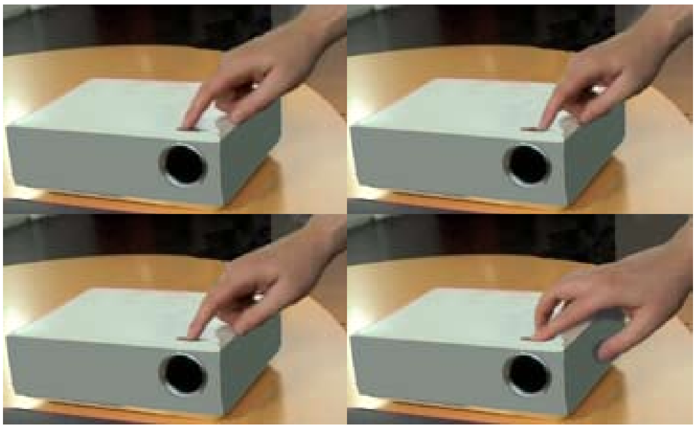


Fig. 3. Reading order is top row, then bottom row: a designer indicating how a wheel on top of an object is meant to be recognizable as round and turnable. He demonstrates the action several times with his finger.

Fig. 4. Reading order is top row (P1, P2), then bottom row (P3, P4): a designer first making a theoretical statement, then indicating an area on the product, reinforcing a point, and making a speech-accompanying finger movement.

The speech being uttered in Figure 3:
"This is round, that shows that you can turn it".

The speech being uttered in Figure 4:
"Now if you look at the convention that is used here then you see the dominance or rather the subordination of the graphics as you see on these buttons. Although the graphic really is fixed in the buttons, …"

In direct relation to the pictures, this could be written like this:
"Now if you look at the convention (P1)
that is used here
then you see (P2)
the dominance (P3)
or rather the subordination of the graphics
as you see on these buttons. Although the
graphic really is fixed (P4)
in the buttons, …"

Table 2. The utterances being made in the interview segment as also shown in Figures 3 and 4.

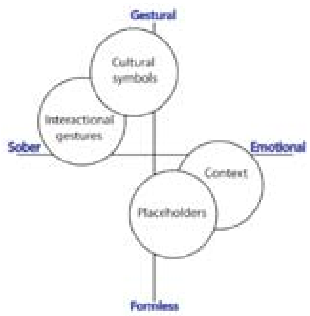


Fig. 5. The distribution of types of gestures over extremes of emotional expressiveness.

Table 3. A new categorisation showing the vertical axis from emotional to non-emotional and the horizontal categories sorted accordingly.

Speech-accompanying gestures (Gesticulations)				
	Category	Sub-category	Gesture, motion or meaning	Code
Not-emotional	Inter-actional gestures	Interaction with a 3D object	Using	IIU
			Indicating	III
			Manipulating	IIM
			Describing the form	IID
			Clustering	IIC
		Functionality, no direct relation with form	Describe its functionality	IFD
			Metaphor (being the object)	IFM
	Cultural symbols	Specified concept	Manual expression	CCM
			Finger expression	CCF
			Body expression	CCB
Emotional		Specified modifier	Manual expression	CMM
			Finger expression	CMF
			Body expression	CMB
	Place-holders	Emphasize aspect	Formless gesture (hand) to support the process	PEF
		Maintain discourse	Formless gesture (hand) to improve the process	PMF
			Butterworths and beats	PMB
	Context	Self-adjusters	Manual expression	CSM
			Finger expression	CSF
			Body expression	CSB
		Change of activation	Active	CAA
			Passive	CAP

to serve as a label. Second, it becomes simplified to function economically, losing its descriptiveness. Third, through this, it becomes generalised and available for recombination with other forms. This step marks the beginning of a language. Kendon does not discuss the emotional content of sign language in relation to things and how they can be changed through design. Nor has sign language to date been adopted as a concept to inform the usage-centred design of objects. This study has found that designers use a lot of gestures. Taken together with insights from design storytelling and role-playing, it becomes conceivable that designers could be provided with a tool that enables them to develop a 'sign language' that is related to the presumed use of the objects they design. By taking account the available insights on sign languages, it could be aimed that such a language does not feel cumbersome and unnatural to the designers.

In terms of communication with other stakeholders, we have seen above that e.g. filmed scenario interactions with products may not be enough for designers to be able to engage with product use in detail. They cannot easily produce such movies without considerable investment, making them a cumbersome tool in the actual design process. However, some form of recording and archiving of played mini-stories as sketched above, might still be useful memory and communication aids for designers. Further in the future, such recorded mini-stories could even be automatically coded and analysed using facial and gestural emotion recognition software, thereby allowing for comparison and aggregation of data.

Acknowledgements

I gratefully acknowledge the work of the students Niels Janszen and Geesje Dam for developing the categorization and pilot analysis as part of a student research project. This work was partly carried out as part of the 'Design for Usability' project (www.designforusability.org), sponsored by the Dutch Ministry of Economic Affairs under the IOP-IPCR program.

Stella Boess
Faculty of Industrial Design Engineering, Delft University of Technology, Delft, The Netherlands

References

1 Boess, S. U. (2008). Meaning in product use: Which terms do designers use in their work? In Procs. DeSForM, Offenbach, Nov 6-7 2008, pp. 20-27. (Philips N.V., Eindhoven).

2 Boess, S.U. (2009). Experiencing product use in product design. Proceedings of ICED, International Conference of Engineering Design. Held 24 - 27 august 2009, Stanford University, Stanford, CA, USA.

3 Cooper, A. (1999). The Inmates are running the Asylum. Indianapolis, IN : Sams

4 Black, A. (2003). Why I work in user experience consulting. In I. Koskinen, K. Battarbee, & Mattelmäki, T. (Eds.), Empathic design (pp. 147-152). Finland: IT Press.

5 Boess, S. U., & Kanis, H. (2007). Meaning in product use – A design perspective. In H. N. J. Schifferstein & P. Hekkert (Eds.), Product Experience (pp. 305-332). San Diego: Elsevier.

6 Norman, D. A. (1988). The design of everyday things. New York: Currency-Doubleday.

7 Erickson, T. (1995). Notes on design practice: stories and prototypes as catalysts for communication. In J. Carroll (ed.). Scenario- Based Design: Envisioning Work and Technology in System Development (pp. 37-58). New York: Wiley.

8 Boess, S. U. 2006). Rationales for role playing in design. In Proceedings of Wonderground, the Design Research Society Conference. Held in Lisbon, Nov 1-4, 2006.

9 Macaulay, C., Jacucci, G., O'Neill, S., Kankaineen, T., & Simpson, M., (2006). The emerging roles of performance within HCI and interaction design. Interacting with Computers, 18(5), 942-955.

10 Buxton, B. (2007). Sketching user experiences. San Francisco: Morgan Kaufman.

11 Venkatraman, V. and Wiethoff, A. (undated). Course description video prototyping in the interaction design pilot year 2008-9. Copenhagen institue of interaction design. Retrieved September 20, 2009 from http://dkds.ciid.dk/py/video-prototyping/overview/.

12 Kendon, A. (2004). Gesture: Visible action as utterance. Cambridge: Cambridge University Press.

13 Hummels, C. & Stappers, P. J. (1998). Meaningful gestures for human computer interaction: Beyond hand postures. In Proceedings for the 3rd IEEE international conference on automatic face and gesture recognition (FG'98), Nara, Japan, 14-16 April 1998. IEEE Computer Society Press, Los Alamos, pp 591-596.

14 Hummels, C. (2000). Gestural design tools: prototypes, experiments and scenarios. Unpublished PhD dissertation. Delft University of Technology, Netherlands.

David Kirsh, Dafne Muntanyola, R. Joanne Jao, Amy Lew, Matt Sugihara
kirsh@ucsd.edu

Choreographic methods for creating novel, high quality dance

Abstract
We undertook a detailed ethnographic study of the dance creation process of a noted choreographer and his distinguished troupe. All choreographer dancer interactions were video'ed, the choreographer and dancers were interviewed extensively each day, as well as other observations and tests performed. The choreographer used three main methods to produce high quality and novel content: showing, making-on, and tasking. We present, analyze and evaluate these methods, and show how these approaches allow the choreographer to increase the creative output of the dancers and himself. His methods, although designed for dance, apply more generally to other creative endeavors, especially where brainstorming is involved, and where the creative process is distributed over many individuals. His approach is also a case study in multi-modal direction, owing to the range of mechanisms he uses to communicate and direct.

Keywords
Choreography, Multi-modal Instruction.

Introduction
Here we discuss our developing understanding of the methods used by a world famous choreographer , (hereafter WM), when he works with his dance troupe, (hereafter RD), to create highly original dance pieces. These methods are of particular interest because, in WM's hands, they have been remarkably successful at generating novel, high quality dance creations. They are also of interest because of what they teach us about distributed creativity more generally, and non-verbal interaction using multi-sensory imagery. Dance is a very physical medium, both in performance and the way it is created. When creating dance, choreographers often engage their dancers in a bodily way. This is not unique to dance but in other domains, it is less evident and harder to study. We are finding that through careful observation and analysis we are acquiring new insights into creativity, and multi-modal communication.
Our discussion has four parts: Methodology, Findings, Analysis, and Discussion.

Methodology
Our goal in this study was to exhaustively collect data of the creative process in dance, to create a complete archive of that process, and to analyze the methods, outcomes and distributed cognition of WM and RD. The dance team worked for thirteen days on a new dance piece at UCSD, the spring of 2009. Their time at UCSD represents about 60% of the total time allocated to creating the final work. Neither the music nor the sets, both specially commissioned by WM, had yet been made. So our first surprise was that music is not used in the early phase of creation as a mechanism for generating dance phrases. Whenever the dancers worked, there was music present. But they danced with

the music, not to it. We will not discuss music further. The data we captured and used in our analyses fall into seven categories. Jointly they comprise a thorough documentation of the entire distributed creative process.

1. ***Video:*** The two dance venues used by the company were instrumented with five high definition video cameras on the walls and two standard camcorders on the ceiling. See Fig 1. These cameras were run an average of six hours a day for thirteen days, covering the times when the choreographer was present and whenever the dancers were practicing movements.
2. ***Field notes:*** Teams of students sat on the sidelines during the entire process and took notes on movements, interactions, and instructions each day. For each dancer there was a dedicated team of 2-3 students, eleven teams in all. Their field notes helped us to organize and annotate the video archive.
3. ***Choreographer interviews:*** The choreographer was interviewed before and after each working day – a total of 22 times in all – often for an hour at a time.
4. ***Dance interviews:*** Four dancers were interviewed two at a time, each day. When appropriate, the dancers 'danced' their answers to our specific questions about the day's activities. This was especially helpful when the day's activities required the dancers to visualize, or use other sensory imagery, to help create movement ideas.
5. ***Motion capture:*** Three dancers, each performing several dance phrases, were captured using a sixteen-camera VICON system. This produced 3-D trajectories of the dancers in motion.
6. ***Psychological tests:*** Each dancer performed a memory test for dance phases and identified key positions or 'movement anchors'. These anchors are used to help recall attributes and positions and offer insights into memory.
7. ***Diaries and notebooks:*** Photographs were taken of all written artifacts used by the dancers and choreographer. These notebooks and diaries are used to help solve problems, record ideas, and remember movements and phrases.

To organize and code this data two classes were created at UCSD to provide the trained labor needed. A master vocabulary of keywords was established and used to produce a single master list of activities, time coded to facilitate video indexing. This served as a guide to what we might find at different moments in the video. The next step was to annotate snippets of video showing activities of particular interest. Students were allowed to choose particular dance phrases from amongst the 14 phrases the troupe performed in the final review on the last two days. They then tracked the activities that led to the evolution of those phrases over the course of the thirteen days, creating snippets that could be compared on a split screen or spliced together to make a video of the morphogenesis of a phrase.

