The Design of a new NICU Patient Area: Combining Design for Usability and Design for Emotion

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Abstract

In the design of medical products both usability and emotional experience are important to be considered. Usability can enhance the work situation of medical staff and ensure patient safety. Emotion related product aspects, on the other hand, influence the recovery pace of patients as well as the work satisfaction of staff. For an optimal medical design both aspects should receive well-balanced attention during the design process.

Usability and emotional experience are currently related in literature. However, about the relation between these two aspects in practical design projects little information is available. Therefore we will discuss the exploration of the practical relation between Design for Usability and Design for Emotion in a design process. We explored the relation during concurrent application of both design approaches to the design of a patient area for a Neonatal Intensive Care Unit (NICU). Our aim was not to develop a new design method, but to explore in practice how both design approaches could be addressed concurrently. This paper describes the applied design approach, its strength and weaknesses as well as the design results. Overall, the NICU design case has proven that the concurrent application of Design for Emotion and Design for Usability is feasible in practice and results in a satisfactory design.

Keywords

Usability; Design For Emotion; Medical Appliance; Participatory Design; Case Study.

Design of medical equipment is still technology driven (e.g. Melles, 2003). However slowly it is starting to upgrade from pure functional and sometimes badly usable towards a design that takes care of its usability as well as of the emotional situation of the users. Furthermore, the patients are more and more perceived as relevant "users" that have to be considered in the design process next to hospital staff.

There are prominent examples of the development towards taking care of the emotional situation of users in "medical" product design: In 2001 IDEO set an example when prescribing a "design cure" to the Missouri Hospital (Hawthorne, 2002). The proposed design concepts concerned the information management and customer service to the patient during his journey through the hospital. The resulting concept was meant to make the "product" hospital more usable as well as more pleasant for the patients.

In 2006 Philips Healthcare Company introduced the concept of "ambient experience" for their large medical appliances. This is meant to soothe and

comfort patients during stressful examinations. Ambient experience by Philips aims to take away the fear of little children, to give adults some distracting occupation and to make a frightening or annoying examination procedure more pleasant. A side effect of ambient experience is that patients can be calmed faster, the procedure takes therefore less time and becomes more efficient.

In the given examples focus is placed on the 'newer' "Design for Emotion" (DfE) approach, although "Design for Usability" (DfU) has not been disregarded. However, it still is not common to integrate both DfE and DfU concurrent in a design process. Therefore the relation between the two approaches in design practice remains vague.

We explored the possibilities to concurrently employ DfE and DfU in design practice during a case study. This study comprised the design of a Neonatal Intensive Care Unit (NICU) patient area. In the design process, design approaches regarding DfU as well as DfE have been concurrently applied to obtain a user friendly design. This case study could serve as an example for similar complex medical design problems and give insight into the practical relationship between DfE and DfU.

Design for emotion and design for usability

In literature several overlapping definitions and theories for "Design for Emotion" (DfE) (e.g. Desmet & Hekkert, 2007) and "Design for Usability"(DfU) are used. The relationship between these two design approaches has been addressed as well (e.g. Desmet & Hekkert, 2007; Tractinsky, Katz & Ikar, 2000), however, mainly in theory. In our research we will explore their relation and combination in respect to the design practice. However to provide a common frame of reference for our research we will first briefly state our definitions of DfU and of DfE and our view on their relationship in theory.

DfE stands for a designer to consciously make his design choices in order to ensure that the final product 'evokes' appropriate emotions. Therefore the designer has to anticipate how a user will emotionally react to a future product. According to Desmet (2003) there are many different, vague and personal emotions and do usually several emotions add up to one reaction. In Desmet's "Multilayered Model of Product Emotions", important factors are the way a person is involved with a product (for instance a goal) and the way somebody evaluates a product (for instance concerning legitimacy). Overall, Desmet distinguishes five different types of emotions; instrumental, surprise, aesthetic, social and interest emotions. User-product relations are often influenced by multiple types of emotions and influencing aspects do not solely lie in the product itself. Therefore part of the designer's consciousness should be that there are aspects involved in the emotional reaction of the user he has no influence on.

Usability, on the other hand, is defined in ISO 9241 as "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". Usability experts are taking into account the emotional reaction of users in the way that they look at the direct user-product interaction and how this interaction and it's result satisfy the user. Other aspects, like for instance how

the looks of a product do influence the emotions of the user, are often not considered. DfU is rooted in cognitive sciences that have a classical scientific basis. Therefore aspects of usability that are hard to "catch" by scientific methods, such as aesthetical aspects, tend to be neglected (Norman, 2002). The over-all usability of a product is often perceived as a quality that is objectively measurable whereas aesthetics are perceived to refer to a subjective experience (Tractinsky et al., 2000).

