Bloody Robots as Emotional Design: *How Emotional Structures May Change Expectations of Technology Use in Hospitals*

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By applying Gilles Fauconnier & Mark Turner's theory of conceptual blending to a design case, this paper demonstrates how experiencing emotional qualities in technology design may influence the way users cognitively reconstruct standard expectations of use. In so doing, the paper expands the dominating appraisal theory of emotion in design in three central respects: (i) the understanding of mixed emotions is deepened; (ii) a more detailed explanation is given of the specific operations involved in appraisal processes grounded in embodied interaction; and (iii) a structural model is proposed for mapping the constitutive role that mixed emotions play in product usage and interaction.

Keywords – User Experience, Emotional Robots, Cognitive Semiotics, Appraisal Theories of Emotion, Conceptual Blending Theory, Embodied Cognition, Embodied Appraisals.

Relevance to Design Practice – The theoretical framework introduced in this paper offers analytical tools that can enable designers to account for the role of mixed emotions and embodied interaction in product experience.

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Introduction

Emotional approaches to technology design have proved very promising for the ongoing proliferation of digital technology into 'soft' sectors within healthcare centers and hospitals. As information technologies are gradually assuming a key role in more direct patient-related tasks (as in *pervasive healthcare*), one overarching goal of HCI-designers working in these domains has been to find methods of incorporating considerations for patient's emotions into the design of interactive healthcare systems. This practice could be described as part of a broader *emotion-driven* design paradigm, to use a term from Desmet and Dijkhuis (2003).

Emotion-driven design in healthcare sectors differs from other emotional approaches in that the designer often needs to have a more nuanced understanding of *mixed emotional states*. Medical treatment typically involves patients living through compound or even conflicting emotional states. The treatment itself might involve unpleasant affective states, yet at the same time patients tend to appraise these stimuli as a necessary evil for achieving a beneficiary goal: cure and well-being. Such instances of what Koole (2009) designates as "emotion regulation" show that emotional user experience is not always perceived to be "valenced" in a clear-cut *bipolar* way (either positive or negative, pleasant or unpleasant), the impression that is easily given by some models using core affective principles (cf. Russell, 1980). Instead, emotion regulation is generally aimed at changing core affective patterns (cf. Koole, 2009, p. 7).

Moreover, patients also have to adapt emotionally to the new functions and circumstances of technology use for healthcare purposes. Basically, this adaptation process requires that standard expectations of use are revised according to the emotional reactions caused by novel or changing eliciting conditions. To facilitate the implementation of new emotionally engaging technologies, designers could thus benefit from gaining further insight into how our bodily feelings, emotions and cognitive operations mutually shape one another.

Recently, we have witnessed a boom in the development of emotion theories in design (see e.g. Desmet, 2002; McDonagh, Hekkert, van Erp, & Gyi, 2004; Norman, 2004). However, to my knowledge, mixed emotions and, in particular, the eliciting of mixed emotions by the appraisal of novel experiential and embodied aspects of technology use have not received the attention they deserve. For instance, Desmet's (Desmet, 2002, p. 124) "basic model of product emotions" is developed primarily with regard to "passive observation," not embodied interaction. Also, in the research literature, novelty appraisals are generally reduced to being merely a question of products and interfaces evoking surprise, fun or pleasure (Desmet & Dijkhuis, 2003; Green & Jordan, 2002), whereas the emotionally motivated reshaping of standard knowledge structures in the user is left largely unspecified.

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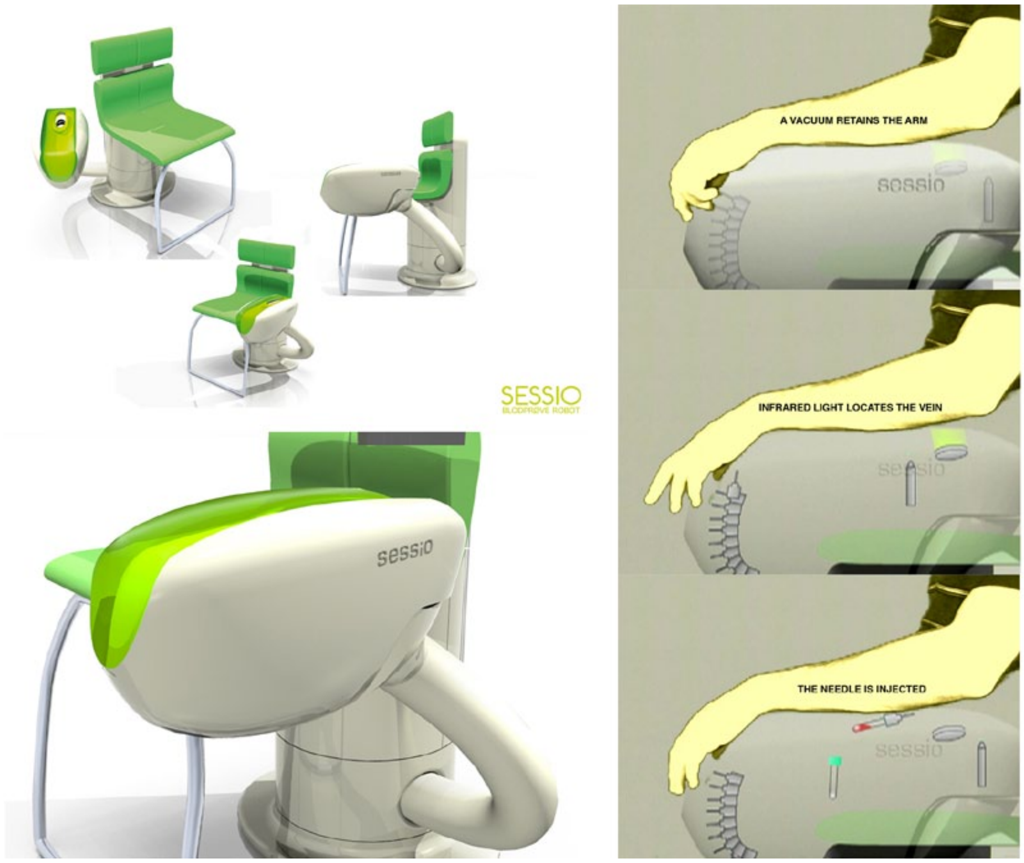

Figure 1. Sessio – A blood-taking robot.

The aim of this paper is, therefore, to increase the designer's understanding of the eliciting of mixed emotions by the appraisal of novel embodied aspects of interactive healthcare design. For this purpose, I will apply Gilles Fauconnier and Mark Turner's (Fauconnier & Turner, 1998, 2002) theory of conceptual blending to a design case.

Blending theory possesses an unexplored potential to fill in those gaps in the existing appraisal theoretical framework that Roseman and Smith (2001) have pointed out. First, it offers a more elaborated account of the human ability to construct mental representations (appraisals, interpretations, judgments), which appraisal theories generally hold to be pivotal for our emotional and bodily transactions with the world (cf. Lazarus, 1991). Secondly, it provides structural models that enable us to articulate the specific operations by which new appraisals and evaluations might occur. These two obvious heuristic values will stand out more clearly as I move from Desmet's model of product emotions to Fauconnier & Turner's network model in my subsequent case analysis of RoBlood.

