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The effect of product characteristic familiarity on product recognition

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Abstract. In order to explore the effect of product appearance characteristic familiarity on product recognition, both EEG experiment and questionnaire evaluation are used in this research. The objective feedback of user is obtained through the EEG experiment and the subjective opinions are collected through the questionnaires. The EEG experiment is combined with the classical learning-recognition paradigm, and the old-new effect of recognition experiment is used as a metric of recognition degree. Experimental results show that the difference of characteristic familiarity does have a significant effect on product recognition. The conclusion can be used in innovation design.

1 Introduction

Due to the fierce competition of product market, the center of product design is changed from product to market, eventually changed to user [1]. In order to stand out in design competition, companies and designers need to study all aspects of user and focus on user needs and purchase intent first, then do product innovation design with key points [2].

In real life shopping situations, although people cannot understand the inherent functions and performances of product at a glance, they can basically know the product's shape and appearance. Thus, the intuitive feeling caused by external factors is an important reason for user impulse consumption [3-4]. Therefore, the creative design of the product appearance has a great influence on consumption.

Based on the market, we study the effect of product appearance characteristic familiarity on product recognition. Product familiarity is one dimension of product knowledge, indicates the number of consumer's product-related experience [5]. There are two representations of product familiarity: the subjective product familiarity represents consumer's self-perception of their familiarity with the product and the objective product familiarities indicate the degree of consumer's true understanding to product [6]. In this article, subject product familiarity is used to reflect the product's common degree in market, the higher the degree of familiarity represents product is more general in market. Punj and Srinivasan suggest that consumers are more familiar with the product will be concerned about the details of product features, otherwise consumers tend to focus only on surface information [7]. Johnson and Russo focus on whether product familiarity can help consumers improving learning products, their study shows that high product familiarity can actually increase learning form product information in the shopping decisions [8]. Yuan et al. measure both objective and subjective familiarity, compare these two kinds of familiarity and discuss the influence of familiarity on the activation domain [9]. In their paper the subjective familiarity is measured by self-judgment questionnaire. Most of previous researches are concentrated on familiarity of whole product. And unlike the past, we split product appearance features and focus on the familiarity of product appearance characteristic elements.

Recognition commonly used in vision, hearing, such as voice recognition, brand recognition, color recognition, face recognition. A product with high recognition can be more impressed than low recognition. As the effective competitive method for enterprise, product identity is a common way to improve product recognition degree. Summarized from the literature, product identity usually has two definitions. One is defined from the perspective of corporate identity and the other one is based on product attributes and user experience point [10]. Characteristic is the foundation of product identification and different products have different features [11]. In previous studies, most of the discussion is about construction of product identity. Yang et al. study about the diversity of difference types of people identifies product [11]. They analyse customers, designers and users' difference of recognition ability and breadth through calculating comparative models. Product recognition has no a standard measure. In our research, we try to use EEG experiment to find out an objective method as the measurement.

With the development of science and technology, the product evaluation methods based on human physiological signal begin to be used. Event-related potentials (ERP) is the brain potential recorded from the head surface by mean superposition method during the cognitive processes, which is a special kind of brain evoked potentials [13].

In recent years, ERP has become an important scientific research basis and has been widely used in many disciplines including design studies. Chen et al. assess the product images cognition of users by ERP, and believe ERP can provide a quantitative index to quantify the level of matching and establish the mapping model of the product images [14].

Syloctt et al. research the influence of product modeling and function on user preference and evaluation from the point of cognitive brain, they alter automobile's simple outline and function parameters and analyse user's decisions at the same time [15]. Nittono uses ERP technique to study users brain cognition under different appearance attraction, in order to find an objective evaluation measure of commodity appearance attraction degree, and find out that the LPP which appears in the forehead can be used to evaluate the attractiveness of appearance [16]. Fu et al. suggest that the difference between users' ERP can be used to assess the user's preference for products, and it can provide a more accurate method to measure user perception [17].