Recently in research the insight is appearing that DfE and DfU do have a close relation. The basis for this is among others laid by the results of several studies that suggest that people perceive a product as more usable when they think that the product is aesthetically attractive (e.g. Tractinsky et al., 2000). Desmet & Hekkert (2007) for instance consider usability to be a "source of product experience". They state that "usability involves goal attainment, which, in appraisal theory, is one of the main dimensions of emotion eliciting appraisal." In this definition the term "product experience" comprises a broader understanding of DfE. However usability does not only comprise perceived values of for instance efficiency or effectiveness of a product. Usability also covers the objectively measured efficiency and effectiveness of this product in relation to other products and the objective of the product. Therefore we approach the relation of DfE and DfU differently.

If we look at the ISO definition of usability the term "satisfaction" actually describes an emotional experience. This is where overlap takes place between the two approaches. This overlap indicates that DfE could be seen as an aspect of DfU. However emotions evoked by products do exceed the spectrum of satisfied to dissatisfied. Therefore the definition of usability is not broad enough to include the whole area of DfE. In our perspective, one aspect of the relationship between DfU and DfE is defined by the shared aspect regarding satisfaction.

However there is a second aspect in this relationship that needs to be considered: In Desmets (2003) multilayered model of product emotions it is stated that the specific goal a user has for using a product is relevant for his emotional response. If the user does not achieve this goal he becomes dissatisfied. The goals the user wants to achieve can vary from impressing other people to efficiently writing down notes. Usability is also about achieving goals with a product. However, impressing others is not the sort of goal that is commonly addressed in usability. Furthermore, the description of goal achievement in the DfE approach is directed at how the user perceives what he has achieved by using the product and about his subjective emotional reaction to this. An objective achievement of a goal, as in DfU theory, is not taken into account.

To our opinion, overlap exists between the two design approaches; however, one cannot be seen as a part of the other. This implies that the two design approaches need to be applied concurrently within a design process in order to address all relevant usability as well as emotional design aspects with the attention they deserve.

In this paper we will present a real-life design case in which DfU and DfE were concurrently applied. Our aim was not to develop a new design method, but to explore in practice how both design approaches could be addressed

concurrently. We will describe the applied design approach, its strength and weaknesses as well as the design results. In the next section the we will introduce the design case.

The case: Designing a patient area for the Neonatal Intensive Care Unit

The case we will employ to explore the concurrent application of DfE and DfU in practice concerns the design of a medical product for a hospital. In the design of medical products, DfU and DfE both are relevant.

When looking at usability developers of sophisticated products for hospitals are challenged by the use situations of these products. Advanced medical products are often used by multiple users with different backgrounds and goals in differing situations (Martin, Norris, Murphy & Crowe 2008). This implies that the products need to be operable for varying persons with diverse backgrounds. The usability of medical products regards staff as well as patients and visitors.

On the other hand there are many emotions involved with being treated at a hospital. Patients' emotions not only relate to what happens to their body but also relate to the products themselves. A child might be afraid of the injection syringe whereas a pregnant woman happily awaits the use of the ultrasound. Emotions elicited by products are not delimited to the patients: Hospital staff is the main user of medical products and therefore will experience emotions in relation to products use.

The design case concerns the development of a product for the Neonatal Intensive Care Unit of a hospital. A Neonatal Intensive Care Unit (NICU) houses premature babies in incubators and includes a large number of medical appliances to monitor and nurse the newborn. For every newborn there is a "patient area", a construction that includes the newborn and the appliances for this patient. In addition it supplies the necessary electrical sockets and medical gas outlets. To ensure the health and safety of the newborn, all of the appliances need to be easily visible and accessible for the medical staff. This need for accessibility, the pure amount of appliances and the lack of space too often result in an openly visible chaos of appliances, cables and tubes, garnished by blinking lights and alarm beeps. This chaos not only complicates the work of nurses and doctors, but also forms, by its technical and confusing appearance, a source of fear for the parents of the little patients.

In the market there are no solutions available that take care of the demands of the NICU. For the current NICU the existing adult ICU solutions have been scaled down to take into account the size of the incubator in comparison to a bed. This however does not respond to the situation at the NICU where the beds may be smaller but the same amount of appliances is used as at the adult ICU. Besides this lack of usability the currently used patient areas usually have a clean, cold and technical look that does not go very well with the idea of nursing tiny babies.