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RoBlood

RoBlood is a series of robots that take blood samples from patients and that are meant to replace bio-analysts in the Danish healthcare sector. Since 1987, blood tests in this sector have increased at a rate of 7% per year, amounting to a total of ten million tests in 2006. Because of this increase, bio-analysts are today using 40% of their working hours in the actual taking of blood. Besides raising the question of whether this rather simple task is an efficient use of the expertise of highly trained analysts, a problem is also arising because the repetitive nature of blood-taking is causing many arm, hand and finger injuries among analysts (Wetton, 2007).

Since blood-taking is a personal and intimate affair, the ultimate goal of the RoBlood project was to design robots with which patients could feel emotionally secure and safe. But how do you make people feel comfortable when intimate human interaction is handed over to a robotic device—a robot, furthermore, being something that many of us happen to associate with the hostile cyborgs and androids that threaten the existence of mankind in sci-fi films such as *Terminator* and *The Matrix*. Is it possible at all to engender a sense of confidence in a robot that is performing a task related to human health and well-being?

The strategy of the design team was to push the 'soft' and 'human' aspects of the workspaces in hospitals to the fore. This strategy is clearly reflected in the way in which technology use, emotions and form are unified in two of the design proposals, named *Sessio* and *Dolphin*. *Sessio* integrates blood-taking robotic technology into the armrest of an organically shaped interactive chair (Figure 1). When the patient places her arm on the armrest, it automatically adjusts in height and follows the patient's movements. Then a comfortable vacuum retains the arm, so that it is enclosed and kept still. The blood-taking starts when, after the position and depth of the vein have been identified, a needle from the armrest is inserted into the patient's arm (cf. Nørhave, Madsen, & Springborg, 2007).

Dolphin is based on a similar concept that involves removing the visual stress of seeing the needle entering the arm by building the blood-taking technology into an organically shaped armrest (Figure 2). The armrest is shaped so that the patient's arm will be comfortably fixed without being locked. Through the material used and the smooth surface, the armrest is meant to create a warm bodily sensation, such as one might experience when being hugged, to draw attention away from the eventual discomfort. Furthermore, the 'hugging' will produce better blood flow in the patient. The one-piece ergonomic shell easily comes off so that it can be wiped and disinfected, thus making it also a hygienic solution (cf. Helgason, Koster, Kristiansen & Larsen, 2007).

Limitations of the Appraisal Approach to Product Emotion

Now, the interesting question to ask is: What kind of process with regard to the eliciting of emotions is involved here? According to Desmet (2002, p. 111), "the key to understanding the eliciting conditions of distinct emotions lies in the characteristic of the appraisal process" (p. 111). An 'appraisal' is conceived as a mental judgment or evaluation of whether a particular product is beneficial, harmful, or not relevant to our well-being. Appraisals are made on the basis of the perception of the sensuous qualities of the product, but are also guided by internal phenomena such as our drives, needs, instincts, motives, goals, values, and so forth—all of which are covered by the notion of *concern* (cf. Frijda, 1986).

In order to illustrate how these components intertwine in the eliciting process, Desmet presents his basic model of product emotions (see Figure. 3). He further argues that product emotions can be modeled according to four major appraisal types: Appealingness, Legitimacy, Motive Compliance, and Novelty.

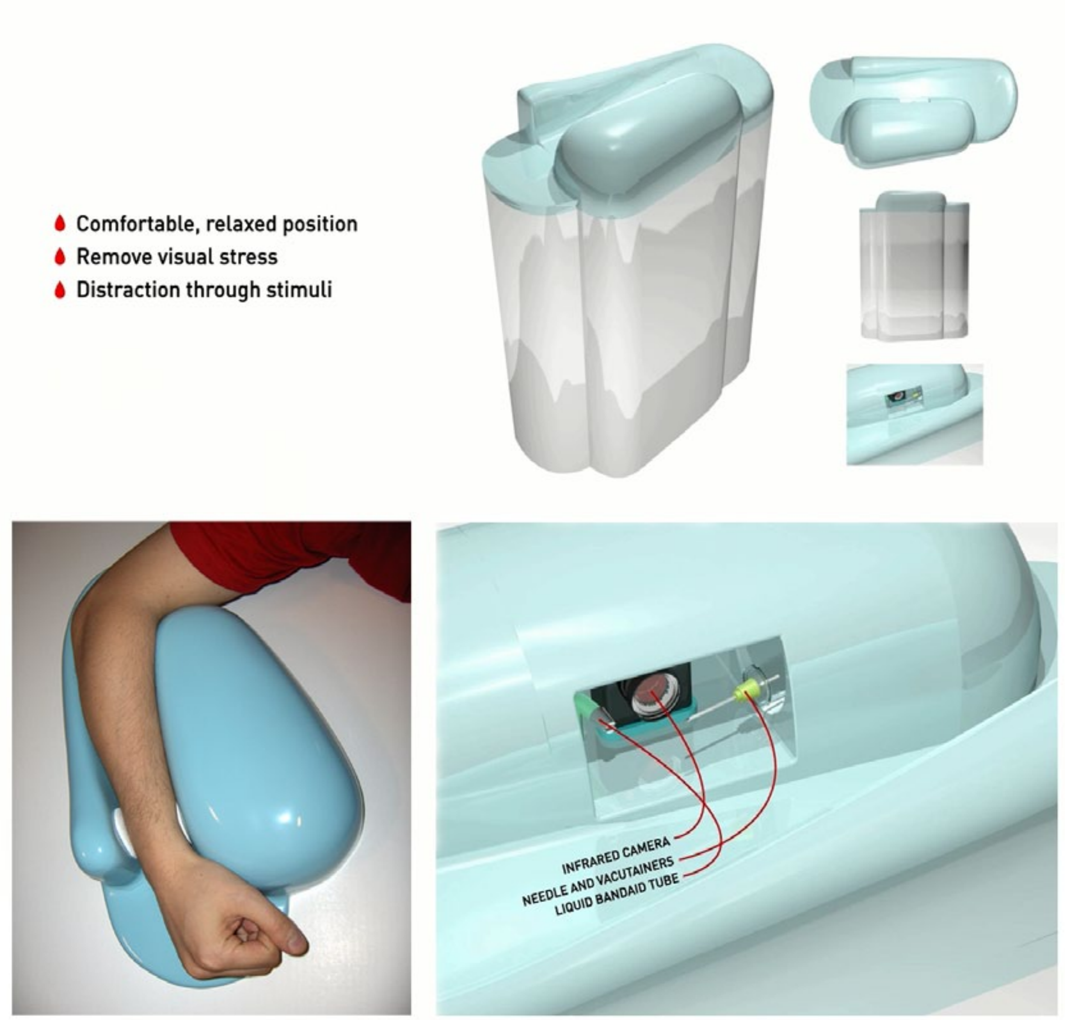

Figure 2. Dolphin.

