An Interface Design Method for E-commerce Sites' Homepage Considering Users' Emotions

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Abstract. This paper proposes a useful method to understand the relationship between web design elements, Kansei evaluation and users' emotions based on Kansei Engineering, taking E-commerce sites for example. Firstly it establishes customers' evaluation image words through a survey of the web interface preference. Then it collects the data of Kansei evaluation and users' emotions to different websites by an emotion assessment test. Lastly it builds the relation models between web design elements, Kansei evaluation and users' emotions using the quantification theory I and partial least squares (PLS) method, and confirms the validity of the models.

Keywords: E-commerce, Emotion, Kansei engineering, Web design, PLS.

1 Introduction

According to the China Internet Network Information Center (CNNIC) 31th "China Internet Development Statistics Report" released in January 2013, Nearly 242 million Chinese people joined the online shopping army. As the netizens change their consuming habit, many businesses have to break away from the traditional mode of operation, using advanced network marketing model to pursue new growth points [1].

Online sales need the support of e-commerce sites. To enterprise, the interfaces of e-commerce sites are not only windows where the enterprises display their image, but also an important means to show the goods and help the user to complete the purchase. It has been an explosion of activity in recent years that how to design a web interface which can grab user's attention and make a better experience for the user.

Presently, study on the web interface design is focused on the following three aspects: usability research, aesthetic research and emotion research.

1.1 Usability Research in the Web Design

The ISO 9241 standard defines website usability as the "effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments [2]." Dr. Jakob Nielsen, a pioneer in the field of usability, proposed usability

V.G. Duffy (Ed.): DHM/HCII 2013, Part II, LNCS 8026, pp. 30–39, 2013.

guidelines in a book of his "usability engineering", which become the main reference for the later scholars to conduct usability studies [3]. Subsequent studies have mostly concentrated on the methods of website usability evaluation and testing. Currently, usability evaluation and testing methods are already quite mature. In general, there are two kinds of methods: One is the analysis or empirical approach [4], For example, Paper [5] verified the important indicators to make the website usable through an empirical approach. The other is evaluation method, including expert evaluation, user evaluation and model evaluation. [6].

1.2 Aesthetic Research in the Web Design

The early research on web design focused on objective indicators of efficiency, while ignoring the important role of the visual aesthetic elements in web design. The word "aesthetics" comes from the Greek Aesthesis, which original meaning is sensory feelings. Following Nielsen, many scholars discovered aesthetic factors can significantly affect the users' usability perception and satisfaction of website through empirical approach [7].

Users interact with the web mainly through some aesthetic elements (such as text and image) on the web, which should be organized according to visual hierarchy to guide users to browse web naturally [8]. Aesthetic element, such as animation, color, style of the text and position of the image, plays a meaningful role in the users' perception on the website [7].

1.3 Emotion Research

Emotion is mainly concern with people's psychological response to external stimuli, such as happy, anger, hate and so on [9,10,11]. The relationship between web page design elements and users' emotions is one of the hot topics which still hold numerous researchers' attention.

Which design elements will impact users' emotions? A lot of scholars has studied on this problem and drawn some valuable conclusions. Paper [12] examined the impact of four web site interface features (structure of information presentation, navigation, text, visual aspects) on the user's emotions. It found that structure of information presentation and navigation significantly influence the emotional state. In addition, the complexity of the web page is also important factors that affect the user's emotion [13]. Experimental study demonstrated that visual complexity of websites has multiple effects on human emotion [14].

For the quantitative relationship between the design elements and emotion, a small number of scholars have done some exploratory research. Paper [15] build a relationship model reflecting different design elements and users' Kansei evaluation of the e-commerce website by applying Kansei Engineering method. Paper [16] established a quantitative relationship between the design elements and Kansei evaluation with regression analysis. However, they could not explain the relationship between emotion and design elements, as well as why the two have relations. In addition, the results do not have a cross-cultural background.

To summarize, the following limitations exist in the current research:

1. Focusing on theory research and practical guidance in web design is far from sufficient. Currently research mainly concerned in clarifying the relationships among various design elements that affect the users' emotions. However, it rarely points out which specific design elements can induce what kind of emotion and put forward some methods to improve the web design. Furthermore, it is difficult to apply their findings to web design in China because of cultural differences.
2. Divide design elements into usability elements and aesthetic elements, and study its impact on emotion respectively. In fact, a lot of web design elements belong to the usability elements, and the aesthetic elements as well, such as the navigation bar and search box, where usability and aesthetics cannot be divided.