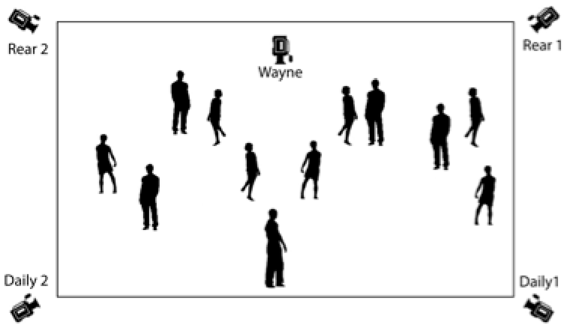


Figure 1: A schematic layout of the high definition video cameras used to capture the interactions between WM and his troupe RD.

Interviews were a further source of insight into the creative process. Each day, WM was asked to explain his goals for the day and describe what actually transpired. The interview was open ended and after the first ten minutes, the conversation turned to basic questions concerning choreographic choice, objectives, values, tasks, imagery, etc. Of the 60 hours of interviews collected from WM and the dancers, 35 hours were transcribed, and the process of keywording and indexing begun. Much of WM's speech during the day was also transcribed from cameras and microphones.

Findings

Multi-modality: When creating a dance in the contemporary tradition, choreographers communicate with their dancers in diverse physical ways. In table 1 we list seven communicative vehicles we observed WM using when working with RD. Each carries specific information for the dancers. Some are obvious: he talked, gestured, used his own body to display what was to be done, and moved to a position on stage, or in relation to others, to show the dancers where to position themselves. But some communicative mechanisms are non-obvious and uncommon outside the dance domain.

For instance, touching a dancer can be used to physically reshape a posture or movement. Its function is more corrective than denotational. If force is applied to a body, even gentle force, its purpose may be not so much to 'describe' a structural shape or a body dynamic, as it is to cause the dancer to change the way s(he) moves, feels, or even thinks. Several factors operate at once: the touch must be exactly at the right time and place; if it communicates a feeling, such as fatigue, anger, or physical distress, the touch needs the right dynamics; and if it communicates a position then the touch must be appropriately corrective, marking the extension of a limb or the direction the body should be moved in.
In a physical context such as dance, where the structures being created are the dynamics of form and position, it is natural to see touch used as a tool for sketching, shaping or correcting. But we observed other less predictable modes of communication, especially with sound.

Vehicles Carrying Information	Information Carried
Words and Syntax	Forms, mood, general tempo, how a role is to be placed
Prosody or intonation	Nuance about shape, tempo, mood
Gesture	Forms, modification of form, dynamics of form
Touch	Correction of form, prodding to incite movement, pivot point
Vocalization	Some structural aspect of form, dynamics of form
Full body display (dancing)	Imitate this form, though in an idealized manner
Position on stage	Position or orientation on stage

Table 1. The choreographer used seven main communicative devices.

Sound for communicating rhythm is almost universal: "One, two, three; one, two, three … ". But sound to communicate form, feeling, or 'quality' is less familiar. WM regularly offered corrections, or communicated some aspect of dynamic form by calling out phrases such as "N'yahh uh oom" or "Tri dah day". We call this use of sound 'vocalization'. The goal of vocalization was clearly to direct and alter dancer movement. But in subsequent studies, we were not able to prove that all dancers interpret the sound the same way. This may be because its function varied between dancers. To some, it communicated a dynamic or gestural form; to others, it communicated a feeling; and to still others, it helped them to remember the dynamics of a phrase they already had mastered. Moreover, because dancer and choreographer were invariably in close proximity when vocalizing, the use of vocalization often led to further interaction. It is usually a move in a sequence of multi-modal interactions.
We also observed emergent communicative meaning arising because multiple modalities, such as words and gestures, gestures and vocalization, were used at once. In table 2, we display a five-minute period of instruction and the duration of different modalities in use. Note how many of the channels overlap. In particular, in the early phase of this instruction – around the first minute – we see that WM combines words with gestures, dancing, touch, and positioning.

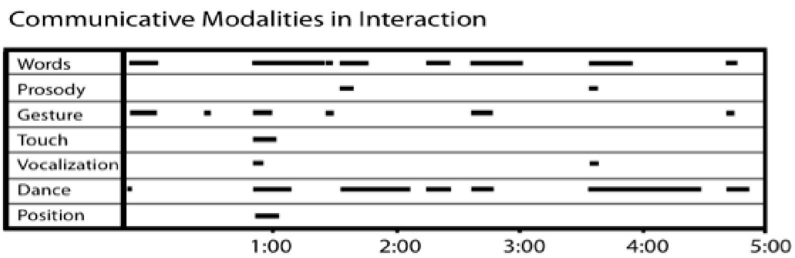


Table 2. In a five-minute period WM uses many different modalities, often at the same time.

Methods of Instruction: We now describe three methods of instruction we found WM using and provide a framework from which to conceptualize their differences.

1. Show a phrase to the whole troupe or large subset. WM uses his own body to display the structure and dynamics of a move or phrase. He has two styles. He either dances amidst the troupe in the same physical orientation as everyone else; or he faces the group, as if teaching. He expects the entire troupe to observe and reproduce the move, though, for some moves, the dancers are expected to execute in a 'more perfect' manner. See figure 2 immediately below.

2a. 2b.

Figure 2. When WM shows the troupe a phrase he either operates amidst the group as if dancing with them (2a), or he stands in front of them, as if teaching in a class (2b).

2. Make a phrase on a target dancer (solo), or a duo, a trio or quartet. This method of direction involves using the bodies of specific dancers as targets on which to shape the form and dynamics of a move or phrase. Typically, the entire troupe watches these target dancers and later will reproduce those movements in their own duos, trios, or quartets. There are also occasions, however, where the point of a 'make on' is solely for the target dancers. See figure 3. A further form of 'making a phrase on' occurs when WM adapts or modifies a phrase originally created by the dancers. In that case, making on is more like reshaping.

3a.

3b.

Figure 3. WM makes on a duo in 3a, and in 3b, the troupe observes and copies. WM is taller and shaved. Notice how close choreographer and target are, and the density of interaction.

3. Task or pose a choreographic problem. In this third kind of direction, the choreographer assigns 'choreographic problems' for the dancers to solve or choreographic 'tasks' for the dancers to complete. Typically, these problems or tasks require the dancers to create some sort of mental imagery – a landscape of Manhattan, the feel of being touched on a certain part of their body, the dynamic and kinematic feel

of being a piston moving back and forth. Often, the way the problem is posed requires the dancers to invent an image or scenario for themselves. The choreographic problem is to use this imagery in some way to create a virtual structure that they are then able to relate to in a 'choreographically' interesting manner. As shown in the pictures on the right and left, one dancer imagines moving a heavy bell around another dancer imagines interacting with a barrel – stepping into it, demarcating its boundaries and then moving outside it and pushing on it from the outside. |Using this threefold classification of methods, we reviewed the video to determine how the methods were involved in the actual creation of phrases.

Evolution of Phrases. In table 3, we show the details concerning the evolution of each phrase. It is apparent that a phrase is never the outcome of a single instruction method or directive. Sometimes the choreographer will come to a session with a clear idea of a movement he wants the dancers to learn. In that case, he will either Show them all, or Make on a duo, trio, or quartet. More often, though, he will begin the creation of a new phrase by assigning a choreographic problem or task. As can be seen below, nine of the sixteen phrases started with a Task, five with a Make On, and two with a Show.

#	Trajectory (minutes spent)	Total Durations (minutes)				Usable Material (m:ss)
		Task	Show	Make	Total	
1	Make (26) | Make (36)	0	0	62	62	1:07
2	Show (42) | Task (3) | Make (28)	3	42	28	73	2:46
3	Show (54) | Task (11) | Make (33)	11	54	33	98	0:34
4	Task (51) | Task (6) | Task (54)	111	0	0	111	Not in Final Review
5	Task (63) | Show (31) | Task (18)	81	31	0	112	Solo: 37:00 Duet: 8:20
6	Make (26) | Show (69) | Make (66)	0	69	92	161	2:12
7	Task (9) → Task (63) → Make (7) | Task (55)	127	0	7	134	3:00
8	Task (40) → Make (46) | Task (49) | Task (31) | Make (35)	155	0	46	201	7:40
9	Task (60) | Task (55) | Task (34) | Task (4)	153	0	0	153	0:53
10	Task (146) → Make (33) | Task (37) | Task (84) | Task (85)	375	0	33	408	Solo: 0:47 Duet: 10:50
11	Make (68) | Task (34)	34	0	68	102	15:05
12	Make (69) | Task (87)	87	0	69	156	1:55
13	Task (67) | Task (58) → Make (124) | Make (37)	125	0	161	286	5:00
14	Task (110) | Task (113)	223	0	0	223	Not in Final Review
15	Task (102) → Make (93) | Make (41) → Task (13)	115	0	134	249	Solo: 1:05 Duet: 2:20
16	Make (51) | Make (5)	0	0	56	56	3:46

Table 3. The evolution of each phrase is shown here as the outcome of several methods. Final length refers to the usable material recorded during the final review. A bar indicates that a day or more passed before the next method was used. An arrow indicates the same day.

Analysis

Each of these methods has its individual strengths and weaknesses, both in terms of productivity, long run value, and creative potential.

Tasking: Based on the time spent using a method, the number of times it was used, and the number of usable minutes generated, the most important method is clearly Tasking / Problem solving. As seen in table 4, 62% of instruction time – that is, time dancers were not practicing – was devoted to working on tasks.

This 62% delivered 60% of the final output. Although tasking sessions were marginally longer, 55 mins. vs. 46 and 44 mins. for making and showing, tasking was still the method of choice, being called on 58% of the time. In interview, the choreographer provided several additional reasons for valuing tasking more highly than other methods. He mentioned that by assigning the dancers problems to solve they stretch their repertoire more effectively – they discover new ways of moving themselves; he, the choreographer, has the opportunity to see new things that the dancers can do, and therefore, he may use those dancers differently in the future or 'make on' them differently; he believed that if a movement originated as a solution to a problem, the dancers are likely to imbue it with greater feeling, affect or quality – what some call greater intentionality; they will find the phrase easier to remember; and they will have intellectual 'anchors' that can serve as reference points in the phrase later.

There are further reasons to view tasking as of special interest, particularly for those interested in the nature of creativity. First, because dancers themselves must solve tasks, and because each dancer's imagination is different, inevitably there will be as many solutions as dancers. These solutions can be vastly different. And even if the phrases a dancer makes falls short of acceptability, it still may engender ideas in WM. We regularly observed him trying out dancer ideas on himself, and then later putting these altered ideas to use in a Show or Make. We also regularly found WM using a dancer's solution as a base that could be reworked or 'massaged' into a different form.

Second, tasks increase the resources available to dancers when looking for inspiration. Imaginary structures or feelings can serve as scaffolds for a dancer. The challenge any dancer faces is to make a sustained phrase: not just a nice move here or there, but something that lasts 40 seconds or a minute. It is no surprise, then, that people like dancing with other people. A person makes a nice foil for a partner to interact with. When a person is absent, a physical structure can serve a similar role, though any dynamism must come from the dancer. On an empty stage, structures are absent. At such moments imagination, when guided, can fill the void. This has the effect that dancers will often be dancing in relation to something that only they are aware of.

Instruction Type	Frequency		Mean Duration	Total Product	
	Times used	% of total instruction time	Minutes	Minutes	% of total instruction time
Task / Problem Solving	29	62.00%	55.17	63.07	60%
Make On	17	30.50%	46.41	25.52	25%
Show	4	7.50%	49	15.24	15%

Table 4. This table shows the frequency, average duration, and fertility of each method of instruction.

Phrase #	Usable Material (minutes)	Proportion of Time Spent on Each Method			Minutes of Material Generated by Each Method		
		Task	Show	Make	Task	Show	Make
1	1:07	--	--	100%	--	--	1:07
2	2:47	4%	58%	38%	0:06	1:35	1:06
3	0:34	11%	55%	34%	0:04	0:19	0:11
4	*	n/a	n/a	n/a	n/a	n/a	n/a
5	45:21	72%	28%	--	32:47	12:34	--
6	2:12	--	43%	57%	--	0:56	1:16
7	3:00	95%	--	5%	2:50	--	0:10
8	7:41	77%	--	23%	5:55	--	1:46
9	0:53	100%	--	--	0:53	--	--
10	11:37	92%	--	8%	10:41	--	0:56
11	15:05	33%	--	67%	5:01	--	10:04
12	1:55	56%	--	44%	1:04	--	0:51
13	5:00	44%	--	56%	2:11	--	2:49
14	*	n/a	n/a	n/a	n/a	n/a	n/a
15	3:25	46%	--	54%	1:35	--	1:50
16	3:46	--	--	100%	--	--	3:46
	1:44:23	Total Length of Material Generated			1:03:07	0:15:24	0:25:52

*Did not appear in final review

Table 5. The fertility of each method can be measured by the number of usable minutes it generates. We assume that each method is responsible for a pro-rated share of the minutes in the final phrase, even though realistically, some methods contribute more to a phrase than others.