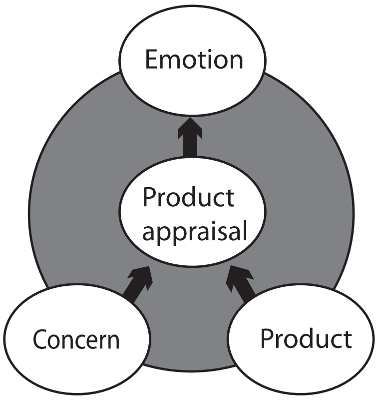

Figure 3. Desmet's basic model of product emotions (adapted from Desmet, 2002).

If we accept this model for the time being and follow the principal methodological guidelines of its use, as they are laid out by Desmet, we are able to distinguish between different product emotions involved in the *Sessio* and *Dolphin* experiences. (Since my focus is on the general model-theoretical assumptions underlying Desmet's framework and not on a discussion of the individual appraisal types, I will leave appraisal of Legimitacy and Motive Compliance out of consideration.)

First, there is the appraisal of Appealingness (Figure 4a). If we assume that people are positively disposed toward curvilinear and organic shapes, then it would be reasonable to claim that the mere visual appearance of either *Sessio* or *Dolphin* is likely to evoke an appraisal of appealingness in the majority of patients. According to the key idea of appraisal theories, then, such an appraisal is able to make patients feel pleasant or good about the technology design.

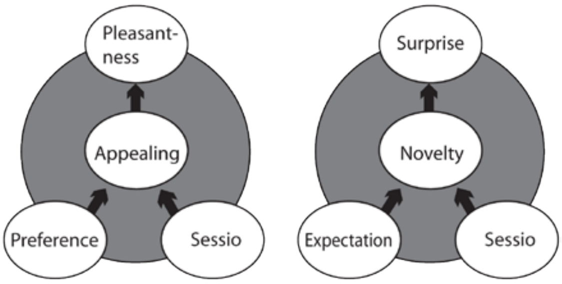

Figure 4: a–Appraisal of Appealingness (left) and b– Appraisal of Novelty (right).

Secondly, there is the appraisal of Novelty (Figure 4b). According to Desmet (2002, p. 117), novelty appraisal is not primarily related to a particular concern type, but to "our knowledge and expectations" (p. 117). It arises, as a result, when we meet unfamiliar products that deviate from what we already know or have learned to expect through previous experiences. Surely, *Sessio* and *Dolphin* are good candidates for evoking this appraisal type as they are designed for functionalities that robots are not normally expected to perform. Robots are most often thought of as being employed for dangerous expeditions in outer space or for manipulating inanimate objects, for example on the assembly line in an automobile factory, not for sensitive and careful operations on human skin. For that reason, the immediate emotional response to follow from a user's cognitive evaluation of *Sessio* or *Dolphin* is likely to be surprise.

Obviously, these brief illustrations by no means do justice to Desmet's otherwise exhaustive framework. Yet they do provide sufficient material for discussing two central challenges that I believe appraisal theories of emotion in design currently face.

The Complex Emotional Structure of Embodied Interaction

Desmet is himself very explicit about the first challenge. As his model is based on passive observation as the primary perceptual mode, it encounters difficulties when it comes to explaining external eliciting conditions involving embodied interaction and actual use in addition to visual experience. We thereby get an incomplete picture of emotional user experience, something that *Dolphin* provides us with a clear example of. Consider again the appraisal of appealingness. As soon as patients start interacting with *Dolphin,* they will experience quite the opposite of pleasantness. Because, in actual use, the healthcare design does not *feel* the way it *looks*. Thus, the experience of the rounded shapes together with the smooth and warm embrace contrasts rather sharply with the feeling of pain caused by the sting of the needle. Pleasantness then suddenly turns into unpleasantness. However, as I will argue later, the unpleasantness does not necessarily suppress the pleasant emotional response completely. Since the smooth pleasant embrace of the arm is co-existent with the puncturing sting, there is good reason to believe that emotions emerging cross-perceptually from different sources are able to co-occur and modify each other.

Cases like this reveal the importance of extending the model to include the perceptual detection of changes in bodily states (see the notion of *embodied appraisals* below) as well as the co-activation of competing emotions caused by embodied interaction with a product.

There is one particular reason why Desmet's model, in its current set-up, is unable to provide us with such an extension. That is because it pictures product emotions as isolated and momentary emotional 'snapshots' in a linear sequence of user experiences (cf. Figures 4a, 4b). Consequently, mixed emotional states are thereby not treated as co-occurring, but as one emotion being temporarily replaced by another in a chain of emotions. To gain full insight into mixed emotions there is, therefore, a need to supplement this linear process view with a network model that encompasses sensuous incongruity as an eliciting factor of divergent emotional responses. This is relevant for many cases involving healthcare design and medical instruments.

Interestingly, Desmet has developed a non-verbal Product Emotion Measurement instrument (abbreviated PrEmo) that enables the designer to work practically with mixed emotional tension in user experience (Desmet, Hekkert, Jacobs, 2000). Furthermore, in a recent article, he describes in some detail how mixed emotions might emerge from sensory incongruity: "One may appraise the color of a product as pleasant, and, at the same time, the tactile quality as unpleasant" (Desmet 2008, p. 395). What needs to be done, though, is to show how these observations can be grounded in a structural description of the appraisal processes that give rise to such emotional complexities. Ludden and her colleagues (Ludden & Schifferstein, 2007; Ludden, Schifferstein, & Hekkert, 2008, 2009) have already succeeded in determining many of the appraisal patterns involved when sensory incongruity evokes surprise. The purpose of the present paper is to add to this ongoing research by introducing a theoretical model that is more sensitive to this kind of emotional experience. My approach will differ slightly from that found in previous studies in that I will argue for complementing appraisal theories of emotion with a semiotic theory of product interpretation based on the notion of embodied cognition. This offers some benefits, as will become more clear in the following sections.

Embodied vs. Cognitive Appraisals

The second challenge to be dealt with here consists, as Damasio (1994) has argued, in describing the role that emotions play in the active shaping of mental states and representations. More specifically, we need to account for what the co-activation of mixed emotions means with regard to the way we make sense out of products. The direction of arrows used in Desmet's (2002) model reflects the opposite and seemingly inconsistent idea in appraisal theories, viz. that emotions are first and foremost *preconditioned and caused* by mental representations, not vice versa (cf. Lazarus, 1991).

Mental representations are no doubt largely responsible for the eliciting of emotions in user experience. For instance, if patients in a hospital are told that a robot named *Dolphin* will take care of their blood tests, many of them are likely to already have a certain concept of what a robot is. Moreover, this concept will in many cases trigger emotions such as anxiety or even fear. Obviously, culture has a huge impact on the content and structure of such concepts. The not exactly flattering portrayal of robots in mainstream film and entertainment might have led to the forging of an unconscious link between anxiety and the concept of robots in people's long-term memories. However, it is crucial to notice that the emotions arising from bodily interaction with *Dolphin* prompt users to transform these standard expectations according to new emotional content (see below).

