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Affective design of products using an audio-based protocol: Application to eyeglass frame

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ABSTRACT

The measurement and understanding of user emotions elicited by product appearance are critical elements of the product development process. This paper proposes a new emotion measurement method, called Auditory Parameter Method. It is a non-verbal technique that uses auditory stimuli (music samples) and association tests for evaluating a set of products, given by their pictures. From user-tests, it provides an assessment of these products according to a series of emotional dimensions. We present the methodological framework used to build the links between user's emotional responses and geometrical features of the products. The method is described on an application case, an eyeglass frame. Analysis of Variance models are employed to examine how various shape factors influence users' emotional responses. To demonstrate the effectiveness of our protocol, we compare the proposed method with the conventional Semantic Differential using Principal Component Analysis and Generalized Procrustes Analysis. The new protocol demonstrates interesting qualities for collecting the intuitive emotions of users and for providing a discriminant measurement of emotions. It can also be used by designers to stimulate creativity.

Relevance to industry: This study presents a methodology to the integration of emotional qualities in the design of products, which taking into account the cognitive and affective processing of users. This very innovative emotion assessment method incorporates the modality of sound, thus complementing research in the field which so far focused on the modality of sight. The design knowledge gained from this method, like the semantic mappings and the interpretation of design attributes, makes it possible to benefit the activity of the designers as a creativity support tool.

1. Introduction

In design practice, the designer has to balance between objective and subjective qualities, between functionality of the technology and emotional expressiveness, in an attempt to satisfy the demands and wishes of prospective users. The success of a product in the marketplace is not only determined by technical and objective content, but also by aesthetic, emotional, and other experiential factors (Petiot and Yannou, 2004). It is crucial for designers to get relevant inputs and to anticipate a user's expectations. Emotions elicited by product appearance can enhance the pleasure of buying, owning and using it (Hirschman and Holbrook, 1982; Bouchard et al., 2009). More and more businesses are realizing that to gain a competitive edge, they must win the customers' heart as well as their mind. Design for emotions plays a more and more important role in product design (McDonagh et al., 2002).

Emotions are defined as an acute and intentional state, which involves a relationship between the person and the stimulus. A difficulty of affective concepts such as emotions is that they are probably as intangible as they are appealing. To be able to instil emotional values in product design, the understanding of user emotions and the measurement of emotions become key challenges, as important as the functionality and usability. This is due to the affinity the user feels for an object that attracts him/her, due to the formation of an emotional relationship with the object. Emotions have a crucial role in the human ability to understand the world, and on how people learn new things. This design aspect is called Emotional Design (Norman, 2004), often synonymously used with Affective Design, which is both the title of a book by Donald Norman and the concept it represents. Similarly, Kansei Engineering (Nagamachi, 1995), the design approach developed in Japan, focuses on the behaviours of people when they perceive images or

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objects, and their links with the product parameters. Kansei is a Japanese word that evokes senses, feelings, emotions and impressions (Yanagisawa and Fukuda, 2004; Schütte et al., 2004). Several techniques have been developed to compose mapping and quantify Kansei qualities.

The knowledge of user emotions is important for product design because it can give the designer interesting information to take design decision. The quantified user emotional reactions and their relationship to physical parameters of the product become an interesting input for product design, to inform the definition of better products and increase the product appeal in both mature and new consumer markets (Barnes and Lillford, 2009). From a design point of view, research in this field is relatively recent and seems to offer promises of delivering quantitative evaluative tools and techniques to support practitioners (Walter, 2011).

Consequently, how to understand and measure user emotions has attracted the attention of many researchers. There are different approaches to reach this goal. Emotional responses can be measured with two categories of methods: psycho physiological measurement instruments and self-report measurement instruments.

Psychophysiological measurements are interesting, because they are able to directly access the primary response to an emotional stimulus (Motte, 2009). The most popular used physiological measurements in design research are (Kim, 2011): Electroencephalogram (EEG), Electrodermal Activity (EDA), Electrocardiography (ECG), Electromyography (EMG), and Eye tracking system. For example, Picard and Scheirer (2001) at MIT Media Lab measured EDA of a large audience with integrated devices on fingers during a daylong set of presentations, in order to investigate their affective reactions. Nevertheless, these devices have limitations for the measurement of emotions. They require a specific lab setting and need a careful calibration. External factors may influence the measurement and the device cannot directly assess the nature of emotions.

