Cognitive Theories of Product Emotion and Their Applications in Emotional Product Design

Anirban Chowdhury, Swathi Matta Reddy, Debkumar Chakrabarti and Sougata Karmakar

Abstract Product attributes which can elicit positive or negative emotions among users, determine product acceptance in market. Different cognitive theories of emotion are found in literature for emotional product design. These theories explain the various aspects of underlying phenomena of emotion generation based on product attributes and their impact on product choice. In present paper, six popular cognitive theories of emotion (viz. 'Kansei Engineering', 'Theories of product personality', 'Pleasure model', 'Product Appraisal Model', 'Emotional Design Model', and, 'Technology as Experience Framework') have been reviewed, stating their potential benefits and limitations. An integrated theoretical framework of emotional product design has been proposed by incorporating different potential approaches of earlier mentioned cognitive theories of emotion. It is expected that developed framework would be helpful to industrial designers, ergonomist, product innovation managers and cognitive scientists towards better emotional product design.

Keywords Cognitive ergonomics · Design · Emotion · Pleasure · Product

1 Introduction

Cognition directed emotion is found in many daily life scenarios/situations, though there are different causes of emotion other than cognition. Actually, cognition and emotions are closely related with each other; and cognition of an object/stimulus may lead to generation of different basic emotions. For example, fear may be evoked due to paying sudden attention to a stranger with a gun in a dark empty road.

A. Chowdhury · S.M. Reddy · D. Chakrabarti · S. Karmakar (✉)
Ergonomics Laboratory, Department of Design, Indian Institute of Technology (IIT) Guwahati, Guwahati 781039, Assam, India
e-mail: karmakar.sougata@gmail.com

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In other case, one student may be pleased being rewarded for top score in a design course. Similar to these incidents, it is possible to generate positive emotions among consumers or users through product design. For the last three decades, designers and human factor researchers are more concerned about formulating design theories based on human cognition and emotion. Some practices regarding application of cognitive theories of emotions in design related industries are in full swing.

Industrial designers/engineers are trying to build different strategies for emotional product design but till date only few cognitive theories of emotion are presently being followed for product, service and interaction designs. Though many cognitive and non-cognitive theories are available in literature; in present paper total six cognitive theories/models of emotional product design which are very relevant to product/service design have been described. These includes 'Kansei Engineering', 'Product Personality', 'Pleasure Model', 'Emotional Design Model', 'Basic Model of Product Appraisal', and, 'Technology as Experience Framework'. Though each established cognitive theory of product emotion has its own potentials, none of the theory is able to explain the underlying process of emotion generation due to design/features of each and every product. Therefore, there is still need to study of cognition and emotion related theories to establish an integrated theoretical framework for better emotional product/service design outcome. In this context, detailed understanding of cognitive theories of emotion is necessary. In the present paper an attempt has been undertaken to bring together available information on cognitive theories of product emotion and to highlight their potentials in product/service design. A theoretical framework has also been developed for better emotional and pleasurable product/service design. Before going into details about cognitive theories of emotion, it is better to know basics of cognition and emotion.

2 Understanding Cognition and Emotion

Cognition is the mental process which includes series of sensory events such as perception, attention, use of short term memory/working memory, exploration of long term memory, information processing, identification and classification of objects, reasoning, decision making etc. [1]. The concept and meanings of cognition may be stated from following perspectives:

- Understanding about objects/events/surrounding environment
- Perception and consequent acceptance of meaning of objects
- Thought/thinking process
- Reasoning and interpretation
- Initiator of emotion(s)

Emotion which is defined as the different mental and bodily changes with certain features, has subjective, behavioral, cognitive and internal/peripheral physiological components [1, 2]. Cognitive processes are associated with emotional responses. Emotions either consciously or unconsciously may vary from time to time, place to

place and situation to situation even in the same place [2]. In his great philosophical path breaking work "On the Origin of species", Darwin [3] first proposed that there are a limited number of basic and universal emotions. Ekman and Friesen [4] stated that there are six basic emotions corresponding to anger, disgust, fear, happiness, sadness, and surprise. Emotion which is actually one type of 'affective state' can have different aspects which are as follows:

