Enjoyable Pressure Cooker: Redesigning Physical Form of Products Based on Product Emotions and Usability Criteria

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Abstract. Physical form and appearance of products are essential and they serve as visceral stimuli for consumers in considering and making a decision to purchase the products. Attractive product design, therefore, is required to elicit positive emotional responses from the consumers. Usability is another critical factor that helps users to use a product easily, and thus enhances their satisfaction. This research focuses on redesigning the physical form of everyday products based on product emotions and usability criteria. Two electric pressure cookers with different brands, but had similar characteristics, were used as the object of study. Emotional responses from thirty participants to these products were measured using *Product Emotions Measurement Instrument* (PrEmo). Interviews were then conducted to clarify their responses. Following this, usability testing involving eight participants was conducted. Each participant was asked to perform eight predetermined tasks and to fill out a questionnaire for assessing usability aspects of the tested products. The procedures resulted in the scores of pleasant and unpleasant emotions, participants' concerns about the products, mean completion time of the given tasks, success rate of the tasks, and scores of usability aspects. These results were used as a basis for redesigning the pressure cookers through modifying their form, appearance, colors, layout of control panel and buttons, symbols on buttons, and information labels. Two new designs were represented in the form of rendered 3D images. Product emotions measurement and usability testing were reused to evaluate the redesigned pressure cookers. The redesigned products showed increased positive emotional responses and improved usability.

Keywords: product emotions, usability, product design, affective design, interaction design

1. INTRODUCTION

Today's business environment is characterized by the increasing number of different companies offering products that have similar technology and functionality. This condition creates strong competition and great challenges for the companies to win the market. To survive, they are demanded to recognize their consumers' needs and to identify factors that influence consumers' decision to purchase a product.

The similarity among many products in terms of their characteristics, technology, quality, and even price, makes the experiential or emotional quality of these products to become more and more essential for enhancing their differential advantage in the market. Users' emotional reactions to a product can often be a decisive factor in a purchasing decision (Desmet 2003). One of the reasons is consumers tend to select a product that is able to fulfill their needs and, at the same time, is emotionally attractive to them. Zhang and Li (2005) argue that affective quality positively impacts on users' cognitive evaluations of a product, which, in turn, can influence their behavioral intention to buy and use it. Furthermore, the importance of understanding and fulfilling user emotional needs in product design has been related to the success of a product in the marketplace (Khalid 2006, Khalid and Helander 2006).

Another critical factor that determines a product's acceptance to the users is its usability, which provides ease of learn and use, satisfaction of use, as well as functionality and utility that are highly valued by the users (Rubin and Chisnell 2008). Criteria that are commonly used to measure usability include efficiency (e.g. completion time on task, mental workload), effectiveness (e.g. task completion, output quality), satisfaction (quantitative and qualitative attitudes), usefulness, memorability, and learnability (ISO 9241-11 1998, Jordan 1998, Nielsen 2012, Rubin and Chisnell 2008).

Users' emotional responses and usability measures can thus be used as a basis for designing and redesigning products. In this research, these emotional and usability criteria are applied to evaluate and to redesign electric pressure cookers. This product category is considered to represent everyday products that comprise similar basic functions and features from one brand to another.

2. PRODUCT EMOTIONS

Product emotions are referred to as a set of emotions that are evoked by product design. A basic model of product emotions, as developed by Desmet (2003), consists of four main components: product, concern, appraisal, and emotion (Figure 1). According to this model, all emotional reactions are consequences of a process of appraisal in which a person perceives a product as favoring or conflicting one or more of his/her concerns (Desmet 2003). Further, in the product emotions concept, products can act as stimuli in three different forms: products as objects, products as agents, and products as events. These three forms of stimuli address three corresponding concerns: attitudes, standards, and goals (Desmet and Hekkert 2002).

