Valence of User's Emotion for Product Appearance based on Facial Electromyography

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ABSTRACT

Some research had shown that there is a certain relationship between product appearance and users' emotion. The researches on users' emotion (feeling) have become one of the focuses in product design and human-machine interaction in recent years. Although emotion recognition has developed more mature in the field of psychology until now, the research on emotion awakened by visual elements such as product appearance is rarely involved. The existing methods of emotion recognition and measurement are more likely to show the states of arousal, interest, mental workload and so on, but difficult to distinguish the positive and negative valence of emotions. Now facial expressions had become a generally accepted way to directly identify specific emotion types. While fEMG measurement would be more suitable for subtle and non significant emotional state. In our study, two groups of experiments were carried out. In the Experiment 1, the different types of product appearance pictures were used as stimuli and in Experiment 2, a pair of product appearance pictures with significant differences in beauty were used as stimuli. The fEMG in the zygomaticus major muscle and corrugator supercilii muscle were collected when the participants watched the pictures of product appearance. After comparison, the root mean square (EMG_RMS) of fEMG was selected as the characteristic value to distinguish the valences of user's emotions to product appearance. The two groups of experiments showed: when the conditions were strictly controlled, the characteristic value of the zygomaticus muscle will increase significantly when the participants watched the pictures of product appearances with high preference. In the case of more than 80%, the increase of EMG_RMS in the zygomatic major muscle could show users' positive emotion to the product appearance. On the other hand, the characteristic value of the corrugator supercilii muscle might increase when the participants watched the pictures of product appearances with low preference. In the case of more than 75%, the increase of EMG_RMS in the corrugator supercilii muscle could show users' negative emotion to the product appearances.

Key Words: Facial Electromyography (fEMG), Valence, Emotion, Product Appearance

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Introduction

Some research had shown that there is a certain relationship between product appearance and user's emotional experience, such as some strong emotions can be awakened by product appearance, of which some are positive, some are negative (Lin *et al.*, 2006). Because of the great relevance between user's emotion and product appearance, its research has become one of the focuses of product design and human-machine interaction in recent years. At present emotion recognition has developed more mature in the field of psychology, but it is mainly the fundamental research on basic emotion and extreme emotion or applied research on human-computer interaction process. While the research on emotion awakened by visual elements such as product appearance is rarely involved after the peak period of experimental aesthetic research. Not only because the difficulty brought by interdisciplinary research, but also because that user's emotion to product appearances is a

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compound emotion, which may be a user's spontaneous arousal of the novelty stimulation of the appearances, or the emotion aroused by user's cognitive evaluation. The emotions are usually not so strong and sometimes even too subtle to be clearly noticed and expressed. All of these increased the difficulty of experiment and research. Therefore, recognizing user's emotion to product appearances quickly and accurately, is not only the urgent need of the fields of design and user research, but also a valuable attempt to identify the delicate and complex compound emotion.

Emotion is a person's attitude experience and corresponding behavior to objective things which contains three parts: subjective experience, external performance (mainly expression) and physiological arousal. The physiological and psychological mechanisms of emotion are very complex, James-Lange (1880's), Cannon-Bard (1929), Papez (1937), MacLean (1949), and Schachter-Singer (1962) all proposed the mechanisms of different human emotions (Meng, 2005). Although there is no uniform definition of emotion yet, it is common understanding that emotion is bound to be accompanied by a series of physiological changes which are controlled by the autonomic nervous system and the endocrine system. At present, the main methods of emotion recognition and measurement include: self-report (scale and questionnaire), autonomic nervous system (ANS) measurement, behavior measurement (speech, facial expression etc.) and brain measurement (EEG and neuroimaging) rising in recent years. The latter three ways all mainly tend to collect physiological indexes.

Dimensional models of emotion attempt to conceptualize human emotions by defining where they lie in two or three dimensions, for example H. Schlosberg (1954) put forward three dimensions of human emotion, including "pleasantness–unpleasantness", "attention–rejection" and "level of activation" and Izard (1977) puts forward four dimensions: pleasure, intensity, excitement and confidence (Izard, 1977). Among them, valence and arousal intensity are the most common dimensions in the dimensional models, which are also the main basis for emotion recognition. But in previous research, recognizing the valence of emotion is always difficult. The dimensions of arousal, attention and psychological load etc. are easier to be measured by the physiological indicators controlled by autonomic nervous system, such as GSR, ECG, impedance and respiration. Schachte and Singer (1962) had proved physiological changes are sure to occur in the occurrence of the mood, but they are not the determinant of emotion. Moreover Artificial autonomy arousal cannot produce emotional experience and it also cannot distinguish the diversity of emotions. Correspondingly, facial expressions show innate consistency with specific emotion and thus generally become an accepted way of directly using to identify specific emotional types.