Based on Kansei Engineering, it establishes a Kansei evaluation scale for the evaluation of e-commerce sites suitable for the Chinese environment. Then, users' Kansei and emotional evaluation data is obtained in an experiment. With these results, it establishes the relation model between the Kansei words, emotional words and web design elements. It is organized as follows. In Section 2, a Kansei evaluation scale is established. In Section 3, an experiment is carried out to obtain Kansei and emotional evaluation data. In Section 4, a model reflecting the relationship of Kansei words and emotional words is proposed by PLS which is validated. In Section 5, the models reflecting the relationship between Kansei words, emotional words and design elements are proposed by PLS which are validated. A conclusion is given at the end of this paper.

2 Scale Building of User Kansei Evaluation

2.1 The Selection of Representative Websites

There are three important design factors affecting the users' emotion response on the appearance design of website in the research domain, that is layout, the whole color set and complexity of website [17-19]. So the representative websites are selected according to these factors.

1. A total of 80 websites were initially collected depending on some navigation websites such as hao123, hao360 etc. and the statistics of websites ranking.
2. A classification was made on these 80 websites. Three classes (i.e. corner style, up-down style and lane style) were determined for the difference of layout. Then light (white, cream-colored etc.) and deep colors (dark red, dark grey etc.) were classified according to the website's hue. Finally classification was made based on the complexity of websites (the size of homepage saved as picture). Three websites not used usually were chose as the representative websites to refrain from the effects of users' habit, that is, www.yifu.com, www.crucco.com and www.masamaso.com.

2.2 The Collection of Kansei Words

The Kansei words were selected according to web design guidebook, textbook of web visual design, survey reports and pertinent literatures, and have a high frequency of use. 14 words were determined after a preliminary investigation. And bipolar adjectives were used for accurate measure of users' Kansei evaluation on web interface, shown as table 1.

Table 1. Kansei Words for E-commerce Web Sites

No.	Kansei Words	No.	Kansei Words
V1	childish-mature	V8	stodgy-artistic
V2	disorder-concise	V9	rough-delicate
V3	neglected-impressive	V10	prim-lively
V4	classic-modern	V11	abrupt-coordinating
V5	dim-clear	V12	discourtesy-courtesy
V6	ordinary-creative	V13	dull-interesting
V7	complicated-simple	V14	feminine-manly

2.3 Questionnaire Design

100 undergraduate students (46 males, 54 females) from Northeastern University participated in the Kansei evaluation from 18 to 27 years. Participants were asked to browse and interact with webs selected in section 2.1 for simple tasks (e.g. find a product), then fill the 7-point questionnaire from -3 to 3 composed of 14 bipolar words shown as table 1.

2.4 The Establishment of Kansei Evaluation Scale

Correlation analysis was made between Kansei words, of which V1, V4, V7, and V14 were deleted for lack of correlation with the whole evaluation. Then reliability analysis indicates a high reliable of the scale with Cronbach alpha coefficient all above 0.8 for Kansei words and the whole evaluation. Two factors were extracted by factor analysis for verifying the structural validity of the scale. They are named as aesthetic factor (V3, V4, V8, V1, V5, V6) and Kansei factor (V7、V9、V2、V10).

3 The Experiment of Kansei and Emotion Evaluation on E-commerce Web

The goal of this experiment in this section is to collect Kansei evaluation and emotion values of users after browsing webs.

3.1 The Selection of Emotional Experience Scale

Basic emotions and emotion changes caused by cognition alternation from external stimuli are main emotions of human being according to emotional psychology. Emotion changes can be obtained by calculating the difference between user's whole emotion(measured by PAD)and component of emotion caused by user's disposition (measured by personality questionnaire FFM)when user' whole emotion is determined [20,21].

3.2 Experiment Design and Data Collection

9 modish e-commerce webs of apparel were selected as stimuli. 20 students (10 males, 10 females) from Northeastern University participated in the experiment. The subjects have prior experience of online shopping aging from 18 to 30. The major steps of this experiment are as follows: in the preliminary procedure, the subjects were required to fill the FFM several days before the experiment. Then the 9 webs were evenly divided into three groups. There are five minutes for relaxing before subjects browsing the first group webs. PAD and Kansei evaluation scale were filled by subjects when finish browsing one web. Then repeat the foregoing step until the three groups webs all browsed by subjects.