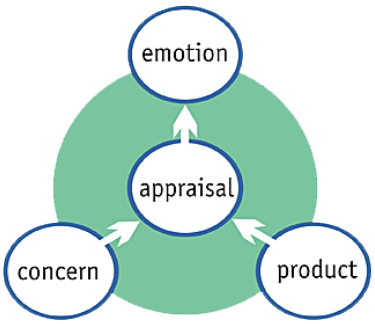

Figure 1: Basic model of product emotions (Desmet 2003)

Desmet (2003) has developed PrEmo (Product Emotion Measurement Instrument) to measure users' emotional responses to a product. PrEmo is a non-verbal self-report tool that assesses fourteen emotions that are commonly elicited by product design. These emotions are categorized into seven pleasant emotions: desire, pleasant surprise, inspiration, amusement, admiration, satisfaction, and fascination; and seven unpleasant emotions: indignation, contempt, disgust, unpleasant surprise, dissatisfaction, disappointment, and boredom (Desmet and Dijkhuis 2003). Each emotion is represented by an expressive cartoon and a three-point scale that is used for determining the level of that particular emotion (Figure 2). The expressive cartoons and the corresponding emotion scale help respondents to report their felt emotions more easily, because they do not have to express their feelings verbally. PrEmo has been validated through the cross-cultural tests of the cartoons and through the comparative analysis between PrEmo and a verbal instrument in measuring product emotions (Desmet 2003).

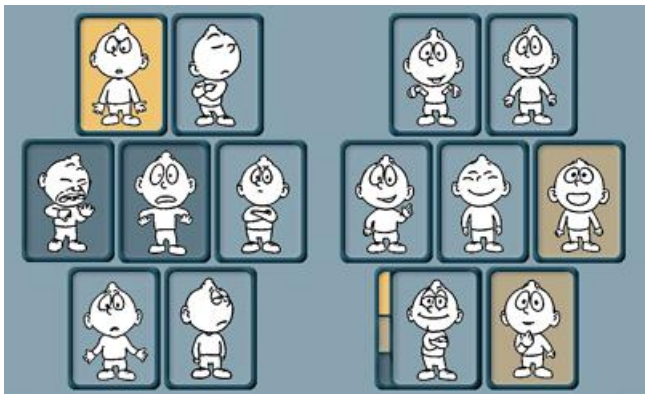

Figure 2: Expressive cartoons representing fourteen emotions in PrEmo (Desmet 2003)

3. USABILITY

Usability, as Rubin and Chisnell (2008) put it, is product characteristics by which users can use the product according to their way and expectation to achieve certain goals without difficulty, hesitation, or questions. International Organization for Standardization defines usability as "the 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" (ISO 9241-11 1998).

Usability has been widely used as a criterion of the goodness of a product or system design. Its attributes include usefulness, efficiency, effectiveness, learnability, satisfaction, accessibility, flexibility, and guessability (Jordan 1998, Nielsen 2012, Rubin and Chisnell 2008).

Usability testing is a method that is used to evaluate a product or system. The test employs participants who represent the target population to assess the degree to which a product or system meets specific usability criteria (Dumas and Redish 1999, Rubin and Chisnell 2008). The types of usability testing are exploratory or formative study, assessment or summative test, validation or verification test, and comparison test (Rubin and Chisnell 2008). The overall goal of usability testing is to identify and rectify usability problems in product or system design prior to release.

4. METHODS AND RESULTS

In this research, product emotions measurement and usability testing were conducted to two samples of electric pressure cookers: Joruzhi 133PL and Sico-Hamada 326E

(Figure 3). These two product samples are different in brands, but similar in their functions, features, technology, and price.

4.1 Product Emotion Measurement

The two product samples were used as stimuli to elicit participants' emotional reactions. Thirty participants (22 females, 8 males) were recruited using purposive sampling technique. Two screening criteria were used: participants are actual users of electric pressure cooker (i.e. they are familiar with the product and have experiences in using the product) and they have never used or owned the two product samples. Participants were shown the two product samples, one at a time. After observing the first product, they were asked to report their felt emotions towards the product using PrEmo questionnaire containing fourteen emotions that were represented by expressive cartoons. Participants must respond to each emotion by selecting one of the three ratings: 0: "I do not feel the emotion expressed by this cartoon", 1: "to some extent I feel the emotion", and 2: "I do feel the emotion". By scoring each of the fourteen emotions, PrEmo was able to capture more than one emotion experienced simultaneously (mixed emotions) by the respondents.

