The Correlation and Appropriateness Between Affect Valence of Consumer and Design Feature: Preliminary Evidence from an Event-Related Potentials Investigation

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Research

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Abstract

Background: Consumer requests in selecting products in recent years have been transformed from the functional practicability to affect request. The affect factors have a great influence on the decision-making process of consumers when purchasing products. This study takes the watch as the research example, discusses the effects and correlation of its design feature to the emotions; the results are supplemented by the objective reflection of measuring brain waves.

Results: Brain wave readings of 16 interviewees with designing backgrounds are recorded, as well as the reflection brain zone and amplitude of the LPC component with the Event-related Potentials (ERPs). The research verified that the shape, percentage, patterns and colors will affect the emotional reactions of consumers' brains.

Conclusions: The research results can promote an ERP measurement tool to detect relevant consumer topics or design research. In addition, the combination and matching of different design elements can also serve as the designing parameters for the innovation of a digit model, as well as raise the systematic emotion design in accordance with the design factors that effectively affect consumers' emotions.

1. Introduction

The design and development targets of designers related to their products have been progressively centralized by the consumers, leading to an increased understanding of consumers' preferred design features of products. However, the products are experiencing decreasing changes with the respect of technical specifications, and the differences in product functions are gradually reduced under the mutual intensive competition of enterprises. The growing focus of consumers regarding the quality of products means that consumers have transformed from seeking satisfaction according to the functions of products to the psychic satisfaction of product image. Purchasing products is no longer a simple function, but some consumer goods enable purchasers to generate emotional fluctuations. Therefore, as far as the consumer is concerned, the product is not only just a tool, but also an emotional connection; the design appearance is also an emotion provoking image (Jordan, 1998). In order to understand consumers' preference for products and their designing methods we need an historical review. In the past, the designers mainly relied on individuals' thoughts to design the shape of products, but they did not comply with the total demands of consumers in the market (Rajapakse et al., 2009). Currently, designers usually create one product for inspiring the visual sense of beauty for potential users through the design elements (e.g. linear, surface and color) and aesthetic principles (e.g. uniformity, contrast ratio, balance and proportion) (Coates, 2003). Some studies prove that the emotions play the important decisive role in purchase decisions (Steenkamp, 2005). Moreover, a sense of beauty featured in the products purchased by consumers also plays a key role in purchase decisions (Hoyer et al., 2012). In the past, the questionnaire measurement method based on the adjectival phrase was mostly applied when discussing the emotional reaction to the products/services of users or consumers (Likert scale). However, the questionnaire results may be affected by the subjective consciousness, e.g. whether the interviewees understand the original meaning of questions, and whether the expression ability of interviewees results in differences related to the content of questionnaires (Wang & Chung, 2017; Jenkins et al., 2009; Lin et al., 2011a, 2011b). Physiological measurement through the heart rate (HR), galvanic skin response (GSR) and electroencephalography (EEG), etc., methods are able to acquire the information. EEG reads the reactions of brain to the information brought by the stimulus, which is relating to the physical activities e.g. identification, comparison, judgment, memory, decision-making, etc. The physiological and emotional reactions have mutual relationships with respect to vision. The brain waves are regarded as a measurement tool for deciding the visual and physical status. In the past, studies identified that the physical and cognitive activities would generate differences in brain waves. This process was able to observe the positive and negative emotional motivation in EEG in seeking to understand the emotional differences (Carretié et al., 2003; Montoya & Sitges, 2006). Therefore, brain waves are appropriate for discussing the reactions aroused by emotional stimulants. This study will objectively examine the relationship between the design elements and emotional reactions to products through the emotion dimension scale and ERP test.

1.1 Emotion dimension measurement

In the emotion dimension scale, valence and arousal are the most common measuring dimensions (Russell, 2003). Valence refers to the degree of happiness. Arousal describes the intensive emotions from calmness to excitement (Russell, 1981, 2003; Lang et al., 2001). Figure 1 displays that the core emotion experience is the coordinate axis comprising the two dimensions of horizontal and vertical, with two dimensions of valence and arousal for judgment and explanation. The horizontal axis is affect valence, which is the degree of negative and positive emotion composed of the Pleasant of positive valence to the Unpleasant of negative valence. The vertical axis is the degree of emotion arousal comprised of the sleepiness aroused from low to the excitement aroused from high, as well as the interactive correlation between the various emotions. Past research indicated that the valence and arousal not only had the emotion memory and different nerves, but also generated some different effects (Mickley, Steinmetz & Kensinger, 2009). Identifying the emotions has the apparent practicality and importance to understand consumer behavior. The effects of emotion handling with the corresponding respect of angle and curve shapes have been supported by the evidence of neurosciences, and highlighted the effects of emotions in the multiple sensory perception handling and shape perception ((Bar & Neta, 2007; Blazhenkova & Melisa, 2017; Brown et al., 2011; Drevets & Raichle, 1998; Palmer et al., 2013; Vuilleumier, 2005). In addition, the subjective valence and arousal class of geometric stimulation are obviously different e.g. the triangle is regarded as the unpleasant and more exciting shape (Armbruster et al., 2014).