In order to describe how direct physically induced emotions may in this way influence the reorganization of existing mental knowledge structures, I believe that there is a need to supplement the concept of *cognitive appraisals* with a concept like *embodied appraisals*. Prinz (2004) suggests "embodied appraisals" as a new concept for explaining how not only mental states, but also *perceptual states* involved in the detection of bodily changes, might cause the eliciting of emotions. In so doing, Prinz actually makes a plea for merging some core assumptions from appraisal theory with the basic claim put forward by advocates of so-called *somatic theories* (James, 1884; Lange, 1885), viz. that emotional experiences are experiences of felt bodily changes. But how is it possible to bridge the gap between these two divergent theories of emotion?

According to Prinz, we should not understand the somatic claim as meaning that emotions are merely identical with bodily states and feelings. If this were the case, we would not be able to distinguish, for instance, feelings of excitement from feelings of anxiety, as these two emotions can entail rather similar changes in bodily states: a racing heartbeat, sweaty palms, and so forth. An emotion such as anxiety does not just function as a heart monitor, but also as part of an elaborate warning system (Prinz, 2004, p. 68). Its purpose is to direct our attention towards a potential threat against our well-being. Emotions are thus about something, or, as Moors (2009) puts it, they "have intentional objects" (p. 636).

At this point, Prinz agrees with Lazarus's idea of emotions representing organism-environment relationships ("core relational themes"), but he is unwilling to ascribe to cognitive appraisals the role of the primary eliciting factor. Instead, he argues that perceptual detections of changes in our sensuous nervous systems are essential: "Emotions track core relational themes by registering changes in the body" (Prinz, 2004, p. 68). To ground his argument, Prinz cites convincing evidence from cognitive neuroscience that indicates that our body and visual system are neurally prewired with our brain so as to evoke emotional responses without the intermediate function of cognitive appraisals. More specifically, Prinz refers to recent studies of the amygdala (one of the areas in the brain known to play a central role in eliciting fear) that provide us with two important findings (Amaral, Price, Pitkänen, & Carmichael, 1992; Amorapanth, LeDoux, & Nader, 2000; Bradley, Codispoti, Cuthbert, & Lang, 2001; Davis, 1998; Emery & Amaral, 2000). First, it seems as if there is a subcortical pathway going from the retina via the thalamus to the amygdala. Second, this indicates that experiences of fear may be triggered without the mediation of the neocortex, the area commonly held to be the seat of cognition and mental representations (Prinz, 2004, p. 34).

Without going too deeply into the complicated question of visual cognition, I do think it is necessary to clarify the implications of these findings, because it will add to the understanding of the heuristic value that the notion of *embodied appraisal* has for appraisal theories of emotion. To borrow an example from Prinz, let's consider a situation in which a person sees what appears to be a snake. We know from studies of visual cognition that the mere sight of a snake-like object will reflect two tiny inverted images on the surface of our retinas (see e.g. Gregory & Langton, 1966; Marr, 1982). Due to the specific cell structures in the retina called receptor fields, which were originally discovered by Kuffler (1953), these raw images then are processed according to some filtering mechanism, which has the purpose of detecting contrast and discontinuities in the incoming light signal. These contrasts are then registered and momentarily stored for further information processing in what is called the thalamus. (Marr (1982) refers to this function, appropriately, as a "working memory buffer.") This is a highly 'design-sensitive' feature of our perceptual system, because the visual form and shape of an object is mediated to us precisely via these contrasts and discontinuities in light intensity.

Now, one of the ultimate goals of visual cognition research is to convey how we are able, on the basis of our perception of visual forms, to recognize a particular phenomenon as belonging to a certain object or event category. For instance, these theories might explain how I am able to recognize whether this snake-like object is a black mamba or a curled-up rope by matching my visual input with prototypical concepts and mental representations available from long-term memory. Because such concept-laden cognitive operations require the intermediate function of the neocortex, visual cognition researchers are typically most interested in uncovering how the visual signal travels from the retina via the thalamus to the neocortex, and what happens through the different stages. However, the neuro-anatomical discovery referred to by Prinz asks us to consider another possibility, namely that of the visual signal taking a "short-cut" from the retina via the thalamus to the amygdala. According to Prinz (2004), this implies that even the "gross shape of a snake-like object, registered by the thalamus, is sufficient to initiate a full-fledged fear response. And there's the rub. If fear can occur without mediation of the neocortex, then perhaps fear can occur without cognition" (p. 34).

I am not prepared to go as far as Prinz, who happens to think that we can discard cognition and cognitive appraisals altogether as the central eliciting factor involved in emotion causation. First, it's too early to say whether this insight into the brain can have such consequences for theories of emotion. The existence of the subcortical pathway discussed by Prinz and others does not entail that the connection to the neocortex is suddenly, as it were, 'turned off.' After all, the visual information still activates this area of the brain, and I fully maintain, along with connectionist theories in neuroscience (Smolensky, 1988), that emotions result from many brain areas working together instead of separately (cf. Damasio, 1994).

Second, there is obviously a difference between snakes and cultural artifacts such as a robot. Whereas our emotional reaction towards snakes might be preprogrammed phylogenetically into the human brain as a survival strategy handed down from our ancestors, the triggering of the emotional experience of robots draws, to a significant extent, upon social and cultural learning. It seems unfeasible to come up with a final decision as to whether somatic or cognitive components initiate the eliciting process.

Third, as Desmet (2008) points out, many appraisal theorists would probably agree with Prinz when he says that cognitive appraisals do "not necessarily involve higher-level cognitive processing […] but may as well involve behavioral and emotional responses" (p. 388). For instance, in multilevel theories of appraisals such as those found in Leventhal and Scherer (1987) and Scherer (2001), cognitive appraisals are generally assumed to operate on three different levels: the conceptual, the schematic, and the sensory-motor level. Appraisals on the conceptual level are "processed via highly cortical, propositional-symbolic mechanisms, requiring consciousness and involving cultural meaning systems" (Scherer, 2001, p. 103). On the schematic level, the appraisal process is based on the learning history of the individual. And appraisal mechanisms on the sensory-motor level are genetically determined and react to stimuli according to what Öhman (1987) calls "biological preparedness" (Scherer, 2001, p. 102).