The same procedure was performed for the second product. Following the completion of PrEmo questionnaire, participants were interviewed to identify their concerns and reasons related to their felt (reported) emotions. The average scores of pleasant and unpleasant emotions for both product samples can be seen in Figure 3. The breakdown of these scores is shown in Figure 4.

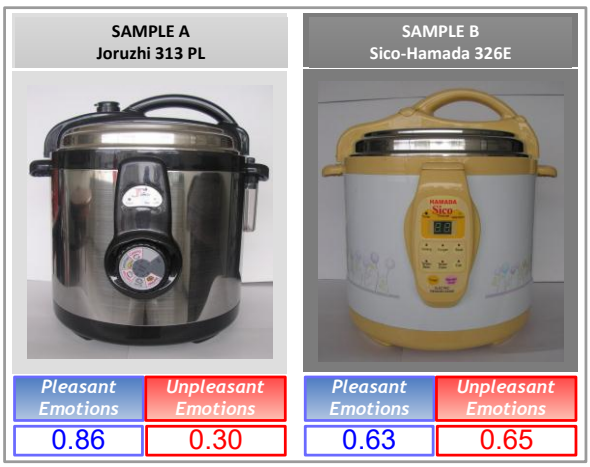

Figure 3: Average scores of pleasant and unpleasant emotions for two product samples

Product sample B evokes a higher average score of unpleasant emotions (0.65) than does product sample A (0.30). This indicates that product sample B is less able to meet users' concerns, compared to product sample A. This inference is supported by the average scores of pleasant emotions, where product sample A results in a higher score (0.86) than does product sample B (0.63). In general, product sample A is good in terms of its physical form, as it significantly elicits higher positive emotions than negative ones, meaning that it favors more users' concerns and needs. Since product sample B receives very similar levels of positive and negative emotions, it overall cannot provide a good emotional impression to the users.

Interviews with the participants provided a set of reasons as to why they felt a particular emotion. Examples of the participants' comments can be seen in Table 1. Based on all the comments, users' concerns related to electric pressure cookers were formulated. They were categorized into standards, attitudes, and goals (Table 2).

4.2 Usability Testing

Usability testing on two samples of electric pressure cookers involved eight participants (7 females, 1 male), who were recruited using purposive sampling technique. The participants must fulfil the same two screening criteria as in product emotions measurement.

The test employed a sequence of procedures. First, a questionnaire was used to ensure the suitability of participants and to gather their demographic data. Second, an orientation script was read to participants to explain the goal of the study and the overview of the test procedures. Next, participants were given several minutes to skim manual instructions of the tested products to provide them an overview of the products' features. Afterward, participants were asked to complete eight tasks contained in a task scenario by using the two product samples. The task scenario was the same for both products; product A was tested first, followed by product B. This stage was observed and recorded using a video camera for later detailed analysis. Having finished the tasks, participants filled out a final questionnaire consisting of closed questions related to usability of the tested products (i.e. ease of use, control panel, symbols, etc.). Finally, an interview was conducted to identify participants' opinions about their experiences in using the tested products, difficulties they encountered, features they liked, and suggestions for improvement.

Performance standards used for measuring usability were maximum completion time (MCT) and successful completion criteria (SCC) of the given tasks. MCT was estimated based on mean completion time of each task from 5 expert users, multiplied by allowance factors of 1.5, 2, or 2.5 depending on the complexity of the task. Meanwhile, SCC was formulated based on usage procedures as stated in manual instructions. Table 3 presents examples of tasks, their MCT, and their SCC.