Insert Fig. 1 here

1.2 Relevant research on ERP and emotions

Currently, visual emotion stimulation has proven to be able to obtain the different components of ERP, including the relevant early-stage perceptual reaction, EPN (early posterior negativity) component arousing attention (Flaisch et al., 2011; Frühholz et al., 2011; Junghofer et al., 2004; Kissler et al., 2007; Herbert et al., 2008; Schacht and Sommer, 2009a; Recio et al., 2011), as well as the LPC (Late Positive Component) (Flaisch et al., 2008, 2011; Herbert et al., 2008; Recio et al., 2011; Schacht & Sommer, 2009a, 2009b; Schupp et al., 2000, 2004). Therefore, the physiological emotion features may appear in the brain rather than the reaction appearing in the body (Cuthbert et al., 2000). This important reaction information can't be obtained by applying the questionnaire. Observing the changes of brain signals and the main ERP brain components by applying the electroencephalogram is regarded as the reaction of consumer perception (Wang & Han, 2014). ERP has the feature of high time resolution; it is able to better reflect the time flow of neural activity with ERP as the index. In terms of the research on emotions, ERP proven to be able to detect the obvious effects through emotion stimulation (positive or negative) e.g. advertisements, facial expression, etc. (Dolcos et al., 2002). In addition, Berridge & Robinson (2003) point out that the left and right sides of the brain simultaneously produce the living reaction when experiencing the pleasant, which indicates a close relation between the emotions and the brain. Moreover, the usage of a high arousal stimulant matches the positive or negative stimulation; low arousal matches neutral simulation images in discussing the amplitude degree of arousal. The research results indicate that high arousal matches positive and negative stimulants with all emotions reflected by the ERP amplitude of different zones in brain (Olofsson et al., 2008). In addition, ERP can observe the correlation of different elements of products to consumers e.g. the property, brand, advertisement of products; as well, it is able to evaluate the different signals through monitoring the brain activities (Hansen et al., 2010).

1.3 LPC evaluation

LPC is regarded as the component related to the evaluation significance, which is widely applied to the research on emotions (Hajcak, et al., 2006; Hajcak & Nieuwenhuis, 2006; Ito et al., 1998). The positive or negative emotions stimulate LPC of 400–800 milliseconds compared with the neutral stimulation (Flaisch et al., 2008). LPC has the feature of Negativity Bias, which will input more attention resources to the images with threatening negative emotions e.g. violation, sensational, blood, anger, fierce animals, etc. In the research on image perception, the factors affecting the time length of attention are based on difficulty (Rayner, 1998; Rayner & Duffy, 1986), interest or intention (Norton, 1971a, 1971b, 1971c; Yarbush, 1967), as well as curiosity, complexity and incompatibility (Henderson et al., 1999; Loftus & Mackworth, 1978). Long-time eye fixation usually refers to the multiple physical processes (Rayner, 1998). For example, when the observer is observing the objects in an image, the incompatible objects may attract the long-time fixation of eyes in the scenery natural composition (Henderson et al., 1999; Loftus & Mackworth, 1978). Olofsson et al. (2008) believes that the amplitude of LPC depends on the volume of the physical resource configuration of subjects. Many studies find that the amplitude of LPC is higher than the positive emotions and neutral emotions (Ito et al., 1998; Kern et al., 2005; Lang et al., 2001; Wood & Kistley, 2006). Ito et al. (1998) tested the images of positive emotions, no emotions and negative emotions, and identified that the LPC amplitude of the images with negative emotions was the highest, higher for the images with positive emotions and also that there was no LPC reaction for neutral emotions. Luo & Huang (2006) also obtained the same results, and identified that the stimulant with emotion images would be shorter than the incubation period of neutral images, which indicated that the subjects would prioritize in order to analyze and evaluate the stimulant with emotion value information. During this process, the subjects could seriously consider and manipulate the entire evaluation process, the information could be thoroughly analyzed, and it was able to include more consideration factors related to the experience. Therefore, the analysis evaluation is a controlling and processing process from top to bottom. The subjects can decide to perform more evaluation to certain stimulants and distribute more physical resources in accordance with their own demands and the actual environmental status. Kern et al. (2005) explain that when the information contained in the positive stimulant was not intensive, people would prefer to prioritize to handle the negative information in the situation of limited resources. This preference is the adaptive response for ensuring biological survival (Luo & Huang, 2006). Because people always easily pay attention to negative information, but have no feelings related to the positive information, when ignoring the positive stimulation, what have been lost the most are the opportunities. But failing to notice the negative stimulation (e.g. predator) may lead to the loss of the instinct of survival. The negative events require shorter time to complete the physical processing of emotion stimulation than the neutral events do, which can provide more physical energy, while saving time to enable the body to act as soon as possible, as well as adapt to the environment in a rapid manner (Lang et al., 2001). In addition, Hamilton & Fallot (1974) identified that the negative features would obtain more weight compared with the positive features, which indicates that the negative images have more influence than the positive images. However, this result is inconsistent with those of other studies (Schapkin et al., 2000; Delplanque et al., 2004; Herbert et al., 2008), which identified that the pleasant stimulant will reinforce the LPC reaction more than the unpleasant stimulant will, and that the ERP amplitude produced by the positive emotion images is stronger than the negative emotion images (Spreckelmeyer et al., 2006). For example, Jacobsen & Höfel (2002) discuss the effects of symmetrical and asymmetric geometric figures (e.g. triangle, square and rhombus) in relation to the esthetical quality. The thinking group with evaluation can arouse stronger LPC amplitude than the browsing group can, without thinking in terms of judging the sense of beauty, and both groups can arouse great LPC amplitude when observing the asymmetric images rather than symmetrical images. As a result, we can understand that not all amplitudes aroused by the negative emotions are larger than those of positive emotions; the main reason is that the negative emotions aroused by the unaesthetic images will not somehow be affected in terms of the aesthetic quality of geometric figures.

