A Wheelchair can be Fun: A Case of Emotion-driven Design

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ABSTRACT
In this paper an approach to emotion-driven design is introduced and demonstrated with a children's wheelchair design case. First, emotional responses towards existing wheelchairs have been assessed with a non-verbal self-report instrument. The results of this assessment were transformed to starting points for a new design with the use of a theoretical model of product emotions. With these starting points a new design was created and detailed into a working prototype. In a second study, the emotional impact of the new design was evaluated. It was found that, with respect to the emotional impact, this new design differentiates in a positive way from existing models. In the light of these findings, it is discussed how theoretical and empirical knowledge can assist designers in their attempts to manipulate the emotional impact of their designs.

Categories and Subject Descriptors
A.m Miscellaneous

General Terms
Design

Keywords
Emotion-driven design, non-verbal measurement, wheelchair.

1. INTRODUCTION
The belief that the emotions of product users are best taken serious appears to gain general acceptance in the field of design research (see e.g. [6]). Likewise, most designers will probably agree that it is advisable to design products that elicit emotions that are experienced as pleasant or desirable. The difficulty of such so-called 'emotion-driven design' however, is that it is difficult to manipulate or even predict the emotional impact of a design. The reason is that emotions are essentially personal and that people differ with respect to their emotional responses towards a given product. It therefore seems to be difficult to find relationships between design features and emotional responses that can be of use in the creative design process. Nevertheless, recent research has resulted in knowledge and tools that may be of use to facilitate emotion-driven design. One of these tools is the Product Emotion Measurement Instrument (PrEmo), an instrument that was developed to measure specifically emotions evoked by product design [2]. PrEmo has been used, for example, to assess emotional responses to automotive design [2] and chairs [1]. Although in these cases PrEmo was used as a tool for evaluation, some experimental design workshops indicated that it can also be used as a design tool [1]. In these workshops PrEmo was used to measure responses towards existing products. The resulting 'emotion profiles' served as a starting point for new designs. On the basis of experiences drawn from these workshops it was suggested that insights in the emotional impact of existing products can be used by designers to manipulate the emotional impact of new designs [1]. In this paper, this proposition is explored with the use of an actual design project in which the second author designed a hand-driven wheelchair for children aged 7 to 12.

2. WHEELCHAIRS FOR CHILDREN
Wheelchairs are good examples of products that, to some degree, have an unpleasant emotional impact. For some reason, the emotional impact is generally not taken into account in the design of these products. Instead, they are designed on the basis of demands predominantly related to ergonomics (e.g., the seat must be adjustable to different body sizes), usability (e.g., the chair must be foldable for transport), and technology (e.g., the design should match the production facilities of the producer). As a result, children's wheelchairs look like 'scaled down' adult wheelchairs with similar framework and functional characteristics, available in a colour range that is adjusted to children (see Figure 2).

A wheelchair should allow the users to be and thus to behave like children. This implies that it should help children to explore and to partake in social play. It therefore should enable the user to overcome obstacles that they will be confronted with in the daily

surroundings (e.g. fields of grass, snow, thresholds, soggy terrains, etcetera). In addition, the designer envisioned it to be important that the wheelchair does not only enable but also express this kind of behaviour. Hence, instead of looking like a (stigmatising) rehabilitation aid, she wanted to design a chair that has the expression of a playful outdoor transportation facilitator that encourages children to go out and explore. Examples of products with a typical outdoor perception are visualised in Figure 1.

Figure 1. Outdoor transportation

The main challenge of the designer was to develop a wheelchair that has a positive emotional impact. It was decided that not only the emotions of the children, but also those of the parents had to be taken into account because these parents can be considered secondary users (e.g. they are responsible for cleaning, handling, folding, and transporting the wheelchair). The approach to this design challenge comprised four main steps:

Step 1. In the first step, the emotional impact of conventional models was examined. The aim of this step was to gain insight in what pleasant and unpleasant emotions are generally evoked by wheelchairs.
Step 2. Whereas in the first step it was examined *what* emotions are evoked, the aim of the second step was to get an understanding of *why* these emotions are evoked. This question was answered by combining theoretical insights with information drawn from discussions with the children and their parents.
Step 3. The third step was the actual design step. In this step the insights gained in the first and second step were used to design a new model.
Step 4. In the final step, the emotional impact of the new model was evaluated by comparing the emotions evoked by this model to those evoked by conventional models.