Expression is an important non-verbal behavior for human to express their emotions. Human expressions include not only the regular facial expressions, but also the weak expression and micro-expression (duration of only 1/25~1/5 seconds). Izard and some other scholars believed that facial expression is the part of emotion. Moreover the evolution of cerebral cortex and the fine differentiation of facial skeletal muscle system are the same process, so some emotions are innate. The researches on inborn blind infant and inter-cultural facial expression (Ekman, 1984) proved that human beings are born with 8~10 basic emotions. Izard proposed the neural mechanism of emotion: when the organism is stimulated, the limbic system and sensory cortex are activated and the activation state of the nerve process are changed. Then the hypothalamic is affected and The hypothalamic and the basal ganglia activate the innate pattern of specific emotions. Through the seventh pairs of cranial nerves, the neural information in cortical motor area which adjust surface expressions are organized and the specific facial expressions will engender. Through the trigeminal nerve and passing the rear hypothalamus, the nerve impulse in facial expression activity reaches cortical sensory area to realize the feedback of facial movements. The cortical integration of facial motion feedback produces emotional experience (Ekman, 1992; Izard, 1971; Han, 2017) (Figure 1).

The collection of facial expression is easier than the collection of other physiological indexes, so the researches have a long history and the results are very rich, especially on the ordinary expressions (Ekman and Rosenberg, 2005). The researches of facial expressions are mainly divided into two categories. The first is the direct evaluation and recognition of facial expressions. In these researches, the component coding system is usually used to evaluate. All muscle activities that can be observed on the face (such as sip mouth, raise brows and so on) are measured and they are evaluated according to the coding system. P. Ekman and W. V. Frisen (1978, 1992) put forward a set of Facial Action Coding System(FACS) in which 44 action units (AU) are used to describe the changes of facial expressions. It is a common standard to systematically categorize the physical expression of emotions. Since then, the researches on facial expression coding system had been very active. MIT, Carnegie Mellon University, University of Maryland, University of Pittsburgh as well as Chinese Academy of Sciences, Tsinghua University and other institutions had carried out related researches and set up a number of human's facial expression databases.

However, analyzing facial expressions by artificial evaluation directly is too subjective and it not suitable for subtle and non significant emotional state. Izard believes that facial expressions occurs instantaneously, so people often fail to perceive the nerve sensation of the facial muscles movement and what they feel are the anger or pleasure experience itself. And in some unusual conditions, some expression feedback cannot reach the consciousness, that is, people can have an expression without experience. Therefore, facial electromyography(fEMG) is better than direct observation of facial expression to recognize non significant emotional changes. Facial electromyography is a bioelectrical signal generated by muscle groups' activities related to emotions (Verma and Tiwaiy, 2013), which can indicate the emotional states (Cheng *et al*., 2014; Capresso *et al*., 2012).

fEMG often can be measured in two positions: (1) Zygomaticus major muscle. Its changes are associated with smile, which may be related to positive emotion. (2) Corrugator supercilii muscle. Its high muscle electrical response may be regarded as the negative emotion and the low muscle electrical response may represent the positive emotion, which may mean people are more relax (Bradley and Lang, 2000). Schwartz *et al*., (1976,1978) asked the participants to imagine their positive and negative emotional events in their lives and measured their fEMG. They found that people showed more EMG activities in Corrugator supercilii muscle when they imagined the sad events than the happy events and less EMG activities in Zygomaticus and its surrounding muscle groups. Schwartz *et al*., (1979) found that people showed more EMG activity in Zygomaticus muscle and less EMG activity in Corrugator supercilii muscle with positive emotions than negative emotions. The EMG activity in zygomatic muscle was the highest when people were happy, while it also increased when they felt fearful and anger. EMG activities in forehead and chin were not obvious during the experiments. Katsis *et al*., (2008) also proved that the physiological signals such as heart rate, skin conductivity and fEMG would change when people were in the states of disgust, happy, anger and pleasure.