- Emotion may be both conscious and unconscious
- It originates from different parts of the brain
- It combines both mental and bodily changes
- It affects attention and information processing in predictable way
- Emotion may influence motivation and behavior

3 Causes of Emotion

Different emotions occur by different stimulus. Causes of emotion can be categorized into two broad classes based on their origins: cognitive and non-cognitive causes [2].

3.1 Cognitive Causes

Cognitive causes of emotion refer to how a thought causes emotion. Cognitive scientists have widely accepted that thoughts can cause emotions but it depends on what kind of thought it is [2]. Many thought such as 'rose is red', 'ice is cold' etc. may have little impact on most people. Thoughts which evoke emotion are likely to be evaluative thoughts. These thoughts assess things in a way that reflects our attitudes towards them. For example, one may not have any emotional response to the thought 'kitchen knife is sharp', but emotion will likely follow the thought that 'kitchen knife is dangerous'. The concept of more dangerous or less dangerous is directly related to one's perception of safety.

3.2 Non-cognitive Causes

It is assumed that perceptual states may evoke/induce emotions by affecting our appraisal process. In most of the cases perception requires interpretation before emotion arises. On contrary, in some cases perceptual states may not require interpretation to elicit an emotion. This second phenomenon is considered as non-cognitive cause of emotion. For example, occurrence of a sudden high pitch sound rapidly generates an emotion. Such stimulus would seem gratuitous to postulate an intervening thought. Similar incidence happens of when fear response is evoked misidentifying coiled rope as snake on the road. In such situation, visual information

that is not yet reached to neocortex (where visual object recognition takes place) via the optic nerves is transmitted to amygdala to generate fear [5]. Thus, fear may already be experienced before our realization that we are not in danger.

Though there are so many other cognitive and no-cognitive causes of emotions, in the present article authors' primary focus is to discuss about cognitive theories of emotion which are very relevant to design practice.

4 Cognitive Theories of Emotion and Their Applications in Product Design

4.1 Kansei Engineering

The concept of Kansei Engineering (KE) was established by Nagamachi [6]. 'Kansei' is the Japanese word that covers several English meanings such as sensitivity, sense, sensibility, feeling, aesthetics, emotion, affection, and intuition. All these words are associated with mental responses to external stimuli, often summarily referred to as feelings. Idea and goal of KE is similar to pleasurable product design. According to Jordan [7], KE is roughly translated as 'Pleasure Engineering' . KE helps the investigator to understand the relationship between formal and experiential properties of a product. KE is also helpful for gaining insights about expectations of users and consequent product properties through these intended user benefits. According to Nagamachi [6, 8], KE follows four basic steps. First step starts with collecting appropriate Kansei words or adjectives related to product of interest from targeted user population. Second step involves establishment of correlation between product features/attributes and Kansei words. In third step, a data bank of these correlations is searched for Kansei words. These words in turn are represented with semantic differential scales, and, analyzed, typically using factor analysis to reduce often large numbers to a manageable set of words. Approaches taken in this step is similar to the semantic product design. Fourth and last step follows evaluation of new design with potential users in terms of Kansei words to establish how close the tested product is to the ideal product. Nagamachi [9] described two different directional approaches/flows of KE . These are 'from design to diagnoses' and 'from context to design'. The first approach involves manipulation of individual attribute of a product in order to test users' overall responses towards the product. In the second approach, qualitative data about products are gathered via field observations and then establishment of relationships between formal properties of design and the user benefits associated with the products. With the help of KE, products could be engineered by the designers based on semantic meanings of the products to improve sales, usability, and user's satisfaction. However, KE cannot predict feelings of consumers directly and unable to explain underlying phenomena in the brain due to product emotion but it is still helpful to explain socially constructed phenomena (for instance, various social factors related to product features and product emotion).