2 The experiment

The EEG experiment uses the form of recognition paradigm combined with ERP and mainly focus on the old-new effect, ERP components and brain resource utilization during the process of recognition. The recognition is based on the memory which is learnt from learning phase, subjects feel familiar with things which have been perceived once. In psychology, recognition is considered as an important indicator for evaluating the level of memory consolidation. Recognition experiment includes learning and recognition phase. Recognition phase is to identify the materials which have appeared before. After the EEG experiment, subjective questionnaire is used to collect subjects' subjective judgment.

2.1 Subjects

21 subjects are recruited in this experiment. One of the female participants is excluded because of the poor electrode contact leads to incomplete data. The remaining 20 subjects are all graduate students with design background, age at 22 ~ 28 and normal visions or corrected vision is normal. The ratio of male and female is 1:1.

2.2 Experimental materials

In this experiment, "Learning - recognition" paradigm is used with 3 (Characteristic elements: shape, color, material) × 3(familiarity degree: high, medium, low) mix design. The experimental material is 90 pieces of synthetic chair，shape, color and materials groups each 30 pieces which contains high, medium and low familiarity each 10 pieces. To exclude irrelevant factors affecting, all images are processed by the uniform size and will be placed in the middle of the screen area. 45(5×3×3=45) pictures will be randomly selected from 90 pictures as learning material and rest 45 pieces will appear in recognition stage.

2.3 Experimental environment and equipment

The experiment is conducted in a bright and no sound interference room. Subjects sit in front of the display screen, adjust the distance and position into to a comfortable State.

Experimental equipment is the Emotiv EEG Head-mounted devices EPOC+ with 16 Channels. The electrodes are located in the standard position (AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, and AF4), P3 and P4 are reference electrodes and the sampling rate is 128Hz.

2.4 EEG experiment procedure

The experiment is divided into three parts: learning phase, resting phase and recognition phase. The flow chart is shown in Figure 1.

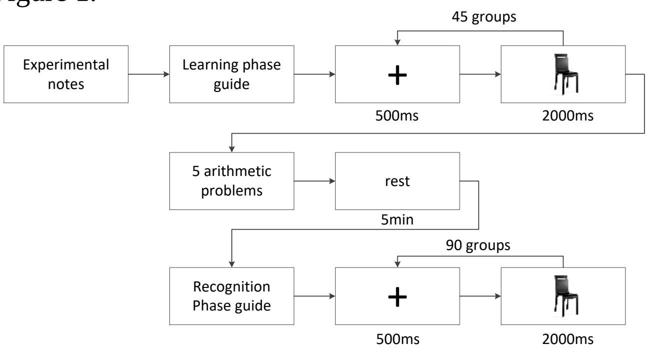

Figure 1: EEG experiment procedure.

In learning phase, subjects need to browse the experimental materials. They are assigned a shopping scenario and use appearance as the purchase criteria. First of each test, a cross will be placed in the middle of the screen to lead subject's attention and disappeared after 500ms, then material picture will be randomly presented 2000ms and after 2000ms the next sequence will be presented automatically. After the completion of the learning phase, participants are required to complete a set of arithmetic to distract attention, then have a 5 minutes' rest before get into recognition phase. In the recognition phase, participants are specifically asked to recall the materials which have seen in the learning phase. When the materials of learning phase appear, participants require to make a response immediately, each material presents only 2000ms.

2.5 Post questionnaire

The after experiment questionnaire materials consist of 7 questionnaires. Questionnaires 1-3 are comparative scoring tables of appearance characteristic elements recognition degree and questionnaires 4-6 are comparative scoring tables of appearance characteristic elements familiarity degree, questionnaires 7 is a comparative scoring tables of the effect size of each characteristic on chair recognition. The scoring process takes an average of 20 minutes.

3 Result

3.1 Behavior data of EEG experiment

The experiment records the judgment and reaction time of subjects during recognition stage, the correct rate and the average reaction time of each group are shown in Table 1. As shown in table, there is a significant decrease in the correct rate and reaction time of each group which means that familiarity has a certain effect on the judgment of the subjects. In terms of correct rate, shape and color groups show that the lower the familiarity degree, the higher the correct rate. In reaction time, shape and color groups show that the lower the familiarity degree, the shorter the reaction time.