1.4 Purpose of the research

The purpose of this research is to investigate the affecting degree from the design factors of products to the positive-negative emotions of consumers, as well as using ERP to measure their emotional reactions. The test simulation uses the watch as the research example. On the basis of current trends of products, the watch design may have various shapes due to the demands of consumers; as well, the style is developing more to decoration, lightening and thinning, individuation, interestingness, etc. The watch is not only the accessory with respect to decoration, but also displays personal features and taste. Therefore, discussing how the watch combination factors influence the aesthetic attitude of consumers and generate the emotion connections is worthwhile. The above-mentioned studies prove the preferences and reactions of the brain to negative information. Since the negative impression bias of

products will greatly influence the consumption decision of customers, understanding the consumers' perspectives is essential in this research; studying and evaluating the negative properties of products are required. Since products can only provide the positive property selection for consumers, we cannot know how the negative preferences influence consumers' decisions in a precise and complete manner. This research posits that it is possible to avoid purchase failure caused by the negative emotions of consumers through understanding the negative information of products. The research results can provide the selection criteria for evaluating the negative property of products for the designers or marketers in an appropriate manner, as well as consider how to improve the products, service, or the brand equity.

2. Method Of Research

2.1 Subject

There were 16 subjects (11 males and 5 females; average age = 23.38; Std = 1.26) with an educational background of college and above in Taiwan and a background of industrial design, in addition to having received professional training on product shape design, so they were able to perform the precise shape image judgment of the products. The subjects have the relevant knowledge of art, which is helpful to the performance of operation demand, especially during the observation test of aesthetic evaluation; the subjects were able to fully apply their aesthetic knowledge to expedite the mechanism of perception and attention (Locher, 1996). This study was reviewed and approved by the Research Ethics Committee National Taiwan University. All participants gave written informed consent in accordance with the Declaration of Helsinki.

2.2. Sample

2.2.1 Card sorting for selecting sample

During the first stage, the experts will classify and select the representative samples by card sorting, for the second stage questionnaire. Three experts with over six years of experience in product design and watch collection were invited (3 males; average age = 45.66; Std = 5.6) to perform the card sorting of the collected 360 watch photos, select the representative samples, and then produce the basic 3D shape through the drawing software Rhino and rendering software KeyShot 5. The samples eliminated the interfering elements e.g. electronic display, number (consider the glyph), color and complex elements (exterior decoration), sorted into the watch frame and watch surface, as shown in the Fig. 2 and Table 1. The watch frame is composed of the 1:1 and 1:1.5 proportions and R angle (with R angle and without R angle). The watch surface comprised the content (tradition and intelligence), background (white and black) and color (black, white and colors) of the watch surface.

Table 1
Sample list.

Type	Design element		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8
frame	shape		Circle	Ellipse	Square	Rectangle	Triangle	Arc		
	Ratio	1:1	Circle	Square	Triangle					
		1:1.5	Ellipse	Rectangle	Arc					
	Radius	Radius	Circle	Ellipse	Square	Rectangle	Triangle	Arc		
		No radius	Square	Rectangle	Triangle	Arc				
surface	Pattern		No depict	Point depict	Line depict	Point and line depict	Line depict (Black)	Information	Intelligent (black and white)	Intelligent (Colorful)
	Content	Traditional	No depict	Point depict	Line depict	Point and line depict	Information			
		Intelligent	Intelligent (black and white)	Intelligent (Colorful)						
	Background	White	No depict	Point depict	Line depict	Information				
		Black	Point and line depict	Line depict (black)	Intelligent (black and white)	Intelligent (colorful)				
	Color	Black and White	No depict	Point depict	Line depict	Point and line depict	Intelligent (black and white)	Information		
		Colorful	Intelligent (Colorful)							

2.2.2 Questionnaire evaluation

The second stage focused on the emotions and attitudes of interviewees to the samples by the means of a questionnaire. It applied the semantic differential scale to select the appropriate samples for brain wave testing. This research invited 30 persons (15 males, 15 females; average age = 21.33; Std = 1) whose educational background is college and above in Taiwan with a background in industrial design and reception of professional training on product shape design; in addition, they were able to perform the precise image judgment related to the product shape. The semantic differential scale (Russell, 2003) applies the raised concept of core emotion, combined with two dimensional emotion reactions: physiology and psychology to constitute the circuplex model of emotions, while the core emotion experience is the coordinate axis composed of the horizontal and vertical dimensions. According to the theory of information aesthetics, the aesthetic emotions aroused by visual information can serve as the standard for aesthetic evaluation judgments, as well as establish the constitution relation with the visual information (Eysenck, 1968). In addition, 'pleasant' is the important reaction for aesthetic emotion (Fechner, 1876), which indicates that the aesthetic perception can arouse the pleasant emotion reaction. Therefore, this research takes the emotion reaction aroused by the aesthetic factors, and regards the emotion valence (Pleasant vs. Unpleasant) as the scoring standard, in addition to applying a Likert scale of one to five for the evaluation.