Based on the above researches and theories, our study tries to identify the valence of users' emotion for product appearance by measuring the participants' fEMG, thus providing a theoretical basis for the scientific evaluation of product appearances and exploring the way to identify the natures of non significant compound emotions by fEMG.

An experimental study of the valence of user's emotion to product appearance based on fEMG

Acquisition of facial electromyography (fEMG)

fEMG is the bioelectrical signal released by the neuromuscular activity in the autonomous movement of human body. It is the comprehensive expression of the superposition of bioelectrical signals on the epidermis in time and space, which was generated by the activity of the muscular activity under the epidermis (Hao, 2014). Its main characteristics are low frequency, weakness and individual differences (Cheng, 2011). Facial electromyography is a weak electrical signal, and its peak-to-peak value is

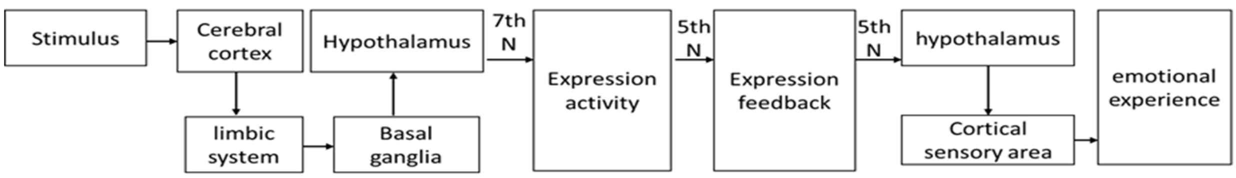

Figure 1. The model of facial feedback activating emotion proposed by Izard

generally only 0~10 mV. The valid energy of the signal is in the frequency range of 0~500Hz, and most of the energy is between 50 Hz and 150 Hz.

In our study the BioLab psychological and behavioral synchronization recording system produced by MindWare Technologies Ltd. was used to collect the EMG signals of the zygomatic major muscle and corrugator supercilii muscle of the participants (Figure 2, figure 3). During the experiment, as shown in Figure 3, adhesive bandages are used to fix the electrodes on the face in order to prevent the electrodes from loosening or even falling-off. Since the participants would feel discomfort at the early stage when the electrodes were stuck on their faces, which might affect the experimental results, we used to stick the electrodes half an hour before the experiment and allowed the participants to adapt them and relax for a period of time.

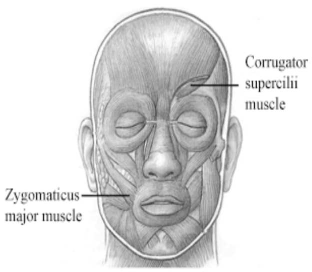

Figure 2. The common measuring parts of fEMG

Figure 3. The parts of collecting the fEMG signals in the experiment

Experiment preparations

There is a correlation between the level of EMG, human age and physical activity, so the participants with the similar age were selected in the experiment. Moreover, if the participants were in the excited state, for example, just after running, they would be asked to rest for a while to calm and then be tested. A total of 18 participants including 8 boys, 10 girls, with ages between 19 - 25, were recruited in the experiment. They were required to be physically and mentally healthy, with normal eyesight or correct visual acuity and no color blindness or color weakness.

The three types of consumer products, including headphones, coffee machines and humidifiers, which are highly depend on appearance and college students were more familiar with, were selected as stimuli. For each type, 5 different products' appearance pictures were selected as stimuli and all the products had already been in the market. In order to avoid the influence of irrelevant variables such as brand and price, the camera angle, size and background of each pictures would be treated as similar as possible. The logos and texts on the products' surfaces were removed as well (Table 1).

Experimental procedures

Before the experiment, the participants were asked to fill in the informed consent, including their name, gender, profession, age and other basic information. They were also introduced the experimental procedures, considerations and the principle of collecting fEMG, making them fully prepared, adapting to the electrodes and being relax, which could ensure the smooth progress of the experiment. In addition, in order to reduce the interference factors of the national current, the time of the experiment began at about 7 p.m.

At the beginning of the experiment, the BioLab system was connected. The vertical camera is on the participants' face and synchronously collected the expressions of the participants when they watched the stimulus materials along with the BioLab system. The value of the sampling rate was set to 1000Hz and the noise reduction was EMG noise reduction. The experiment began after the waveform of the EMG signals was normal.