Due to its specific demands, the NICU is an ideal design case to explore the possibilities for concurrent application of DfU and DfE approaches.

Design approach

Since DfU and DfE both address the 'human' side of the design process, we choose to actively involve the users in the design process by incorporating participatory design techniques in our concurrent DfE/DfU design approach. The involvement of end-users is important, since particularly in medical design few designers are familiar with and can therefore anticipate the specific use situation of the product and the demands that arise from it. Neither can the emotional situation of the parents that have their child lying at the NICU be envisioned to the full extend by persons that have not experienced a similar situation. As Williams (2001) states it:

"The CCU (critical care unit) staff nurses will be the health care providers at the bedside 24 hours a day and should be actively involved in planning the layout of patient rooms and the unit in general" (p.36) and "Patients and families are wonderful sources of information and could be asked to provide suggestions/ideas on how to make the Critical Care Unit and waiting areas more functional, comfortable, and friendly" (p.36).

Users were therefore actively included in the NICU design process. From the hospital staff we included doctors, assistant doctors, nurses, cleaners and technical service employees. The patients themselves could obviously not be included in the design process actively for they have not learned to utter their opinions and ideas yet. However, the families of the newborn were included in the design process since they usually spend a lot of time next to the incubator of their child and are in great distress about the situation. In respect for their personal situation, the involvement of parents was however mainly limited to the participation in interviews and questionnaires.

In the approach for the design of the NICU patient area three design phases are distinguished: *problem inventory, concept development* and *concept evaluation and improvement*.

Phase 1: Problem inventory

The problem inventory comprised observations, interviews, surveys and literature research to gain information about the product environment and demands that must be met to allow an optimal development of the premature child. It was researched how parents and staff perceive the NICU and what the problems with today's patient areas are. Besides medical standards, aspects regarding DfE as well as DfU were studied concurrently in this phase.

To obtain insight in the usability aspects regarding the NICU, doctors and parents were interviewed and surveyed regarding today's situation on the NICU and their ideas for improvement. This was accompanied by observation of the working procedures. The literature research covered medical literature about the Neonatal Individualized Developmental Care and Assessment Program, norms, standards and advice for NICU set up (in particular (White, 2003)). Additionally current patient area solutions were investigated. The most worthy contributions to design for usability resulted from interviews, surveys and observations since most researched literature turned out to be less specific than required.

Desmet's "Multilayered Model of Product Emotions" (2003) was used to structure the research on emotional aspects. DfE aspects were inquired in interviews and surveys together with usability. It was found that parents and staff were able to contribute worthy information about their perceptions of the present NICU. Little literature was found regarding DfE approaches for medical products. Some information was found regarding how parents and especially mothers perceive their role on the NICU (e.g. Heermann, Wilson & Wilhelm, 2005). This gave a view on the feelings of the parents about the situation. Additionally, there is a body of literature on so called "healing design" (e.g. Stichler, 2001; Ulrich, 1992). Healing design implies hospital design that positively influences the recovery of patients. Healing design is connected to DfE: The surroundings influence the emotional situation of the patients in a positive way (and probably just this improvement of emotional situation contributes to the recovery).

During interviews and surveys questions on DfU and DfE related aspects were asked simultaneously. The participants were found to mostly connect and carefully weight both aspects in their considerations. In observations and literature research both areas were covered as well. However, due to the separate areas of DfU and DfE in research theory, most researched literature related to either one of the aspects. The observations, practical reports and users' advice about NICU interior design did relate to both aspects simultaneously.

Phase2: Concept development

For the concept development it was considered infeasible to address all elements of the design at once. Therefore the approach was taken to address several elements of the design sequentially. However, with respect to the design of each element the DfU and DfE approaches were as much as possible applied concurrently.

The first element regarded the placement of appliances around the incubator. A participatory approach was applied to define the most suitable placement of the appliances. Nurses were provided with a scale model, consisting of blocks that represented the different appliances, such as breathing support devices, drains, infusion pumps. Based on Brandt (2005), the level of detail of the model was chosen low to ensure that the discussion would concentrate on the appliance placement and not on other issues of the patient area. The nurses were asked to arrange the blocks in the model around the incubator in a way that would suit their working practice as well as safety. They were also asked to take care of the positions of tubes and electrical cords to prevent intertwining of them. After several times rearranging the blocks the nurses were able to find a solution everybody participating could agree with.