A third virtue of tasks is that they breed diversity; the phrase one dancer comes up with may be stylistically different than the phrase another comes up with.

Making: As can be seen from table 4, Making is responsible for 30.5% of WM's time and 25% of the final product. Why is Making more prevalent than Showing? The reason, we speculate, is that making, like tasking, is a technique that helps WM reach beyond himself. It is a mechanism for fostering novelty. In a make on, WM uses another dancer's body in place of his own. The phrase that emerges invariably reflects something of the personal style of the dancer and something of the body style. In interviews, the dancers freely recognized that the way a phrase turns out, and the authority on how it should be performed always lies with the 'makee'. Moreover, since making on involves a close coupling of choreographer and dancer the phrases that arise must be the product of a collaboration of sorts, even if the creative contributions are unequal.

To explore this idea we counted the number and duration of turns that choreographer and dancer take while engaged in a make-on vs. the number of turns taken during a show. Our conjecture was that making on is far more like a conversational dialogue than showing, so we expected to find more back and forth activity. That is exactly what we did find. As shown in figure 5 the number of momentary stops, pauses or opportunities for non-verbal dialogue that we observed in a randomly chosen 'make' far exceeds those we observed in a randomly chosen 'show'. There were 32 turnovers in ten minutes of making vs. 14 in ten minutes of showing. This is to be expected given the differences between making and showing, since in making WM must be responsive to exactly what the target dancers are doing. When WM is making he is invariably close to the solo, duo or trio he is making on and so he will naturally work with them in a physical, tactile way. As they move so will he. Because of the physical nature of dancing, its speed and change in position, we would predict that the level and frequency of interaction would necessarily be high.

In figure 5 we display dancer and choreographer mutual activity over five minutes of Showing vs. five minutes of Making. We analyzed ten minutes but display only five for greater visibility. The top activity line displays a showing episode; the bottom activity line is a making episode. When he Shows, WM, on average, communicates longer and the dancers practice longer. This is to be expected because they must copy him. But when he Makes he works in shorter bursts with the dancers. Overall, there are more exchanges, however. Accordingly, Making is more interactive than Showing.

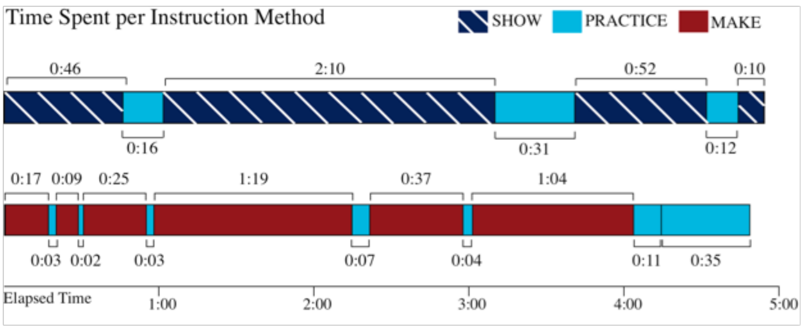


Figure 5. These two activity lines show that there is more physical 'dialogue' occurring

Showing: Based on time and frequency, Showing is the least popular, but also, in some ways, it is the most potent. Every minute spent Showing yields 4.7 secs of usable product, compared to 2.4 secs of Tasking and 1.9 secs of Making. This makes sense since WM only Shows when he has material that he feels is likely to be usable. But unlike the other methods, Showing is the least collaborative method. The choreographer stands to learn little from the dancers. In table 6 we display the average number of seconds yielded by a minute of work in each of the different instructional methods.

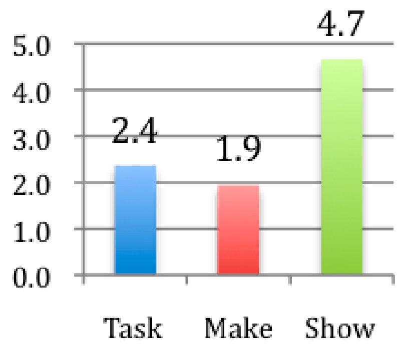


Table 6. Yield (in secs) of a minute of method.

Group Attention, Group Intention: We began observing what dancers watched most; what they had in their center of attention. By center of attention, we mean the person whom the troupe observes, particularly while WM is instructing. Our prediction was that when WM is Showing, he is, himself, the center of attention; when WM is Making on a single dancer, or on a duo, the center of attention is WM and the makees jointly if we ask about the rest of the dancers, and it is WM alone if we ask about the makees (the targets); and when WM is Tasking, or when the dancers are themselves solving a choreographic problem, they are their own center of attention.

And, indeed, the center of attention usually does behave in this common sense way. But not precisely. In cases where WM is 'Making on' a trio, the remainder of the troupe will listen to WM but watch the trio. Their attention is split, as we predicted. But they use the trio, and not WM, as the reference for the movement. They listen to WM but watch the target.

The term reference is one we heard the dancers use to designate the authority, or role model, for the group when there is a question about the nature of a given movement. When a choreographer Makes on a dancer, or a small group, it is reasonable to assume that the group evolving the movement, rather than the choreographer, is the center of attention and the way they perform the movement is the referent. We

confirmed this through interview. Once a target makee has mastered a phrase, and often even before, s(he) or they are taken to be performing the movement in the definitive way. We observed many times that WM, too, will rely on makees to recall the movement made on them, when he needs it again in the future.
So far, this only weakly stretches our preconceived ideas. If the referent is the person who best knows a given phrase, it is natural to look to that person as the local authority. If a movement is being Shown, however, shouldn't WM be the referent? He is the one who thought it up, he is the one who danced it to Show how it is to be executed, and he is the one we expect to remember it perfectly. Our biggest surprise was that this is not always true.
The reason things sometimes deviate is that when WM is Showing, there is often another dancer who acts as a Surrogate Reference. This is a dancer who can be counted on to precisely master the key aspects of the movement in near real time. Invariably, a surrogate reference will be someone who has worked with a choreographer a long time, or s(he) will be someone with outlier skills in copying. A surrogate reference will be someone who reliably interprets what WM is trying to get the dancers to do, and can display that intent in a more accessible manner. The result is that there are cases where WM instructs by Showing, but many of the troupe, after initially watching WM, will actually watch the surrogate referent during subsequent re-showings by WM. In the instance we observed, this other dancer, A, is the longest standing member of the troupe. In interview with other dancers, it was reported that A has the best anticipation of what WM is trying to Show, and that, accordingly, it is often easier to copy A's movements than WM's. See figure 5.

Showing a Phrase Making a Phrase on a Trio

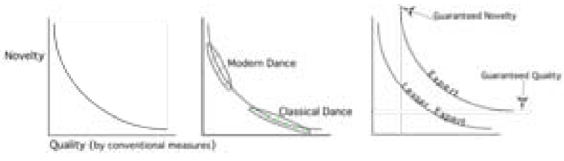
5a. 5b.

Figure 5. In 5a, WM is showing a phrase and so is, himself, a reference for the dancers. But one of the dancers – a surrogate reference – knows WM's intentions well and executes them in ways the others can follow easily. In 5b, WM makes on a trio and they serve as a reference for the onlooking dancers who must also learn the trio.

It is tempting to suppose that the movement performed by the reference dancer, or especially by the surrogate reference, is the very movement that all dancers should learn and memorize. Even this, however, is not always the case. At each moment, there is an intended movement – the Platonic ideal of that movement. But because of body idiosyncrasies, or because the ideal movement requires considerable practice, the Platonic movement each member of the troupe is aiming for may not yet have been displayed. The troupe may know what they are aiming for but no one has executed it yet. We call this ideal movement the intended reference movement.
The idea of a reference movement as an abstraction is supported by our observations about the surrogate reference. In some phrases, there are several surrogate references, each one specializing in particular aspects of the phrase: One dancer may be counted on to precisely note the grips or stance; another may be counted on to precisely note the emotional dynamics. The complete phrase must incorporate all of these elements. And to learn that phrase, different dancers may be called on by WM, during rehearsal, to show off the phrase. This distributed memory is part of what makes dance creation a worthy domain for the study of distributed creativity.

Discussion

We now turn to a more general discussion of the problematique of dance creation and what we have learned about the creative value of different instructional methods.
A major challenge in creating a new piece of choreography is that the work should ideally be both novel and of high quality (beautiful, interesting, absorbing). Achieving both attributes is especially difficult because of a trade-off: it is easier to be novel if one's work need not meet existing norms of quality; it is easier to produce recognizably high quality work if one's work need not be novel.
Quality can be thought of as analogous to reliability in design. For instance, in classical ballet, where the movements have been refined over years, new works are essentially reliable forms combined in reliable ways.



6a. 6b. 6c.

Figure 6. 6a shows the basic iso-goodness curve. 6b shows that modern choreographers are biased toward novel work whereas classical ballet choreographers are biased toward quality.

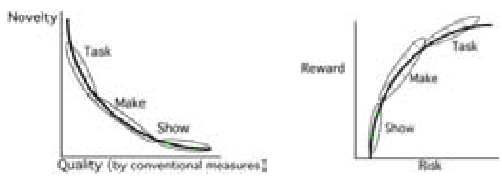


Figure 7. Iso-curves can be used to show where the methods of Show, Make and Task lie on a risk-reward curve.

In figure 6a, we represent this trade-off on a iso-goodness curve. It represents the goodness of a choreographic product in terms of its novelty and quality. A very novel piece may be valued as highly as a high quality piece. And a piece of exceptional quality may be valued as highly as a piece of exceptional novelty.

Historically, modern dance has differed from classical dance in its norms for what is good. The best modern work should lie more toward the novel side, using few tried and true dance forms, and containing more inventive never-before-seen forms and moves. Accordingly, the best new creations in modern dance should lie somewhere near the upper left of the curve. See figure 6b. Creations in classical ballet, by contrast, lie somewhere around the lower right. Despite these different biases or preferences, most work, with the exception of the best, tends to lie near the middle of the curve between novelty and classical quality (or beauty) because it is easier to create a piece in the middle region than at either extreme. Fig 6c illustrates that better choreographers live on a better iso-curve. Their work never follows below a threshold of novelty and quality.

Great choreographers are noteworthy because they are able to push their iso-curve outward. See figure 6c. They can ensure that even their most novel, risky pieces meet a certain acceptable level of recognizable quality, and even their most safe pieces meet a certain acceptable level of novelty. How do they do this? How can they take risks and still be confident of coming through?

The answer, we suggest, is that different choreographic methods have different risk reward profiles. Reliability in design is achieved through a wise distribution of methods, akin to an asset allocation. In figure 7, we show our view of the risk reward structure of WM's methods of Showing, Making, Tasking. Showing is the most reliable use of time, but the least generative. Making is still a highly reliable use of time but leads to a larger set of novel moves. Tasking is the least reliable, in the sense that some tasks lead to no usable output. But it is also the most generative in providing novel movement. Choreographers with an eye to time and success will divide their time wisely among all three methods.

Our parting conclusion: The domain of choreography is a rich arena for research on the nature of distributed creative cognition, on multi-modal instruction, and phenomena of group attention, mental imagery and interactivity. We have just begun our inquiry into these areas and hope that others, too, will see the value of close observational and empirical study of artistic creativity.

Acknowledgements

The authors thank the students of Cognitive Science classes 160/260W and 160/260S for countless hours coding and organizing our hundreds of hours of video. We also thank Scott deLahunta and Phil Barnard for insightful conversations; and of course, the generous time and kindness of Wayne McGregor and all the dancers in Random Dance.