4.2 Theories of Product Personality

Product personality assignment is an approach which was developed by 'Philip Design' [10]. The concept of product personality comes from semantic meaning(s) of the product and it is closely associated with product semantics (the study of relationships between signs and the objects/products they refer to or signify). These symbolic meanings may refer to physical product itself and the product can be described by human personality characteristics which are termed as 'product personality' [7, 10]. Consumers not only consider product in terms of their functionality but also often thinks about product's personality like human beings [11, 16]. Product personality has prominent influence on product choice while functionality and usability across products are same. For example, a person can be happy, cute, and honest; similarly a product may appears like happy, cute, and honest. Although, personality of a product is reflected mainly through visual attributes of the product, it may also be perceived through physical interaction [12]. There are some proposed models of product personality which conclude the role of product personality on product choice [11, 13–15]. Personality congruence model well explains why people would like to select a product based on product personality [15]. This model states that product personality influences product choice due to personality congruence effect of consumers but not due to user congruence effect. According to this model, product personality depends on product attributes and if perceived personality of a product matches with personality of the consumer then consumer would like to choose the product. It is necessary to state that product personality assignment is one of the important techniques for pleasurable product design [7]. In a recent study, it is reported that different usability dimensions are associated with different product personality characteristics [16] and users selects a product that represents comparatively more positive personality characters such as lively, interesting, childish etc. Designers may manipulate characteristics of a product using personality assignment technique to make it pleasurable one to achieve more market acceptance than its competitive products with similar usability.

4.3 Pleasure Model

This model was proposed by Jordan [7]. This alternative affective model focuses more on pleasurable aspects of our interactions with products. This model considers all the potential benefits that a product can deliver. Pleasure model of Jordan, proposes four conceptually distinct types of pleasure [7]. These include (a) Physio-pleasure; (b) Socio-pleasure; (c) Psycho-pleasure and (d) Ideo-pleasure. Physio-pleasure is related with bodily aspects which are connected to sensory experiences about product, e.g. tactual pleasure of holding a mobile phone. Socio-pleasure refers to enjoyments derived from relationships with others. Products can facilitate social interactions in different ways. For example, a coffee maker

provides a service which may act as a central focus of attraction of small social gathering 'Coffee evening'. Psycho-pleasure is associated with cognitive and emotional reactions. A product may need a particular level of cognitive ability to use it and the product attributes/interaction style may elicit emotional response based on the experience about the product. Ideo-pleasure refers to people's understanding of their own values. For example, a product made up of biodegradable materials is associated with value of environmental responsibilities of user.

Similar to 'Maslow's hierarchy of needs', Jordan [7] highlighted about a hierarchy of consumer needs. In this hierarchy Jordan placed pleasure in the third level after usability and functionality as per user's priority. According to Jordan, while consumers/users take a purchase decision, they are firstly concerned about functionality, then usability and lastly pleasure. While functionality and usability of many products are similar, pleasure plays important role in product selection. Though pleasure model does not able to explain how pleasures happen in biological and behavioral level, but it helps designers to think about ways of expression of different kind of pleasure through product attributes/interaction styles. Another drawback of this model is that it does not prescribe how to incorporate all types of pleasures into a single product. This model talks much about product acceptance on the basis of pleasure; but role of other emotion (e.g. fear, anger, surprise etc.) in product choice is still less clear.

4.4 Basic Model of Product Appraisal

A model of product appraisal process was developed by Desmet and coworkers [17, 18]. This model is similar to Frijda's 'action readiness account' [19] and chiefly based on appraisal theory of Ortony et al. [20]. According to this model, product appraisal depends on product attributes and the judgment of product design against a concern; and, the appraisal leads to emotion (Fig. 1). For example, if attitude (concern) towards a product (stimulus) is positive, appeal of that product (appraisal) may lead to emotion (joy/pleasure/happiness).