The second element concerned the construction of the physical patient area around the appliances. To obtain insight in the exact consequences the patient area construction had for the working area as well as the visitors' area, a second participatory technique was applied: Concept dimensions were assessed directly by indicating them by means of tape on the ground around the incubator within the current NICU. Nurses depicted to operate appliances and parents were asked to sit in chairs next to the incubator. By this means iterative improvements could be made and evaluated.

The applied approach seems to relate to usability only at first sight. However when considering the research results it becomes clear that the aspects do as well refer to DfE. One example is that social and aesthetic emotions were concerned: In the interviews parents and staff stated that they wished the patient area to look orderly. By arranging appliances in a way that prevents "cable chaos" around the incubator this need could be addressed. In similar ways the appliance arrangement affects other emotions.

Other elements of concept development, such as materialisation and product aesthetics were addressed directly by the designer. Based on the problem inventory phase and the participatory design of the placement of the appliances and the construction of the physical patient area, the designer developed three concept designs. In this process, the designer explicitly weighted the design decisions concurrently against the requirements from the perspective of both DfU and DfE. During the development concepts or changes were discussed with users to gain feedback for improvement on both aspects iteratively.

Phase 3: Concept evaluation and improvement

The last phase in the design approach comprised the concept evaluation and improvement. For an optimal evaluation with regard to both emotional and usability aspects, it is essential that users can actually experience the design. Users should preferably be able to have a real-life interaction with the design in the actual use situation. However, for both safety and efficiency reasons it was not feasible to test several concept prototypes in the NICU. Therefore, it was chosen to conduct a participatory session in a mixed reality setting: In an evaluation session hospital staff engaged with virtual representations of the candidate designs and judged them on usability as well as on emotional impact.

The session started with the presentation of all three concepts. The concepts were presented on a screen as pictures and in three similar animations. Afterwards, rendered pictures of the designs were projected life-size on a concave screen. All three concepts showed the same colour and material qualities to prevent a choice solely based on the styling of the product. A simple table was placed in front of the projection, representing the incubator. On the table there was placed a baby dummy fitted with medical material. Figures 1 and 2 illustrate the used set-up. Participants, consisting of nurses and doctors were asked to play out nursing scenarios within the set-up. This approach enabled the users to immerse into the use situation and assess the spatial arrangement, dimensions and aesthetics of the candidate designs far more accurately compared to being presented by pictures only.