References

1. Banks, M. (2005). Visual methods in social research. London: Sage.
2. Bourdieu, P. (1998). Les règles de l'art The Rules of Art.. Paris: Seuil.
3. Buscatto, M. (2008). L'art et la Manière : Ethnographies du Travail Artistique Art and Form: Ethnographies of Artistic Work.. Ethnologie Française, 1(37), 5-13.
4. Carter, A. (1998). The routledge dance studies reader. New York: Routledge.
5. Franzosi, R. (2004). From words to numbers: Narrative, data and social science. Cambridge: Cambridge University Press.
6. Gallagher, Sh. (2005). How the body shapes the mind. Chicago: University of Chicago Press.
7. Goodwin, Ch. (1994). Professional vision. American Anthropologist, 96(3), 606-633.
8. Williams, R. (2006). Using ethnography to study instruction. In Proceedings of the 7th International Conference of the Learning Sciences. Mahwah, NJ: Lawrence Erlbaum.

David Kirsh,
Dafne Muntanyola,
R. Joanne Jao,
Amy Lew
and Matt Sugihara
Dept of Cognitive Science, University of California, San Diego, USA

Miquel Prats and Steve Garner
m.prats@open.ac.uk

Making meaning: developing an understanding of form in distance design education

Abstract
Design education throughout the world provides students with a variety of experiences that help them develop an understanding of form and shape. The conventional model of such education requires students to participate in studio and workshop-based projects to develop skills through the creation of models and prototypes. However, with the increase in distance education worldwide we need to explore new ways for students to create and manipulate form remotely. This paper presents new work at the Open University, UK which set out to engage design students in form-making from a distance. Participants were given access to technical and design support that took rough sketches of chair designs and converted these into tangible scale models which were mailed back to the students. Several cycles of this activity generated data on how such supported modelling activity stimulated students' creative ability, design knowledge and motivation. This paper proposes new priorities for distance design education.

Keywords
Distance Learning, Design Education, Physical Models, Form.

1 Introduction

Design education aims to develop in students the necessary skills and knowledge for design problem solving. The characteristics of design problems have been widely and variously discussed over the past five decades but two characteristics stand out as significant; design problems display complexity and they contain elements of uncertainty such as missing or ambiguous information. As a consequence the strategies for design education from school age to undergraduate level must go beyond the application of set procedures and develop in students a cognitive capacity for integrating creative problem finding with creative problem solving. Donald Schön [1] proposed that such integration requires an active rather than a passive approach, reinforcing the notion of 'learning while doing' which lies at the core of the atelier-style of design education in our universities and colleges. Schön's 'reflection-in-action', has proved influential and remains so as new models of distance design education emerge in universities worldwide. Schön asserts that creative reflection requires a stimulus to trigger innovative thinking. Traditionally design students have been encouraged to generate a wide range of representations in their design project work and these have partly functioned as trigger devices to support the type of reflection-in-action identified by Schön. The making of representations such as drawings and three-dimensional models are particularly valuable to students as they grapple with the creation and evaluation of form and shape in design. Some of this representation-making activity is careful and measured while at other times it can be fast and loose depending on its function for the designer [2] and [3].

While there is great variety in types of design representations, physical models can raise design issues in ways that drawings and diagrams often cannot [4]. It's for this reason that the making of physical models remains an essential part of the education process in some design disciplines such as product design, sculpture and architecture. Even disciplines such as graphic communication and interaction design recognise the value of three-dimensional constructions as trigger devices in creative thinking. There are many different types of physical models each with different purposes [5]. For example, prototypes provide an effective means to test or communicate design ideas, especially in the later stages of development [6]. In contrast, quick lash-ups or form models can be extremely useful in the early conceptual stage of a design task. They can be useful for testing design specifications or for evaluating a potential appearance [7]. But physical modelling isn't just about externalising ideas. Perhaps more importantly physical models help designers learn about the problems they are trying to solve.

It has been argued that the ability to engage students with rapid and physical feedback during their design process is an essential ingredient in the acquisition of confidence and professional creativity [8]. As a consequence, the conventional model of such education requires students to participate face-to-face in studio and workshop-based projects to develop skills through the creation of models and prototypes. However, with the increase in distance education worldwide we need to explore new ways for students to create and manipulate form remotely - perhaps from their homes or workplaces.

According to Welsh [9] universities and other institutions are increasingly seeking to offer an online learning experience to potential customers. Partly this is seen as an opportunity for reducing costs but there is now much accumulated evidence that 'e-learning' can deliver high quality education in the arts, sciences and humanities and open up new student markets. Bohemia's [10] on-line delivery of the Design Management course, for example, provided cost savings, but more importantly, not only the aims of the course were achieved but also assisted students to develop distance communication and virtual teamwork skills. There is certainly a growing demand for education and training that can be taken part-time and which doesn't require the student to travel. But can design education exploit an e-learning approach? Can distance design education really go beyond teaching students 'about' design and involve them in learning 'through' design? The Open University has offered distance design education since the 1970s but only recently has it been possible to recreate some of the characteristics of a typical studio-based design course. New technologies now allow students to share design ideas and conduct online group work. Computer-aided design (CAD) is readily available and facilitates new types of digital modelling. But the making of three-dimensional models has always proved a difficult component to support. Partly the problem is that students don't have access to the types of tools and materials commonly found in face-to-face design education. Neither do they have access to teaching and technical staff for guidance, or their peers for collaboration and comparison as they develop their skills of making. If the making of three-dimensional representations of form are vital to the sort of reflection-in-action processes described by Schön then universities that seek to offer design education need to find ways to support this. With this in mind a short piece of research was conducted by the authors at the Open University early in 2009.

2 Description of the study

The Open University project took place over four months and engaged volunteer second-level undergraduate students in form-making from a distance. In its planning it took McCullough's [11] premise that design students studying via a distance learning approach must be able to engage with physical models as well as with digital tools and outputs. It was informed both by generic guidance on e-Learning, e.g. [12] and recent design initiatives such as the remote rapid prototyping laboratory set up at Tennessee Tech University in the US [13]. This particular facility allows students to generate three-dimensional models from a remote location.

This project sought to gain an understanding of the value to design students of making physical models. In particular it sought to explore the value and feasibility of providing a rapid prototyping service from the 'FabLab' to novice students without computer-aided design and rapid prototyping skills. All the students engaged with the project from their own remote locations. The Rapid

Fabrication Laboratory (FabLab) was set up within The Design Group at the Open University in 2006. It offers a range of equipment for rapid prototyping including a laser cutter, Fused Deposition Modelling (FDM) 3D printer and 3D laser scanner among many others. Other more traditional subtractive processes such as milling are also available. These tools offer engineers and designers quick and easy ways to iterate between digital representations and physical representations.

Students on the Open University course 'Design and Designing' were invited to take part in the study. This is a 60 credit module and while their skills and experience of design differed all could be considered as novice or inexperienced design students. One participant had completed a graphic design course and one a course in art and design. For some this was their first Open University course. Of the seven students who originally volunteered, two had to withdraw from the study during the first week for personal reasons so five participants completed the study. Four were based in the UK and one in Germany. Students were mature, that is, aged over 25, male and female.

The chosen context for the study was chair design using flat sheet material. The reason for this is that it was very similar to the context for an assignment in Design and Designing taking place at the same time. A number of support materials on chair design had previously been sent to all the participants through the normal course mailings. Using this context was highly motivating to all participants but they were prohibited from gaining an unfair advantage over their peers by submitting their models for assessment. However it did mean the students could tap into research and development with which they were already familiar and they could generate ideas and variations more quickly than if they had been given an entirely new context. The brief asked students to design a chair for children to be made in medium density fibreboard (MDF) which could be sold flat-pack and assembled at home. It was required that the chair designs could be assembled without glue and with the minimum of fixings such as screws or bolts. Students were also limited to one thickness of MDF, 15mm. In this way it was possible to support the design thinking of the participants by providing them with models of their design ideas. These were fifth-scale models and the component parts were cut out from 3mm thick MDF using a laser cutter. This machine cuts a variety of flat materials such as wood, plastic, and fabric. It works by directing a high powered laser beam onto the material which it either cuts or engraves, depending on how the machine has been set up. The laser cutter receives the cutting or engraving specification from a computer file and can make pieces of any shape in high precision in a matter of minutes.

Participant students were permitted to submit any form of sketch representation of their initial chair design and this was modelled for them in the 3mm MDF using a laser cutter. Since it was important to the study to support the participants at whatever level of design skill they possessed it meant that the tutor received design concepts in a variety of levels of detail. In this study, the tutor, which is one of the authors of this paper, was the person in charge to develop the CAD drawings and physical models. Typically participants supplied hand-drawn sketches that required careful interrogation in order to interpret what the student intended. The tutor produced a new CAD drawing that, as far as possible, matched the instruction given in the sketch. This CAD file was used to control the laser cutter and generate the component parts. These were then posted to participants to assemble. After evaluation of the constructed model participants were asked to communicate with the tutor about the changes they wanted to make and once again annotated sketches were used to communicate their intentions. Some students chose to attach scans of their sketches to email in order to speed up the communication process. Then the tutor made a new scale model according to instructions and posted it back to the student. The manufacture of each set of component parts could be easily completed within one day and each cycle could be completed in 4-5 days. Participants were allowed a maximum of four cycles of making and changing.

3 The conduct of the study

All participants began the task by developing their design ideas using pen or pencil and paper. Two students supplemented their drawings with simple cardboard models of their initial chair design. Both said that since their perspective drawing skills were poor they felt the models helped them communicate intention. One pointed out that the model also assisted her to test the stability of the chair.

Students sent their annotated drawings (and in the cases above, images of their cardboard models) to the tutor via mail, or email if work could be scanned. Fig. 1 shows some examples of drawings from this first cycle a), second cycle b), and fourth cycle c). The submissions reveal the attempts to capture sufficient information while wrestling with conventions such as layout. Dimensioning, for example, reveals missing or conflicting dimensions, or mixing values between centimetres and millimetres. In addition, some students included extensive notes when they could not express their ideas through drawings alone as this student that pointed out 'I have no idea how to specify that so I went with what I could communicate with some certainty'. Despite this, it was possible to understand the design intentions of all students and, with little effort, the components of the scale models of the chairs were redrawn into the computer by the tutor. Then, these were cut out with the laser cutter and sent back to students via the post service.

