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EMG and GSR signals for evaluating user's perception of different types of ceramic flooring

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ABSTRACT

Most product evaluations rely on questionnaires to convert subjective data, or user opinion, to objective data. However, some users may feel inhibited or unable to decide in cases where product differences are very subtle. Other techniques such as physiological measurements can contribute to the understanding of perceptions by incorporating measurements that do not involve conscious processes. This paper presents the results of a research project concerning the use of three biosignals for evaluating user perception: electromyography (EMG) activity of the zygomaticus major, EMG of the corrugator supercilii, and galvanic skin response (GSR). These signals were recorded in the subjects while three calibration images (neutral face, smiling face and frowning face) and eight ceramic flooring images were being projected. The results revealed that types of ceramic tile flooring can be differentiated by GSR values, creating two groups elicited by the users' emotional response. On the other hand, significant differences were found in the EMG signals, especially in the zygomaticus major, elicited by the calibration images. The results indicate that the analysis of this type of signal has a potential use in the understanding of product perception. The results provided by the recording of zygomaticus major signals while subjects observed the calibration images show that the smiling face image elicited positive activity of the zygomaticus major.

Relevance to industry: Identification of the aspects of product design that are considered to be the most important to potential users is an essential field for many industries. Numerous methodological techniques have been developed to try to understand these processes, nearly all of which are based on user opinion. However, it seems clear from a scientific point of view that subconscious processes play an important role in the aspects relating to perception and decision-making. This paper proposes a feasible approach using non-invasive physiological measurements.

1. Introduction

1.1. Emotional design

Since people use products to accomplish their goals and satisfy their needs, one of the issues involved in design and manufacturing is trying to fit product specifications with user goals and needs. This is one of the main objectives of user-centered design (Gould and Lewis, 1985). The usual approach in product development describes the influence that a product has on the user through customer satisfaction. That approach says little about what actually happens in the interaction between user and product. A more profound description would take into account how the product makes the user feel. If, for example, we look at dissatisfaction, it could be used to describe anything that does not please the user. The customer may be irritated or disappointed. By looking at the characteristics of user–product interaction one by one rather than in combination, we can derive more useful information that could help us in developing new products. Several other authors have also addressed this topic, some of the more noteworthy being Nagamachi (1995), Desmet (2002), Jordan (2000), Norman (2004) and Picard (1997).

Emotions play an important role in product design. Users' perception of any product or service can be obtained by analyzing their feelings. This analysis can be obtained by using either quantitative or qualitative methods.

One example of a quantitative method is that used by Kansei Engineering (Nagamachi, 1995), which describes the relation between users and products by looking at how different design attributes correlate with the feelings of users. It was developed in Japan in the 1970s and was defined by its creator Nagamachi as a technology for translating consumer feelings and images of

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a product into design elements. Products are evaluated on semantic differential scales (Osgood et al., 1957) and also categorized with respect to their attributes (e.g. color and shape). Statistical methods are then used to find correlations between attributes and perceived expression or users' feelings. These statistical data are used in the development of new products to make inferences from the feelings elicited by the properties of a new design. Another quantitative method is conjoint analysis, which measures consumer preferences on the attributes of a product or service (Aaker and Day, 1986). Conjoint analysis data can be recorded using two different methods: the two-factor-at-a-time tradeoff method or the multiple factor full-concept method.

An example of a qualitative framework is that suggested by Jordan (2000), who suggested a hierarchy of product appreciation similar to Maslow's (1968) hierarchy of needs. In Jordan's hierarchy the basis is functionality; the second level in the hierarchy is concerned with usability. The third and final level is denoted "pleasure" and has to do with appreciation based on aspects that are harder to anticipate, e.g. cultural values and personal preferences. Jordan quotes Tiger's (1997) framework of four pleasures and describes how products can evoke social, ideological, physiological or psychological pleasures. As competition increases, it becomes more important to meet the higher objectives in the hierarchy. Speaking solely about different pleasures may be limited, and provides only slightly more information than an approach focusing on satisfaction or delight. In reality, humans display a wide variety of different emotions in relation to product interaction, and these emotions may influence both the general well-being of the user and the purchase decision. Desmet (2002) studied emotions in relation to images of products and developed an instrument to measure seven unpleasant emotions (indignation, contempt, disgust, unpleasant surprise, dissatisfaction, disappointment, and boredom) and seven pleasant emotions (desire, pleasant surprise, inspiration, amusement, admiration, satisfaction, and fascination) in relation to product appearance.