In the experiment, the stimulus pictures were played on the other computer. 5 pictures of each product type were played in the form of PPT, each of which was shown for 15 seconds with a 10 seconds black screen inserted between two adjacent pictures. In order to avoid speech changing the fEMG signals, an opening guide was added on the front of the pictures and an closing remark was added after 5 pictures. Finally, a slide containing thumbnails of 5 pictures was shown to the participants and they were asked to select the most favorite 1~2 appearances from the 5 product pictures(a~e in Table 1) and fill in the questionnaires. Furthermore, after watching the stimulus pictures of a product type, the participants would rest for at least half an hour

Table 1. The stimuli for experiment 1 (five pictures of the three types of products)

	a	b	c	d	e
Humidifiers					
Headsets					
Coffee machines					

before they started the next round of experiment until all three types of products were completed.

Experimental data processing and feature extraction

After collecting the fEMG signals, the invalid data would be removed according to the collection records and video records, such as the electrodes fell off or the participants coughed. Finally 18 groups of valid EMG data for the type of humidifiers, 17 groups o for the type of headsets and 12 groups for the type of coffee machines were obtained in zygomatic major muscle; 11 groups of valid EMG data for the type of humidifiers, 12 groups for the type of headsets and 10 groups for the type of coffee machines were obtained in corrugator supercilii muscle.

Because fEMG signals were very weak, there could inevitably be a variety of interference signals during the acquisition process, which would have a great influence on the application of EMG signals. Therefore, we needed to eliminate or reduce these noises by various means (Li and Wang, 2017). Through a series of comparative studies, the Sym8 wavelet function and three-scale wavelet decomposition were selected to reduce noise. In addition, the signals after noise reduction was filtered through the notch filter to filter the 50 Hz power frequency interference.

Due to the individual differences in the facial EMG, the EMG signals of each subject should be standardized. That is to say, the fEMG of the participants in watching pictures subtracted the average values of fEMG of the participants in the calm state. As shown in formula (1):

$$X_0 = Xe - Xc \tag{1}$$

Among them, X_0 were the standardized EMG data, Xe were the EMG data collected when the participants watched the pictures and Xc were the mean values of EMG when the participants watched the black screens.

After the original EMG signals were processed by noise reduction and standardization, it was necessary to extract various characteristic values for analysis. In the previous related literatures, researchers had extracted many characteristics from the physiological signals, including time domain, frequency domain and nonlinear characteristics etc. (Vrijsen *et al*., 2013; Valenza *et al*., 2013). In the experiment, we mainly choose the time domain characteristics of fEMG for analysis. The time domain analysis of EMG signals is to regard the EMG signals as a function of time and to calculate the means amplitude histograms of the signals value to reflect the changes of signal amplitude in time dimension. The common used characteristics included the means value, the maximum and minimum values, the integral electromyography value (iEMG), the root mean square value (RMS), the mean square deviation and the median etc. (Liu *et al*., 2015; Wu *et al*., 2010). Through the pre-analysis, RMS was chosen as the statistical characteristic and it was recorded as EMG_RMS.

Table 2. One-Way ANOVA for the zygomatic major muscle EMG_RMS of the 5 headsets

Source	SS	df	MS.	F	P-value	F crit
Between Groups	0.000028	4	0.000007	2.5951	0.0425	2.4859
Within Groups	0.000215	80	0.000003			
Total	0.000242	84				

Note: The level of significance is 0.05

Table 3. Multiple comparisons analysis for the zygomatic major muscle EMG_RMS corresponding to the 5 headsets appearances

(I) Picture Letters	(J) Picture Letters	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
a	b	-0.001129	0.000562	***0.048***	-0.002247	-0.000011
	c	-0.000251	0.000562	0.656	-0.001369	0.000867
	d	-0.000288	0.000562	0.609	-0.001406	0.000829
	e	-0.001485	0.000562	***0.010***	-0.002603	-0.000367
b	a	0.001129	0.000562	***0.048***	0.000011	0.002247
	c	0.000878	0.000562	0.122	-0.000240	0.001996
	d	0.000840	0.000562	0.139	-0.000277	0.001958
	e	-0.000356	0.000562	0.528	-0.001474	0.000761
c	a	0.000251	0.000562	0.656	-0.000867	0.001369
	b	-0.000878	0.000562	0.122	-0.001996	0.000240
	d	-0.000038	0.000562	0.947	-0.001156	0.001080
	e	-0.001234	0.000562	***0.031***	-0.002352	-0.000117
d	a	0.000288	0.000562	0.609	-0.000829	0.001406
	b	-0.000840	0.000562	0.139	-0.001958	0.000277
	c	0.000038	0.000562	0.947	-0.001080	0.001156
	e	-0.001197	0.000562	***0.036***	-0.002315	-0.000079
e	a	0.001485	0.000562	***0.010***	0.000367	0.002603
	b	0.000356	0.000562	0.528	-0.000761	0.001474
	c	0.001234	0.000562	***0.031***	0.000117	0.002352
	d	0.001197	0.000562	***0.036***	0.000079	0.002315