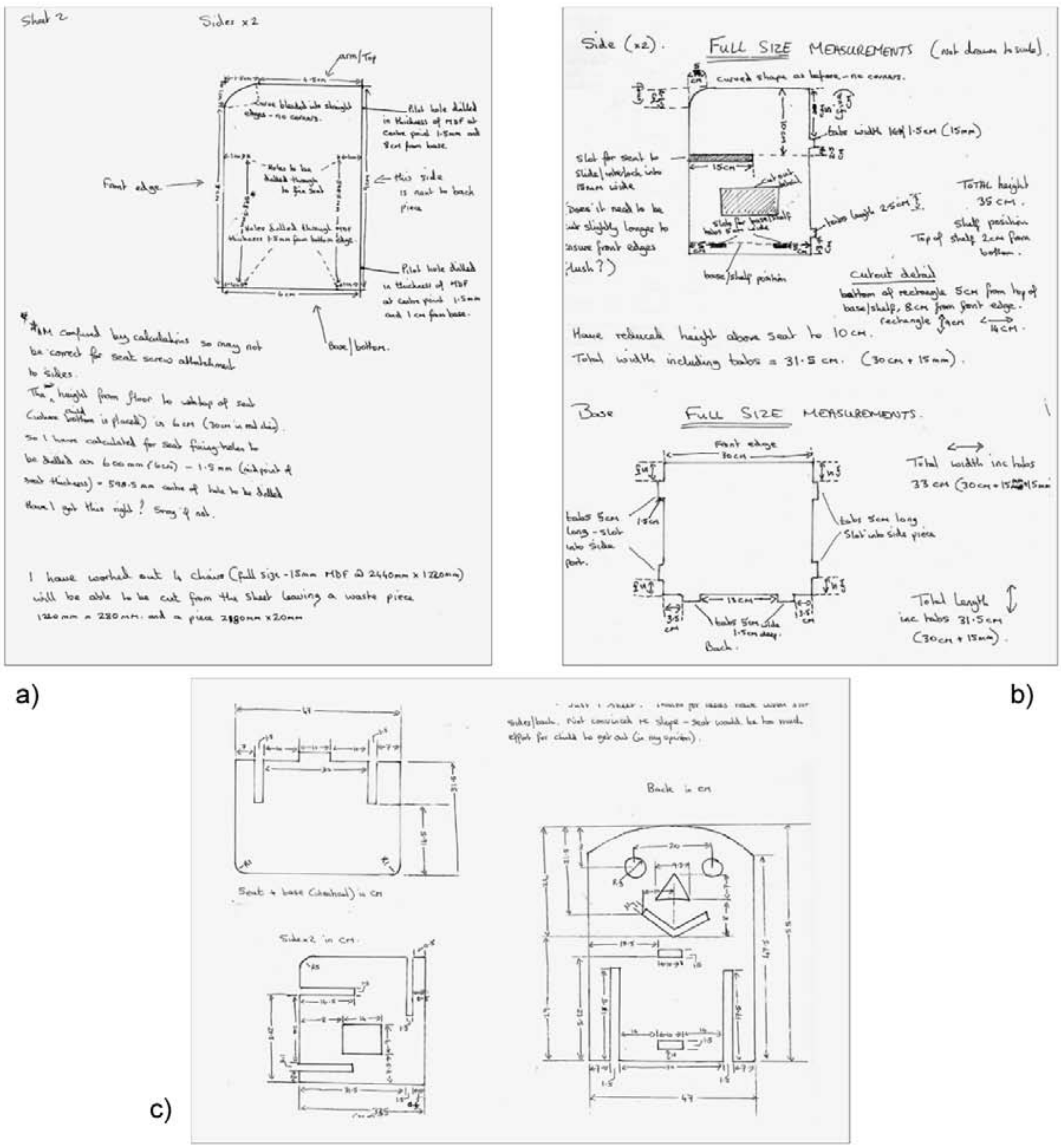


Fig. 1. Sketch pages from the first a), second b), and fourth cycle c) of one participant.

When the dimensions in the drawings from the students had errors or miscalculations the pieces were cut as instructed, even if they did not fit together correctly. Thus, students had the opportunity to get physical feedback on their mistakes. Additionally, their drawings were returned to them with corrections and suggestions on how to improve their graphic communication.
The drawings in Fig. 1 provide an illustration of the improvement of students' skills in communicating their ideas. The sheets a) and b) in Fig. 1 contain some initial drawings with several notes which make the task of redrawing the pieces into the computer laborious; the drawings made in the last iteration of the study, sheet c), are more comprehensive and include much less annotation.

The first design concepts submitted frequently failed to adequately address the requirements laid down in the design brief. These included the requirement that the chair should be assembled without glue and minimum of fixings. Feedback from the students suggest that they were not avoiding the requirement but they were not able to creatively address it. One student commented 'I am coming up blank on fixings that could be used that don't require holes to be drilled. And I am aware that glue is not an option'. For example, some students included pre-drilled screw holes in some components. Once they had received feedback on assembly methods these were replaced by superior design features such as mortise-and-tenon joints or finger joints. In one case two sets of pieces – pieces with pre-drilled holes and a jointed set – were sent to the maker so they had tangible feedback on different design and assembly methods. Fig. 2 shows this example of two sets of pieces.

4 Making meaning through supported modelling

As noted in the introduction to this paper, the making of models is a normal and everyday activity in face-to-face design education. Academic and technical support is made available through a programme of studio and workshop experiences that gradually allow students to develop their skills and knowledge of modelling in design. Even by the end of the first year of a typical undergraduate design programme students will be equipped to make a wide range of models ranging from the briefest of sketch models to highly finished form models or prototypes. However, supporting modelmaking as a part of distance design education has particular and significant problems. Students are unlikely to have access to tools, materials and machines for modelmaking and there are major health and safety issues to getting students to engage in shaping and forming even basic materials such as cardboard.
This study has documented a rather time-consuming process of technical support and it may be reasonable to ask whether the investment was worth the outputs of a few scale models. To answer this, and to further our understanding of why modelling forms a key element in future distance design education we must return to 'why' students need to model.

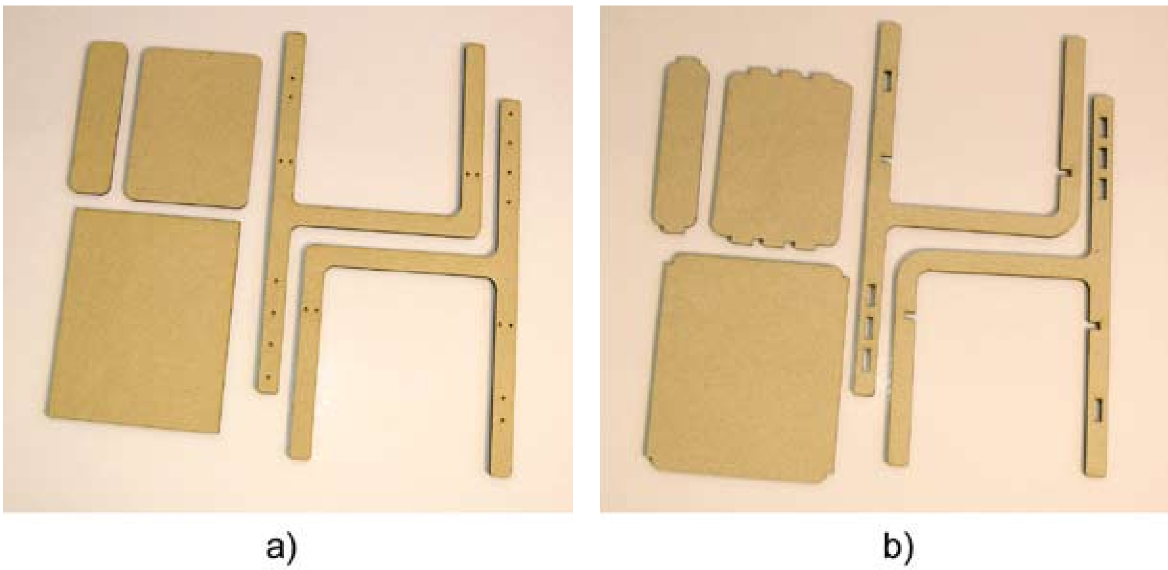


Fig. 2. a) pieces as instructed by the student and b) suggested pieces using mortise-and-tenon joints and finger joints.

Clearly the three-dimensional scale models of the chairs provide very clear proposals. They provide very clear communication of intention – probably as good if not better than any drawings of the chairs. But communication is only one function of such modelling. A far more significant function is the ability for three dimensional models to engage the maker in a private creative dialogue. The making of even quite rough and quick models allows the designer to assess and extend their thinking, to see relationships, to turn the ideas around in their head as well as in their hands. This is particularly important for novice designers where cognitive modelling – that ability for turning over ideas in the mind – is not yet developed. In fact, the making of tangible models might be the very stimulus needed to develop skills of mental modelling.

So making tangible models is not about externalising ideas, although this is one valuable function. More importantly it assists novice designers to develop notions of form and shape. It allows them to understand relationships between forms through the senses of touch and sight. It is a vital stage in developing a more mature capacity to hold, rotate and join shapes in the mind and as such it forms a vital link in developing skills with a wide range of digital design tools such as software for the creation of structure and surfaces on artefacts.

Any model of distance design education cannot afford to ignore the development of these competencies. The feedback from the participants in this study reveal how physical models motivated students' to develop an understanding of the principles of form in design and stimulated their creative thinking. Perhaps most importantly, it engaged people in matters of design form before they developed the skills to create and manufacture their own design form. The findings have

Fig. 3. Development of design concepts.

implications for the future of face-to-face as well as distance design education because we have traditionally preferred to develop technical skills with tools and materials at the expense of developing cognitive skills associated with reflection, integration and evaluation.
In this study the students were relieved of the technical skills (skills that they may learn in more advanced design courses) but still benefited from seeing their ideas emerge through three-dimensional form.
Sandler [14] asserts that the choice of algorithm for solving a mathematical problem is like the choice of a physical model in engineering. In both cases students need to understand why they need to ask the right questions in their modelling strategy. Of course students can learn about form through other means, e.g. drawings or computational programs [15], but using physical models engages the mind with visual and tactile stimulation. They offer opportunities for what Schön characterised as reflection-in-action – a rich activity that is both contemplative and creative.
The feedback from the study also reveals the power for models to increase the confidence of novice designers. Modelling prompted participants to explore more ambitious ideas. As one student stated 'I was nervous at the start and very conservative in design but with the models I gained confidence and became excited waiting for my model to come and eager to make design improvements'.
The conversion of students' rough drawings into a tangible chair motivated them to explore their ideas further. Discovery and understanding of new assembly techniques contributed to students' desire to improve their design ideas; as one student pointed out at the end of the study 'I have enjoyed the whole learning experience, especially how the joining can limit design or trigger new ideas'. Also physical models assisted students to realistically reflect upon their ideas and motivate them in making functional and aesthetic adjustments on their designs. The progression of the design concepts in Fig. 3 illustrates evolution of jointing and assembly. With new confidence in a concept or detail so ambition increases.

5 Conclusions

It's clear that the traditional model of face-to-face design education with its studios, workshops and display areas is an expensive model to sustain. It seems equally clear that all institutions offering design education at undergraduate level will adopt some aspects of distance learning even if these are intended only to support and enhance a predominantly face-to-face experience.
For many design students, even novice ones, the making of physical models is a natural and spontaneous act that they take to enthusiastically. Any requirement to have to develop digital or machine skills may act to suppress this vital enthusiasm for making and modelling. This work reveals a successful engagement with modelling before any teaching of the traditional skills and knowledge needed for the safe modelling of design ideas. This work suggests that giving students access to three-dimensional models is vital to their design learning. This is not because such models help students communicate their proposals for form and shape but that they assist students in the very act of thinking about form and shape. This thinking skill, this cognitive modelling, is one of the core building blocks in design education. It has obvious application in those design disciplines concerned with three dimensional outputs such as transport design or architecture but it also has value in extending the cognitive skills of designers looking to build a career in graphic communication or interaction design.
In the work presented here participants were given access to technical and design support that took rough sketches of chair designs and converted these to tangible scale models which were posted back to the students. Several cycles of this activity revealed an important value for this type of support – particularly for novice design students
Of course there are negative outcomes too. Interpreting and transferring sketch drawings from paper to CAD is time consuming for the person supporting the students. However it is possible that this might make a good context for peer support – perhaps level 2 students supporting level 1 novices. If, as this paper suggests, design novices can cultivate an understanding of design form through distance collaborative interaction then a world of new commercial possibilities opens up for the involvement of users in collaborative product innovation. Design organisations could educate their customers and then integrate their new competence in the co-creation of consumer products, vehicles, fashion items, perhaps even buildings. It would be a radically new way of making meaning. The work presented here is both curriculum development and research. It illuminates an agenda for research and as such there is much still to do.

Acknowledgments

The authors thank the participants in the study and The Open University for its financial support for Miquel Prats.