1.2. Emotion analysis using biosignals

Most of the methodologies described in the preceding section rely on questionnaires that try to convert subjective data (user opinion) into more objective data. However, these methods are insufficient and depend heavily on individual circumstances. On the one hand, users may have problems in deciding between two products because the differences are very subtle or because the decision is rather complex. On the other hand, users may deliberately modify their opinion if they do not want to express their true feelings, feel inhibited, or feel unconsciously influenced by the experimenter (Czerwinski et al., 2001; Nielsen and Levy, 1994). Unconscious processes affect decision-making processes (Tversky and Kahneman, 1973) and the decision-making process also has an implicit stress component (Regueiro and León, 2003) that can distort the user's opinion.

User perception is highly linked to user emotion. If one product makes a good impression on a user then it will elicit positive emotions. Therefore, user preferences can be understood by analyzing user emotions.

There are two main theories regarding emotions: categorical appraisal and dimensional appraisal. The first describes emotions as discrete elements: there is a set that describes all possible emotions. Dimensional appraisal describes emotions as points that can be located in a multidimensional space, usually a plane (two dimensions). However, within the dimensional appraisal, there are different representations. Two of the more accepted are arousal and valence (Cacioppo et al., 1993), and arousal and approach withdrawal (Coan and Allen, 2004). In both representations, the arousal parameter represents emotion activation and is similar to emotion intensity. Valence determines whether emotion is positive or negative. On the other hand, approach withdrawal determines whether emotions make that person tend towards the cause of the emotion or not.

The dimensional approach is especially suitable for emotion recognition using physiological signals. During the last decade, researchers have employed different body signals based on a dimensional appraisal, depending on the kind of emotions. The most widespread are electromyography (EMG) signals, heart rate (HR), blood pressure (BP), galvanic skin response (GSR), electroencephalography (EEG), temperature, and respiration rate (Berntson et al., 1993). Some studies have reported relationships between GSR and the level of arousal (Lang, 1995) and other studies associated fear with high levels of tonic excitation and high-phase skin conductance (Lanzetta and Orr, 1986).

Within EMG measures, facial EMG measures are the most commonly used for emotion recognition. Facial EMG is useful in studies of emotions that are so weak that facial action coding is insensitive (Cacioppo et al., 1990). There are two muscles involved in emotion recognition: the zygomaticus major, related to smiling, and the corrugator supercilii, related to frowning. Schwartz was the first researcher to relate both muscles with emotions. He and his colleagues noticed that unpleasant images elicited greater activity of the corrugator supercilii and pleasant images elicited greater activity of the zygomaticus major (Brown and Schwartz, 1980; Schwartz et al., 1976a, b). Some researchers have noticed higher activity of the corrugator supercilii with unpleasant images than zygomaticus major with pleasant images (Lang et al., 1993; Larsen et al., 2003). Furthermore, EMG variation depending on the valence is linear and negative in the corrugator, but is a J-shaped function in the zygomaticus (Greenwald et al., 1989). If emotional intensity increases, then EMG activity tends to increase. Nevertheless, this is not completely clear, because some researches suggest that it happens especially in the corrugator, while others suggest the opposite (Witvliet and Vrana, 1995). Cacioppo et al. (1986) suggest that EMG facial can differentiate both valence and intensity.

Different signals and methods have been used, with both advantages and disadvantages, but it is necessary to combine different measurements to improve the results. For example, HR increases more for anger, fear, and sadness and decreases for disgust. Finger temperature increases for anger and decreases for fear and surprise (Ekman et al., 1983). Another approach uses ECG, EMG, respiration, and skin conductance as a stress detector (Healey and Picard, 2000) or uses skin conductance and HR for analyzing happiness, sadness, and neutrality by means of films (Gross and Levenson, 1997) or uses EEG, electrooculogram signals (EOG), ECG, and HR for evaluating the mental workload during a dual task (Ryu and Myung, 2005). Following this tendency, our research will use EMG and GSR signals.

Although researchers have achieved acceptable results in emotional research with facial EMG and GSR signals, their application for evaluating products is not widespread. The main problem is the low-emotional charge of certain products such as types of floor covering. These products elicit low-level signals that make analysis and classification difficult.

The main purpose of the work presented in this paper was to check the capacity of facial EMG signals and GSR signal to evaluate ceramic flooring.

2. Materials and methods

2.1. Participants

Eight participants, four women and four men with ages between 24 and 30, took part in the study.