4 The Relation Modeling between Kansei Evaluation and Emotional Experience

4.1 Model Building Based on PLS Regression

A regression model with the free variable set X of Kansei words (from V1 to V10) and the dependent variable set Y of three emotional dimensions was built respectively. As shown in formula 1, 2 and 3.

$$P=2.0238-0.0393V1-0.0834V2+0.2180V3+0.1841V4+0.2992V5-0.0212V6-0.2855V7+0.0672V8+0.2593V9+0.1262V10 \quad (1)$$

$$A=3.7194-0.0392V1-0.0699V2+0.1437V3+0.1247V4+0.2088V5-0.0284V6-0.2190V7+0.0389V8+0.1671V9+0.0762V10 \quad (2)$$

$$D=5.9332-0.0277V1-0.0326V2+0.0091V3+0.0142V4+0.0351V5-0.0292V6-0.0722V7-0.0077V8+0.0102V9-0.0084V10 \quad (3)$$

4.2 Model Verification

The predictive figure was made with the predictive values of pleasure, arousal and dominance as the abscissa and the observed values as ordinate to test the validity of models. There is little difference between predictive values and observed if all the points distributed evenly near the diagonal. The results are shown as fig.1.

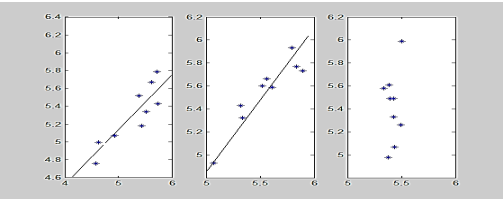

Fig. 1. The predictive result of PLS regression models

From Fig.1, the observed values of pleasure and arousal keep in line with the predictive according to PLS regression models, while the PLS model is invalid for the dominance. A survey was done to test the validity of models further. 10 questionnaires were issued to evaluate three webs randomly selected from the nine representatives, and the mean values of Kansei evaluation were used as inputs to the PLS models of pleasure and arousal. A comparison between predictive values from equations and observed indicates the difference was not statistically significant.

4.3 Interpretations of the Models

Kansei words can interpret pleasure and arousal well and have a consistency for them from the foregoing results. Pertinent literatures indicate that moderate intensity positive emotion is conducive to promote thinking and decision making, overstrain with high arousal and otherwise inadvertency when users browse webs not good for producing positive emotion. Hence there is a positive correlation between pleasure and arousal indicating that well designed webs using appropriate factors can keep balanced state of pleasure and arousal when users browse webs. Moreover Kansei words are hardly to interpret and predict dominance, used to describe users' feelings on web interface, while dominance is just an emotional experience during interactive with webs. So there is no obvious relation between them.

In detail, Kansei words such as V3, V4, V5, V7, and V9 can interpret users' emotion well, of which V3, V4, V5, and V9 have a positive effect indicating stronger pleasure and arousal with higher scores. V3, V4, and V5 belong to aesthetic factors meaning lively and bright colors (e.g. red), and innovative as well as artistic factors can bring pleasure to users and maintain a level of arousal to attract users' attention simultaneously. And V9 is one factor of sensory. Users will have better emotional experience when integrating emotion into product design according to Norman. Some design factors are required to bring users warmth and comfort and maintain users' pleasure and arousal. V7 has a negative effect on users' emotion for dynamic design factors in some webs. While these dynamic factors make users feel boring and distract users' attention as well such as products images change in some intervals and banner ads rotation.

The other Kansei words (i.e. V1, V2, V6, V8, and V10) are moderate words and have a stable level on pleasure and arousal. Take V1 for an example, it means that simple and refreshing webs make users pleasure. While users feel boring and have a low arousal when browsing webs with too simple contents.

5 Relation Model Building between Homepage Design and User Experience

5.1 Extraction and Coding of Web Design Elements

Major design features were determined by eye tracking when users browsing homepages of e-commerce websites. Categories of each item were obtained by comparison, analysis, filter and consult from designers based on the 80 webs' homepages determined in section 2.1.

Table 2. The Design Elements of E-commerce Web Sites' Homepage

Major design features	Item	Category			
The overall design features (A)	Color (A_1)	Light tone (A_{11})	Dark tone (A_{12})		
	Complexity (A_2)	Less than three (A_{21})	More than three (A_{22})		
	Layout (A_3)	Left-corner (A_{31})	Right-corner (A_{32})	Up-down (A_{33})	Three-column (A_{34})
	Ratio of text and picture (A_4)	Mainly by the text (A_{41})	Equally (A_{42})	Mainly by the picture (A_{43})	
Navigation (B)	Background color (B_1)	White (B_{11})	Red (B_{12})	Charcoal grey (B_{13})	
	Interactive effect (B_2)	Label (B_{21})	Drop-down (B_{22})	Ordinary link (B_{23})	
List of goods category (C)	Interactive effect (C_1)	Down-suspension (C_{11})	Ordinary link (C_{12})	Right-suspension box (C_{13})	
Banner (D)	Form (D_1)	Pictures (D_{11})	Pictures and texts (D_{12})		
	Dynamic effect (D_2)	Gradual change (D_{21})	Up-down (D_{22})		
Goods display system (E)	Way of display (E_1)	Static (E_{11})	Rotation display (E_{12})		
	Way of picture segmentation (E_2)	Boundary clear (E_{21})	Blank (E_{22})		
	Way of goods' compound mode (E_3)	Irregular (E_{31})	Uniform size (E_{32})	Matched (E_{33})	