In Table 3, according to the questionnaire survey results during the second stage, 30 pictures were selected respectively for the positive high emotion valence and negative low emotion valence as the samples for brain wave test by taking the affect valence as the selection standard. In addition, another 30 colorful scenery pictures (neutral pictures) from the Nencki Affective Picture System (NAPS) were selected as the neutral stimulant (Riegel et al., 2016). There were 90 pictures in total (see Fig. 3) as the samples for the brain wave test.

Table 3

Group mean LPC amplitudes of the responses to positive, negative, and neuronal conditions that were recorded from 9 electrodes over 9 regions of the scalp: left-anterior (F3), middle-anterior (Fz), right-anterior (F4), left-central (C3), middle-central (Cz), right-central (C4), left-posterior (P3), middle-posterior (Pz), and right-posterior (P4) (standard deviation of the mean in parentheses).

Condition	left- anterior	middle- anterior	right- anterior	left- central	middle- central	right- central	left- posterior	middle- posterior	right- posterior
positive	0.67 (2.06)	0.75 (2.00)	0.90 (2.18)	0.83 (1.31)	0.91 (1.30)	0.86 (1.16)	0.99 (0.98)	1.16 (0.96)	0.95 (0.75)
negative	1.49 (1.60)	1.60 (1.72)	1.62 (1.60)	1.61 (1.11)	1.68 (1.25)	1.59 (1.11)	1.65 (1.06)	1.88 (1.03)	1.67 (0.86)
neuronal	0.37 (2.34)	0.31 (2.28)	0.22 (2.29)	0.50 (1.45)	0.24 (1.58)	0.14 (1.50)	0.67 (0.88)	0.52 (1.02)	0.37 (1.06)

Table 2

Descriptive statistics for samples of positive high affect valence and negative low affect valence.

sample	N	Mean	Std.	Range
positive	30	3.45	0.39	4.07-3.00
negative	30	2.06	0.30	2.53-1.33

Insert Fig. 3 here

2.3 ERP recording

This research applied the 32 channel Bluetooth wireless physiological feedback instrument NeXus-32 (Holland Mind Media Company) as the test device. The electrode impedance is 5 kΩ, the brain wave record frequency is 250 Hz, and the document filtering with 0.5-60Hz. The noise was filtered through BioTrace + software, taking the eye movement signal of maximum amplitude (over 80 μV) appearing in each signal (Chuang & Chen, 2004; Onton et al., 2006) and the frontal lobe signal with frequency larger than 20 Hz (Shackman et al., 2009) as the standard. The document of the brain wave test was processed and analyzed by applying the WINEEG 2.124.95 software. Brain wave segmentation was continuously recorded; the total time interval was 0 to 1000 ms, from the appearance of stimulation to 1000 ms after the stimulation. EEG documents were transformed into the ERP format. ERP amplitude was selected during the interval from 680 ms to 860 ms. Afterwards, the overlaying and averaging to the brain wave section for the subjects in the same sample group was performed, and the grand averaging of the brain wave amplitudes of all subjects in carrying out the statistical analysis.

2.4 Procedure

The subjects were required to stay in the recording room with sound insulation effect and the environment light was usually the daily lamp. Before the test, the subjects sat on the chairs with their eyes about 60 cm from the center of the screen. After confirming the subjects understood the testing procedures, the test started. As shown in the Fig. 4, one cross diagram would initially appear on the screen center for staring and the time was 1000 ms. Afterwards, with the time interval of 1000 ms (ISI), the picture of products appeared for 2000 ms; after another 1000 ms (ISI), it changed to the next group of samples. There were 90 groups of samples in total; each group of samples appeared once at random, with a break for 10 minutes in the middle. The time points for recording the brain wave document started after the samples appeared, after 2000 ms.

2.5 ERP analysis

On the basis of the previous research (L Carretié et al., 1997; Holmes et al., 2003), F3, Fz, F4, C3, Cz, C4, P3, PZ, and P4 were selected and divided into zones: left-anterior (F3), middle-anterior (Fz), right-anterior (F4), left-central (C3), middle-central (Cz), right-central (C4), left-posterior (P3), middle-posterior (Pz), and right-posterior (P4)). Figure 5 displays the ERP amplitudes for F3, Fz, F4, C3, Cz, C4, P3, PZ, and P4. The brain wave movements for all the stimulants were such that the LPC amplitude lowest peak appeared at the Cz site at approximately 644 ms and the highest peak approximately at 748 ms; then the wave shape descended, forming one complete LPC wave shape at 680 ms to 800 ms. Therefore, the brain wave selected the LPC component after the appearance of the target object during the selecting time interval, which is the average amplitude between approximately 680 ms to 800 ms. This measurement interval referred to the previous N600 (Brown et al., 2012; Schindler et al., 2015).

In terms of the detection of brain wave, the Repeated Measures ANOVA was applied to detect the LPC amplitude and ERP document for watch shape. With respect to the LPC amplitude, MANOVA detected the factors, including: emotion (positive, negative and neutral), anterior-posterior causality (anterior, central and posterior), and the left-right scalp region (left, medial, and right) of the scalp electrode locations. With respect to the watch shape, MANOVA detected the factors, including: watch frame shape (round, ellipse, square, rectangle, triangle and arc), frame proportion (1:1 and 1:1.5), frame R angle (with R angle and without R angle), watch pattern (non-curving, point curving, line curving, point-line curving, multi-information, line curving (black), intelligent (black-white), and intelligent color)), watch surface content (tradition and intelligence), watch surface background (white and black), and

surface color (black, white and color). The second-time MANOVA performed the double-factor MANOVA analysis in accordance with the significant factors to ascertain any potential significant factor. For Non-Sphericity, F detection calibrates the freedom with G-G (Greenhouse-Geisser Correction). The [Post-Hoc Comparison] uses [Bonferroni Corrections] for comparison.