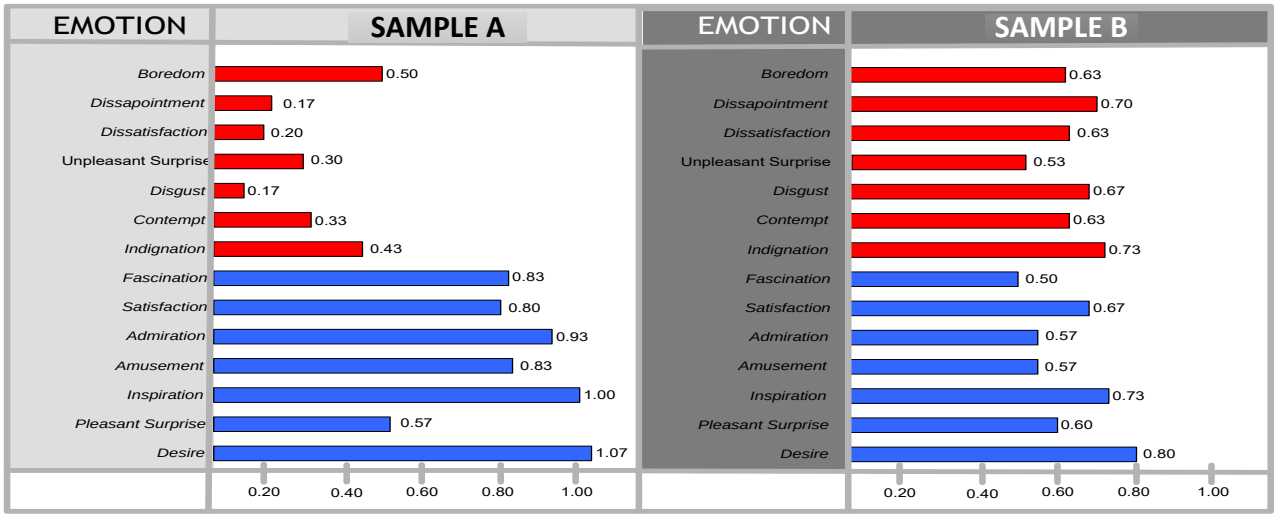

Figure 4: Breakdown of product emotions scores of two product samples

Table 1: Examples of participants' comments to product sample A

Emotions	Participants' comments
Desire	*The design of product looks elegant, so it gives a luxurious impression*
	It has a medium size, so it is portable, but at the same time it is not too small
Inspiration	*The combination of black and metallic colors makes the product looks futuristic*
	Features at the rotary knob can make it easier to handle and rotate
Unpleasant surprise	*The rotary knob makes the cooker looks unsophisticated*
	The product does not have an electronic visual display to show the timer
Boredom	*The basic form of the product is old-fashioned and not innovative*
	The black color makes the product seems monotonous

Table 2: Users' concerns related to electric pressure cooker products

Type of concerns	Users' concerns
Standards	Electric pressure cookers must have a main function that helps users to cook
	Controls must be easy to operate
	Symbols on control panel must be easy to understand
	Electric pressure cookers must have a proper combination of colors
Attitudes	Users like electric pressure cookers that look elegant
	Users like electric pressure cookers that have an uncomplicated control panel
	Users like electric pressure cookers that have interesting and easy-to-understand symbols
Goals	Besides functioning well as a cooking device, electric pressure cookers need to have an interesting and modern design to provide the owner with stimulation and proud feeling
	Electric pressure cookers are expected to have features that are easy to understand and to operate

Usability testing resulted in quantitative and qualitative data. Table 4 shows the mean completion time of each task from eight respondents and the number of respondents who successfully completed the tasks according to SCC. For each product sample, the percentage of tasks that could be completed under MCT and the percentage of successful participants for a particular task were calculated. These percentages contributed to the usability level of both product samples in terms of efficiency and effectiveness. In general, product sample B (usability level: 46.88%) is more usable than product sample A (usability level: 29.69%). However, both products cannot be considered to have good usability, as they do not achieve a minimum usability score of 70%, as recommended by Rubin and Chisnell (2008).