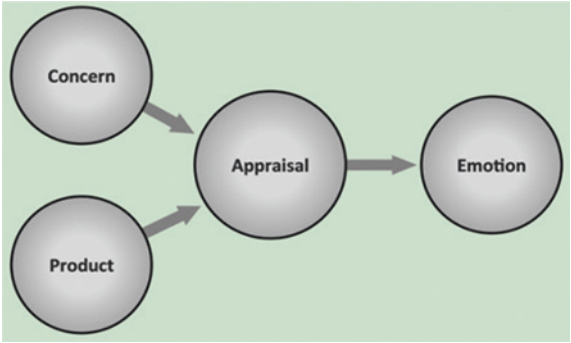

Fig. 1 Model of product appraisals. *Source* This figure is adapted from [17]

In this model a holistic approach has been taken for explanation towards generation of emotions due to product through appraisal process. Therefore, this model will be beneficial for designers to explain how a product may elicit emotion among users.

4.5 Emotional Design Model

This model was established by Norman and his colleagues, Andrew Ortony and William Revelle [21]. It explains how emotion and behavior are determined by different levels in the brain. According to this model, there are three levels of brain organizations which are related to emotion regulation (Fig. 2). First level which is known as visceral level, is associated with immediate communication in response to change in surrounding environment. Second level -behavioral level involved in regulation/control of our everyday behavior. At the highest level, brain further processes and anticipates the signals of behavioral level. This third level is called reflective level.

According to Norman's model [21, 22], visceral level responds rapidly, making judgments about what is good or bad, safe or dangerous, pleasurable or disgusting etc. It also triggers different emotional responses against stimuli, such as fear, joy, anger and sadness which are combination of physiological and behavioral responses. For example if someone finds a large hairy spider in the bathroom, he/she experiences fear and screams. These screaming or running away are due to the response from the behavioral level wherefrom most human activities are controlled. In reflective level people decides how to control emotion and how to respond further towards the stimulus.

Several explanations have been made on the basis of this model e.g. how we respond to stressful or pleasurable situations. The central theme of this model is that our affective state be it positive or negative, depends on how we think about the situation. For example, when we are tensed, the emotional response is to focus on the problem at hand and try to resolve it. In such situation, our bodies respond

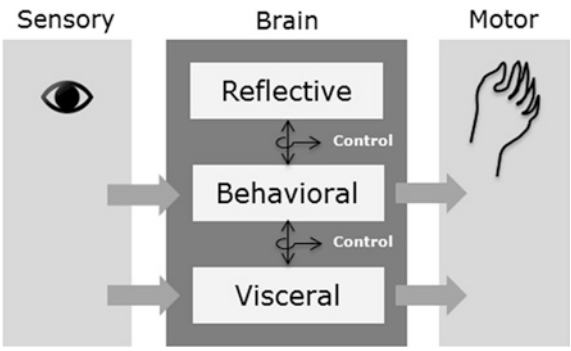

Fig. 2 Model of emotional design. *Source* This figure is adapted from [21]

Table 1 Examples of affects in relation to different sensory modalities

Affect	Positive	Negative
Visual	Smiling faces	Frowning disgusted faces
Touch	Rounded objects	Sharp objects
Hearing	Soothing/harmonious sounds	Harsh/discordant sound
Smell	Sweet smells	Smell of spoiled egg
Taste	Sweet taste	Bitter taste

Source Information presented in this table was adapted from [21]

by enhancing our muscles tone and sweating. On contrary, when people are happy due to wining of their favorite team in a cricket match, emotional responses are to lough, cheer, and jump about. Human body relaxes in such moments.

Following above discussions, few questions arise in our mind regarding application of this theory in product design. (A) Should designers create products according to varying emotional states of the users/consumers? (B) Is it realistic to conceptualize this type of product?