**. The mean difference is significant at the 0.05 level.*

After extracting the characteristic value, there were 84 valid data in the three product types and each group contained 420 EMG_RMS data corresponding to the 3X5 pictures.

Data statistics and analysis

Matlab 2012 was used to calculate the characteristic values (EMG_RMS) and then One-Way ANOVA was used with SPSS to verify whether there were significant differences in EMG_RMS of each appearance pictures of every product type. The statistical methods of the three product types were the same and here took the earphone product as an example.

(1) Difference test of EMG_RMS corresponding to the appearance pictures of each product type.
The appearances of the headsets were used as the independent variable and 17 groups of the participants' zygomatic major muscle EMG_RMS were used as dependent variable to carry out the One-Way ANOVA. The null hypothesis H_0 was: there was no significant difference in the participants' zygomatic major muscle EMG_RMS of the 5 headsets appearances. The results of one-way ANOVA for the zygomatic major muscle EMG_RMS were shown in Table 2.

F=2.5951 > F crit=2.4859, P-value =0.0425 < 0.05, therefore the original assumption that H_0 is not accepted and the appearances of the 5 headsets can cause significant difference in EMG_RMS of zygomatic major muscle. The LSD method was used to carry out multiple comparison analysis of the EMG_RMS of every headsets appearances. The result is shown in Table 3 and the mean values of zygomatic major muscle EMG_RMS of the five appearances was mapped as Figure 4.

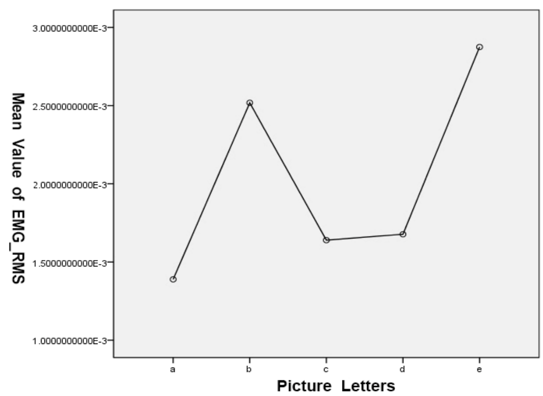

Figure 4. The chart for the mean of zygomatic major muscle EMG_RMS of the headsets

As shown in Figure 4, the average EMG_RMS of headsets b and headsets e are significantly higher than the other headsets, while headsets a was significantly lower than other headsets. From the results of multiple comparison analysis (in Table 3), there were significant differences between the zygomatic major muscle EMG_RMS of headsets a and headsets b, headsets e respectively.

Table 4. One-Way ANOVA of the corrugator supercilii muscle EMG_RMS of the headsets

Source	SS	df	MS	F	P-value	F crit
Between Groups	0.000010	4	0.000002	0.1503	0.9623	2.4937
Within Groups	0.001198	75	0.000016			
Total	0.001208	79				

Note: The level of significance is 0.05.

Then the appearances of the headsets were used as the independent variable and 12 groups of the participants' corrugator supercilii muscle EMG_RMS were used as dependent variable to carry out the One-Way ANOVA. The results of one-way ANOVA for the corrugator supercilii muscle EMG_RMS for the 5 headsets appearances were shown in Table 4. F=0.1503<F crit=2.4937, P-value=0.9623>0.05, Therefore, accept the original hypothesis and there was no significant difference in the corrugator supercilii muscle EMG_RMS for the five appearances of the headsets.