From this it follows that in Scherer (2001) appraisal operations on the sensory-motor level are conceived as cognitive components having a function similar to that of Prinz's embodied appraisal. That is, the unconscious, non-mentalistic evaluation of physically induced stimuli in terms of our well-being (see e.g. Scherer, 1987, pp. 104-105). Therefore, Prinz's critique seems unwarranted. However, Prinz's critique leveled against appraisal theories points toward a crucial need for making some semantic clarifications. Extending the term cognitive appraisals, as Scherer does, to include almost everything from genetically disposed pattern registration of stimuli to individual interpretations and culturally determined categorizations of these stimuli, is of course most likely to cause too many misunderstandings. Analytical terms lose their explanatory power when they blur rather than demarcate the natures of different phenomena. Yet, the work of Leventhal and Scherer (1987) and Scherer (2001) indeed call for exploring possible points of overlap and convergence between somatic and appraisal approaches. And this is precisely where Prinz, in my view, is making a valuable contribution to a theory of emotion. Instead of choosing between embodied or cognitive appraisals as being constitutive for emotion causation, Prinz's notion of embodied appraisal should be regarded as widening the scope of appraisal theories by making them fit for describing the behavioral and visceral emotional responses unfolding underneath higher-level cognition. I also maintain that making a distinction between embodied and cognitive appraisals is useful for analytical purposes.

In the snake example above, an embodied appraisal would thus correspond to the behavioral process through which the perceptual detection of changes of light intensity on the retina are able to evoke a fear response or a feeling of relief, depending on whether the object one is confronting turns out to be actually a snake or a rope. It deserves to be called an appraisal, because it warns us of a potential danger to our well-being. Yet, this danger could also be represented by the propositional-symbolic structure of a cognitive appraisal, say, "It's a black mamba!" It would contain the same meaning, though it is expressed through different forms (Prinz, 2004, p. 62).

In my view we cannot fully account for how emotions are directly induced from actual usage or bodily interaction with a design product, unless appraisal theories are broadened so that they are able to encompass embodied appraisals as an analytical concept. When we touch or handle a product with our body, embodied appraisals will often be responsible for how haptic signals from the peripheral nervous system cause emotional reactions in us towards beneficiary or harmful events in the world. The surface of our skin is deeply rooted in the emotional centers of our brain. Rifts and openings mark critical situations and immediately call for emotional reactions in order to sharpen our attention and perhaps take precautionary action. This is not only relevant with regard to a blood-taking robot, but to all kinds of design products that involve intimate interaction. Furthermore, in cases in which mixed and conflicting emotions are at stake, I contend that these emotions will often stem from a subtle interplay between embodied and cognitive appraisals. Recent studies on so-called *emotion regulation* seem to support this claim. As Petrovic and Ingvar (2002) have shown, regulation of pain often involves both lower-order automatic responses and higher order dynamic cognitive mechanisms. This of course needs to be further investigated in the field of design research.

The Focus of This Study

As we will see shortly, the acknowledgment of both embodied and cognitive appraisals is a critical step towards describing the role that emotions play in learning and adaptational processes. Consequently, a structural model of emotions in design should also account for this extension. To sum up, in the remainder of this paper, I want to focus on the following three requirements for an appraisal model of emotions in design:

- Explaining how bodily interaction and embodied appraisals interweave with visual perception and cognitive appraisals in product emotion.
- Clarifying some of the eliciting principles regulating the co-activation of emotional conflicts.
- Modeling how mixed emotions might change user expectations through embodied appraisals.

The Conceptual Integration of Emotion and Cognition

In what follows I will argue that all of these requirements are met by Fauconnier and Turner's (1998, 2002) blending theory. So, even if it is traditionally counted as belonging to the branches of cognitive semiotics and cognitive linguistics, blending theory also contains significant insights for appraisal theories of emotion in design. In fact, as I see it, many of the theoretical conflicts between somatic and appraisal theories of emotion are likely to be resolved by blending theory. This relies on the fact that blending theory is a semiotic theory of how we form mental representations and categories based upon the notion of embodied cognition. There is as yet no consensus in cognitive science concerning embodied cognition (see e.g. Anderson, 2003; Wilson, 2002; Ziemke, Zlatev, & Frank, 2007). In the present article, I take embodied cognition as referring to the assumption that the body is involved in all forms of human cognition, including abstract activities such as language or symbolic reasoning (cf. Ziemke & Frank, 2007, p. 2). Or as Johnson and Rohrer (2007) put it: "Any explanation of the nature and workings of mind, even the most abstract conceptualization and reasoning, must have its roots in our organismic capacities for perception, feeling, object manipulation and bodily movement" (p. 23).

Before demonstrating how blending theory is able to increase understanding of the appraisal patterns that are involved in a person's emotional interaction with a blood-taking robot, let me just briefly introduce some necessary building blocks. (General introductions to the use of blending theory in interaction design research can be found in Imaz and Benyon, 2007; Markussen, in press; Markussen and Krogh, 2008).

Blending theory is essentially based on the notion of *mental spaces*. A mental space can be seen as a "conceptual package" constructed in our mind *as* we think and talk for purposes of local understanding and action (cf. Fauconnier & Turner, 2002, p. 40). A mental space is thus built up dynamically in working memory out of salient elements and relations given through our perceptual and bodily interactions with the physical world. But in its organization of this experiential content, a mental space equally draws upon schematic structures available from long-term memory such as frames (Fillmore, 1975) and image schemas (Lakoff and Johnson, 1980, 1999). More clarity can be cast on mental space construction if we turn toward the context of our case example.

Upon entering a hospital for a blood test, we normally experience waiting rooms, nurses chatting in corridors, hospital porters transporting patients between surgery areas and wards, the distinct smell of disinfectants and medicaments, and so forth; all sorts of experiential information cue us as we construct a mental space of our purpose for being there. Additionally, we might employ conceptual structures of expectation acquired through similar experiences in the past, which specify the nature of relevant activity, events, and roles for interpersonal transaction (cf. Fauconnier & Turner, 2002, p. 104). Presumably, most Danish patients have become familiar with the activity of having their blood taken as a result of Denmark's public vaccination program. Therefore, it is reasonable to believe that a large group of patients possess a fairly well-developed set of expectations. This set might include concepts such as *healthcare professional, syringe, patient, a body, blood samples*, etc. Similarly, these elements can be organized according to a conceptually "scripted" (Schank & Abelson, 1977) sequence of blood-taking actions, for example: *identification of vein* > *insertion of syringe* > *analysis of blood sample* > *diagnosis* > *treatment*, and so on. When the elements and relations of a mental space are organized in this way, "as a package we already know, we say that the mental space is *framed* and we call that organization a *frame*" (Fauconnier & Turner, 2002, p. 102).

All of this is actually well-known. What is less known, is how framed mental spaces get modified under the pressure of incoming information in local contexts, such as the unfamiliar sensuous and emotional aspects of new artifacts. In other words: What happens to a mental space when we see and use a product that does not quite fit into our conceptual structures of expectation? One of the major achievements of Fauconnier and Turner is to have discovered that such experiences are governed by the principles of what they call "conceptual blending." In the following, I will apply the theory of conceptual blending in my analysis of *Dolphin*.

Modeling User Experience

As user experience unfolds, a rich array of mental spaces is typically set up with mutual connections between them (Fauconnier, 2007, p. 352). In my attempt to unravel the interplay of embodied appraisals and cognitive appraisals in the *Dolphin* experience, it is useful to distinguish between two basic mental spaces.