Table 1: The mean correct rate（%）and the mean reaction time（ms）of subjects in recognition phase（m ± sd）

Group	Behavior	Familiarity degree		
		High	*Medium*	*Low*
Shape	*Correct rate*	71 ± 28	72 ± 27	84 ± 1
	Reaction time	1264 ± 253	1196 ± 190	1112 ± 175
Color	*Correct rate*	60 ± 23	61 ± 26	61 ± 32
	Reaction time	1258 ± 241	1192 ± 228	1205 ± 258
Material	*Correct rate*	75 ± 23	66±23	68 ± 23
	Reaction time	1259 ± 221	1211 ± 212	1207 ± 157

3.2 EEG data

During the recognition process, the old stimulus may induce a more positive-going ERP waveform than new stimulus is called the old-new effect, which is a special and original phenomenon of ERP and can be used in memory research, the effects are expected to occurs at 300-500ms after stimulus appears and will continue 300-600ms. Early frontal lobe old-new effect appears in 300-500ms at the bilateral frontal electrodes associated with familiarity. The parietal lobe old-new effect appears in 500-800ms and sensitive to the strength of memory traces, can reflects the success retrieval and recall of the stimulus in the explicit memory, associated with the extraction of specific information.

The total ERP average waveform graph and the average ERP waveforms of each familiarity degrees in each characteristic group are shown in Figure 2. As shown in the figures, all of the different characteristic groups produce a positive-going waveform in the time period of 200-1000ms and there are some differences between each characteristic groups and each familiarity degrees of each group, it may have some relationship with the new-old effects. According to the related literature, the roughly period of old-new effect and the observation of ERP average waveform, the average amplitude of recognition phase period is divided to 200-400ms, 400ms-600ms and 600-1000ms to do analysis of variance for repeated measurements.

Analysis of the mean amplitude shows that main effects of old-new stimulus are significant in 200-400ms period ($F (1, 75) = 169.75$, $p = 0.00 < 0.05$) and old stimulus cause more positive-going waves than new stimulus. The characteristic groups have significant effects ($F (2, 75) = 224.5$，$p = 0.00 < 0.05$) and the familiarity degrees also have significant effects ($F (1.99, 145.03) = 732.97$，$p = 0.00 < 0.05$). There also exist significant main effects of brain electrodes ($F (1.23, 92.27) = 2226.24$, $p = 0.00 < 0.05$). Doing further analysis on the old-new stimuli and the brain electrodes, there exists interaction effect between these two factors ($F (1.33, 99.61) = 504.74$, $p = 0.00 < 0.05$). Though simple effect analysis can find out that there is obvious old-new effect in the front electrodes AF3, AF4 and the central electrodes FC5, but not apparent in posterior electrodes, it reflects a significant early frontal area old-new effect. Analysing the old-new effect distribution of each characteristic group, the effect of each group are more widely distributed in the brain areas under high familiarity than low familiarity, and the medium familiarity does not cause old-new effect in any electrode. Focus on the frontal area electrodes, find out that three groups induce significant old-new effect under high familiarity, while only color group shows old-new effect under low familiarity.