The results of one-way ANOVA (The level of significance is 0.05) of zygomatic major muscle EMG_RMS of the humidifiers are F=2.5897>F crit=2.4790, P-value=0.0424<0.05, so the original hypothesis is rejected, that is, the appearances of the 5 humidifiers can cause significant difference in zygomatic major muscle EMG_RMS. The LSD method is used to carry out multiple comparative analysis of the EMG_RMS for each picture, which shows that the EMG_RMS of humidifiers b was significantly higher than that of the others, while humidifiers a and humidifiers e were significantly lower than other humidifiers. The results of one-way ANOVA (The level of significance is 0.05) of corrugator supercilii muscle EMG_RMS is F=0.2075<F crit=2.5572, P-value=0.9331>0.05, that is, there is no significant difference in the statistical characteristics of corrugator supercilii muscle EMG_RMS for the five product appearances of the humidifiers.

The results of one-way ANOVA (The level of significance is 0.05) of zygomatic major muscle EMG_RMS for the coffee machines are F=3.0954>F crit=2.5397, P-value=0.0228<0.05, so the appearances of the 5 coffee machines can cause significant difference in zygomatic major muscle EMG_RMS. The result of multiple comparative analysis shows that the EMG_RMS of the coffee machines e is significantly higher than that of the others, while the coffee machines b and the coffee machines d are significantly lower than others. The results of one-way ANOVA (The level of significance is 0.05) of corrugator supercilii muscle EMG_RMS is F=0.1121<F crit=2.5787, P-value =0.9776>0.05, that is, there is no significant difference in the statistical characteristics of corrugator supercilii muscle EMG_RMS of the five product appearances of the humidifiers.

In terms of meaning, the root mean square value (EMG_RMS) of the muscle electrical signals

Table 5. The statistics of the EMG_RMS of zygomatic major muscle for the headsets

Participant number	EMG_RMS-1	EMG_RMS-2	EMG_RMS-3	EMG_RMS-4	EMG_RMS-5	Two pictures with the largest EMG_RMS value (from large to small)	The favored pictures filled in the questionnaires	Matching degree
1	0.000724	0.001224	0.000836	0.000745	0.000743	bc	be	0.5
2	0.000191	0.000197	0.000161	0.000159	0.000170	ba	be	0.5
3	0.000131	0.000369	0.000144	0.000148	0.000235	be	be	1
4	0.000395	0.000442	0.001008	0.000469	0.002323	ec	e	1
5	0.000176	0.000449	0.000333	0.000202	0.000365	be	be	1
6	0.000153	0.000198	0.000160	0.000162	0.000346	eb	b	0.5
7	0.001713	0.002327	0.001698	0.001894	0.004218	eb	be	1
8	0.001457	0.005409	0.004470	0.003264	0.005555	eb	be	1
9	0.001472	0.003722	0.001456	0.001203	0.004695	eb	e	1
10	0.001389	0.004971	0.001172	0.001161	0.004542	be	be	1
11	0.001253	0.001650	0.001350	0.001286	0.003200	eb	e	1
12	0.001343	0.003450	0.001407	0.001405	0.003501	eb	be	1
13	0.001339	0.002265	0.001599	0.001448	0.002799	eb	be	0
14	0.001309	0.002417	0.001434	0.001425	0.002204	be	be	1
15	0.003486	0.004557	0.003618	0.003742	0.005928	eb	be	1
16	0.003249	0.003706	0.002976	0.003098	0.003700	be	be	1
17	0.003833	0.005451	0.004054	0.006705	0.004337	db	bd	1

represented the fluctuation of the fEMG when the participants watched the stimulus. The experimental results showed that the zygomatic major muscle EMG_RMS increased significantly

(2) Statistics of matching degree between the EMG_RMS values and user preferences.
The results of the experiments were compared with the results of the questionnaire. Take the headset product as an example. As shown in Table 5, we compared two pictures with the largest zygomatic major muscle (from large to small) EMG_RMS value with the favorite 1~2 pictures that were filled in the questionnaires.

The calculation method was as follows:

When there were 2 favored appearance pictures were filled in the questionnaire, if one of the two pictures was the same as one of the two pictures with larger EMG_RMS value, the matching degree was 0.5; if the two pictures were both the same , the matching degree was 1; if both were different, the matching degree was 0.

When only one favored picture was filled out in the questionnaire, if the favored picture was the same as the picture with the largest EMG_RMS, the matching degree was 1; if the favored picture was the same as the picture with the second largest EMG_RMS, The matching degree was 0.5; The matching degree was 0 in other cases.