Creating product according to varying emotional states or conceptualization of such product is less practical but Norman's model is applicable in context specific design practice. Norman mentioned that a product which is intended to be used during leisure time or moment of fun, designers need not to worry about amount and type of information coming from product interface but they should concentrate on how to make the product more enjoyable. On contrary, he argued that for designing interface for serious task e.g. car driving, designers need to pay attention to all information required to perform that task and the interface should be clearly visible and unambiguous in feedback. Most acceptable application of his model is how to design products in relation to the three levels of information processing. Visceral design is widely applied for providing product's look, feel and sound good. Designers can use aesthetic techniques to make product emotional e.g. designers may use clean lines, balance, colour, shapes and texture for this purpose. According to this model, some affects related to our senses and their valances have been presented in Table 1 which may be useful for product/interface design.

4.6 Technology as Experience Framework

McCarthy and Wright [23] proposed a framework regarding user experience to explain how user feels about the product in different phases of product experience. They proposed that there are four core threads which are responsible for the user's holistic experiences. These are the 'sensual thread', 'emotional thread', 'compositional thread', and 'spatio-temporal thread'. The 'sensual thread' is concerned with our sensory engagement with situation and is similar to visceral level of Norman's model [21]. For examples, sensory engagement during interactivity of users with cell phones, computer games, chat-room etc. The 'emotional threads'

involve common human emotions, such as sorrow, anger, happiness etc. which are influenced during product use. For example, a person may feel anger while facing problems in typing due to faulty key board. The 'compositional thread' refers to narrative part of product experience; as it unfolds the way a person make sense of them. For example, if consumers experience frustration during product purchase process due to e-retailer's website design related problems, they may not purchase products from the same website though they like the products. The 'spatio-temporal thread' is concerned with space and time in which our experiences take place and effect of various factors which influence space and time. For example, people avoid crowd and prefer quiet place/ambience for important discussion. Space designers may think about such situation for their design implementation.

5 Theoretical Framework for Designing Emotional Product

An integrated framework has been developed after identification of advantages and disadvantages about theories discussed in the above sections for designing of emotionally appealing product. Benefits and drawbacks of above described six theories presented in Table 2. In proposed framework different potential and useful components

Table 2 Examples of affects in relation to different sensory modalities

Theories	Advantages	Disadvantages
Kansei engineering	Relates product appearance with different emotional and semantic meanings of product	Not able to explain how emotion is generated by product
Product personality theory	Relates product appearance/ usability with different emotional and human personality related semantic meanings	Though it is able to explain consumer congruence effect but still unable to explain how emotion is generated
Pleasure model	Explains different sources of product pleasure e.g. physiological, psychological, ideological and sociological	Not able to explain cognition and emotion related behavioral information processing
Product appraisal model	Can explain how context and emotional product attribute generate emotion through appraisal	Less empirical evidences are found on directly related to product design and validating this model
Emotional design model	Can explain psycho-physiological basis of emotional information processing and product choice	Less empirical evidences are found on directly related to product design and validating this model
Technology as experience framework	Highlights on way to overcome different threats of user experiences in real time scenarios	Not able to explain cognition and emotion related behavioral information processing

of emotional product design have been included from various cognitive theories of emotion. Designers may take following considerations while designing emotional products (see Fig. 3). This framework highlights in details about both pre-design and methodological considerations to make a product more emotionally attached.

Various pre-design concerns of the proposed framework would help designers to consider about different aspects for designing emotional product. Prior to emotional product design, designers need to consider context of design, feasibility of value addition through emotional attributes of the product, different sources of pleasant user experiences, suitable way of emotion expression through product characteristics involving one or more sensory modalities, and socio-economic feasibility for unambiguous emotional product purchase decision. When, designers are able to presume and conceptualize product/service design features based on all these pre-design consideration, they may proceed to subsequent development of prototypes.