Step 1: Emotional Impact of Wheelchairs

In an explorative study, the emotional responses towards conventional wheelchairs of both children and their parents have been assessed. In this study eight children (five boys and three girls; age varied between 7 and 12 years old) and their parents participated. The stimuli in this study were six models (with similar functional characteristics and different appearance) that have been selected to represent a cross-section of wheelchairs that were available at the time of the study (Figure 2).

Each model was photographed against a white background and with a similar camera position. Participants were instructed to use PrEmo to report their emotional responses to each of these six models.

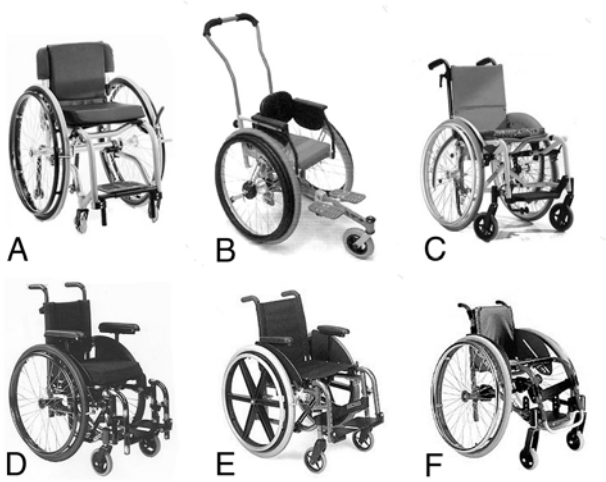


Figure 2. Six stimuli used in Study 1

Product Emotion Measurement Instrument

PrEmo, a non-verbal self-report instrument, measures 14 emotions that are often elicited by product design [2]. This instrument was developed because existing (verbal and nonverbal) instruments are not able to measure the subtle non-basic emotions that typically evoked by product design [1]. Of the 14 measured emotions, seven are pleasant (i.e. *desire, pleasant surprise, inspiration, amusement, admiration, satisfaction,* and *fascination*), and seven are unpleasant (i.e., *indignation, contempt, disgust, unpleasant surprise, dissatisfaction, disappointment,* and *boredom*). Instead of relying on words, respondents can report their emotions with the use of expressive animations. Each of the 14 measured emotions is portrayed with an animated cartoon manikin by means of dynamic facial, bodily, and vocal expression, and presented on a computer interface. Participants can report their responses by selecting those animations that correspond with their felt emotion(s). Figure 3 shows three examples of emotions expressed by the PrEmo manikin.

Figure 3. Four PrEmo animation stills (fascination, satisfaction, disgust, and contempt)

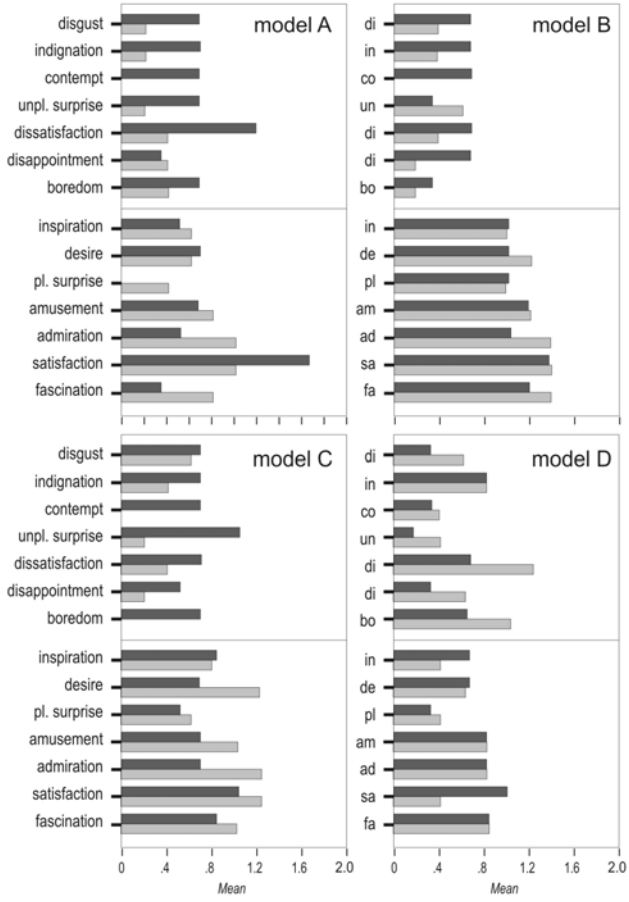
The interface of PrEmo depicts stills of the 14 animations. A (hidden) three-point scale accompanies each still. These scales represent the following ratings: “I do feel the emotion,” “to some extent I feel the emotion,” “and “I do not feel the emotion expressed by this animation.” During an experiment, the respondents are first shown a (picture of a) product and