3. Results

3.1 LPC effect (600–800 ms)

Table 3 indicates the LPC average amplitude and standard deviation for the positive, negative and neutral stimulants. The average amplitude (standard deviation) of positive stimulant is 0.89(1.41), the average amplitude (standard deviation) of negative stimulant is 1.64(1.26), and the average amplitude (standard deviation) of neutral stimulant is 0.37(1.60). The neutral stimulant is obviously lower than the positive and negative stimulants. Generally speaking, due to the neutral stimulant having no elements related to emotions, the subjects will not produce any emotional reaction (Ito et al., 1998). The positive, negative and neutral stimulants will all arouse high amplitude to the afterbrain.

Table 4, with respect to the overall detection of MANOVA to LPC, the emotions have the main effect ($F[2, 30] = 5.51, p < .05$). Moreover, emotion x left–right factor has the interactive effect ($F[4, 60] = 2.84, p < .05, \epsilon = .68$) and anterior–posterior x left–right factor has the interactive effect ($F[4, 60] = 3.02, p = .05, \epsilon = .63$). The detection of the double-factor MANOVA in a positive vs. neuronal comparison identified that emotion and the left–right factor do not have the interactive effect ($p = .12$), and through the detection of double-factor MANOVA negative vs. neuronal it found that emotions and the left–right factor do not have the interactive effect ($F[2, 30] = 4.43, p < .05, \epsilon = .73$). After the post detection, the amplitude of the negative in the left, medial, and right zones is obviously larger than the neuronal (respectively $F[1, 15] = 5.08, p < .05$; $F[1, 15] = 9.46, p < .01$; $F[1, 15] = 9.45, p < .01$), and that through the detection of double-factor MANOVA that a positive vs. negative comparison showed that emotion and left–right factor do not have the interactive effect ($p = .90$).

Table 4
LPC amplitude results for MANOVA analysis for positive, negative and neutral emotions.

items	MS	F	Sig.	Amp.
emotion	83.16	5.51	0.02	*
anterior–posterior	3.16	0.51	0.51	
left–right	0.26	0.83	0.45	
emotion x anterior–posterior	0.17	0.05	0.94	
emotion x left–right	0.51	2.84	0.03	*
neuronal x positive	0.48	2.58	0.12	
neuronal x negative	0.33	4.43	0.03	*
neuronal x negative at left	9.20	5.08	0.04	* Neu.<Neg.
neuronal x negative at medial	14.89	9.46	0.01	** Neu.<Neg.
neuronal x negative at right	15.28	9.45	0.01	** Neu.<Neg.
anterior–posterior x left–right	0.33	3.02	0.05	*
<i>*p < .05 ** p < .01 ***p < .001</i>				

3.2 Influence of designed shape on emotion

Table 5 indicates the LPC average amplitude of frame and surface under the positive and negative stimulants. The average amplitudes (standard deviation) of frame under the positive and negative stimulants are 0.65 (2.42) and 1.49 (1.69), respectively; the average amplitudes (standard deviation) of the surface under the positive and negative stimulants are 0.77 (2.09) and 1.50 (2.19), respectively.

Table 5
LPC average amplitudes for frame and surface with positive and negative stimulants.

Type	Element		positive		negative	
			mean	SD	mean	SD
Frame	Shape	Circle	0.66	2.64	0	0
		Ellipse	-1.74	5.51	1.75	3.03
		Square	0.98	1.34	1.2	1.95
		Rectangle	1.51	1.96	1.51	1.88
		Triangle	1.27	2.7	1.86	1.61
		Arc	0.91	1.75	1.84	3.03
	Ratio	1:1	0.86	1.37	1.87	1.17
		1:1.5	0.76	1.64	1.21	1.55
	Radius	Radius	0.93	1.18	2.18	1.46
		No radius	0.34	4.08	1.48	1.23
Surface	Pattern	No depict	1.76	2.49	1.94	2.28
		Point depict	1.71	1.75	0.88	3.21
		Line depict	0.71	2.55	1.24	2.29
		Point and line depict	-0.32	3	0.94	1.86
		Line depict (Black)	1.33	2.22	2.14	2.12
		Information	0.05	2.86	2.11	1.76
		Intelligent (black and white)	0.91	2.56	2.19	1.81
		Intelligent (Colorful)	0.33	2.36	0.89	4.01
	Content	Traditional	0.87	1.18	1.54	1.03
		Intelligent	0.62	1.85	1.54	2.58
	Background	White	1.06	1.37	1.54	1.3
		Black	0.56	1.6	1.54	1.39
	Color	Black and White	0.88	1.12	1.63	1.05
		Colorful	0.33	2.36	0.89	4.01

By comparing the values of average amplitudes, the amplitude for the frame shape is the highest with the negative triangle, and the negative arc takes second place, while the amplitude for the positive ellipse shape is the lowest. The amplitude for the frame proportion is the highest with the negative 1:1, and the lowest for positive 1:1.5. The amplitude for the frame R angle is the highest with the negative R angle, and the lowest for the positive without R angle. In addition, the amplitude for the surface pattern is the highest with negative intelligence (black-white), and the negative line curving (black) takes second place, while the amplitude for the positive intelligent point curving is the lowest. The amplitude for the surface background is the highest with the negative white and black, and the lowest for positive black. The amplitude for surface color is the highest with the negative white and black, and the lowest for positive black. The amplitude for surface color is the highest with the negative black-white, and the lowest for positive color. In conclusion, regardless of the frame or surface, the LPC average amplitudes for all negative stimulants are the highest, and the lowest for positive stimulants.

