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Evaluating the effect of interactions between appearance-related product designs and facial characteristics on social affectivity

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ABSTRACT

For products that can improve the appearance of the user, such as facial accessories, both the characteristics of the product user and design features must be considered in design evaluation. This paper proposes an experimental evaluation scheme that investigates the interactions between the design features of 3D eyeglasses frames and user facial characteristics. Face models of users containing both geometric and image data were constructed using 3D scanning. A face deformation method was developed to manipulate individual facial features without changing the other features on the face models. In the evaluation scheme, participants judged synthetic faces, which had varied eye distances and orientations and were wearing factorized eyeglasses frames, according to three affective measures related to the personality attributes of confidence, friendliness, and attractiveness. The experimental results show that changing certain design features influences the impressions of the face models with varied facial characteristics. The proposed scheme facilitates designing products that strengthen the impression of specific personality traits by accommodating individual differences in facial features.

Relevance to industry: The evaluation scheme proposed in this paper facilitates designing products that strengthen the impression of specific personality traits by accommodating individual differences in facial features. By the scheme, companies can create products and services that satisfy individual customer requirements of personalized design.

1. Introduction

Design prototype evaluation is essential for successful new product development. The evaluation results often serve as a valuable input for identifying the necessary design modifications to fulfill user requirements. Regarding products that help to enhance the appearances of their users, such as facial accessories, the characteristics of the users are as vital as the product design features and should be examined simultaneously. The product studied in this paper, the eyeglasses frame, is strongly associated with facial characteristics. Although they were originally used as a tool to treat sight problems, it is not uncommon to see people, some of whom have perfect vision, wearing eyeglasses to change or enhance their facial appearance.

In Langlois and Roggman (1990), the term “attractiveness” was first used to measure the aesthetics of human faces. Langlois' team collected photographs of female faces and asked a group of adult participants to rate the attractiveness of each face. A similar method was used in a later study by Slater et al. (Slater et al., 1998). Researchers have applied image processing and morphing techniques to produce an ideal face model such as the “average face” in Langlois and Roggman (1990) and Komori et al. (2009) or the “symmetrical face” in Koehler et al. (2002). The synthesized faces were considered more attractive than other unaltered faces. Numerous researchers have focused on the social aspects of facial recognition and believe that facial characteristics provide a critical guide to personality attributes (Hassin and Trope, 2000). Evidence exists showing consistencies between self-reported and perceived personality attributes when the human face is the only source of information (Penton-Voak et al., 2006). By extrapolating from facial images, Perrett et al. (1998) found that the masculinity of faces is related to the degree of dominance of the face owner.

Kansei engineering ([a]Nagamachi, 1995), developed by Nagamachi in 1990s, is a widely adapted approach for analyzing a user's affective responses towards the design features of a product ([b]Nagamachi, 2002). The semantic differential (SD) method

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(Osgood and Tannenbaum, 1957) is commonly used in Kansei engineering studies to elicit users' affective responses, which are recorded using the levels of user agreement on a group of bipolar adjectives describing the design features of a product (Hsiao et al., 2010). Kansei engineering has been applied to investigate a wide range of product design issues, from the design of small products, such as consumer electronics (Chuang et al., 2001), to large products such as car interiors (Jindo and Hirasago, 1997) and industrial machinery (Nakada, 1997). Lo and Chu (2009) proposed a parametric approach that explicitly defines the profile of 3D eyeglasses frames as Bézier curves to study users' affective responses regarding the profile variations. This approach enabled predicting a user's affective response by using regression models that were parameterized according to the design factors of the frame profile. Lu and Petiot (2014) proposed a new emotion measurement method that uses auditory stimuli and association tests for evaluating eyeglass frame designs. Experimental results validated that this method is a good alternative to conventional semantic differential approach in capturing emotional responses of product users. These studies address the relationships between design features and affective responses. However, most studies did not focus on the relationship between product designs and a person's appearance. In a subsequent study, Lo and Chu (2014) suggested using socially-oriented affective measures to evaluate appearance-related products. Facial shape was included in their study to investigate how the design of eyeglasses frames influences the appearances of different facial shapes. Mochimaru et al. (2008) developed a Kansei model that estimates the impression ratings of various combinations of representative faces and spectacle frames. 96 images (8 face models × 12 frames) were shown to 75 female observers and impression ratings for 14 adjective words were obtained for each image using visual analog scales. It is not clear whether those representative face models were created by varying facial features or how the face models with different features were generated. They (Mochimaru et al., 2008) developed an eyeglass frame recommendation system based on the experimental findings. This system suggests a proper frame size based on the measured 3D face shape of an individual user and reports on the impression ratings of specific affective responses created by wearing a selected eyeglass frame on the individual face.