References

1. Schön, D. A. (1983). The reflective practitioner: How professional think in action. New York: Basic Books.
2. Kroes, P. (2002). Design methodology and the nature of technical artefacts. Design Studies, 23(3), 287-302.
3. Sass, L., & Oxman, R. (2006). Materializing design: The implications of rapid prototyping in digital design. Design Studies, 27(3), 325-355.
4. Yang, M. C., & Epstein, D. J. (2005). A study of prototypes, design activity, and design outcome. Design Studies, 26(6), 649-669.
5. Ullman, D. G. (2003). The mechanical design process. New York: McGraw-Hill.
6. Schrage, M., & Peters, T. (1999). Serious play: How the world's best companies simulate to innovate. Boston: Harvard Business School Press.
7. Breslin, M. (2008). ZIBA Design and the FedEx project. Design Issues, 24(1), 41-54.
8. Green, G., & Smrcek, L. (2006). On the developing role of physical models in engineering design education. European Journal of Engineering Education, 31(2), 191-200.
9. Welsh, E. T., Wanberg, C. R., Brown, K. G., & Simmering, M. J. (2003). E-learning: Emerging uses, empirical results and future directions. International Journal of Training & Development, 7(4), 245-258.
10. Bohemia, E. (2003). Development of distance communication and virtual teamwork skills through online-based teaching. In B. E. Sarrias et al. (Eds.), Proceedings of the International Conference on Engineering Education. Valencia, Spain: ICEE.
11. McCullough, M. (1998). Abstracting craft: The practiced digital hand. Cambridge: MIT Press.
12. Huffaker, D. (2004). The e-learning design challenge: Technology, models and design principles. American Society for Training & Development (ASTD): E-Learning White Papers.
13. Fidan, I. (2008). Work in progress: Onground versus distance rapid prototyping practices. In Proceedings of the 38th IEEE/ASEE Frontiers in Education Conference. Saratoga Springs, NY, October 22-25.
14. Sandler, B. Z. (2002). Engineering design as an intellectual problem. European Journal of Engineering Education, 27(2), 157-172.
15. Oh, Y., Johnson, G., Gross, M. D., & Do, E. (2006). The designosaur and the furniture factory: Simple software for fast fabrication. In Proceedings of the 2nd International Conference on Design Computing and Cognition (pp. 123-140). Netherland: Springer.

Miquel Prats,
Steve Garner
The Design Group,
The Open University,
Milton Keynes, UK

Yi-Heng Lee and Chao-Ming Wang
s966402@mail.yzu.edu.tw

Fuzzy zone

1 The concept

Fuzzy zone describes the dynamic impression of the physical world for people. In our physical world, we always ignore the fuzzy zone and the answer of the object is always yes or no. If we saw the object in the physical world with fuzzy-view, we would find the knowing things will be more width. This work is used as a metaphor for above concept. People could make a choice of dropping from the weak alkaline solution to the iodine liquor is in the glass container. The locally projecting image captured by the camera will more and more fuzzy and fluid with dropping the weak alkaline solution to the glass container. Alternatively, people also could choose another weak acid solution with dropping; the color of the iodine liquor will turn into transparence and the projecting image will be more and more distinct. During the period of dropping solution, the fluid sound will appear in the background. The fuzzy and fluid image with the sound will trigger people into the so-called reality.

2 The interactive technologies

Fuzzy Zone consists of two acrylic containers with colors, a glass container, glass droppers, the weak acid solution, the weak alkaline solution, cameras and a projector. There are the weak alkaline solution in the black acrylic container and the weak acid solution in the white acrylic container. The middle of the installation is a glass container is filled with the transparent iodine liquor (see Figure 1).

Real-time feedback and processing on image is developed by MAX/MSP/JITTER. Using a camera to analyze and recognize the color and light in the glass container. According to the analyzing data, we mapped them into the changing pixels of the image captured by the camera, then transformed the matrix of the image pixels to simulate fluid physical animation in JITTER (see Figure 2). During the period of dropping solution, the recorded sound will play in the background, and then dropping more the weak alkaline solution will bring fuzzier image and fluid sound.

Yi-Heng Lee
The Department of Information Communication, Yuan Ze University, Taiwan

Chao-Ming Wang
The Department of Digital Media Design, National Yunlin University of Science and Technology, Taiwan

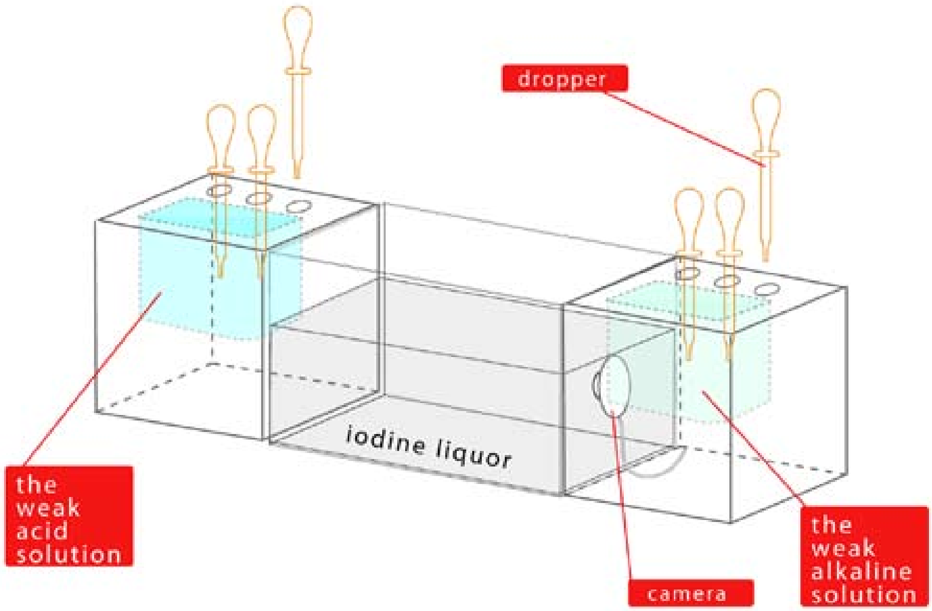


Fig. 1. The construction of Fuzzy Zone.

Fig. 2. The projecting image will more and more fuzzy and fluid with dropping the weak alkaline solution to the glass container.

Eric Toering, Pakwing Man, Frank de Jong
post@erictoering.nl

Dance rail: an interactive installation that provokes aesthetic movement

Abstract
The Dance Rail is an interactive installation that attracts people and motivates them to move. It is a rail with embedded light and sensors. The resulting lighting pattern has been designed to stimulate as much movement as possible without additional instructions. The shape is based on choreographic material of world famous choreographer Wayne McGregor.

Keywords
Choreography, Interactive installations, Public spaces, Aesthetics, Lighting design.

1 The design concept

During two months a multidisciplinary team consisting of Industrial Design students from Eindhoven University of Technology (Tu/e) and Cognitive Science students from University of California, San Diego (UCSD), worked together on making an interactive installation. The goal of the installation is to stimulate people to experience and think about movement with their body. The installation is related to an extensive research into dance creation at UCSD in February 2009 by prof. David Kirsh. That research concerns the new choreography of Wayne McGregor with his dance company Random Dance. The installation will be placed in the front house of the Sadler's Wells theatre in London during the premiere of the performance.

Because of the exposure to the public our aim was to create and deliver interactive and aesthetic quality. The installation is a 20 feet (6 meter) long rail in the shape of a dancers' movement. The shape has been selected from parts of the choreography that have significant relevance for the UCSD research and which have strong links to the theme of the dance. The shape has been tested and adjusted to provoke fluid motion. Patrons visiting the venue are being stimulated to touch and interact with the rail by a lighting pattern in the rail. As soon as touch is detected, the lighting adapts and flows though the rail, along with the visitor.

To create this installation we developed ways to bend acrylic tube, we created our own connection- and support mechanisms, through which all the electronics are guided and hidden from view. We designed the interaction, developed high speed lighting circuitry and programmed custom software to run the lighting program. In two months time we developed an installation where all the time the focus has been on quality and consistency, appropriate for an environment such as modern dance theatre Sadler's Wells.

Fig. 1 Overview of the installation

Fig. 2 Lighting effects

Eric Toering,
Pakwing Man,
Frank de Jong
Eindhoven University of Technology, Faculty of Industrial Design, Eindhoven, The Netherlands

2 The interactive technologies integrated in the design

In the installation are 45 circuit boards, each holding two high power color LED's and one capacity sensor sensitive to touch. The 45 boards are driven by two modified Arduino-boards connected to a PC, which runs custom software, written in C#.net. The installation can switch between multiple interaction programs, adapting to different demo needs.

A video of the installation is online:
http://www.youtube.com/watch?v=hfHsPb8Nl2Q

Special thanks to Kees Overbeeke, Caroline Hummels, Philip Ross and David Kirsh

Tung-Jung Sung, Pai-Yu Chang, Wei-Chih Hsu, Wen-Wei Chang, Chi-Wei Kuo, Yi-Ting Hou, Chi-Shiang Wu, Yao-Joe Yang
sungtj@mail.ntust.edu.tw

Interactive design for older adults: design experience from a wireless intelligent medication-taking system

1 Design concept

Nowadays, many older adults face a common medical problem that they need to constantly take medications to maintain their health. As a result, how to take medications properly plays a vital role in the treatment effects. The main purpose of designing an intelligent and aesthetic medication- taking device, named win_health, is to provide an effective healthcare support system for older adults who are a group that is less well able to see, hear, and understand medical information than the general population. Basically, win_health consists of one main server with a touch-screen panel and seven portable pillboxes. Furthermore, win_health is an intermediate for interaction between older adults, family members, and hospitals. In particular, win_health is a user-friendly system that can not only instruct the user in a step-by-step manner to fill in the pills into the portable pillbox, but also keep track of medicine-taking through wireless internet and sensing technologies. Fig. 1 shows interactive systems design of win_health, while Fig. 2 illustrates some of the user interface designs of win_health.

2 The interactive technologies integrated in the design

To effectively improve the medication management practices for older adults who need to take medication regularly, win_health adopts several types of interactive technologies. The human-machine interactive design of win_health includes a user-friendly operating interface and an alarm/emergency call function on the main server, four intelligent LED light bulbs for reminding the patient to take the medication on each portable pillbox, one embedded MSP430 chip for processing the related wireless signals, and an interactive control system programmed by the LabView software.

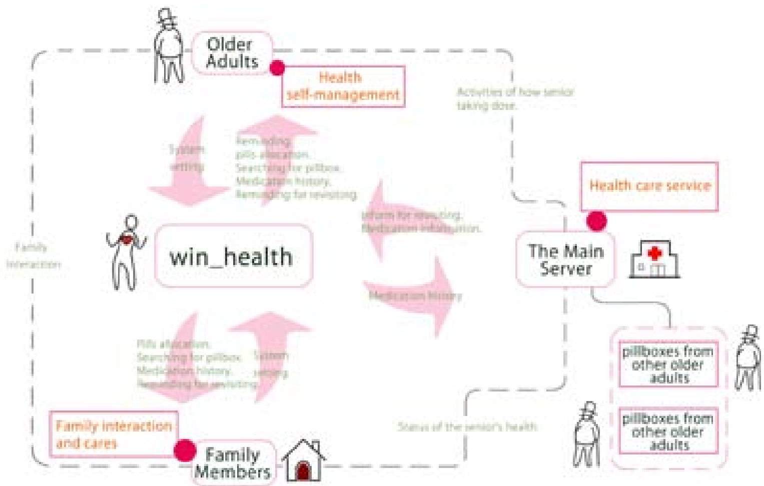


Fig.1 Interactive systems design of win_health

Fig. 2 User interface designs of win_health

Fig. 3 One main server with seven portable pillboxes
The pillboxes can be charged by being directly plugged into the fillisters of the main server.

Fig. 4 One main server and one detachable pillbox
The user can take one or more pillboxes based on his or her actual needs.

Fig. 5 The touchscreen panel with adjustable angles (0°~45°)
The user can easily adjust a suitable angle of an operation panel.

Fig. 6 One pillbox comprises four side-by-side containers labeled with morning, noon, early-evening, and late-night icons respectively.
The design of the pillbox emphasizes a higher degree of visual appeal, readability, and usability.

Fig. 7 Upon receiving the signal, the LED light bulb of the corresponding container is turned on.
The pillbox will make sound at the corresponding container, when it is time to take the medicine.

Fig. 8 Opening the container with LED lighting
With pill safety concerns, each container is designed with the features of anti-sunshine and moisture-proof.