subsequently instructed to use the animations to report their emotion(s) evoked by the product. While they view an animation, they must ask themselves the following question: "does this animation express what I feel?" Subsequently, they use the three-point scale to answer this question. Visual feedback of the scorings is provided by the background color of the animation frame.

The study was conducted at a youth centre for disabled children. Each respondent participated individually. Only after the study was completed the children were allowed to discuss their reports with their parents. The order in which the stimuli were presented was randomised over respondents.

Results

The bars in Figure 4 visualise the mean scores for all stimuli. The figure indicates that the wheelchairs evoke differ with respect to the emotions they evoke. Model E appears to evoke mainly unpleasant emotions (e.g. *disappointment* and *boredom*). Contrasting, model B and F evoke mainly pleasant emotions (e.g. *inspiration* and *admiration*). The remaining three models appear to evoke 'mixed emotions.' Model C for example, evokes both *satisfaction* and *unpleasant surprise*, and model D evokes *fascination* and *dissatisfaction*.



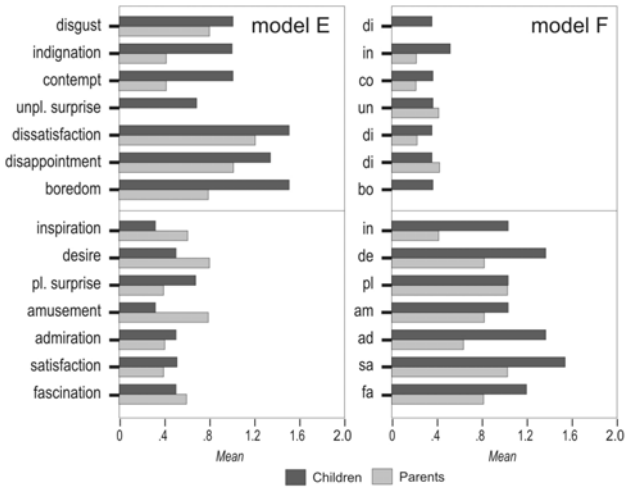


Figure 4. Emotional Responses to six Wheelchairs

A second result that catches the eye is that there are considerable differences between the responses of the children and their parents. For example, towards model E, the children feel much more *contempt* than their parents, whereas the parents feel more *admiration* than their children.

2.2 Step 2: Understand the eliciting conditions

What is the point of measuring emotions evoked by products? More interesting than to discover which particular emotions are evoked by a set of stimuli, is to understand *why* those stimuli evoke these particular emotions. Hence, the interpretation of PrEmo results requires theoretical propositions about how product emotions are related to the product's appearance and interaction, and the characteristics of the person who experiences the emotions. In this project these propositions were drawn from the 'model of product emotions' reported by Desmet and Hekkert [3].

A product will only elicit an emotion if it either matches or mismatches a concern. When a product is appraised to mismatch (one of our) concerns, it evokes an unpleasant emotion, when it matches a pleasant. The interplay between the concerns of the users and the product features determines which particular emotion is evoked. Often, products evoke 'mixed emotions,' that is more than one emotion simultaneously, because they are appraised as relevant for more than one concern. A particular watch, for example, may evoke *attraction* because of its colour (attitude: "I like blue"), *dissatisfaction* because of the weight (standard: "watches should be light"), and *admiration* because of its sophisticated mechanism (standard: "designers should be innovative").

