The Influence of Emotion Expression on Ergonomics in Interface Design

Mohan Yang
School of Design and Arts
Beijing Institute of Technology
Beijing, China
yang_489281930@hotmail.com

Bowen Sun*
School of Design and Arts
Beijing Institute of Technology
Beijing, China
doersun@gmail.com

Jianming Yang
School of Design and Arts
Beijing Institute of Technology
Beijing, China
yangjianming66@sina.com

***Abstract*—Emotions always participate in user behavior before consciousness, and all of our behaviors are affected by emotional thinking. Therefore, in digital interface design, how to more objectively evaluate whether the interface meets the design expectations has always been an important research field in user experience research. Based on the perspective of the influence of interface visual representation on user emotions, this paper aims to improve the objectivity of the evaluation results of the visual representation design of the information interface. We use the combination of kano model and AHP analysis method, propose an interface emotion-guided performance evaluation method based on the emotional representation of the information interface, and validate the method through examples. It is more accurate and objective in the evaluation, which assists the designer in more targeted analysis and optimizing the interface design.**

***Keywords*—emotional cognition, Kano model, analytic hierarchy process, interface design**

I. BACKGROUND

In face of the increasingly fierce competition in the internet market, the interactive interface design pays more attention to fit the user psychology and meet users' invisible needs, instead of focusing on the development and implementation of functions as previous. This makes sure that users become loyal to the platform and to the market. With the digital human-computer interface gradually applied to more professional fields (e.g nuclear power plant control, military command and driving command), its complexity and professionalism tend to cause greater consumption of users' cognitive and attention resources. This scenario puts forward the need for more requirements related to interactive interface design.

Therefore, theories that focus on user psychology and behavior, such as 'Emotional Design', are more commonly applied to human-computer interaction interface design. By guiding the psychological needs of users, the cognitive burden is reduced. However, in design practice, it is found that not all users can operate according to the original design expectations, and sometimes the situation doesn't match the expectation. The fundamental reason is that users do not always rely on rational thinking to make judgments while using the process. On the contrary, users are most likely affected by their behavior operations – especially their emotions – due to the intervention of subconscious psychological behaviors.

*Corresponding author: B. Sun(doersun@gmail.com)

II. EMOTIONS - ATTENTION TO THE COGNITIVE THEORY RESEARCH

Emotion plays an important regulating role in people's behavior and decision-making. But the activity of the emotion system is not controlled by rational consciousness. The "emotional section" of the human brain is the first reflecting region to make emotional intuitive judgments based on sensory signals, preceding our logical thinking [1]. Emotional arousal and emotion-based choices are usually unavoidable ahead of any conscious analysis. In earlier theoretical studies, emotion was often seen as an obstacle that interferes with the main cognitive decision-making process. The impulsive emotional system sometimes interferes with the more ordered rational system [2]. But recently studies have confirmed that human beings have obvious advantages in processing stimuli with emotional information. Flanker's Stroop task demonstrated that emotional stimuli could automatically attract attention and thus interfere with ongoing tasks. By "stop signal task", Verbruggen and Houwer [3] believed that the presentation of the emotional stimulus produced a response delay regardless of the valence of the emotional stimulus, thereby interrupting the ongoing cognitive control activities. In visual search, people are more sensitive to emotional information than neutral information.

In studies on attention cognition, Desimone and Duncan (1995) point out that [4]"Attention is not a high-speed spotlight. It can't scan every item in the field of view. Instead, slow and competitive interactions between items in the field of vision will make attention emerge". This competitive interaction process especially has a more obvious influence to interface design. Human beings rely on visual search obtaining the interface information over 90%. Because we are constrained by our limited resources of attention, the brain will filter information for information processing. In this process, the external stimulus will restrict the individual's goal-oriented behavior. Gawronski, Deutsch, and Strack have demonstrated in their research on visual search that approach or avoidance behavior can regulate the pattern of attention allocation. Emotional stimuli that are inconsistent with the current behavior are more likely to capture attention than emotional stimuli that are consistent with the behavior [5]. And because of the differences in individual factors including personality, cognitive level and emotional sensitivity, the

same stimulus will produce different responses in different people (Fig.1).