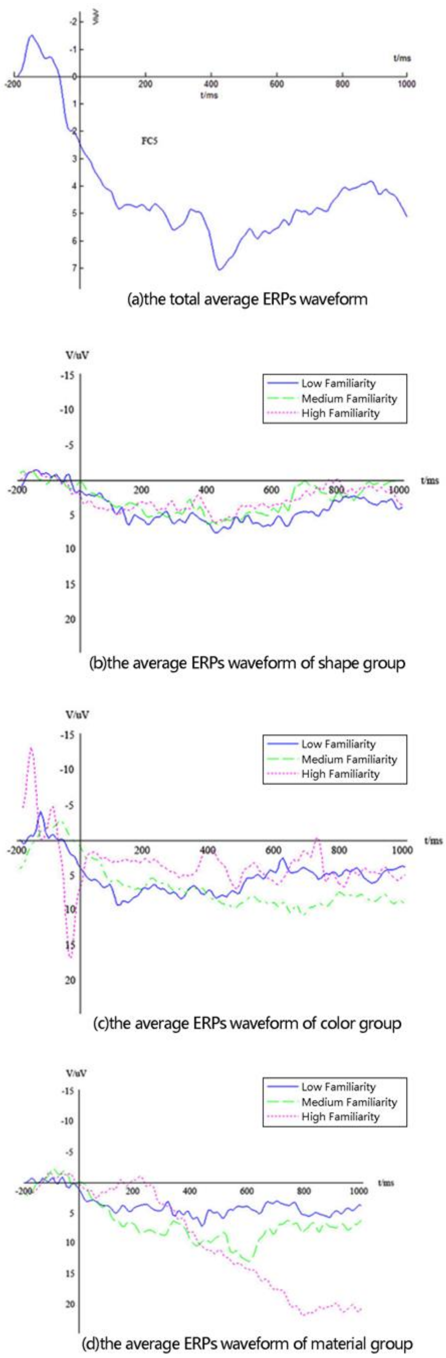

Figure 2: The total average ERPs waveform and the average ERPs waveform of shape, color and material group (in FC5)

In the period of 400-600ms, the old and new stimuli have significant main effect ($F (1, 75) = 447.53$, $p = 0.00 < 0.05$), the characteristic has significant main effect ($F (2, 75) = 227.77$, $p = 0.00 < 0.05$), the familiarity has significant main effect ($F (1.77, 132.52) = 382.78$, $p = 0.00 < 0.05$) and the main effect of brain is also significant ($F (1.96, 147.28) = 3204.45$, $p = 0.00 < 0.05$). There is interaction effect between old-new stimulus and brain distribution ($F (1.06, 79.35) = 385.23$, $p = 0.00 < 0.05$). The simple effect analysis between old-new stimuli and familiarity finds out that only in the case of high familiarity the old-new effect can be found in all area. The interaction effect is also found among old-new stimulus, characteristic, familiarity, and electrodes ($F (3.55, 133.01) = 475.87$, $p = 0.00 < 0.05$). In shape group, the medium and high familiarity cause more widely old-new effect, but in color and material group, the effects exist in all three brain parts only in the case of high familiarity degree, and exist in central area in the case of low familiarity.

The results of analysis of variance for repeated measurements in the 600-1000ms period show that old-new stimulus has significant main effect ($F (1, 150) = 1035.27$, $p = 0.00 < 0.05$), characteristic has significant main effect ($F (2, 150) = 275.220$, $p = 0.00 < 0.05$), familiarity has significant effect ($F (1.60, 239.52) = 187.65$, $p = 0.00 < 0.05$) and the brain electrodes also has significant effect ($F (1.68, 251.98) = 676.047$, $p = 0.00 < 0.05$). There also exist interaction effects among old-new stimulus, characteristic, familiarity and brain electrodes ($F (3.55, 133.01) = 475.87$, $p = 0.00 < 0.05$). In shape group, high and medium familiarity produced old-new effect in most electrodes. In color group, high familiarity produces the effect in central and back area electrodes and medium familiarity produces in central area. Low familiarity does not cause the effect in any electrode in shape and color group. In material group, the high familiarity situation is similar with color group but the medium group causes no effect and low familiarity causes the effect in central area.

The different time periods brain electrical activity mapping of each group is shown in figure 3. Though the figures can reflect activation intensity of brain area and the greater the absolute value of the voltage, the stronger the activation.

In shape groups (Figure 3a), under the condition of low familiarity, the frontal area of brain is highly negative activated, it supposed to be FN400. In terms of medium familiarity, the parietal region is highest activated in 400ms and the component is presumed to be P3, then the activation gradually weakened. In highly familiarity, the activation of frontal brain is continued strong and the activation of parietal region strengthens gradually which is presumed to be late positive components (LPC). On the whole, the brain's resource occupation of high familiarity is more than medium and low familiarity and memory strength is also much deeper.