Cognitive theories of emotion propose that each particular emotion is related to a particular type of underlying concern (see [8]). The eliciting conditions of *admiration* for example, always involve a 'social standard,' that is, a standard of behaviour [7]. For the model of product emotions these theories have been used to distinguish the underlying concern types of all PrEmo emotions. In the second step, these insights in the relationship between emotions and their underlying concerns were used to disentangle the relationship between wheelchair design and the emotional responses found in the first step. In this step both the children and their parents were interviewed in which they were

invited to explain and elaborate on their responses towards the models in Study 1.

With the use of these discussions it was possible to explain the mixed emotions evoked by the wheelchairs in terms of the underlying concerns. It was found, for example, that model A evokes *satisfaction* because it matches the concern "I want a wheelchair that is fast and sportive" (given the low seat and small skate front wheels). The fact that the same model also evoked *dissatisfaction* was caused by a mismatch with the concern "I like a wheelchair that is cheerful" (because the frame and seating are coloured grey). Also differences between the responses of the children and their parents can be explained in terms of underlying concerns. For example, the children experience *contempt* towards model C because it mismatches the concern "I want a wheelchair that makes me look independent" (given of the expressly visible push-handles) whereas their parents are *satisfied* with the wheelchair because the same handles match their concern "I want a wheelchair that enables comfortable pushing." Table 1 summarizes the concerns of both the children and the parents that were distilled from the discussions and conversations.

Table 1. Concerns of the children and their parents

Concern type	Children	Parents
Standards: wheelchairs should	- not be childish - be comfortable	- not be stigmatising - enable sport activities
Attitudes: I like wheelchairs that look	- cheerful - colourful	- stylish - clear and simple
Goals: I want a wheelchair	- that is not prototypical - that is fast and sportive - that make me look independent - that can be driven without hindrance	- to be light and manoeuvrable - to be tough - that facilitates comfortable pushing - to be able to easily pass obstructions - that can be transported easily

It is interesting to see that contradicting emotional responses are not necessarily caused by contradicting concerns. An example is model D. Children are *satisfied* whereas parents are *dissatisfied* by this model. The interviews revealed that both emotions are caused by the design of the seat. The children are *satisfied* because the big robust seat looks comfortable (concern: wheelchairs should be comfortable) and the parents are *dissatisfied* because the big seat looks 'handicapped' (concern: wheelchairs should not be stigmatising). Ergo, it is not the seat as such but the meanings attached to it that evokes contrasting emotions. This implies that it is not impossible to create a seat that is satisfying for both the children and their parents, as long as it is seen by the children as comfortable and by the parents as not-stigmatizing.

2.3 Step 3: the Design Challenge

The challenge was to design a wheelchair that corresponds with both the concerns of the children and those of their parents. If so, the wheelchair is expected to have a pleasant emotional impact on both the children and their parents. Some of the concerns that were found in the second step relate to functional qualities of the chair (e.g. "I want a wheelchair that is easy to transport") whereas others relate to the expressive qualities (e.g. "a wheelchair should not be childish"). In the design process, the designer explored both these functional and expressive qualities. The exploration of the functional qualities resulted in a functional concept, which is shown in Figure 6.

The concept is a highly maneuverable wheelchair with three wheels and optimal indoor and outdoor driving characteristics. Important features are the simple and rigid frame, the spring-balanced anti-tip wheels (for additional maneuverability when tipped backwards) and the (big) single front wheel (to simplify passing over small obstacles and difficult surfaces).

The expressive qualities were explored with collages and sketches. Establishing an outdoor perception was taken as a starting point for the exterior design of the wheelchair. Figure 5 shows a detail of one of a series of four collages that was created to visualise an outdoor expression that was envisioned to fit the expressive concerns of both the Children and their parents. This has resulted in a wheelchair with the appearance of a BMX-bicycle, since both usage and appearance of this product fit the description.