Table 3: Example of tasks, SCC, and MCT for product sample A

Task	Description	Performance Standards		
2	Ensure that the steam closing button is set properly	SCC:		Set the steam closing button upright to the position where the indicator exactly points the label *"Airproof/Sealed Completely"*
		MCT:		1.4 seconds x 1.5 = 2.1 seconds
6	Set the electric pressure cooker to reheat mung bean congee, then cancel that function	SCC:	1	Set the rotary knob to a normal position, then position it properly to the *"Keep Warm"* menu
			2	Rotate the rotary knob clockwise until 'click' sound is heard
		MCT:		4 seconds x 2 = 8 seconds

Table 4: Mean completion time and maximum completion time (MCT) of each task

Product Sample A				
Task	**Mean CT (sec.)**	**Max. CT (sec.)**	**Number of successful participants**	**Percentage of successful completion (%)**
1	30.75	21.2	4	4 / 8 = 50
2	3.88	2.1	3	37.5
3	996.63	909	1	12.5
4	**22.63**	24.5	3	37.5
5	8.88	8.8	4	50
6	10.25	8	3	37.5
7	936.38	669.6	3	37.5
8	**845.13**	865	1	12.5
	2 / 8 = 25%		**Mean percentage = 34.38%**	
Usability level = 29.69%				

Product Sample B				
Task	**Mean CT (sec.)**	**Max. CT (sec.)**	**Number of successful participants**	**Percentage of successful completion (%)**
1	29.38	22.8	4	4 / 8 = 50
2	3.75	2.4	3	37.5
3	**814.63**	862.5	5	62.5
4	**22.88**	23	3	37.5
5	**10.13**	10.4	4	50
6	11.13	8	3	37.5
7	856.63	655.2	2	25
8	**848.63**	852	4	50
	4 / 8 = 50%		**Mean percentage = 43.75%**	
Usability level = 46.88%				

Table 5: Questionnaire results for product sample A and B

Question	Average Score	
	Product Sample A	**Product Sample B**
1: Ease of use	3	2.88
2: Symbols	2.5	3.5
3: Control panel	3	2.63
4: Manual instruction	3.25	3.63
5: Satisfaction	2.88	3.13
Overall Score	**2.93**	**3.15**

The final questionnaire asked respondents' opinions related to five aspects: ease of use, symbols, control panel, manual instruction, and satisfaction in using the tested products. Each question was answered by selecting one of five ratings (Likert scale): 1 = very negative, 2 = negative, 3 = neutral, 4 = positive, and 5 = very positive. The results are recapitulated in Table 5. The overall scores for both product samples (product A: 2.93; product B: 3.15) indicate that participants tend to select neutral response in assessing usability of the products. This means that product sample A and B are perceived as not fully meeting users' usability needs, and thus their design needs to be improved to increase their usability level.

Based on the interview, it can be identified that participants generally have difficulties in understanding the functions of the products and in using them without consulting to manual instructions. The rotary knob in product sample A is judged to be confusing to operate. Several different functions that are controlled by the same button also causes usage problems to the users. All participants agree that product sample B is easier to operate because it is operated using push buttons, and not rotary knobs as in product A. Last but not least, participants prefer the use of symbols, instead of written label only, in order to

help them understand the product's functions and control panel better.

5. PRODUCT REDESIGN AND EVALUATION

Based on the information derived from product emotions measurement and usability testing on product sample A and B, redesign on these electric pressure cookers was performed. The redesign was focused on improvement of the current designs. Therefore, the design changes were the adaptation of product sample A and B that were modified in the following aspects: shape, appearance, colors, layout of control panel and menu buttons, symbols on each menu button, and information labels that explain the functions of each button. These changes referred to the participants' concerns about pressure cooker products and to factors that elicited particular emotions. In addition, usability level of the product and aspects that may cause usability problems were taken into account during the redesign process.