In color group (Figure 3b), each familiarity degree presents significant LPC. Under all three kinds of familiarity, the frontal area of brain is highly negative activated which is presumed to be the early frontal area old-new effect with FN400 component. And P3 component appears in parietal region at 400ms. Meanwhile, the activation of parietal region increases during 600-1000ms period indicating late positive components appears.

In material group (Figure 3c), under low and high familiarity the activation of parietal region reaches peak value at 600ms and under medium familiarity the late positive components is not apparent.

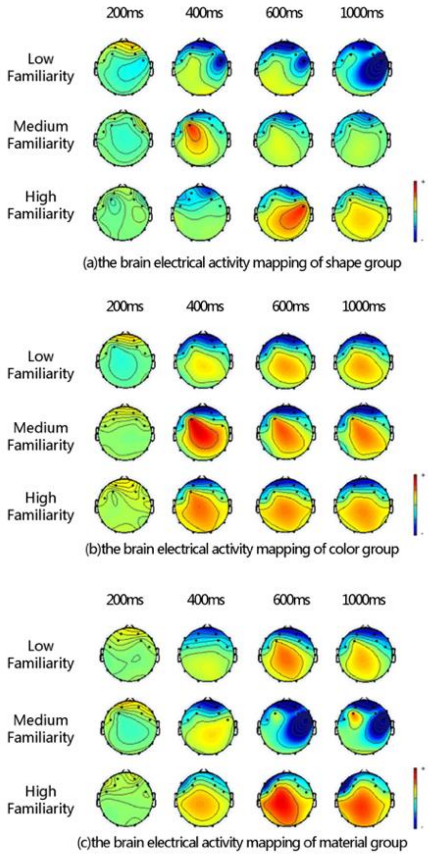

Figure 3: The brain electrical activity mapping of each group

To observe the three groups can find out that three groups have obvious negative activation in frontal area, presumably is the appearance of FN400 and reflects the early old-new effect of frontal area. And the parietal region is positive activated at 400ms which probably is P3 and means the processing of memory. And in 600-1000ms period, the parietal region appears another positive peak which may be late positive component and represents the old-new effect in the parietal region.

3.3 Questionnaire data

The questionnaires are analysed by AHP. First, we calculate the geometric average of the 20 subjects' criterion layer data, and obtain the judgment matrix. The judgment matrix which contains the chairs' recognition contribution degree of three characteristics is shown in Table 2. Checking the consistency，CI<0.1, thus the consistency is satisfied.

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i} = \frac{0.9441}{0.9372} + \frac{1.2968}{1.284} + \frac{0.7835}{0.7788} = 3.0234$$

$$\mathrm{CR} = \frac{CI}{RI} = \frac{0.0117}{0.52} = 0.0225 \quad \mathrm{CI} = \frac{\lambda_{max}\text{-}n}{n\text{-}1} = 0.0117$$

Table 2: The matrix and weight of criterion layer indicator

	Shape	**Color**	**Material**	**Weight**
Shape	1	0.6248	1.4031	0.3124
Color	1.6004	1	1.4209	0.4280
Material	0.7127	0.7038	1	0.2596

Then calculating the sub-criterion layer indicator and checking the consistency. According to the sub-criterion layer indicator, four chairs are designed from feasible combination of different characteristic elements of highest recognition weight, second highest weight, second lowest weight, and lowest weight, as shown in Figure 4 and the weight of each scheme is shown in table 3. According to the result of AHP, the recognition order of the chairs from the highest recognition to the lowest is 1-2-3-4. Experiments are performed to check the validity of weight ratio obtained by AHP. 50 subjects sort the fours and the results are shown in Table 4. The average order of the 50 subjects from the highest recognition to the lowest recognition is 1-2-3-4, which matches the results of AHP.

Figure 4: The brain electrical activity mapping of each group

Table 3: This is an example of a table caption.