After developing probable prototypes, user evaluation can be performed using methodological concerns. Methods and techniques mentioned in Fig. 3 can be followed for prototype evaluation. In addition, evaluation of emotional product design may further be extended with some advanced neurophysiological techniques (such as eye-tracking, facial EMG, GSR, and MRI [24–27]). In this context it is worthy to mention that 'Somatic Marker Hypothesis' [28] is also very relevant for identification of neurophysiological basis of emotional product choice decision. After whole evaluation of prototypes, designers can take decision for redesigning of product or they can proceed for manufacturing. Thus, the proposed framework would be beneficial for designer to get overall idea about emotional product design and steps to be followed for the same.

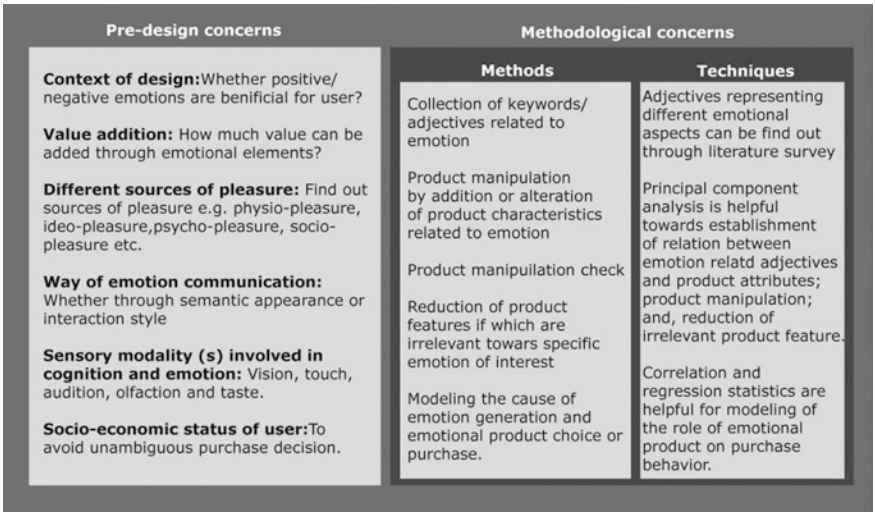

Fig. 3 Framework to design emotional product

6 Summary and Conclusion

Present paper covers six well established models for emotional product design. Each model and theory has its unique potential for emotional product design. First three models (viz. Kansei Engineering [6, 9], Product Personality Assignment [7, 10] and Pleasure Model [7]) described in this paper are mainly related to semantic product design but these models are not able to explain emotional signal processing and other bodily changes. On contrary, 'Basic Model of Product Appraisal' [17] and 'Emotional Product Design Model' [21] are more effective to explain the underlying cognitive and emotion processing in the brain. Technology as experience framework highlights some important aspect of product design such as trendiness and some other socio-economic aspects that users perceive in the market while purchasing a product. Based on advantages and disadvantages of aforesaid six models an integrated framework has been developed for product design with improved emotional appeal. Therefore, it can be concluded that theoretical framework for emotional product design which has been come out from present paper by incorporation of valuable inputs from important cognitive theories of emotional product design, will be helpful for visual communication designers, interaction designers, ergonomists, product innovation manager and cognitive scientists for designing and developing emotional products.