Perceiving the visual form of the device (cf. Desmet's "product appearance") consists of extracting salient features that are provisionally stored in a mental space. From this users are able to recognize the shape of an armrest, but probably not to infer that the resting function of this armrest is combined with a blood-taking function. However, provided that they are verbally informed about its primary use, and considering the richness of contextual clues, it is more than likely that users will frame this product experience within a standard BLOOD-TAKING frame. Frames are also defined as mental spaces that have become entrenched in long-term memory through repeated actions and experience (Fauconnier, 2007, p. 352). Hence, we can depict the mental projection of the BLOOD-TAKING frame onto the visual appearance of *Dolphin* as part of a *conceptual blending* of two mental spaces (Figure 5).

This so-called *network model* is an attempt to reveal that framing *Dolphin* is not simply a matter of mentally projecting every element of the existing BLOOD-TAKING frame (mental space 2) onto the perceived form (mental space 1). For instance, *Dolphin* is obviously not mistaken for a healthcare professional, but is conceived mentally as fulfilling the *role, job and intentions* of such a person. What the framing operation consists of is thus more specifically a 'selective projection' (lines a, b, c) of a general *intentionality pattern* (indicated by the square). The job consists of getting a blood sample by using a syringe. The intention is to diagnose the symptoms of an illness and ultimately to heal the patient. The role concerns the identity and personality traits of the agent doing the job. Whereas the role of the professional is usually paired with the ability to distance oneself emotionally from one's job, in the case of blood-taking, patients do normally expect the agent to feel empathy for their situation. Another part of that role is to distract the patient as the needle enters the arm.

The intentionality pattern available for robotic devices is not so richly structured (the dashed square) and even collides with the pre-existing BLOOD-TAKING frame at some points (the arrows pointing in opposite directions). Robots are not designed to be empathic in doing their job; they are mostly used for dealing with inanimate objects, not with human patients; the intrusion of technology into the human body is not (yet) thought in folk psychology to cause healing, but often the opposite (cf. the image of cyborgs, androids threatening humans); and so forth. However, what the organic shape of *Dolphin* invites patients to do is conceptually to leave this robotic intentionality pattern un-activated and to blend only its physical elements with the intentionality pattern from input space 2. The blend is a third mental space that makes composite structure available that did not exist in the separate inputs (Fauconnier & Turner, 2002, p. 42). On the basis of such conceptual integration, new inferential and mental judgments can be made, which may of course elicit unexpected emotional responses: a cognitive appraisal of a considerate robot evoking surprise.

Blending Structures at the Level of Embodied Interaction

So far, I have uncovered some of the blending operations underlying the cognitive appraisals of Appealingness and Novelty.

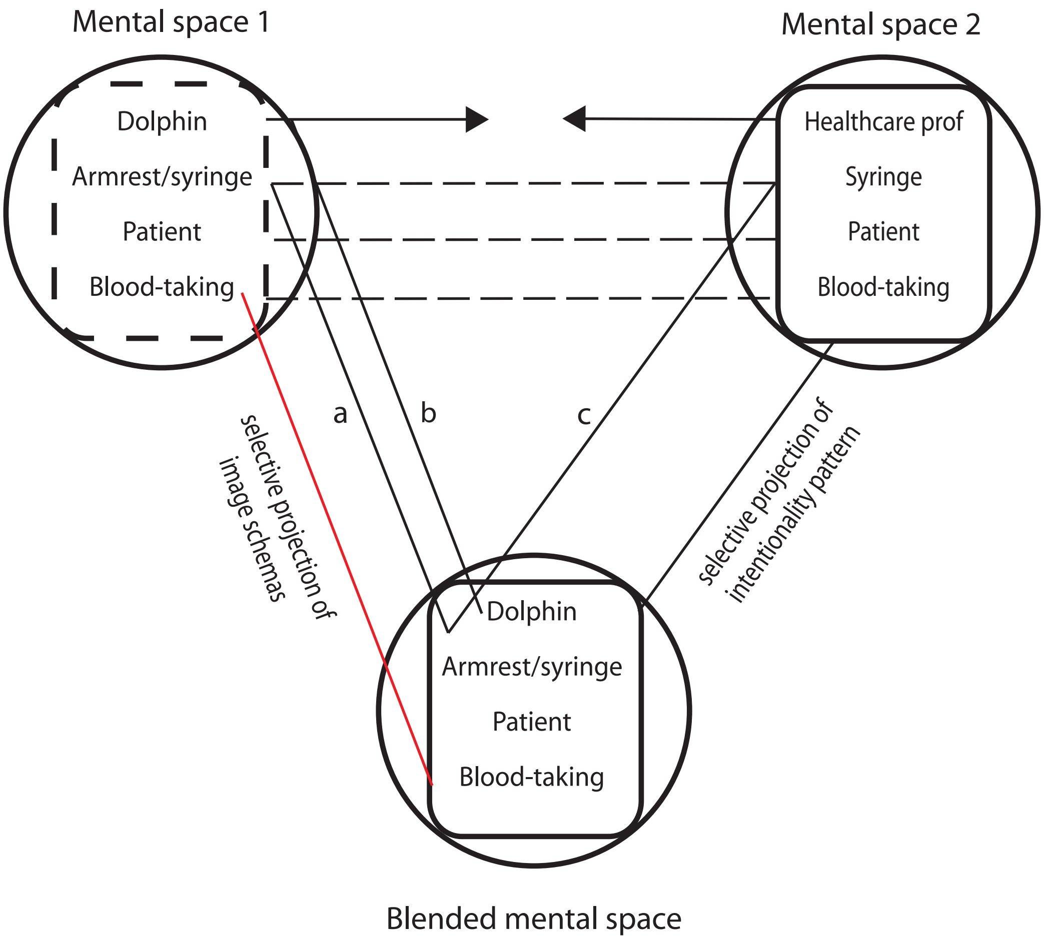

Figure 5. Conceptual blending of mixed emotional content and frame structure.

What remains is to account for how the kinaesthetic and haptic feelings of the body equally contribute with organizing emotional structures to the blend. This is where the notions of embodied appraisal and mixed emotions enter the picture.

The bodily interaction with *Dolphin* differs from the standard act of tapping blood. Building the syringe instrument into the armrest means that *Dolphin* is able to activate a bodily feeling that is normally absent. Recall that in the armrest the feeling of a warm and smooth embrace is evoked through tactual interaction with the patient's arm. Being embraced by something typically elicits one of two mutually exclusive bodily feelings. Either we feel claustrophobically confined, or we feel ourselves protected from external forces. I suggest that *Dolphin* gives rise to the second bodily response, since we tend to feel safe and confident in those situations in which larger parts of our skin are embraced in a soft and intimate way as in a hug or when we cover ourselves with a blanket. Yet, this bodily feeling changes into a sting of pain as soon as the needle is inserted. However, since the insertion and embrace are enacted simultaneously, it is important that these two bodily feelings are seen as co-activated.