Figure 5. Expressive Collage

The final design (see Figure 6) is the outcome of a series of sketches in which the visual language of the collages was applied to the functional concept. Apart from looking tough and sportive, the BMX bicycle encourages children to challenge themselves by exploring the surroundings or their own limits by performing stunts. This kind of tough and active usage is desired because it matches the concerns. The exterior of the wheelchair clearly expresses that it enables this kind of usage. The robust structure, large tube diameter and treaded tires of the wheelchair indicate that it can resist tough handling. The 'bumper' that is located above the front wheel indicates that bumping is permitted. When up, the pushing bar enables comfortable pushing. If it is not in use, it can be temporarily pushed downward, where it appears to be part of the backrest frame. In this manner, both the children's concern (coming across independently) and the parents concern (pushing comfortably) are met.

Realistic renderings and a working prototype were created for the final step of the project in which the emotional impact of this model was evaluated with a second PrEmo study.

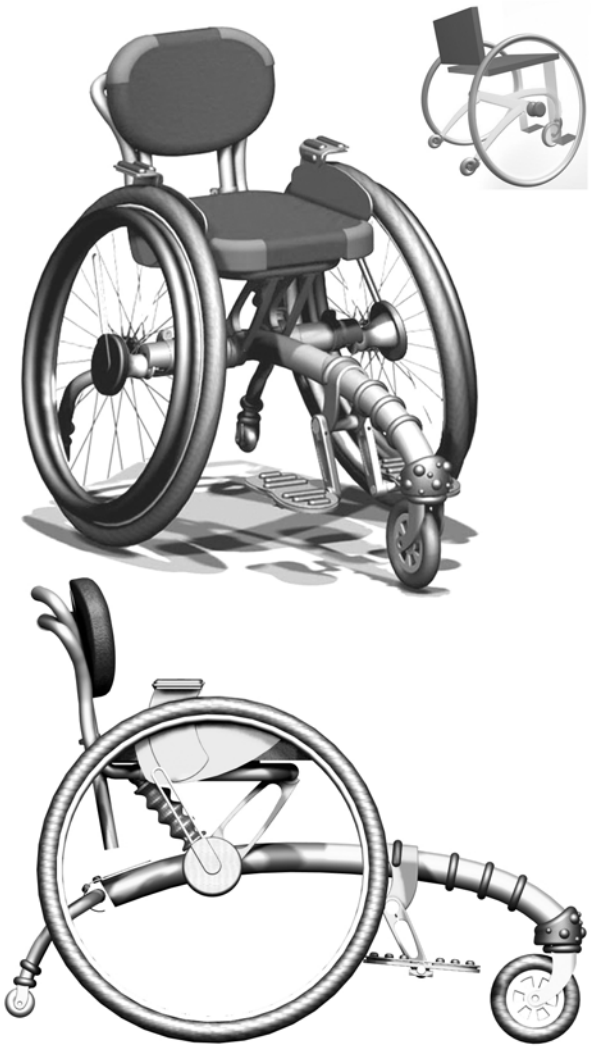


Figure 6. Functional Concept and Final Design

2.4 Step 4: Evaluation

A second study (Study 2) was conducted to evaluate the emotional impact of the new design. Similar to Study 1, eight children and their parents used PrEmo to report their responses to six wheelchairs. None of the respondents had participated in Study 1. Of the six stimuli, one was the new model, and the other five were model A, B, C, D, and F that were used in Study 1. The picture of the new model was made against a white background and with the same camera position as those of the other stimuli. In the instruction, participants were suggested that each of the six models is currently available.

Figure 7 shows the results of this study. The bars represent the mean responses of both the children and their parents. The figure clearly indicates that the emotions evoked by the designed model differ from those evoked by the other wheelchairs (see Figure 4). The new model evokes extraordinary high levels of *inspiration, satisfaction, and fascination.*