Table 6 indicates the two-factor MANOVA comparison for neuronal vs. positive, and neuronal vs. negative emotions. In terms of the frame shape, the triangle and arc with negative emotions are significantly higher than the neutral ($F[1, 15] = 7.08, p < .05$), while the other shapes (round, ellipse, square and rectangle) have no significant difference to any emotion. With respect to proportion, only the negative emotion 1:1 proportion is significantly higher than the neutral ($F[1, 15] = 13.14, p < .01$). In terms of R angle, the negative emotion with R angle and without R angle is significantly higher than the neutral ($F[1, 15] = 14.89, p < .01$; $F[1, 15] = 5.33, p < .05$).

Table 6
MANOVA results for positive, negative, and neuronal emotions.

Type	Element		emotion	MS	η	Sig.	Amp.	
Frame	Shape	Circle	neuronal vs. positive	0.69	0.17	0.69		
			neuronal vs. negative	1.10	1.03	0.33		
		Ellipse	neuronal vs. positive	35.57	2.41	0.14		
			neuronal vs. negative	15.25	3.02	0.10		
		Square	neuronal vs. positive	2.97	1.34	0.27		
			neuronal vs. negative	5.45	2.09	0.17		
		Rectangle	neuronal vs. positive	10.43	3.79	0.07		
			neuronal vs. negative	28.16	14.32	0.12		
		Triangle	neuronal vs. positive	21.55	4.22	0.24		
			neuronal vs. negative	17.64	7.08	0.02	*	Neu.<Neg.
	Ratio	Arc	neuronal vs. positive	13.17	4.67	0.34		
			neuronal vs. negative	39.16	4.82	0.03	*	Neu.<Neg.
		1:1	neuronal vs. positive	1.92	1.86	0.19		
			neuronal vs. negative	17.99	13.14	0.002	**	Neu.<Neg.
		1:1.5	neuronal vs. positive	1.23	0.48	0.50		
			neuronal vs. negative	5.64	1.94	0.18		
	Radius	Radius	neuronal vs. positive	2.53	1.74	0.21		
			neuronal vs. negative	26.26	14.89	0.002	**	Neu.<Neg.
		No radius	neuronal vs. positive	0.01	0.001	0.97		
			neuronal vs. negative	9.84	5.33	0.04	*	Neu.<Neg.
Surface	Pattern	No depict	neuronal vs. positive	15.48	5.05	0.04	*	Neu.<Pos..
			neuronal vs. negative	19.78	10.59	0.01	**	Neu.<Neg.
		Point depict	neuronal vs. positive	14.33	10.62	0.01	**	Neu.<Pos.
			neuronal vs. negative	2.05	0.28	0.60		
		Line depict	neuronal vs. positive	0.94	0.37	0.55		
			neuronal vs. negative	5.99	1.46	0.25		
		Point and line depict	neuronal vs. positive	3.80	0.68	0.42		
			neuronal vs. negative	2.57	0.82	0.38		
		Line depict (Black)	neuronal vs. positive	7.32	1.27	0.28		
			neuronal vs. negative	24.95	6.22	0.03	*	Neu.<Neg.
		Information	neuronal vs. positive	0.81	0.14	0.71		
			neuronal vs. negative	24.18	8.06	0.01	**	Neu.<Neg.
		Intelligent (black and white)	neuronal vs. positive	2.35	0.81	0.38		
			neuronal vs. negative	26.58	11.99	0.003	**	Neu.<Neg.
		Intelligent (Colorful)	neuronal vs. positive	0.01	0.003	0.96		
			neuronal vs. negative	2.17	0.23	0.64		
	Content	Traditional	neuronal vs. positive	2.03	1.33	0.27		
			neuronal vs. negative	10.93	6.14	0.03	*	Neu.<Neg.
		Intelligent	neuronal vs. positive	0.51	0.27	0.61		
			neuronal vs. negative	10.98	2.51	0.13		

Type	Element		emotion	MS	η^2	Sig.	Amp.	
	Background	White	neuronal vs. positive	3.79	3.49	0.08	*	Neu.<Neg.
			neuronal vs. negative	10.96	5.70	0.03		
		Black	neuronal vs. positive	0.29	0.12	0.73		
			neuronal vs. negative	10.93	4.78	0.05		
	Color	Black and White	neuronal vs. positive	2.07	1.61	0.22	*	Neu.<Neg.
			neuronal vs. negative	12.75	7.51	0.02		
		Colorful	neuronal vs. positive	0.01	0.003	0.96		
			neuronal vs. negative	2.17	0.23	0.64		

In terms of the surface pattern, the negative emotion patterns, including the non-curving, point curving, multi-information, line curving (black) and intelligent (black-white) LPC, the amplitude is significant higher than the neutral (respectively $F[1, 15] = 5.05, p < .05$; $F[1, 15] = 10.62, p = .01$; $F[1, 15] = 8.06, p < .05$; $F[1, 15] = 11.99, p < .01$), and the positive emotion of non-curving is also significant higher than the neutral ($F[1, 15] = 7.08, p < .05$). In addition, in terms of the content, the content of the negative traditional form is significant higher than the neutral ($F[1, 15] = 6.14, p < .05$). In terms of the background, the white and black background of the negative emotion is significant higher than the neutral (respectively, $F[1, 15] = 5.70, p < .05$ and $F[1, 15] = 4.78, p = .05$). In terms of the color, the black-white surface of the negative emotion is significantly higher than the neutral ($F[1, 15] = 7.51, p < .05$).