Johnson (1987) has convincingly demonstrated how pre-conceptual *image schematic* structures underlie and organize such kinaesthetic and haptic feelings of the body. To understand the co-activation of bodily feelings, it might therefore be helpful to apply this concept. The surrounding of one's arm is experientially organized according to a schema of ENCLOSING, as depicted in Figure 6.1. The open square along with the two arrows illustrates how *Dolphin*'s armrest acts as a CONTAINER closing in on a body part (the circle). On the other hand, the insertion of the needle evokes the sense of an ENTRY into a CONTAINER (Figure 6.2). Here, the needle is experienced as following a penetrating path that creates its own opening into the body. In this instance the body is itself profiled as being the CONTAINER (the square) of a contained object (a portion of blood; the small circle). Since all of this is happening as part of the same haptic experience, it is reasonable to assume that the two image schematic structures are integrated at this embodied level (Figure 6.3).

This image schematic analysis of bodily interaction offers a detailed structural description of embodied appraisals acting as an eliciting factor of mixed emotional states—provided, of course, that we believe along with Prinz (2004) that perceptual states arising from the detection of changes in bodily feelings are able to elicit emotions. Yet I claim that a proper understanding of *Dolphin*'s emotional profile hinges upon this notion of embodied appraisals.

In actual use, it would not be accurate to say that one emotion is experienced as being superseded by another emotion. Rather, one emotion is being encapsulated by the other emotion as the structural description intends to indicate. This might be an important experiential effect. Having a needle inserted into our body is not experienced as pleasant, but since a pleasant embrace encapsulates this unpleasant emotion, it is at the same time downplayed or even counterbalanced.

Now, one of the central assumptions of Fauconnier and Turner (2002) is that, through conceptual blending, image schematic structures of bodily experience can be integrated into the organization of higher-order mental representations. If we accept this line of thought, then Figure 6 could be seen as exemplifying the organizational structure that is projected into the blend from input 1 (the red blood-taking line in Figure 5). What I am saying is that, in actual use, patients could be led through their embodied interaction with the robot to blend new image schematic structures with the standard intentionality pattern inherent in the expected BLOOD-TAKING frame. And this conceptual blending would cause a different emotional response than usual. Thus, as this blend is achieved in the user's online experience, the intertwining of embodied and cognitive appraisal structures allows for building a new emotional content into a reorganized concept—the emotional robot. This insight is crucial for understanding the role of embodied appraisals and mixed emotions in the reorganization of user expectation.

Future Research Perspectives

This interpretation deserves two further comments. First, it appears as if the conceptual blending process underlying this emotionally motivated reorganization of preexisting knowledge structures follows the exact same principles as what, in the research

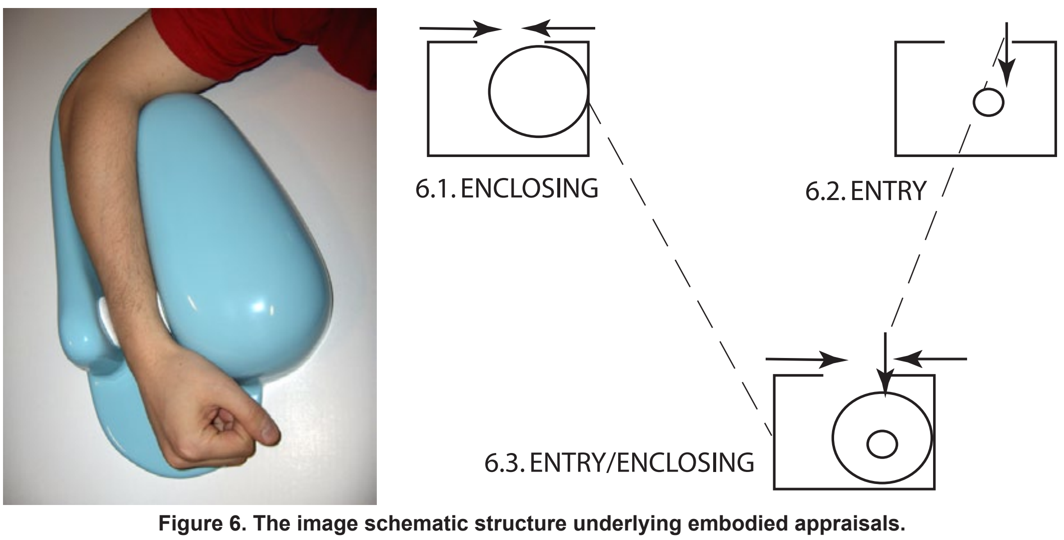

Figure 6. The image schematic structure underlying embodied appraisals.

literature, is known as a "cognitive reappraisal." According to Koole (2009), a cognitive reappraisal is at stake when people "reduce the emotional impact of an event by changing their subjective evaluations of this event [...] Cognitive reappraisal may take the form of: (a) reinterpreting situational or contextual aspects of stimuli (e.g. imagining a potentially upsetting image is fake); or (b) distancing oneself from stimuli by adopting a detached, third-person perspective" (p. 23).

Surely, patients are required to change their subjective evaluations of the normal blood-taking frame by reinterpreting situational and contextual aspects such as the innovative use of robots. So the answer to the question of conceptual blending being conceived as a cognitive reappraisal of the first kind seems to be in the affirmative. Moreover, what is also interesting to note is that, during cognitive reappraisal processes, emotional regions in the brain (the amygdala and insula) may become inversely coupled to the activation of specific regions in the prefrontal cortex (Koole, 2009, p. 24). That might indicate how new emotional content can be reorganized into the concept of robots and standard conceptual scripts for people's goal-oriented behavior in blood-taking action sequences. Among other executive tasks, the prefrontal cortex is thus involved in the planning of complex cognitive behavior and decision-making.

However, on one central point it is difficult to make the identification of conceptual blending with cognitive reappraisal in the present example. Koole (2009) underlines that "reappraisal triggers *top-down control* of emotion-generating systems" (my italics, p. 24). Following from this, we must assume that, if inverse coupling of the robot concept and blood-taking frame with more pleasant emotional responses is successfully instigated in the brain (through people's repeated interaction with *Dolphin*), top-down processes will be responsible for the control of emotion regulation. But it is important to recognize that inverse coupling (and hence cognitive reappraisals) cannot be accounted for by top-down principles alone. Inverse coupling acts as an operational link between emotion regulation and emotional causation, both of which must be considered as being equally governed by *bottom-up principles*. As we have seen in the *Dolphin* case, bodily interaction, and the embodied appraisals arising from this, play a crucial role in the process of cognitive reappraisal and the establishing of an emotion regulation pattern. The idea of embodied appraisals as it is laid out by Prinz (2004) and further explained with reference to Marr (1982) is founded on a bottom-up model of the human cognitive system. Therefore, unless the concept of cognitive reappraisals is stretched so as to include the potential part played by bottom-up processes in emotion causation and regulation, I will argue that the constitutive principles underlying the reorganization of user expectations in the *Dolphin* case are better explained by the model of conceptual blending I have presented in this paper. Having said this, further parallel investigations of the basic mechanisms of both conceptual blending and cognitive reappraisal would be of much value for the understanding of the complex nature of mixed emotions.