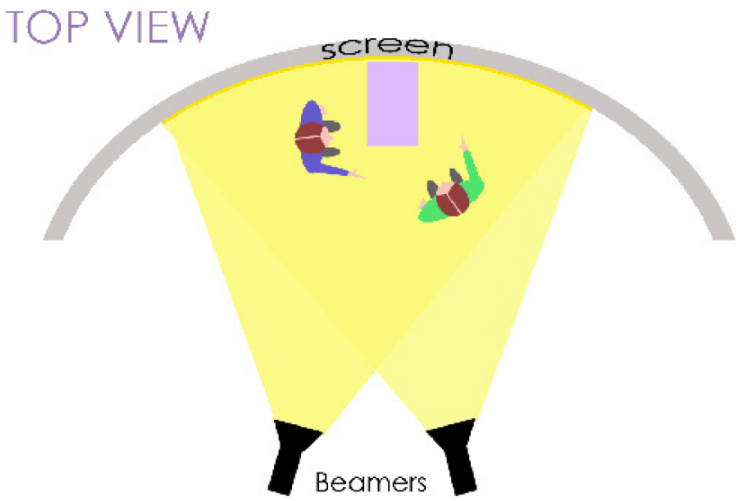

Fig. 1. Top view of mixed reality set up

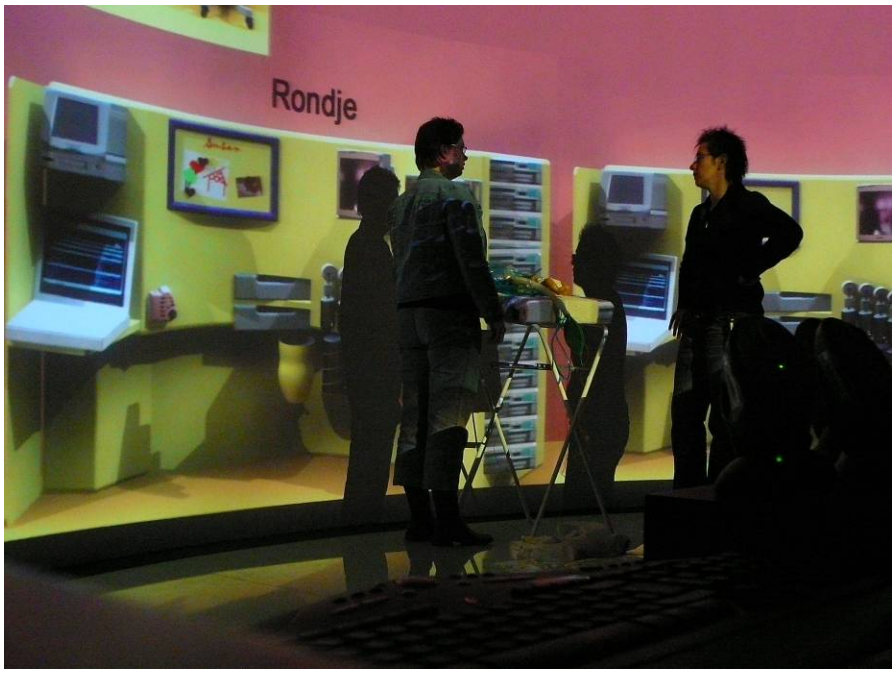

Fig. 2. Mixed reality set up

The participants felt stimulated and enabled to contribute to the evaluation process. In the beginning every participant had taken seat in the audience area and single persons needed to be invited to play out a scenario. However after a short time everybody had left his or her seat and entered the scene to participate in the discussion or point out elements on the screen.

The participants started with making a first concept choice based on how they estimated the emotional impact of the concepts. Herein a half round format of the patient area was preferred for it was perceived as very cosy. However, after playing out the nursing scenarios, the participants concluded that this concept was not optimal with respect to aspects like accessibility of the appliances in general and the placement of often used or crucial

appliances. Therefore finally another proposed concept was unanimously chosen. This process showed that the invited users prioritized accessibility of appliances above cosiness.

In a second step, the users were invited to suggest improvements for the chosen concept. In this step, all participants were sitting around a screen with a frontal view of the patient area. Every participant had a laptop with sketching tablet in front of him or her and was able to sketch his or her ideas on the picture. On a central screen these drawing activities were visible for the whole group. The drawing devices and the screen worked as a communication tool that simplified the discussion about proposals since a new proposal could be made visible to everybody instantly. Hereby, the possibilities for misunderstanding that might occur in a verbal discussion were minimized: everybody had the same reference.

In these sessions participants were able to evaluate concepts on both DfE and DfU aspects. Concerning DfE the aesthetic qualities of the patient areas were assessed; the general geometric forms were rated. Participants furthermore evaluated goal achievement, amongst others the accessibility of appliances. The perceived achievement of this goal concerned DfE but accessibility is also an element of usability. By asking the users to play out scenes within the representations of the patient area the designer could rate the efficiency of the concepts in an objective, usability focused way.

Resulting design

Based on the problem inventory, the vision formulated regarding the new patient area was that it should add in the best possible way to nursing premature children conform to their medical situation. Ergonomic aspects, physical- and cognitive interaction aspects and safety aspects should be taken into account to make a safe and appropriate treatment of the patients possible.

For the parents and medical staff the patient area should evoke a feeling of safety. Parents should be able to feel at home next to the incubator en be given the freedom to create a space of privacy during their visits. They should be convinced that their child is taken care of in a well arranged and protective environment. A patient area must not only contribute to a calm appearance of the patient area itself but of the whole NICU. Medical staff should be supported to be able to monitor and nurse the baby as good as possible. Their work also needed to become more comfortable with respect to the ergonomic standards.

The delineated design approach has resulted in the new NICU patient area the "Family Shell". Figure 3 shows a picture of the realized prototype of the Family Shell.

Fig. 3. Family Shell prototype

In the new design the child is placed central and the appliances have been pushed to the background. Family Shell provides the parents with some privacy in the patient area. Parents indicated that they wished they had more power to change the situation . Although this is hard to realize through design, an attempt is made by providing them a way to individualize the patient area.

To create a similar appearance to home the aesthetics that are usually employed in baby products soft colours and rounded forms were applied. The design of the patient area supports an impression of hygiene by order and light coloured surfaces.

The appliances have been placed on a concave designed and therefore easily accessible workstation. The most frequently used and most vital appliances are placed at the left side of the incubator and can be handled by the user standing in front of the workstation. All outlets are placed next to the appliances that are connected to them. The appliances are positioned in the field of vision of the user and this is done in a way that minimizes the distances wires and tubes have to span. By this means the medical staff has a good overview of the situation, which benefits safety and a pleasant working environment.