After matching the participants' zygomatic major muscle EMG_RMS value and the pictures preferred by the participants in the questionnaires, the matching rates between the zygomatic major muscle EMG_RMS corresponding to each product appearance and the user's subjective evaluation were obtained. The calculation results were as shown in the formula (2). Finally, the matching rate of the headset was 85.29%.

$$(0.5+0.5+1+1+1+0.5+1+1+1+1+1+1+0+1+1+1+1)\div 17\times 100\%=85.29\% \qquad (2)$$

The matching rate of the other two product types were calculated in the same way. The matching rate of humidifiers was 83.33% and the matching rate of coffee machines was 79.19%.

The above results showed that when participants watched the product pictures with high preference, the zygomatic major muscle EMG were significantly higher, while the corrugator supercilii muscle EMG did not show statistical difference in the experiment. According to the when the users looked at the appearances of some products, while the the corrugator supercilii muscle EMG_RMS had no significant difference.

previous literatures, it was speculated that the corrugator supercilii muscle might have a better distinguish effect on negative emotion. We hypothesized that the selected stimulus in Experiment 1 were all more mature listed products with no specific appearances, which could not cause strong negative emotions, so there was no significant difference effect. Based on that hypothesis, Experiment 2 was carried out.

An experimental study of the distinction between users' positive and negative emotion to product appearance

In order to verify whether the fEMG of the zygomatic major muscle and corrugator supercilii muscle can distinguish users' positive and negative emotions when they watch the product appearances, Experiment 2 was carried out with a beautiful harvester and an ugly harvester as stimuli.

In Experiment 2, according to the standard of Experiment 1, 14 college students were recruited includeing 7 males and 7 females, and the appearances of two harvesters in Figure 5 were selected as the stimulus materials.

The experiment procedures was the same as the experiment 1. Two pictures were randomly played to the participants, and the participants' facial EMG signals were collected at the same time. After the play was finished, the participants were asked to fill out the questionnaires and select a more preferred harvesters (a or b). Experiment data processing method, the characteristic value (EMG_RMS) extraction and the statistical methods were the same as Experiment 1 as well. The average value of the zygomatic major muscle EMG_RMS and corrugator supercilii muscle EMG_RMS of the two harvesters were obtained in table 6.

Take the appearances of the harvesters as the independent variable, the zygomatic major muscle EMG_RMS and the corrugator supercilii muscle EMG_RMS separately as dependent variables separately for one-way ANOVA. The results of the single one-way ANOVA (The level of significance is 0.05) of the zygomatic major muscle EMG_RMS showed that F=12.26558>F crit=4.225201, P-value=0.001687<0.05, with significant differences; The results of the single one-way ANOVA of corrugator supercilii muscle

EMG_RMS showed that there was no significant differences at the 0.05 significant level.

a

b

Figure 5. Experiment materials in Experiment 2

Table 6. The Characteristic value (EMG_RMS) of the two products

Characteristic value(EMG_RMS)	Zygomatic major muscle	Corrugator supercilii muscle
Harvester a	0.003011	0.004728
Harvester b	0.008042	0.003283

But at the 0.1 significant level, F=3.7490<F crit=4.2252, P-value=0.0638 <0.1, there was significant differences.

The results showed that the zygomatic major muscle EMG_RMS of the two harvester appearances had significant differences in statistical significance, that is, the average EMG_RMS value of the beautiful harvester was significantly higher. The average corrugator supercilii muscle EMG_RMS value showed no statistically significance at the 0.05 significant level, but there was significant differences at the 0.1 level and the corrugator supercilii muscle EMG_RMS of the ugly harvester increased.

Then compare the picture with the high zygomatic major muscle EMG_RMS value with the participants' favorite picture filled in the questionnaires. The calculation method was: if the picture with higher EMG_RMS value was the same with the participants' favorite picture, the matching degree was 1; If not, then 0. As Table 7 showed, the matching rate of the zygomatic major muscle EMG_RMS was 92.86%. Then compare the picture with the high corrugator supercilii muscle EMG_RMS value with the non preference picture filled in the questionnaire. As Table 8 showed the matching rate of the corrugator supercilii muscle EMG_RMS was 78.57%. The above results confirmed that the characteristic value (EMG_RMS) of the zygomatic major muscle can identify the positive (preferred) users' emotions to the products appearances; and the characteristic value(EMG_RMS) of the corrugator supercilii muscle can also be used to distinguish the negative users' emotions to the products appearances in some degree.