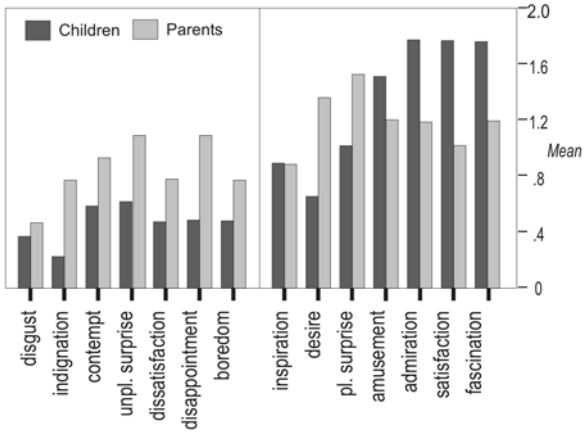


Figure 7. Emotions Evoked by the Wheelchair Design

Note that the parents experience more mixed emotions than the children. Besides pleasant emotions, they experience also unpleasant emotions, such as *disappointment* and *unpleasant surprise*. When these results were discussed with the parents, it appeared that they experience these unpleasant emotions because the new model is 'too modern' or 'too uncommon.' Although this matched their concern that a wheelchair should not be stigmatizing, it appeared to mismatch another concern: "a wheelchair should not make my child conspicuous." In other words, the wheelchair was seen too special to let the child blend into the crowd.

3. DISCUSSION

It should be noted that the studies conducted in this project assessed the emotional impact of the wheelchairs at one given moment in time. In the evaluation study only the first response to the new design was measured. It is therefore not said that the parents will also react *unpleasantly surprised* once they have become familiar with the model. A second limitation of both the first and the second study is that only the responses evoked by the *appearance* of the wheelchairs were measured. The experience of actually using the wheelchair was not taken into account. Naturally, the emotional impact of using the wheelchair is as least as important as the impact of the appearance. The designer of the new wheelchair explicitly did not only focus on merely the appearance but on the total wheelchair concept. For example, the use of spring balanced back-wheels creates new usage possibilities. To have some feedback on the emotional experience of these new possibilities, some children have been invited to use the prototype in an outdoor setting. These children reported to be very excited about the new usage possibilities. Given the PrEmo results combined with these findings it was concluded that the new design was successful in having a more pleasant emotional impact than the conventional wheelchairs for children.

4. GENERAL DISCUSSION

Various methods have been developed over the years to incorporate user experience in the design process, varying from cultural probes [9] to more generative tools encompassing high user involvement such as ethnographic fieldwork [10] and participatory design techniques [11]. These are examples of methods that have been designed to increase the designer's

understanding of the users' needs, aspirations and abilities. Other approaches are used to stimulate and inspire designers to create designs that allow for rich or engaging experiences. An example is 'vision in product design' that forces designers to free themselves from restrictions or requirements and, instead, look for desirable possibilities [12]. The approach reported in this paper differs from those approaches in that it specifically focuses on the emotional impact of design instead of on the general subjective experience, and that it was developed on the basis of contemporary general theories of emotion.

Naturally, there is a difference between understanding how products evoke emotions, and actually being able to manipulate the emotional impact of a design. However, this paper illustrates that emotion-driven design can benefit from theories of emotion because these theories can offer designers handles for discussing the emotional impact of design characteristics with the intended user. The approach can be applied to any kind of design problem. In our own research we have experimented with the design of mobile telephones [4], and are currently experimenting with solutions to support the mental comfort of patients during medical treatments.

In the current project, the concern profiles have been formulated on the basis of a study of emotional responses to existing wheelchairs. It would have been interesting to include not only wheelchairs but also other products, such as products that are used in a similar context or products that are designed to have a similar expression (e.g. BMX bikes and snowboards). One can compare the responses to these other products with those evoked by the actual wheelchairs. This approach can help designers in their efforts to understand the concern profile of the users. Another opportunity would be to include also non-users in the study (i.e. children that do not use wheelchairs). This can give insight on stigmatizing aspects of wheelchairs.

One may argue that it is not sensible to use an analysis of existing products as the starting point for new designs. The solution space defined by existing products might repress rather than inspire and stimulate the designer to create innovative and fitting solutions. The design project presented in this paper illustrates that this does not have to be the case. It is important to realise however that, in the proposed approach, the existing products have not been examined *as such* but used as a vehicle for studying the concerns of the users with respect to these products. And understanding the user, particularly at this abstract level, can help the designer to design a product that 'feels good,' both on a conceptual and on an expressive level.

In other words, the proposed approach enables designers to understand the consumer and at the same time surpass the direct wishes of the users and therefore to create something that both befits the users' wishes and at the same time is new and stimulating for them.

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