4. Discussion

This research takes the watch as the case example, applies visual geometric shapes with high and low emotion valence (positive and negative emotion) to measure how ERP detects different product designing features influencing the emotional reaction of the brain, to understand the relationship between the designing elements of product and the emotional reaction, which facilitates the understanding of the preferences of consumers and enhance the purchase chance. The previous research has proven that emotion plays an important decision-making role in purchasing (Laros & Steenkamp, 2005). The ERP results indicate that negative emotions shaped with low valence can improve the LPC amplitude. The LPC amplitude of positive emotion valence is lower than the shape of negative emotion. The afterbrain is the major brain zone for processing the positive and negative emotions. The distribution range for the positive and negative emotions in the scalp topographic map differs. Although the color is the main factor deciding the product emotion (Jang & Kim, 2007), appearance, proportion and pattern are also influential factors. We will next further discuss the designing factors significantly influencing the emotion valence.

4.1 Loading degree of emotion influenced by the difficulty of aesthetic evaluation

This research identifies that the negative stimulant will arouse the higher LPC amplitude more than the positive stimulant will. This result is consistent with the previous result, which indicates that LPC is influenced by the attention resource of psychological distribution, and that negative emotional pictures will arouse the higher LPC amplitude more than the positive emotion pictures will (Ito et al., 1998; Kern et al., 2005; Lang et al., 2001; Wood & Kisley, 2006). On the basis of limited psychological distribution, people will prioritize in processing the reasons of issues with threats. This research focuses on the evaluation of shape aesthetic perception, which differs from using stimulants with intensive and threatening properties in the past. Generally speaking, the long fixation time usually involves a number of psychological processes (Rayner, 1998). In addition, the visual difficulty of image (Rayner, 1998; Rayner & Duffy, 1986) is one of the factors influencing the attention time length. The longer the attention time, the greater the distribution of attention resources! The subjects are able to decide to perform the evaluation related to the stimulation in accordance with their own demands and specific environment, as well as distribute more psychological resources (Luo & Huang, 2006). Whether the stimulants require rigorous consideration is the key to influencing the LPC amplitude. The operation of this research focuses on the processing and judgment of aesthetic shapes, which enables the subjects to prioritize to consider the strongest stimulant influencing the aesthetic perception, which is possibly that the shape with negative emotion is noticed initially, thereby enhancing the LPC amplitude. On the contrary, the subjects employ comparatively less mental resources with respect to the shape with aesthetic factors; thus, the LPC reaction aroused will be lower.

4.2 Visual zone of brain processing aesthetic evaluation

The visual zone of the afterbrain is one of the important zones for aesthetic evaluation. In this research, the LPC effect distribution for the scalp topographic map of positive and negative evaluations is different. The distribution of positive emotions is centralized in the central and afterbrain zones, and the negative emotion is evenly distributed in the afterbrain. The visual cortex for these zones is located in the occipital lobe at the back of the brain, which is the zone mainly responsible for processing visual information (Zeki et al., 1991). According to the theory of information aesthetics, there is a relation between the aesthetic emotion and visual information (Eysenck, 1968). Regardless of the aesthetic evaluation of positive or negative emotions, the visual zone can be regarded as the reference for the aesthetic value in judging where it belongs in the brain zone.

4.3 Feature influencing product affect valence

The shape, pattern and color of products play the decision-making role in expressing the product emotion; they can change the emotions and reaction of consumers to the product. Previous research identified that the new, complex and inconsistent articles in the image could attract the long-time staring of

subjects (Henderson et al., 1999; Loftus & Mackworth, 1978). Therefore, in terms of the frame, the sharpness (e.g. triangle) or special shapes (e.g. arc) may arouse inconsistent feelings in subjects and the negative emotions, leading to higher LPC amplitude. The triangle shape elicits a negative emotional reaction; conversely, the round shape elicits positive emotions. This result is consistent with the results of Bar & Neta (2006), Hsu et al. (2000), and Ohkura et al. (2008) who conclude that round articles are perceived as more beautiful than the sharp articles; consumers prefer the appearance with curves rather than with sharp angles. In terms of the frame proportion, consumers prefer the proportion of 1:1 in regard to the appearance of products (Jung & Badke-Schaub, 2017). In this research, the triangle with the 1:1 proportion of negative emotion obtained the highest LPC amplitude among all shapes, which possibly implies enhancing the overall 1:1 negative emotional reaction. Angles, e.g. V shape or triangle, etc., will deliver negative emotion information (e.g. threat) (Larson et al., 2012). Thus, we may conclude that the frame with a triangular appearance will arouse negative emotions.