Tung-Jung Sung,
Pai-Yu Chang,
Yi-Ting Hou1,
Chi-Shiang Wu
Department of Industrial and Commercial Design, National Taiwan University of Science and Technology, Taipei, Taiwan

Wei-Chih Hsu,
Wen-Wei Chang,
Chi-Wei Kuo,
Yao-Joe Yang
Department of Mechanical Engineering, National Taiwan University, Taipei, Taiwan

Hsien-Hui Tang, Wen-Jong Wu, Yanb Bee Lee, Chih-Ying Yang, Ching-Yi Chan, Wen-Chieh Fang, Gwen Hsiao, Cheng-Wei Chen, Poming Chen, W Po-Yu Chen, Chien-Chia Liu, Shiang Wen Cheng, Mu-Chern Fong, Yueh-Hsien Lin
drhhtang@mail.ntust.edu.tw

SPACE JAM: non-PC user interface for inter-generational communication

Abstract
SPACE JAM is a multi-user shared environment for inter-generational communication. Our vision is to connect people of different generations without forcing them to adopt a new communication tool. Users interact with SPACE JAM in a way that feels most natural to them. This project demonstrates the way in which our everyday environment can be augmented with computational capabilities while maintaining the natural interactions that their users associate with them.

Keywords
Communication, Technological Generation Gap, Interface, Mixed Reality, Tangible Media

1 Introduction

Having been brought up with different genres of technologies, different generations communicate differently. Grandparents prefer communicating with physical objects, while teenagers tend to use PC-based communication methods. In this paper, we present SPACE JAM, a multi-user shared environment for inter-generational communication. Our vision is to connect people of different generations without forcing them to adopt a new communication tool that is alien to them.

2 Implementation

The setup of SPACE JAM consists of a computer, a video camera, and a projector, which are placed in front of an ordinary physical wall (Fig. 1). Those Users, like our grandparents, who feel more comfortable with real environment work with SPACE JAM in the way they are accustomed to for years. They can leave a message to their family members or planning their schedule simply by placing a physical sticky note on the wall and adding a tag, which indicates the receiver. The note image is then captured by the camera and sent to the designated person on the assigned day. (Fig. 2) Users can also browse digital photos by placing a physical picture frame on the wall. The color of the frame indicates the photo album they choose. The photo slideshow is then displayed by the projector according to the position of the frame.

Teenagers, on the other hand, send the messages or photos to their grandparents with their favor digital devices. Using the projector, they can display the messages and the photos on their grandparents' wall. (Video showcase: http://insight.ntu.edu.tw/sites/all/ files/ video.html)

The primary contribution of this work lies in bridging the gap between reality-based and PC-based communications, and, therefore, enhances connectedness and intimacy among family members from different generations. This project demonstrates a way in which our everyday objects can be augmented with computational capabilities while maintaining the familiar meaning that their users associate with them.

Fig. 1. The setup of SPACE JAM

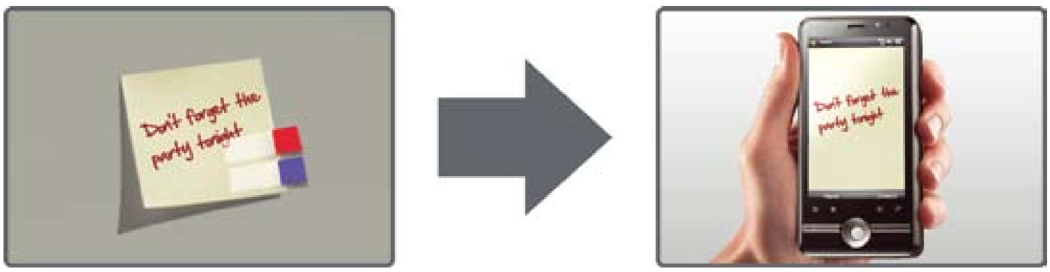


Fig. 2. Sending a message from the physical wall to the mobile phone

Hsien-Hui Tang[1], Wen-Jong Wu[2] Yanb Bee Lee, Chih-Ying Yang, Ching-Yi Chan, Wen-Chieh Fang Gwen Hsiao, Cheng-Wei Chen, Poming Chen[2], W Po-Yu Chen Chien-Chia Liu, Shiang Wen Cheng, Mu-Chern Fong, Yueh-Hsien Lin

[1] Assistant Professor, Department of Commercial and Industrial Design, NTUST

[2] Assistant Professor, Department of Engineer Science and Ocean Engineering, NTU

Scottie Chih-Chieh Huang and Shen-Guan Shih
scottie.c.c.huang@gmaul.com & 2sgshih@mail.ntust.edu.tw

Information fluid in smart tiles

Abstract
The smart tile is a sensor network and tangible-user interface based building material. It is also an information processing unit that exchanges information with neighbouring tiles, works autonomously and collaboratively with other tiles to form a network that processes and transmits information to support context-aware computing. It can real-time aware the dynamic configuration of interior spaces and the dweller's activities happened at somewhere, and then recognizing and disseminating information with light to whole environment.

Keywords
Smart building, smart tile, context-awareness

1 Design Concept
The smart tile is a sensor network and tangible-user (TUI) interface based building material. Cellular Automata (CA) concept is designed and implemented in a module- "smart_tile", make the individual tiles can be connected to each other to form an information network in a space. By having smart tiles, floor is augmented as a sensitive skin, which can real-time aware the dynamic configuration of interior spaces and the dweller's activities happened at somewhere. It may provide abundant informations in a space as an open source, and applying for environmental facilities making them become intelligent, enable to assist dwellers with domestic work in some situations. In this demo, we introducing this smart_tiles module, which can visulizing the inforamtion created by putting objects under tiles. Through the colorful illuminate happening, the information is disseminating to whole the space spontaneously.

2 Interactive technologies integrated in the design
Smart_tile module consists of a 12cm×12cm board, attached with 3 ATmega168 chips, an infrared transmitter, an infrared receiver, four full colour LED, four pressure switches, and four computer connectors. Each module can be connected to four neighbouring module through the connectors. The connections provide sharing of power and information. PWM (pulse width modulation message) is used for exchanging information between modules.
A set of parameters is used to define the state of a tile. The rules for the transmission of each parameter from one tile to another can be specified independently according to the need. In this demo here are three parameters, visually represented with red, green and blue lights from the full colour LED. We call the three parameters read, green and blue pheromones, for the intensities of these parameters decreases with distance, simulating the distributional pattern of chemicals such as pheromone from their sources to surroundings.

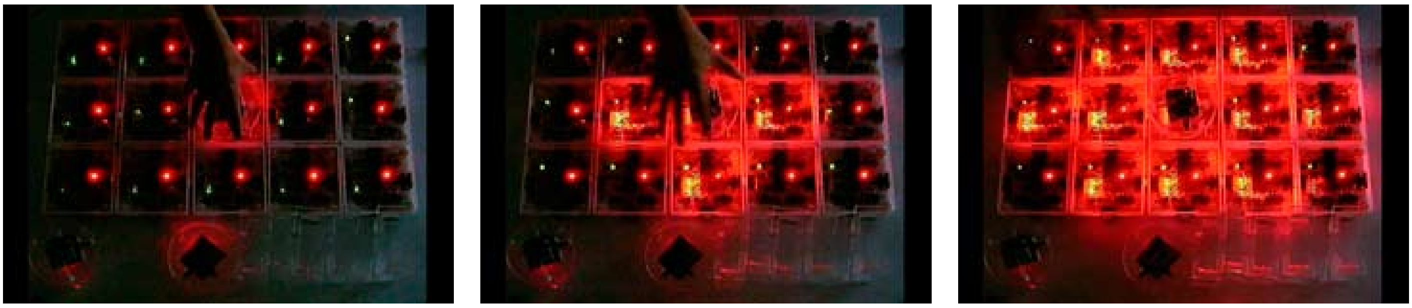


Figure 1. The dissemination of read pheromone

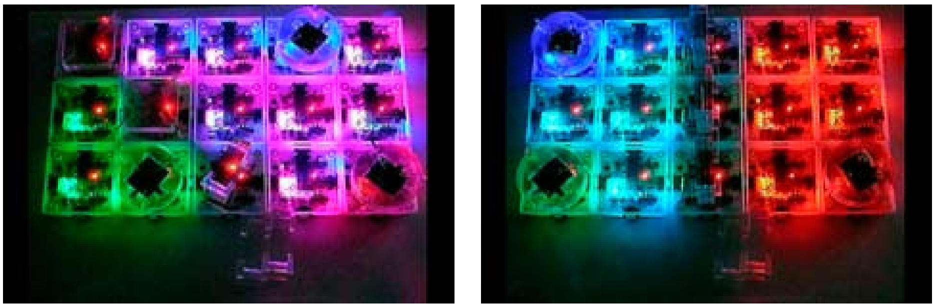


Figure 2. Blocks block the transmission of pheromones
(http://www.youtube.com/watch?v=fYhWXB9aud0. Accessed 22 September 2009.)

Figure 1 shows how the floor disseminates pheromone. The photo on the left shows someone puts a source of red pheromone on the central part of the floor. The photo on the right shows that the red pheromone disseminates to the connected area immediately.

Photos in figure 2 show that the placements of blocks block the transmission of pheromones. In the photo on the left, three blocks are placed linearly to form a wall that divides the floor into two areas. The green and blue pheromones share the area on the left, whereas the red pheromone is distributed within the area on the right. In the photo on the right, three blocks are placed diagonally. The distribution of green pheromone is enclosed in the triangular area on the left bottom, whereas the blue and red pheromones share the area on the top right.
In this interactive demo, we have numbers of tiles to put on the 2m*2m table in darkened area, and need one standard 20amp 110volt outlet for the piece. Besides the tiles, we also provide blue, green, and red pheromones objects, and block objects here. Attendee can move the position of objects to see the whole tiles' colors smoothly changing with adaptability.

Scottie Chih-Chieh Huang and Shen-Guan Shih
Group of Architectural Synergy, National Taiwan University of Science and Technology

Maxe Fisher and Karna Sigurðardóttir
maxe.fisher@gmail.com

The Concrete & The Ephemeral

Abstract
The Concrete & The Ephemeral is a research project that explores the intersection of design and drama. Inspired by the responsive relationship of an object to the body, it focuses on the ritual of dining in dramaturgical interpretation of the scenario. The research aims to mine the rituals of the everyday as a means of unmasking and evolving inherent myths and as a means to restore a performative symbiosis between objects and the body as both an expression and extension of the complexity of contemporary culture.

Keywords
Actions and Gestures, Design Performance, Myth, Dramaturgy, Things, Interdisciplinary Practice-Led Research.

We argue that when dramaturgy is combined with design thinking, novel interdisciplinary research avenues open to expand current ideas regarding our contemporary relationship to things especially as they become increasingly more complex and unstable. New technologies are also bringing about new ways of engagement, precipitating new animated means of exploration. By introducing to the design process the qualities of theatre, some contemporary cultural myths are unveiled in a familiar scenario. The ritual of dining was chosen as the cultural context and expression in this practice-led research for its inherent qualities; the nature of being a shared experience, of being participatory and performative, ubiquitous and often full of passion. The Concrete & The Ephemeral is a multifaceted experimental project, being both subject and object, as well as the technique and the material.

The project references the increasing pertinence of an experience or interactivity to explore a temporal actuality with things. Within the domain of industrial design current designerly methodologies rarely consider the lived experience in time and through time. The research into this scenario of the everyday and its semantic meaning enhanced, challenged and expressed the intensity of our relationships to things. It is here where design and dramaturgy intermix to evoke and awaken as well as to evolve and inspire.

The interplay between design and drama offered a new framework to reveal hidden myths and histories embodied within existing things and rituals that otherwise would remain masked and unknown from a vast set of histories whose techniques are learned and whose meaning is symbolized in gestures and artefacts.

This practice-led research which we define as intuitive (designerly), responsive (performative), and referential (continuous) contributes to novel methods of research, and to designing and creating the potential for the performative to emerge from within everyday artefacts.

The designing of these artefacts for and within the performance allowed us to understand more provocatively our relationship to them. The responsive animated gestures and the participatory conversation between the actors and things are manifest forms of culture and cultural continuity. The exaggeration of the performative and the interpretive in the daily scenario is found through the techniques of dramaturgy, allowing the familiar to nourish in the imaginative. Significantly, the experiential exposed through the drama allowed for the artefacts' own phenomenology and for their mythical history and nature to come forth. This strongly acknowledges the relevance of the phenomenological experience as an extension of our own myths and our collective tacit knowledge which permeates in time through our artefacts.