Combined with the classification of variable in table 2, the 9 representatives were coded. Different items of one design elements are mutually exclusive in each web. So 0 and 1 were used to distinguish them, 0 represents no item in web design, and the opposite is the other way around.

5.2 Relation Model Building between Homepage Design and Kansei Evaluation

Model Building. Partial least square estimation was applied for insufficient samples with 31 design elements and only 9 representative samples to construct the relation model of Kansei words and design variables, the contribution rate of Kansei words of their corresponding design variables. Take "disorder-concise" as an example, the corresponding model is shown as formula 4.

$$\begin{aligned} Y = 3.771 &+ \begin{pmatrix} 0.634A_{11} \\ -0.662A_{12} \end{pmatrix} + \begin{pmatrix} -0.274A_{21} \\ 0.246A_{22} \end{pmatrix} + \begin{pmatrix} -0.256A_{31} \\ 0.133A_{32} \\ 0.491A_{33} \\ -0.565B_{34} \end{pmatrix} + \begin{pmatrix} -0.614A_{41} \\ 0.157A_{42} \\ 0.352A_{43} \end{pmatrix} + \begin{pmatrix} 0.067B_{11} \\ 0.740B_{12} \\ -0.748B_{13} \end{pmatrix} \\ &+ \begin{pmatrix} -0.267B_{21} \\ 0.086B_{22} \\ 0.157B_{23} \end{pmatrix} + \begin{pmatrix} 0.157C_{11} \\ 0.342C_{12} \\ -0.614C_{13} \end{pmatrix} + \begin{pmatrix} -0.118D_{11} \\ 0.095D_{12} \end{pmatrix} + \begin{pmatrix} 0.277D_{21} \\ -0.3D_{22} \end{pmatrix} + \begin{pmatrix} 0.114E_{11} \\ -0.142E_{12} \end{pmatrix} + \begin{pmatrix} -0.368E_{21} \\ 0.345E_{22} \end{pmatrix} + \begin{pmatrix} 0.009E_{31} \\ -0.165E_{32} \\ 0.106E_{33} \end{pmatrix} \end{aligned} \tag{4}$$

As can be seen from formula 4, the first level of navigation has the highest contribution rate while banner lowest indicating that background color of navigation must be red to satisfy users and the deploying style of banner has no effect on users. There are 11 coefficients of design variables below zero. These variables will make the web disorder, of which four design variables have the worst effect i.e. dark grey background used for navigation, deep color background applied for the whole web, three-column layout or left corner and text dominant.

The following design solution is made to obtain a concise web from foregoing analysis. Firstly the color of the overall web should be light and has a layout not more than 3 columns. And up-down style should be made with pictures dominant. The background color of navigation should be red. Ordinary link should be used for interaction and category list, banners with text and picture of gradient color and static style for products deploying, leaving blank between pictures and same size pictures for product portfolio.

Model Test. Data from section 3 and "disorder-concise" were used for model test. 4 webs were selected randomly from the 9 representatives. A comparison was did between the predictive value obtain from regression models and scores of Kansei words obtained via questionnaires. Paired sample test was did indicating insignificant difference between predictive values and observed and the models are valid.

5.3 The Relation Model between Homepage Design and User Emotion

Model Building. Similar regression equations can be determined by applying PLS regression analysis to construct the relation between homepage design variables and user emotion. The formulas are 5 and 6.