Self-report measurement is an appropriate and efficient technique to reflect user's emotional desires. There has been much research on emotions in design based on this approach. They try to seek a suitable tool as a measurement scale for quantifying the subjective emotional responses. We can benefit from many existing outcomes. A non-verbal pictorial assessment technique, the Self-Assessment Manikin (Lang, 1980), directly measures the pleasure, arousal, and dominance associated with a person's affective reactions to a wide variety of stimuli (Bradley and Lang, 1994). The Product Emotion Measurement Instrument (PrEmo) (Desmet et al., 2000, 2003) is based on animations of a cartoon character. All emotions are regarded as stemming from a relatively small number of basic emotion categories. Another example, the Plutchik's wheel of emotions (Plutchik, 1980), argues that all emotions are mixtures of 'basic' emotions and therefore can be described according to a predefined list of terms. In Kansei Engineering context, the Semantic Differential (Osgood et al., 1957) has become the backbone of this methodology. It consists in listing relevant attributes of the product category to analyse and carrying out user-tests in which the subject must assess, on scales, the products according to these attributes. The attributes are often defined by pairs of antonymous adjectives, which lie at either end of a seven point quantitative scale. A semantic space, Euclidean and multidimensional, is then postulated. Factor Analysis and Principal Components Analysis (PCA) may be used to reduce the dimensionality of the space and to find the underlying factors. They are used for the analysis of families of products or for the detailed analysis of a particular product. To adapt to the context of emotions, a new basic-emotion based semantic differential method is proposed in (Huang et al., 2012). It helps in clarifying the relationship between emotional terms (Kansei tags) and product attributes.

Emotional reactions can be evoked by stimuli with different sensory modalities. Nevertheless, we noticed that the existing emotion measurement methods generally use verbal attributes or emotional visual pictures, and few are concerned with other sensory modalities. These other sensory modalities, such as hearing, may provide interesting qualities for the measurement of emotions. In order to extend this exploratory domain, we propose a methodology called the Auditory Parameter Method. It is based on auditory stimuli to elicit user emotions and to develop an emotion measurement. We have been interested by auditory stimuli as an emotion measurement scale for three reasons. First, most people agree that auditory sensations, such as sound or music, can arouse profound and deep emotional reactions (Clos and Bouchard, 2009; Kaernbach et al., 2011). Acoustic cues activate motivational circuits underlying emotional expression in ways similar to pictures or adjectives (Liu and Chang, 2010; Bradley and Lang, 2000). Second, people's response to sounds is less sensitive than words to intercultural differences. Finally, auditory stimuli as emotion assessment scales are more operable and comprehensible for naive subjects, or for children who are still illiterate, or for disabled who may have vision problems.

The overall appearance of a product is a combination of its chromatic attributes and its geometric attributes. Both types of attributes should be taken into account for making assessments of appearance. Particularly, the physical shape of a product plays a critical role in its market success. The manipulation of product shape is therefore an important way through which designers communicate messages and elicit affective responses from consumers (Hsiao et al., 2006). The shape can evoke specific affection when customers have contact with a specific product, which is a common psychological response of a customer to the semiotic content of product (Luo et al., 2012). For this reason, hundreds of studies have been conducted to investigate the relationship between a wide range of product shape and the affective responses, using Kansei Engineering or other methods (Lee and Chang, 2010; Shang et al., 2000; Chuang et al., 2001). Retrieving customer's affective response promptly and efficiently using such information in the process of product shape manipulation is significant.

In this context, we are interested in the characterization of user emotions and issues concerning their measurement. The objective of our work is to understand users' perceptions and emotions about the product and to translate them into the design attributes of the product. The work has its roots in the Affective Design and Kansei Engineering philosophy. A new method of emotion measurement is proposed and illustrated with a product shape case study involving user-tests. Next, we build up computational models of the users' emotional responses to different shape factors of the product. To verify the effectiveness of our method, we also compare the results with the Semantic Differential Method.

In this paper, we describe the two user-tests we carried out, applied to the perception of eyeglass frame 3D digital models, given by their pictures. In Section 2, we present the description of materials and methods. Section 3 presents the analysis of the results. Conclusions and perspectives are drawn in Section 4.

2. Materials and methods

The overall framework of the whole research process is shown in Fig. 1. The whole methodology can be described in three main stages. The outcome of a previous stage contributes to the next stage. Firstly, after selecting a product that constitutes the theme of the research (in our case eyeglass frame), four tasks are prepared for the experiment: definition of the design factors of the product, definition of the experimental design, 3D model