The resulting design was perceived as attractive and feasible by the hospital and a working prototype of the patient area has been commissioned to test the product in the real working environment.

Evaluation of design approach

First and foremost, the NICU design case has proven that the concurrent application of DfU and DfE is feasible in practice. The design approach has resulted in a design that is embraced by its stakeholders. Stakeholders

indicated that the design articulates the concurrent design approach it resulted from; it is assessed as a unique, refreshing design that meets high standards with regard to both usability and emotional aspects.

However, some strengths and weaknesses can be identified regarding the applied design approach. It was found to be laborious to keep an overview of all relevant design aspects at once. At several points in the design process, a trade-off needed to be made between usability and emotional aspects. Decisions were forced to be made regarding the priority of each design aspect. Although sometimes difficult, these decisions ensured that usability and emotional aspect received equal attention and no aspect was overlooked.

The used design approach revealed to be time consuming and required the participation of busy hospital staff. Yet the approach has been applied to an expensive, very complex product that needs to fulfil many and sometimes opposing needs. From this perspective, most of the used techniques were quite efficient. Especially the concept evaluation session allowed for a solid choice and improvement of a concept with respect to usability as well as emotion related aspects within a time-frame of only three hours.

The participation of end-users in the design process was perceived as very valuable, since only they can truly indicate the requirements regarding both usability and emotional aspects. Furthermore, in the design of these kind of medical appliances designers often lack the knowledge and experience to reliably evaluate concept designs regarding these requirements. User participation during concept evaluation also provided the designer direct insight in how the users weighted usability and emotional aspects against each other. User participation in the concept generation phase was only realised with respect to limited elements of the design. Although more intensive participation in this phase could have benefited the design, the authors stress that the input of the designer in the solution generation and the integration of design elements was found to be essential. Furthermore, the designer should be aware not to get overwhelmed by the enthusiasm of the participants for a certain design. The designer has to keep a critical, reflecting role and ensure that the participants assess the design regarding all relevant aspects.

Discussion

In the past both DfU and DfE approaches have been applied to design processes. However, if simultaneously applied, usually one of the aspects is considered as leading, whereas the other is only addressed in the final design stages and is basically the balancing item. The concurrent application of DfU and DfE approaches as applied in the described design case ensures a well balance between both design aspects in the design process. This approach is expected to be more efficient and to result in less need for design modifications in the later (i.e. more expensive) design stages.

However, some solutions to either DfE or DfU aspects could only be found with different user groups or by the use of different techniques. For example, the parents were not able to identify the best workable appliance placement. On the other hand the nurses could not tell us how parents perceive their privacy

on the NICU and how they would like the privacy situation to be. The first, usability related aspect could only be found by participatory techniques whereas the second, more emotion related aspect could only be explored in interviews.

Furthermore, the approach also has the risk to result in a more limited range of usability as well as emotional aspects to be considered in the design process. DfU is easily reduced to considering ergonomic aspects alone, whereas aesthetics may become the main focus from DfE perspective. Designers should be consciously aware of this pitfall and actively avoid it.

On the other hand, the design case illustrated that for several design aspects the goals from DfU and DfE coincide to such level that the designer is no longer aware of designing from two different perspectives. If for instance cable chaos behind the incubator is avoided this serves both aspects: The patient area looks more orderly and therefore evokes better emotions on the social emotion field. At the same moment this improvement serves usability because medical staff can easily exchange tubes.

Conclusion

For an optimal medical design, usability and emotional design aspects should receive well-balanced attention during the design process. In this paper the possibilities for the concurrent application of Design for Emotion and Design for Usability have been explored in practice. For this purpose the design of a NICU patient area was selected. The design case has proven that the concurrent application of Design for Emotion and Design for Usability is feasible in practice. Keeping a well-balanced eye on both aspects throughout the whole design process was perceived as challenging, yet rewarding. The resulting design is assessed by its stakeholders as a unique, refreshing design that meets high standards with regard to both usability and emotional aspects. It is envisioned that the concurrent application of Design for Emotion and Design for Usability in the early phases of product design will reduce the number of needed design revisions and therefore improve process efficiency. Users revealed to be well able to provide valuable and well-balanced input regarding both usability and emotional design aspects. Active user participation is therefore advised in future cases of concurrent application of Design for Emotion and Design for Usability.

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