The redesign process resulted in two redesign alternatives, as can be seen in Figure 5. These redesign alternatives still had the same basic functions as in current pressure cooker designs. To identify whether the current designs were improved, the redesign alternatives were evaluated using the same methods as before. For product emotions measurement, thirty respondents (26 females, 4 males) were recruited using the same sampling technique and screening criteria as in previous measurement. As emotion stimuli, each redesign alternative was represented by a virtual prototype in the form of four 3D pictures of the product with different angles and one picture focusing on the control panel. Participants were shown the prototypes and asked to report their felt emotions using PrEmo questionnaire. The average scores of pleasant and unpleasant emotions of both redesign alternatives are presented in Table 6. For comparison, the scores of current designs are also shown in the same table. It can be seen that there is improvement in the product emotions scores of the two design alternatives, compared to those of the current designs. Specifically, redesign alternative 2 generates the highest pleasant emotions score (0.89) and the lowest unpleasant emotions score (0.25). This indicates that the redesign alternatives have a better ability to evoke positive emotional responses from the users. Interview was also conducted to explore the reasons of respondents' felt emotions. Positive comments to the redesign alternatives were given mainly to their unique shape, combination of black and metallic colors, helpful information labels and symbols, and the design of control panel and electronic display that is attractive and easy to understand.

Usability testing was also conducted to the redesign alternatives to evaluate their usability level. However, the method was slightly different from the one employed in previous testing, since participants only observed the virtual prototypes and did not actually use the products. The type of usability testing used was exploratory test, in which participants were given eight questions related to the use of the redesigned products. Each question linked to its corresponding predetermined success criteria, against which participants' answers would be assessed. The success level in answering the list of questions was considered to reflect the usability level of the redesign alternatives.

Eight participants (6 females, 2 males) were recruited using purposive sampling technique based on the same screening criteria as in previous usability testing. These participants were different from those in earlier test. The redesign alternatives were shown to the participants in the form of four 3D pictures of the product from different viewpoints and one picture depicting the control panel. Consulting to the pictures, participants answered the list of questions given. Table 7 shows an example of these questions and its criteria of correct answer. Each question correctly answered resulted in a certain score. The maximum score that could be achieved by a participant was 330. This maximum score was considered to represent the maximum usability level of the tested product. Table 8 summarizes the average total scores from eight participants for the redesign alternatives. The scores were then converted into usability levels of the tested products.

Based on Table 8, usability levels of the redesign alternatives increase considerably, compared to those of the product samples. In particular, redesign alternative 2 results in a higher usability score than redesign alternative 1 (81.82% vs. 77.65%). However, both alternatives have exceeded the minimum score of 70% as suggested by Rubin and Chisnell (2008). It should be noted that the comparison of usability levels between redesign alternatives and current designs is a rough estimation only, and should not be considered completely accurate. This is because of the differences in the methods employed for their usability testing.

Product emotions measurement and usability testing indicate that redesign alternative 2 outperforms alternative 1. All measures consistently show that alternative 2 is better than its counterpart, as can be identified from higher pleasant emotions score (alternative 1: 0.88 vs. alternative 2: 0.89), lower unpleasant emotions score (alternative 1: 0.29 vs. alternative 2: 0.25), and higher usability level (alternative 1: 77.65% vs. alternative 2: 81.82%). Thus, it can be expected that redesign alternative 2 has a better capability in evoking users' positive emotional reactions and in facilitating the users to use the product easily. Therefore, this outcome can be implemented in the design and development of electric pressure cookers to enhance the product's differential advantage among competitors.

Figure 5: Redesign alternatives (top row: alternative 1; bottom row: alternative 2)

Table 6: Pleasant and unpleasant emotions scores of redesign alternatives and current designs

	Redesign Alternative 1	Redesign Alternative 2	Product Sample A	Product Sample B
Pleasant Emotions	0.88	**0.89**	0.86	0.63
Unpleasant Emotions	0.29	**0.25**	0.30	0.65

Table 7: Example of question and its correct answer criteria

Question	Criteria of Correct Answer	
	Redesign Alternative 1	Redesign Alternative 2
3. You would like to open the lid of the pressure cooker. How could you open it? What should you do to close the cooker back?	a. The lid can be opened by holding the lid's handle firmly, and then turning the lid clockwise.	a. The lid can be opened by pressing the 'PUSH' button on the top of the lid's handle.
	b. The cooker can be closed by placing the lid in the correct position and turning it counter-clockwise.	b. The cooker can be closed by returning the lid into closing position and firmly pressing the lid downward until it is locked automatically.