References

1. Andrade, J., May, J.: Cognitive Psychology. BIOS Scientific Publishers, Oxford (2007)
2. Prinz, J.: Emotion. In: Frankish, K., Ramsey, W.M. (eds.) The Cambridge Hand Book of Cognitive Science, pp. 193–211. Cambridge University Press, Cambridge (2012)
3. Darwin, C.: The Expression of Emotions in Man and Animals. John Murray, London (1872)
4. Ekman, P., Friesen, W.: Constant across cultures in the face and emotion. J. Pers. Soc. Psychol. **17**, 124–129 (1971)
5. LeDoux, G.E.: The Emotional Brain. Simon & Schuster, New York (1996)
6. Nagamachi, M.: Kansei engineering: a new ergonomic consumer oriented technology for product development. Int. J. Ind. Ergon. **15**, 3–11 (1995)
7. Jordan, P.W.: Designing Pleasurable Products. CRC Press, Boca Raton (2000)
8. Nagamachi, M.: Kansei Engineering. Kaibundo Publishing, Tokyo (1996)
9. Nagamachi, M.: The Story of Kansei Engineering. Kaibundo Publishing, Tokyo (1995)
10. Jordan, P.W.: Products as personalities. In Robertson, S.A. (ed.) Contemporary Ergonomics, pp. 73–78 (1997)
11. Govers, P., Hekkert, P., Schoormans, J.P.L.: Happy, cute and tough can designers create a product personality that consumers understand?. In: McDonagh, D., Hekkert, P., Erp, J.V., Gyi, D. (eds.) Design and Emotion, pp. 345–349 (2004)
12. Desmet, P.M.A., Nicolás, J.C.O., Schoormans, J.P.L.: Product personality in physical interaction. Des. Stud. **29**, 458–477 (2008)
13. Dumitrescu, A.: A Model of product personality. In: 4th European Computing Conference, World Scientific and Engineering Academy and Society (WSEAS), pp 88–93 (2010)
14. Govers, P.C.M., Schoormans, J.P.L.: Product personality and its influence on consumer preference. J. Consum. Mark. **22**, 189–197 (2005)
15. McDonagha, D., Bruseberg, A., Haslam, C.: Visual product evaluation: exploring users' emotional relationships with products. Appl. Ergon. **33**, 231–240 (2002)

16. Chowdhury, A., Reddy, S. M., Karmakar, S., Ghosh, S., Chakrabarti, D.: Is perception of product personality related with product usability? A cognitive ergonomics perspective. In: Parimalam, P., Premalatha, M.R., Banumathi, P. (eds.) Ergonomics for Enchanced Productivity, pp 177–182 (2013)
17. Desmet, P.M.A.: Designing emotions. PhD thesis, Department of Industrial Design Engineering, Delft University of Technology (2002)
18. Desmet, P.M.A., Hekkert, P.: The basis of product emotions. In: Green, W., Jordan, P. (eds.), Pleasure with Products Beyond Usability, pp 60–68 (2002)
19. Frijda, N.H.: The Emotions. Cambridge University Press, Cambridge (1986)
20. Ortony, A., Clore, G.L., Collins, A.: The Cognitive Structure of Emotions. Cambridge University Press, Cambridge (1988)
21. Norman, D.: Emotional Design: Why we Love (or Hate) Everyday Things. Basic BooK, London (2004)
22. Boehner, K., DePaula, R., Dourish, P., Sengers, P.: How emotion is made and measured. Int. J. Hum. Comput. Stud. **65**, 275–291 (2007)
23. McCarthy, J., Wright, P.: Technology as Experience. MIT Press, Cambridge (2004)
24. Mele, M.L., Federici, S.: Gaze and eye-tracking solutions for psychological research. Cogn. Process. **13**(1), S261–S265 (2012)
25. Miesler, L., Leder, H., Herrmann, A.: Isn't it cute: an evolutionary perspective of baby-schema effects in visual product designs. Int. J. Des. **5**(3), 17–30 (2011)
26. Laparra-Hernández, J., Belda-Lois, J.M., Medina, E., Campos, N., Poveda, R.: EMG and GSR signals for evaluating user's perception of different types of ceramic flooring. Int. J. Indus. Ergon. **39**, 326–332 (2009)
27. Balconi, M., Bortolotti, A., Gonzaga, L.: Emotional face recognition, EMG response, and medial prefrontal activity in empathic behaviour. Neurosci. Res. **71**, 251–259 (2011)
28. Damasio, A.R.: The somatic marker hypothesis and the possible functions of the prefrontal cortex. Philos. Trans. Royal Soc. Lond. B **351**, 1413–1420 (1996)