This research method allowed for the exploration of details of gestures, the ephemeral nature of human actions while still celebrating the context in which they occur. The artefacts (The Concrete) and the gestures (The Ephemeral) perform in a symbiotic type of cause and effect not only in their immediacy of the cultural context: the dining ritual but by extension into broader social and cultural issues through a meaningful dialogue between the body and the artefact.

The intuitive nature of the research process relies upon the final act, The Performance, to reveal new understandings and its contribution to knowledge derived from the responses of the actors to the forms and the context, highlighting that open questions in regards to the contribution to knowledge require the performance, the participants and the audience to complete the research. The nature of our research is a real time expression being the technique (movement) and the material (semantic) in the relationship to form and movement in the lived continuity of interactivity, an interactivity which is underpinned by technology in the form things or implements and in the techniques of gesture and movement. Both in the making and at the event itself, The Performance acts as a catalyst between and amongst diverse backgrounds, all working together towards the goal of creating a new interpretation and experience, yielding new meaning in how we express culture. Culture, being our collective memory, myth and ongoing narrative.

Maxe Fisher
Victoria University,
School of Design,
Wellington,
New Zealand,
Karna Sigurðardóttir
Independent Designer,
BDes, Victoria University

Chih-Ying Yang, Rung-Huei Liang, Wen-Jong Wu, Mang-Yang Lee, Kuo-Chun Tseng, Rong-Hao Liang, Hung-Jung Lin,Yi-Chu Lin, Yen-Hao Chen, Cheng-Dar Chiang, Bing-Yu Chen, Kai-Yin Cheng, Yu-Ming Chu
liang@mail.ntust.edu.tw

Memory bricolage table for the elderly

Abstract
In this paper, we explored the possibility of a new media approach for elders' self-review and inter-family sharing. Acknowledging to the new phenomenon of ageing society, we base our interactive design on daily practice of using a tabletop with the purpose to help elders evoke and enrich their memory life through objects they use every day.

Keywords
Ambient Technology, Interactive Design, Slow Technology, Poetic Space, Documentary Photography, Ubiquitous Computing.

1. Design concept
Serving other than purely practical communication purpose, our design aims to create an everyday scenario providing a companion experience in which elders could evoke and share their memory with their family [1, 6]. In order to create a natural sharing environment, we base our design on a tabletop that triggers an everyday interaction among people using it.

2. Implementation
We went into elder's memory and explored how and what ageing people review their life. In order to present this diversity of memory, we poetize the living space and memory process [2] with the metaphor of water and embed users into two interface modes, an ambient mode and an interactive mode.

2.1 Ambient mode
This ambient mode evokes users' memory by releasing system-driven elements into their tabletop. These elements are categorized by the solar terms. Since the twenty-four solar terms show the relationship between universe, season, climate, agriculture, and medicine, many elders in Taiwan still follow these terms in their everyday activities including health care, folk festivals, foods, and so on (Fig. 1). Therefore, our system will automatically pick up photographs of the same solar terms in the past for elders to recall.

2.2 Interactive mode
Inspired by the notion of bricolage [3], we try to trigger an interaction that was born in users' feel of memory and how they want the memory process to be. This interactive mode aims to serve as a portal that builds connection between objects and memory and presents the memory bricolage through users' manipulation of objects. Rather than using a memento as a proximity-triggered token [4], constructing and arranging everyday objects with novelty and aesthetics, an elder becomes a bricoleur of both digital and material forms as a whole [5]. (Fig. 2)
We classify objects into four categories: time, place, people and event, which provide sufficient variety of material for bricolage. Placing multiple objects will bring out photos which have relation with objects. These photos will be shown on the center of objects, others will be shown on periphery (Fig.2).

Chih-Ying Yang[1], Rung-Huei Liang[2], Wen-Jong Wu[3], Mang-Yang Lee[2], Kuo-Chun Tseng[2], Rong-Hao Liang[4], Hung-Jung Lin[2], Yi-Chu Lin[2], Yen-Hao Chen[2], Cheng-Dar Chiang[2], Bing-Yu Chen[5], Kai-Yin Cheng[6], Yu-Ming Chu[7]

[1]Center of Innovation and Synergy for Intelligent Home and Living Technology, Taipei, Taiwan
[2]Dept. of Commercial and Industrial Design, National Taiwan University of Science and Technology, Taipei, Taiwan
[3]Dept. of Engineering Science and Ocean Engineering, National Taiwan University, Taipei, Taiwan
[4]Dept. of Electrical Engineering, National Taiwan University, Taipei, Taiwan
[5]Dept. of Information Management, National Taiwan University, Taipei, Taiwan
[6]Dept. of Computer Science and Information Engineering, National Taiwan University, Taipei, Taiwan
[7]Unison Art Association

2.3 Technologies

We use computer-vision and image recognition technologies to build a multi-touch tabletop. Our software will catch the image via a webcam and recognize position of tags which stuck on the back of objects. Thereupon the projector will project the relative photos to the screen.

Reference

1. Tollmar, K., Junestrand, S., & Torgny, O. (2000). Virtually living together: A design framework for new communication media. In Proceedings of the ACM Symposium on Designing Interactive Systems (pp. 83-91). New York: ACM.
2. Bachelard, G. (1994). The poetics of space. Boston: Beacon Press.
3. Turkle, S. (2007). Evocative objects: Things we think with. Cambridge: MIT Press.
4. Hoven, E., & Eggen, B. (2008). Informing augmented memory system design through autobiographical memory theory. Personal and Ubiquitous Computing, 12(6), 433-443.
5. Petrelli, D., van den Hoven, E., & Whittaker, S. (2009). Making history: Intentional capture of future memories. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1723-1732). New York: ACM.
6. Apted, T., Kay, J., & Quigley, A. (2006). Tabletop sharing of digital photographs for the elderly. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 781-790). New York: ACM.

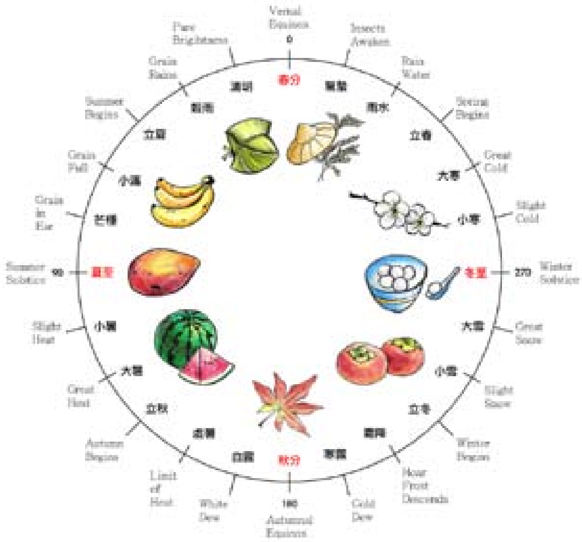


Fig. 1. The 24 solar terms.

Fig. 2. Physical objects and digital media on a tabletop form a hybrid bricolage of memory.

Fig.3. The Photo of the desk installation.

Jun Hu and Sjriek Alers
j.hu@tue.nl

AdMoVeo: an educational robotic platform for learning behavior programming

Abstract
Most of the design students do not have inherent affinity towards programming and electronics. The AdMoVeo robotic platform is designed, purely for teaching the industrial design students basic skills of programming and for motivating and encouraging the design students to explore their creativity with their passions in graphical and behavioral design.

1 Introduction
Like many other design departments, we are facing the challenge of teaching the engineering principles and practices such as computer science and mathematical modeling to design students that are neither mathematicians nor computer scientists [1]. Most of the students in our department do not have an inherent affinity towards programming and electronics. But they do have passion in visual designs and product behaviors. Traditional ways of teaching programming and electronics by lectures combined with exercises had been tried in our department, but the students found that it was hard for them to build the link between the theory and the practice. Design students are often eager to put the just learned knowledge into their practice, if not immediately, as quickly as possible. Any longer delay in delivering the hands-on experience only builds up their frustrations and disappointments. The AdMoVeo robotic platform is designed purely for the purpose of teaching the industrial design students basic skills of programming. Moreover we aim at a platform that motivates and encourages the design students to explore their creativity with their passions in graphical and behavioral design, which in turn gives them spontaneous and intrinsic drive in learning programming.

2 Hardware design
The design of AdMoVeo features a detachable Arduino Diecimila board and two wheels integrated within the round shape of the chassis (Fig. 1). The chassis and motor mount are made from transparent acryl glass, giving it a see-through look into everything inside. The sensors include two line readers at the bottom, three infrared distance sensors at the sides and in the front with sensibility of 0 to 20cm, two light sensors in the front, two sound sensors at the sides and two optional encoders coupled to wheels. The actuators include two motors driving two wheels, a buzzer and a RGB color LED integrated into the acryl chassis. An XBee module is optional for wireless communication.

3 Software design
The software design is based on a layered structure of composition and inheritance. It has mainly two major parts – the firmware IDuino running in the Arduino microcontroller of the AdMoVeo robot, and the Java API library for programming and controlling AdMoVeo in the Processing programming environment. Processing is an open source programming language and

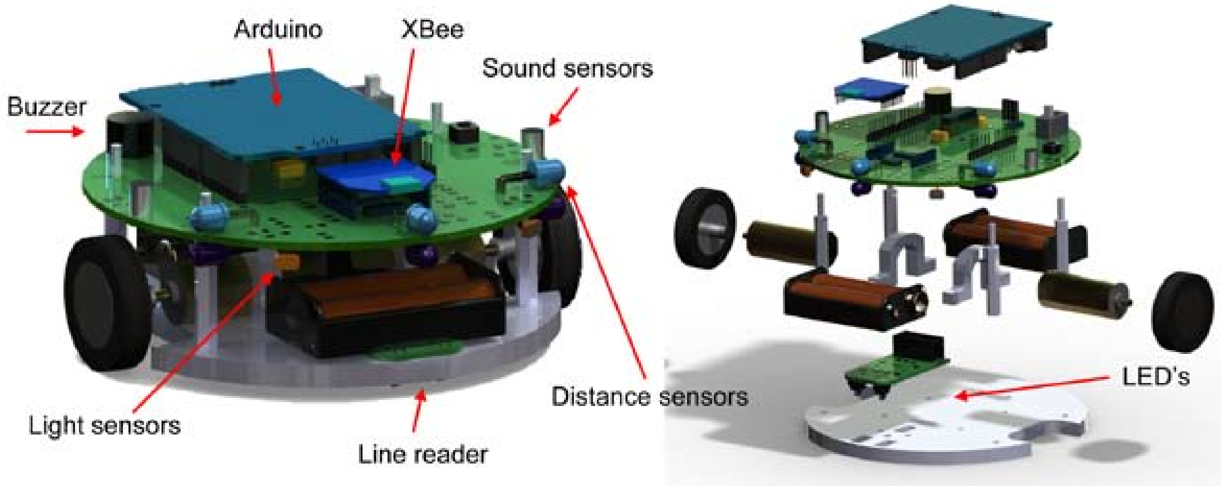


Fig. 1. 3D rendering of the design of AdMoVeo

environment widely used by artists, designers and researchers to program images, animation, and interactions.

4 More Information

More details about the design of the AdMoVeo are described in [2] and at admovel.nl. Information about the Creative Programming course can be found at wiki.id.tue.nl/creapro, and example videos created by students are available at wiki.id.tue.nl/creapro/WallOfFame.

References

1. Vlist, B. v. d., Westelaken, R., Bartneck, C., Jun, H., Ahn, R., Barakova, E., et al. (2008). Teaching machine learning to design students. In Z. Pan, X. Zhang, A. E. Rhalibi, W. Woo, & Y. Li (Eds.), Technologies for e-learning and digital entertainment, LNCS (Vol. 5093/2008, pp. 206-217). Berlin: Springer.
2. Alers, S. & Hu, J. (2009) AdMoVeo: A robotic platform for teaching creative programming to designers. In M. Chang, R. Kuo, Kinshuk, G.-D. Chen, & M. Hirose (Eds.), Proceedings of Learning by Playing. Game-based Education System Design and Development (pp. 410-421). Berlin: Springer.

Jun Hu,
Sjriek Alers
Department of Industrial Design
Eindhoven University of Technology,
The Netherlands