Table 8: Usability levels of redesign alternatives and current designs

	Average Score	Maximum Score	Usability Level
Redesign Alternative 1	256.25	330	77.65%
Redesign Alternative 2	270	330	**81.82%**
Product Sample A			29.69%
Product Sample B			46.88%

6. CONCLUSION AND FUTURE DIRECTIONS

The use of both product emotions measurement and usability testing is beneficial and effective for evaluating the design of products or systems. This evaluation can identify problems existing in current design and provide a basis for redesigning and improving the products or systems. This paper demonstrates the application of product emotions measurement and usability testing to assess and to redesign electric pressure cooker products. Two product samples were selected and used as the object of study. These product samples were redesigned, resulting in two redesign alternatives. Utilizing the information obtained from product emotions measurement and usability testing as the improvement basis, the redesign alternatives are proven to be better than the current designs, as can be inferred from higher pleasant emotions scores, lower unpleasant emotions scores, and higher usability levels. Thus, the redesigned pressure cookers are expected to be able to influence users' purchasing decision by eliciting their positive emotions and by providing good usability.

At the time this study was conducted, PrEmo was a validated and well-known instrument for measuring product emotions. However, Laurans and Desmet (2012) recently propose PrEmo2, which is claimed to be an improved version of the original PrEmo. Instead of a three-point scale, PrEmo2 uses a five-point scale measurement, ranging from "I do not feel this" to " I do feel this strongly". Furthermore, PrEmo2 replaces several original emotions with the new ones such as social-context emotions (e.g. pride and shame). Another obvious difference is the use of new character style that maximizes expressivity. In future research, PrEmo2 can be applied to the same products used in this research to explore if its use produces different or better results. Another research direction is to apply product emotions measurement and usability testing to different types of products, including websites and mobile applications.

REFERENCES

Desmet, P. M. A. (2003) Measuring emotions: Development and application of an instrument to measure emotional responses to products. In M. A. Blythe, K. Overbeeke, A. F. Monk and P. C. Wright (Eds.), *Funology: From Usability to Enjoyment*. Kluwer Academic Publishers, Dordrecht, pp. 111-123.

Desmet, P. M. A., and Dijkhuis, E. (2003) A wheelchair can be fun: A case of emotion-driven design. In *Proceedings of the International Conference on Designing Pleasurable Products and Interfaces - DPPI'03*. ACM Press, New York, 22-27.

Desmet, P. M. A., and Hekkert, P. (2002) The basis of product emotions. In W. S. Green and P. W. Jordan (Eds.), *Pleasure with Products: Beyond Usability*. Taylor & Francis, London, pp. 60-68.

Dumas, J. S., and Redish, J. (1999) *A Practical Guide to UsabilityTtesting*. Intellect Books, Exeter, England.

ISO 9241-11. (1998) *Ergonomic requirements for office work with visual display terminals (VDTs) - Part 11: Guidance on usability.* International Organization for Standardization (ISO), Switzerland.

Jordan, P. W. (1998) *An Introduction to Usability*. Taylor & Francis, London.

Khalid, H. M. (2006) Embracing diversity in user needs for affective design. *Applied Ergonomics*, **37(4)**, 409-418.

Khalid, H. M., and Helander, M. G. (2006) Customer emotional needs in product design. *Concurrent Engineering: Research and Applications*, **14(3)**, 197-206.

Laurans, G., and Desmet, P. (2012) Introducing PrEmo2: New directions for the non-verbal measurement of emotion in design. In *Proceedings of the 8th International Design and Emotion Conference*. Central Saint Martins College of Arts & Design, London.

Nielsen, J. (2012, January 4). *Usability 101: Introduction to usability*. Retrieved from http://www.nngroup.com/articles/usability-101-introduction-to-usability/

Rubin, J. and Chisnell, D. (2008), *Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests, 2nd Edition*. Wiley Publishing, Inc., Indiana.

Zhang, P., and Li, N., (2005) The importance of affective quality. *Communications of the ACM*, **48(9)**, 105-108.