$$\begin{aligned} \bar{P} = 4.9387 &+ \begin{pmatrix} 0.2922A_{11} \\ -0.1141A_{12} \end{pmatrix} + \begin{pmatrix} 0.3046A_{21} \\ -0.1283A_{22} \end{pmatrix} + \begin{pmatrix} -0.1512A_{31} \\ -0.2768A_{32} \\ 0.3722A_{33} \\ 0.2926B_{34} \end{pmatrix} + \begin{pmatrix} -0.0999A_{41} \\ 0.2268A_{42} \\ 0.0623A_{43} \end{pmatrix} + \begin{pmatrix} 0.0983B_{11} \\ 0.2627B_{12} \\ -0.2372B_{13} \end{pmatrix} \\ &+ \begin{pmatrix} -0.064B_{21} \\ 0.017B_{22} \\ -0.2372B_{23} \end{pmatrix} + \begin{pmatrix} 0.2194C_{11} \\ -0.2489C_{12} \\ 0.2268C_{13} \end{pmatrix} + \begin{pmatrix} 0.1298D_{11} \\ 0.0192D_{12} \end{pmatrix} + \begin{pmatrix} -0.61D_{21} \\ 0.21D_{22} \end{pmatrix} + \begin{pmatrix} -0.2275E_{11} \\ 0.4056E_{12} \end{pmatrix} + \begin{pmatrix} 0.0034E_{21} \\ 0.1456E_{22} \end{pmatrix} + \begin{pmatrix} 0.0498E_{31} \\ 0.132E_{32} \\ -0.0087E_{33} \end{pmatrix} \end{aligned} \tag{5}$$

$$\tilde{A} = 5.282 + \begin{pmatrix} 0.2767A_{11} \\ -0.1187A_{12} \end{pmatrix} + \begin{pmatrix} 0.2726A_{21} \\ -0.1146A_{22} \end{pmatrix} + \begin{pmatrix} -0.1424A_{31} \\ 0.2368A_{32} \\ 0.3171A_{33} \\ 0.2768B_{34} \end{pmatrix} + \begin{pmatrix} -1.016A_{41} \\ 0.2193A_{42} \\ 0.053A_{43} \end{pmatrix} + \begin{pmatrix} 0.079B_{11} \\ 0.2529B_{12} \\ -0.2232B_{13} \end{pmatrix}$$
$$+ \begin{pmatrix} 0.0406B_{21} \\ 0.065B_{22} \\ 0.1734B_{23} \end{pmatrix} + \begin{pmatrix} 0.1734C_{11} \\ -0.2158C_{12} \\ 0.2193C_{13} \end{pmatrix} + \begin{pmatrix} 0.1089D_{11} \\ 0.0233D_{12} \end{pmatrix} + \begin{pmatrix} -0.0446D_{21} \\ 0.1768D_{22} \end{pmatrix} + \begin{pmatrix} -0.191\mathrm{E}_{11} \\ 0.349E_{12} \end{pmatrix} + \begin{pmatrix} 0.0185\mathrm{E}_{21} \\ 0.1136E_{22} \end{pmatrix} + \begin{pmatrix} 0.0567\mathrm{E}_{31} \\ 0.0976E_{32} \\ -0.0033E_{33} \end{pmatrix} \quad (6)$$

The following design solution should be made to obtain a pleasure and arousal web from formulas 5 and 6. Firstly the color of the overall web should be light tone and has a layout not more than 3 columns with an up-down style. And the content of webs should keep a balance between text and pictures, the background color of navigation should be red with an ordinary link, the category list should be played with a right-suspending box style, banners with combination in a up-down style, leaving blank between pictures and keeping the same size of pictures for product portfolio in a rotation display style.

Model Test. 4 webs were selected randomly from the 9 representatives based on the data obtained from emotion evaluation in section 3. Paired sample test was did indicating insignificant difference between predictive values and observed of pleasure and arousal and the models are valid.

6 Conclusion

Based on e-commerce website as the research object, it established a Kansei evaluation scale, extracted key web design elements, and obtained user's Kansei and emotional evaluation data of 9 typical website through an experiment of Kansei and emotional evaluation on e-commerce web. It established the relation model between the Kansei words, emotional words and web design elements using PLS and verified the validity of the models. The results demonstrated that design elements of e-commerce website can be selected according to users' pleasure and arousal .That is, the website can be can be designed according to users' Kansei words to meet users' emotional needs. Research methods and conclusions provide reference for web designers to design website according to the user's emotional needs.

There are still some deficiencies of this study. Firstly, it is need improve the method of selecting the design elements of the website. Representative design elements of website were selected through eye tracking in this study, which was timesaver but could not include all the design elements. Secondly, using the real website in the experiment couldn't avoid the impact of other factors (such as the kinds of goods) on user's Kansei and emotional evaluation. Future research should design website to control the variety of design elements to examine the impact of different design elements on the user's Kansei evaluation and emotional experience.

Acknowledgments. The author would like to acknowledge the national natural science foundation for its contribution to the research in this paper. National natural science foundation: 71171041.

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