In terms of the surface pattern, the designing elements and arrangement with the clear visual elements and complex distribution will arouse the higher LPC amplitude. The water pattern belongs to the radial balance in the principle of aesthetic forms, which refers to taking the point as the center, surrounded by the circular arrangement of radiation or roundness to form the type of radiation, which enables the entire shape and structure to be stable and produce the visual effect of rhythm (Chiu et al., 2006). If the non-curving, point curving, information and intelligent patterns lack the significant radiation lining arrangement, in terms of the aesthetic form, the imbalance will produce visual instability and psychological imbalance, thereby arousing a strong negative emotional reaction. In addition, the drawings complying with the balance principle will avoid the perceptual mess or laxity; the subjects will be able to effectively browse the drawing (Locher & Nodine, 1989).

In terms of the surface content, the product with a new appearance and white-black color will arouse the higher LPC amplitude to the greatest degree, bringing sensual fantasy, entertainment and happy feelings for the consumers (Hirschman et al., 1982). This differs from Baxter's (1995) belief that the consumers will be influenced by old attractions, as they are able to identify the product of the same type they used to use or prefer; the preference degree for the old type is higher than for the new type. The results of this research reveal that the consumers of traditional surface products maintain the visual feature images due to their long time design, which will reflect negative emotions regarding novelty. On the contrary, the new intelligent surface content will more easily arouse greater feelings of interest and attention among the subjects. With respect to the surface background and color, the color is the final element attracting the consumers, as well as an important element in deciding the product emotion and convincing them to purchase (Jang & Kim, 2007). In this study, the product applied the white-black background image, which delivers higher negative emotion than the color, and the white-black can enhance the brain wave focus of people. This is consistent with the results of Wang et al. (2016) and Nijdam (2009) who indicate that the black color will arouse a stronger emotion reaction than white color will. Moreover, the white color disseminates a positive impression to remind the users of the clean, pure, fresh, beautiful, gentle and natural emotions (Saito, 1996), while the black color is dark and blurry (Na & Suk, 2014). Therefore, it is extremely important to select the appropriate color and deliver the required product emotion in the product design.

5. Conclusion And Suggestions

This research discusses the influence of visual watch design features on the subjects. The research proves that the sharp appearance (e.g. triangle) or special shapes (e.g. arc) will arouse inconsistent negative feelings. The old type products (e.g. round and square) will arouse more negative emotions than the new types. Due to the brain memory retaining the previous fixed visual feature image, if the type is not new, it will produce higher LPC amplitude. In addition, the black-white will deliver high negative emotion than the color matching. This research takes brain waves as the objective evaluation tool and considers cognitive bias for its subjective questionnaire, and the design features of the watch will indeed measure the obvious ERP effect. It is expected that the research results will promote the EPP measurement tool to be integrated into the other designing subjects or research. Moreover, the combination of different designing elements streamlined by this research will also serve as the designing parameters in the innovation of digit models. According to the designing factors that can effectively influence the people's emotion, the systematic emotion design is presented, which is appropriate to the actual product design.

It is recommended that future research includes: (1) improving the typicality of neutral stimulants, e.g. scenery drawings, people, animals, etc., deemed in this research as overly complex, which may stimulate some brain zones and cause high ERP amplitudes. It is recommended that future research use gray color pictures as the neutral stimulants, as it can reduce unnecessary stimulation. (2) Increase the intelligent surface and color background type: Although this research includes these samples, the number is not equal in proportion, which may emotionally imbalance the brain wave amplitude. This will enable the selection of more different types of intelligent surfaces and colors for research in the future to equalize the proportion of samples quantity. (3) Improve the visual sensitivity of subjects as the LPC effect of brain waves is the negative stimulant that is higher than the positive and neutral stimulants. But the subjects are still unable to effectively distinguish the differences between the positive and neutral stimulants. It is recommended to initially perform the appropriateness test (including the thinking and sensitivity survey) in terms of selecting the subjects so as to select the proper subjects, as well as improve the designing sensitivity of subjects to the product shape, appearance, internal designing elements and minor differences.

Declarations

- - Ethics approval and consent to participate: The ethics approval granted by the Research Ethics Committee National Taiwan University (NTU-REC No. 201712EM022).
- - Consent to publish: I Ching-Yi Wang give my consent for information about myself to be published in Behavioral and Brain Functions, Ching-Yi Wang. I understand that the information will be published without my relative's name attached, but that full anonymity cannot be guaranteed. I

understand that the text and any pictures or videos published in the article will be freely available on the internet and may be seen by the general public. The pictures, videos and text may also appear on other websites or in print, may be translated into other languages or used for commercial purposes. I have been offered the opportunity to read the manuscript.

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- - Authors' Contributions: All authors have approved the manuscript before submission, including the names and order of authors, and that all authors receive the submission and all substantive correspondence with editors, as well as the full reviews, verifying that all data, figures, materials (including reagents), and code, even those developed or provided by other authors, comply with the transparency and reproducibility standards of both the field and journal.
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Figures

Figure 1

Dimension of affect: horizontal axis is valence; vertical axis is arousal (russell, 2003)

Figure 2

Basic types of watch frame and watch surface shape

Figure 3

Positive, negative, and neutral samples

Figure 4

ERP testing procedure

Figure 5

ERP waveform: LPC position is at approximately 680 ms to 800 ms

Supplementary Files

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