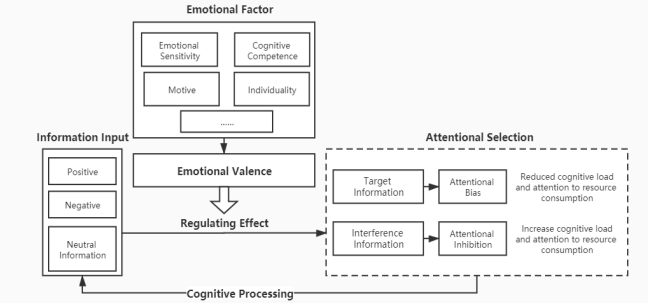

Fig.1. Emotional system regulation process

As for emotional valence in attention resource capture, most studies show that positive and negative stimulus information can capture attention resources and thus obtain cognitive priority processing. However, there are different views regarding which positive or negative emotion has the advantage in attention resource capture. Arguing about emotional psychology, Garon et al., found that compared with neutral and positive events, the human brain is more sensitive to negative emotional events and can attract attention resources more quickly and automatically. Because of that, people tend to prioritize negative events to adapt to survival [6]. Several studies indicate that when attention resource are limited, negative stimuli get priority processing [7]. Other related researches have shown that when individuals are in a certain emotional state, they are more willing to give priority to processing the same information related to that emotion, and focus their attention resources on the objects that make them produce positive emotions. It means that emotions play a regulating role in the interaction between users and objects. Positive emotions can make difficult items more acceptable, while negative emotions force users to focus on dealing with difficulties.

Through the influence of emotional valence on attention space, it was found that positive emotions had a promoting effect on target search, which was more likely to stimulate individuals to expand the attention space in visual search, while negative emotions would show the contraction of attention space.

In addition, the study on the emotional dimension arousal has showed that, excessive emotional stimulation, especially negative stimulation, will cause users to produce avoidant emotional regulation. It requires more cognitive resources for emotional regulation, but also increase the consumption of unnecessary cognitive resources [8], and will affect the allocation of attention resources. Brian Boxer Wachler's research on the relationship between attention resources and stimulus suggests that too little or too much stimulus will divert attention resources and cause distraction or difficulty in concentration. Moderate stimulation will make people in the "optimal stimulation" state, and people will have the best attention drive at this time (Fig. 2) [9].

The relationship between visual information and attention is mainly reflected in the passivity of visual perception and the initiative of information presentation. Therefore, if someone wants to reach the "best functional range" of users' attention and cognition, it is important to grasp the inner connection between emotional stimuli and attention resources. Therefore, in order to explore the rules of emotional activities, some psychological and physiological measures are usually used to provide more accurate data and research directions.

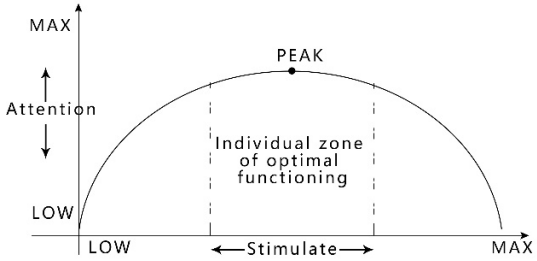

Fig.2. Brian Boxer Wachler's inverted U curve

III. EMOTIONS- ATTENTION TO COGNITIVE MEASURING METHODS RESEARCH

In emotional psychology research, human emotions are generally composed of three aspects: the psychological subjective feeling, the physiological arousal and the external expression of behavior [10] (Fig.3). The former two are mainly the inner state or experience of emotional existence, while the latter is manifested as outward expressions in most cases.

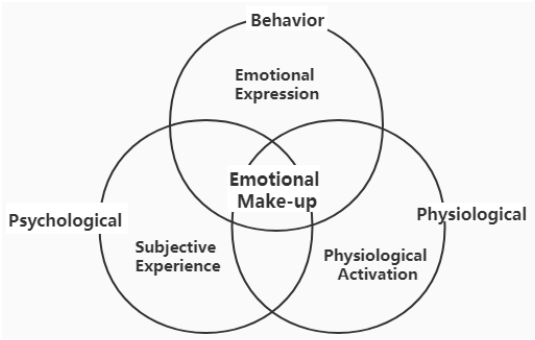

Fig.3. Emotional Composition Diagram

When users experience a kind of emotion, they can feel the intensity of this emotion and manifest through the changes of physiological characteristics，like heart rate (HR) and skin conductance responses (SCR), Finger Pulse Volume (FPV), blood pressure. All of them are effective indicators for measuring emotional changes. Lang, Greenwald, Brandly et al. (1993) proposed that the most common physiological indicator is Facial Electromyography (EMG) [11] that was once used as an indicator to observe facial muscle activities, such as the upturn of the corners of the mouth, the elevation of the cheeks, or the frowning, when people were exposed to external stimuli, respectively associated with positive and negative emotions. In recent years, behavioral medical studies on other emotional related physiological indicators have also pointed out that negative emotional pictures can cause significant increases in diastolic blood pressure, systolic blood pressure, and salivary cortisol levels, while positive emotional pictures can cause significant decreases in systolic blood pressure and heart rate [12,13,14]. In terms of the effect on the sympathetic nervous system, visual stimulation of negative emotions can cause rise blood pressure by activating the sympathetic nervous system. These physiological index measurements will more closely explore the subconscious level of emotional fluctuations which always be ignored. These measurements can directly reflect the emotions and

accurately provide data support for research as a measurement method for the evaluation of interface emotional dimension.