The second comment to be made is this. Since empirical data are lacking, we cannot of course be certain as to how people are going to react in reality. Some patients might actually experience an intensification of their pain. The pleasant emotion of feeling safe and confident might thus collapse into the anxious feeling of being captured at the moment the needle is felt. This unpleasant feeling of being captured while being harmed might enhance the experience of pain. This possible scenario is important to keep in mind, because it asks the design team to consider what decisions to make in the future development of the robot.

A natural next step to take would consist in doing more empirical research on how people react *in vivo* in order to verify or falsify the interpretational hypothesis laid out here. In conducting such research, I propose that blending theory can inform the empirical research team by providing a firmly grounded theoretical model that can be used in developing the experimental design for probing the entanglement between embodied and cognitive components in the appraisal process. Moreover, to get an even more complete picture of how to control these components in mixed emotion causation, advanced scanning techniques such as FMRI and positron emission tomography present themselves as useful tools for further investigation. With the use of these techniques, recent studies in cognitive neuroscience have indicated that pain intensity can be lowered significantly by designing so-called *distraction tasks*. For instance, in an interesting experiment done by Dunckley et al. (2007), it was demonstrated that presenting subjects with different auditory frequencies through headphones while they experienced bodily-induced pain through electrical pulses had the potential to cause attentional modulation or counterbalancing of their somatic pain. Similarly, exploring different distraction tasks that could be built into the blood-taking robot might result in substantial new knowledge as to how the desirable calming effect can be achieved through manipulation of the human body and perceptual system.

In addition to distraction tasks involving sensuous stimuli, another possibility would consist in finding other regulatory means for reducing people's anxiety, for instance, interpersonal and social means of emotion regulation. Perhaps a nurse is still needed to emphasize with and distract the patient, through verbal instructions, but who is now freed from his or her former obligations of controlling the insertion instrument. In this case, the robot would still prevent a large number of work-related injuries, and would free up time and energy that could be invested in the caretaking of patients. Alternatively, relatives and other patient groups could be seen as valuable resources for creating social interaction with the patient, thereby drawing attention away from the unpleasant somatic pain. Imagine integrating *Dolphin* and *Sessio* into a unified blood-taking robot installed in a combined waiting room and ambulatory, made more accessible and open. Family members would be able to hold hands with the patient, or, patients that must regularly visit a hospital, such as diabetics and kidney patients, could share common experiences, socialize and perhaps even instruct each other while they are waiting for a blood-test (see Figure 7). In cognitive psychological research, there is a growing interest in how such means are able to influence people's regulation of their emotions (for an overview, see Koole, 2009), and the further development of the blood-taking robot could benefit from drawing on this emergent research area.

Figure 7. Social interaction as a strategy for emotion regulation.

Concluding Remarks

The contribution of this paper is twofold. First, I have sketched the outlines for an integrative theory of emotions in design. Second, my intention has been to show how this theory is useful for our understanding of mixed emotions experienced in relation to the use of technology design within the healthcare sector.

In terms of theory construction, I have argued that Fauconnier and Turner's (1998, 2002) blending theory may serve as a conceptual framework unifying somatic and appraisal theories of emotions. This of course needs to be elaborated on much further. One of the main obstacles for achieving this goal consists in finding a way of combining these two rather different approaches. As Griffiths and Scarantino (2009) point out, proponents of somatic and cognitive theories of emotions agree that, "The primary function of emotions […] is to provide the organism's decision-making systems with information about the significance of a stimulus situation" (p. 437). Their views depart, however, on what processes provide the organism with this information. Whereas neo-Jamesians like Prinz (2004) tend to see embodied appraisals as essential, cognitive theorists like Lazarus (1991) see mental evaluations and other higher-level cognitive operations as constitutive. I do not believe, though, that a clear-cut decision in favor of *either* embodied *or* cognitive appraisals is preferable, and I am also skeptical whether such a decision can even be reached. At least, we need to wait for what further insights into emotional cognition the relatively new discipline of neuroscience will bring forth. Alternatively, I therefore suggest that we keep both terms in play.

Cognitive appraisals may not be tailor-made for explaining bodily induced emotions, but the concept is important for understanding how emotions are evoked when we make mental interpretations and evaluations on the basis of visual perception, and how contextual and cultural factors may influence these meaning constructions. Embodied appraisals, on the other hand, may present difficulties in describing the cultural aspects of emotional cognition, but the concept enables us to account for how direct, physically induced emotions arise from actual usage of and bodily interaction with a design product.

But merely identifying these theoretical building blocks is certainly not enough. One must also be able to explain how they relate and integrate in the actual processes of emotional experience. The explanatory strength of blending theory concerning this issue results from its foundational assumption that human experience always unfolds as a complex interpretational process, including both higher-level cognitive operations and embodied experience. This assumption is firmly grounded in cognitive linguistic and semiotic studies on how pre-conceptual structures arising from perceptual and sensorimotor activities are tightly woven into the fabric of mental and conceptual meaning. Image schemas and their metaphorical projections onto more abstract semantic domains in thought and language are a well-documented example of this (Hampe and Grady, 2005; Lakoff and Johnson, 1980, 1999). What is less understood, however, is the way in which image schemas are embedded within affect-laden and value-laden experience (Johnson, 2007). Although I have only had the opportunity to provide scarce information on this topic here, I do hope that my case analysis has at least given an idea of how blending theory as used in design studies of product emotions may contribute cross-disciplinarily by providing central insights into this basic problem in cognitive semiotics.

The second contribution concerns the question of how blending theory can enhance our view of emotions in design. Blending theory calls our attention to the importance of product interpretation for understanding appraisal structures and the role of embodied aspects in the eliciting of product experience. Elsewhere, I have given a detailed explanation of how blending theory may account for the interweaving of aesthetic experience, emotions and mental representations involved in human interaction with responsive environments (Markussen, *in press*). In the present paper my aim has been more specifically to describe how the eliciting of mixed emotions through novel embodied interaction with technology may result in the conceptual reorganization of user expectations. On the basis of my study of a 'bloody robot,' I would like to conclude that blending theory contributes to appraisal theories with these specific offerings:

- Detailed knowledge of the interpretational labor underlying already identified cognitive appraisal types such as Novelty and Appealingness.
- The opportunity to incorporate embodied appraisals into the appraisal theoretical framework for product emotions.
- Detailed structural descriptions of the eliciting of mixed emotions from the embodied appraisal of novel experiential aspects of technology design.
- A structural model of the role that embodied interaction and mixed emotion play in conceptually reshaping user expectations.

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Appendix

Video screenshot	Title and link
	**Dolphin** URL:http://www.youtube.com/6000design#play/uploads/2/v6Aa8pPZpG0 (This video is not discussed in this study, but it explains the concept and development of the blood-sampling robotic device)