	Scheme 1	**Scheme 2**	**Scheme 3**	**Scheme 4**
Shape	0.2652	0.2056	0.0396	0.0375
Color	0.2320	0.1445	0.0488	0.0356
Material	0.2268	0.1741	0.0360	0.0325
Recognition	0.2410	0.1713	0.0426	0.0354

Table 4: This is an example of a table caption.

	No.1	**No.2**	**No.3**	**No.4**	**Average**
Scheme 1	74%	18%	8%	0%	1.58
Scheme 2	4%	52%	36%	8%	2.24
Scheme 3	12%	18%	54%	16%	2.5
Scheme 4	10%	12%	2%	76%	3.68

The consistency between recognition and familiarity is checked to reveal the relationship between different characteristic elements and recognition. The familiarity of shape is markedly negative related to recognition, as $r(7) = -0.727$，$p=0.026<0.5$; The familiarity of color is markedly negative related to recognition, as $r(7) = -0.691$，$p=0.039<0.5$；The familiarity of material is markedly negative related to recognition, as $r(7) = -0.862$，$p=0.003<0.5$. Above all, conclusion can be obtained those three elements all have markedly negative related to recognition

4 Discussion

The analysis of behavior results shows that the correct rate and reaction time have some differences among each group. In the shape and color groups, participants respond quickly with low familiarity chairs, the reaction time is short and the accuracy is high, which may be due to the originality of low familiarity chairs and reflects the high recognition.

The analysis of EEG data displays that the three characteristic groups all shows significant early frontal old-new effect and later parietal old-new effect. The Early frontal old-new effect is associated with the familiarity, which is a pure intuitive response before recall any details. Seen from the familiarity, highly familiarity degree gives rise to wider old-new effect than other degrees which perhaps because of the influence of original familiarity feeling from the pictures. Seen from the group, there are some differences. The early frontal old-new effect is broadly apparent in color group, especially in low familiarity, which means in the early period of recognition process color has the biggest effect. The parietal old-new effect is sensitive with impression. Seen from the familiarity, high and medium familiarity has more intense old-new effect than low familiarity. In the case of low familiarity color and material group have more apparent old-new effect and in the case of high familiarity, the old-new effect is more obvious in shape group. Through analysis, the greater effect of shape in high familiarity maybe because of the original impression of high familiarity shape has a great influence on the recognition.

In General, the different characteristic has the different impact on recognition and the different degree of familiarity has different impact on recognition. Although there are differences between the degrees of familiarity, we cannot determine the order of influence size of each familiarity on recognition. Throughout three groups, high familiarity and low familiarity have a great influence on recognition, the former is reflected in the later period of recognition process because of its original familiarity feelings and the latter is embodied in the early period of recognition process which is due to the feeling of freshness and the impact of bright colors.

The analysis of AHP results shows that the order of influence size on recognition is color > shape > material, color has the greatest impact on recognition. Through the verification experiment, we can find out that shape, color and material has different effects on product recognition. The chair which consists of high recognition characteristic elements has high recognition, the recognition of characteristic element has a positive effect on overall product recognition and due to the negative correlation relationship between familiarity and recognition we can figure out that the higher the recognition of characteristic, the lower the familiarity and the higher the product recognition.

5 Conclusion

This research uses EEG experiment to explore the effect of characteristic familiarity on product recognition, and it has certain significance to product innovation design. When designer try to improve product appearance, low familiarity color elements and high familiarity shape elements are good choices to increase product recognition. Although the pursuit of recognition is important, design schemes should be corresponds to user's aesthetic. Through the old-new effect of EEG experiment can able to compare the recognition roughly. The different results of experiment and questionnaire survey indicate that the subjective judgment and objective measurement are different, different experimental method has its own advantages and limitations. In future product research, we can choose a suitable method according to its advantages and disadvantages, the dimension of research variables, and whether the problem can be judged by subjectivity and other consideration factors, so that we can collect and analyze data more comprehensively and obtain an accurate experimental results and conclusions.

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