Table 7. The statistics of EMG_RMS of zygomatic major muscle of the harvesters

Participants	Harvester A's EMG_RMS	Harvester B's EMG_RMS	The picture number with the high EMG_RMS	The picture with high preference in the questionnaires	Matching degree
1	0.008095	0.022715	b	b	1
2	0.003460	0.005038	b	b	1
3	0.002163	0.007257	b	b	1
4	0.002394	0.007858	b	b	1
5	0.002620	0.007923	b	b	1
6	0.001402	0.007514	b	b	1
7	0.003804	0.004792	b	b	1
8	0.004820	0.005050	b	b	1
9	0.002243	0.008247	b	b	1
10	0.002172	0.008594	b	b	1
11	0.002271	0.011305	b	b	1
12	0.002438	0.011789	b	b	1
13	0.002822	0.002691	a	b	0
14	0.001445	0.001817	b	b	1

Table 8. The statistics of EMG_RMS of corrugator supercilii muscle of the harvesters

Harvester A's EMG_RMS	Harvester B's EMG_RMS	The picture number with the high EMG_RMS	The picture with low preference in the questionnaires	Matching degree
0.002159	0.002096	a	a	1
0.002717	0.001808	a	a	1
0.008400	0.005156	a	a	1
0.004912	0.005584	b	a	0
0.004984	0.003856	a	a	1
0.003627	0.003715	b	a	0
0.003644	0.003562	a	a	1
0.003798	0.002311	a	a	1
0.003975	0.003552	a	a	1
0.004117	0.002845	a	a	1
0.003968	0.002337	a	a	1
0.001381	0.002741	b	a	0
0.010406	0.004242	a	a	1
0.008103	0.002156	a	a	1

Conclusions

The correct identification of the users' emotion to the product appearance is helpful to the design and evaluation of the product. This study attempts to identify the user's emotional valence to the product appearance through the facial electromyographic signals of the zygomatic major muscle and the corrugator supercilii muscle.

In the study, two groups of experiments were designed. In the first experiment, the three types of products, headsets, coffee machines and humidifiers, which had high dependence on the appearances and were more familiar with the participants, were selected as the stimuli and two kinds of muscle electrical signals were collected when the participants watched the appearance pictures of the products.

The results of the Experiment 1 show that:
(1) the EMG_RMS of the zygomatic major muscle of the different appearances of each product type had significant difference at the 0.05 significant level, but there was no significant difference in the EMG_RMS of the corrugator supercilii muscle.
(2) Compare the appearance pictures with the two highest zygomatic major muscle EMG_RMS with the most preferred 1~2 appearance pictures filled in the questionnaires. The matching rate of the humidifier products was 83.33%, the matching rate of the headset products type was 85.29%, and the matching rate of the coffee machine products was 79.19%. The results showed that the increase of EMG_RMS in the zygomatic major muscle was likely to show the positive emotion experience of the product.

In Experiment 2, a pair of product appearance pictures with significant beauty contrast were presented as stimuli to the participants, and the facial electromyography signals of the zygomatic major muscle and corrugator supercilii muscles of the participants were collected as well. The results of Experiment 2 verified the conclusion of Experiment 1. The zygomatic major muscle EMG_RMS still could show the participants' positive emotion better and the matching rate of the pictures of the preferred products was as high as 92.86%. On the other hand, the corrugator supercilii muscle EMG_RMS also showed significant differences at the 0.1 significant level, and the matching rate of negative emotions reached 78.57%. Therefore, the increased corrugator supercilii muscle EMG_RMS might present the negative emotions of the participants to the product appearances.

To sum up, using the root mean square value (EMG_RMS) of the facial electromyography signals as the characteristic value, is feasible to detect and identify the valence of users' emotion to the product appearance. Under the condition of strict control, the EMG_RMS of the facial electromyography signals of the zygomatic major muscle increased significantly when the participants watched the appearance pictures of high preference. In the case of more than 85%, the increase in the zygomatic major muscle EMG_RMS shows that the participants have a positive emotion on the appearance. Moreover, when the participants watched the disgusting product appearance, the corrugator supercilii muscle EMG_RMS can play a certain distinction. In the case of more than 70%, the increase of the corrugator supercilii muscle EMG_RMS can present the negative emotions of the participants.

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