This work attempts to bridge the research gap in prior studies from two perspectives. Most of the digitally manipulated faces in the mentioned studies were presented as 2D visual stimuli. Whether the experimental results that were based on 2D images can be generalized to 3D products remains an issue for research. Because of the advance of 3D scanning technologies, realistic 3D face models of product users can be constructed and rich information can be employed as visual stimuli in product evaluation. These scanned models contain both geometric and image data that enable modifying the models with a high degree of flexibility. Synthetic 3D face models are produced by deforming individual facial features without changing other facial features. Using this deformation mechanism, we investigated the interactions between appearance-related product designs and the facial characteristics of the product users in this study. Using the eyeglasses frame as the target product, an evaluation scheme was proposed to examine whether and how the frame designs interacting with two facial characteristics affect the impression of specific personality traits. In a factorial experiment, participants judged deformed face models, which had varied eye distances and orientations and were wearing the factorized eyeglasses frames, according to three affective measures, namely confidence, friendliness, and attractiveness. The experimental results reveal how accommodating individual differences in facial features can enhance product designs related to user appearance.

2. Evaluation scheme

The proposed evaluation scheme is based on the concept of Kansei engineering and was conducted in the form of a factorial experiment (Montgomery, 2006). This experimental technique allows the simultaneous study of the effects of multiple independent variables, which are manipulated by adjusting the predefined levels of selected factors. Therefore, examining how the variables individually and interactively influence the participants' responses is possible. The factors investigated in this experiment include the facial characteristics and design features of the eyeglasses frames. The responses are the perceived levels of the selected affective measures.

The proposed scheme contains five steps, as shown in Fig. 1. A face shape classification test was first conducted to identify the most representative faces from a group of subjects. The 3D face models of the identified people were captured using a 3D face scanner. Next, we estimated the minimal changes that the participants could recognize from the changed facial features. These changes determined the parameter settings in the later affectivity measurement. The factorized face models and the eyeglasses frame models were created according to these settings. The same group of participants participated in the affectivity measure experiment and its experimental results were analyzed statistically. Each step is explained in detail in the following sections.

2.1. Representative face models

The first step of the evaluation scheme was to select representative 3D face models for affectivity measurement. We recruited a total of 70 college students (35 males and 35 females) from 18 to 25 years of age to participate in the face selection. A frontal photograph was taken for each student, who exhibited a neutral facial

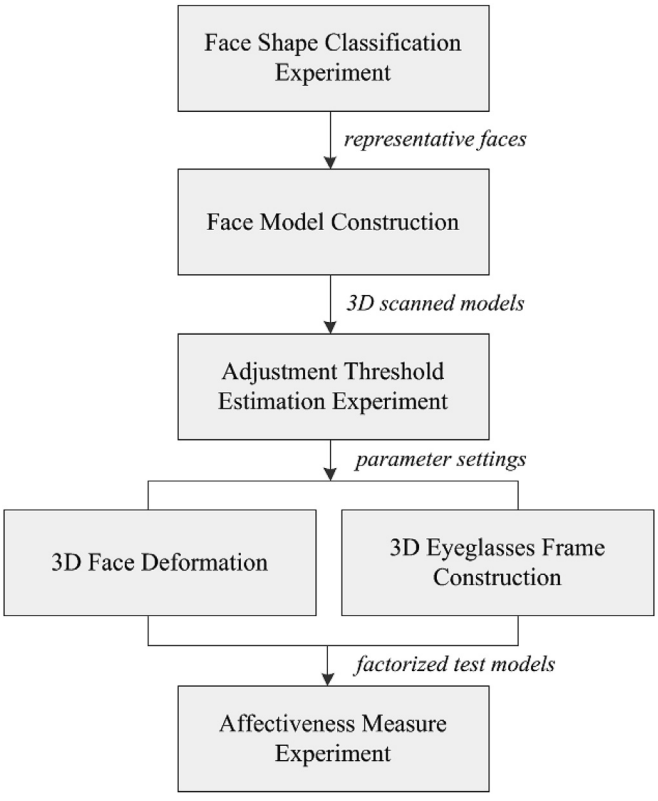

Fig. 1. The proposed evaluation scheme.