In addition, user questionnaire survey method also widely used in this aspect. These methods can directly observe and evaluate user experience that are widely used in design evaluation research (e.g perceptual engineering and situational awareness). Regarding the comprehensive evaluation methods, AHP (Analytic Hierarchy Process) and level-grey related analytic method are the most common interface evaluation methods. These methods establish a relationship model between factors, conduct qualitative and quantitative analysis, providing the evidence for subsequent research and decision-making. However, the extraction of factors in these analysis methods have always depended on the subjective cognition. Such as user interviews or expert evaluation methods that are easily causes the duplication of factors or inconsistent dimensions.

Therefore, based on the theory of the relationship between emotion and attention, this article firstly uses the kano model to carry out a relatively objective quantitative analysis and screening of subjective factors, and then constructs an evaluation model of emotional influence factors in interface design through the analytic hierarchy process.

IV. Research Ideas and Design

In the theoretical study of emotion and attention cognition, the perspective of attention selection control, it is generally divided into Exogenous attention and Endogenous attention. The distribution of exogenous attention mainly depends on the characteristics of external stimulus and the intensity of stimulus. The influence of these stimulus characteristics on selective attention is usually manifested according to the location, scope, and detail orientation of it. When it comes to the intensity of stimulus, it is mainly reflected in the specificity between the stimulus information representation and other types of information representation. Combining the two dimensions - valence and arousal - in an emotional dimension, it possible to obtain three new categories:

- Interface emotional features (positive and negative emotional features), that regards stimulus as features of good and bad emotions that can enhance the user's attention capture by interface information;
- Orientation of emotional expression information (location, range, detail orientation): Emotional stimulus information in the interface layout that regard location, size, text, color and other visual coding design as potential impacts on the representation effect of emotional stimulus and the capture efficiency of attention resources;
- Intensity of emotional expression of interface information.

This paper combines emotional stimulation and emotional dimension theory, through the kano model analysis of the relationship between user needs and emotional elements, explores the design performance priority of visual elements in interface design, so as to guide interface design work and better allocate user attention resources. Then, according to the research results, the optimized interface scheme is evaluated through the analytic hierarchy process to determine the best interface scheme.

A. Use Kano model for index extraction

In interface research, the guiding effect of emotional stimulation on users is basically based on user's needs. When the information guidance design meets user's needs, the user can perform interface-related operations more efficiently according to the guidance. Nevertheless, if the information guidance violates the user's needs, the guidance effect will not only be unavailable, but also causes obstacles to the user's operation. What's worse, it may even cause the user to produce disgusting emotions to affect the subsequent interface guidance efficiency.

The two-dimensional model satisfaction theory points out that when the product provides certain factors, it may not be satisfied with users, and may even cause dissatisfaction; and whether certain factors are provided, users believe that there is no difference. Therefore, according to the two-dimensional model the designed Kano model divides the product components according to user experience, takes into account the user's subjective feelings and the objective performance of the product, and selects the product elements that truly meet the user's needs, which exactly meets the needs and reality of screening emotional stimulus information factors in the system interface Happening.

This paper uses the Kano model questionnaire to investigate whether the design of visual information factors in the interface (such as charts, pictures, icons, etc.) meets the user's emotional guidance needs when users are performing interface operations, so as to make basic requirements for interface visual components "must-be quality (M)", "expected demand one-dimensional quality (O)", "attractive quality (A)", "indifferent quality(I)" and "reverse quality(R)" (Tab.I). According to the kano model classification theory, the basic factors, performance factors and motivation factors that have the most influence on the user's emotional perception are extracted, and the must-be quality > expected demand one-dimensional quality > attractive quality.

TABLE I. Kano Quality Factor Classification.

Influence factors		**Reverse problem**				
		Like	***Must be***	***No differ-ence***	***Can bear***	***Heat***
Positive problem	***Like***	Q	A	A	A	O
	Must be	R	I	I	I	M
	No difference	R	I	I	I	M
	Can bear	R	I	I	I	M
	Heat	R	R	R	R	Q

B. Use AHP for Index importance ranking

As a method for solving multi-objective decision-making problems, AHP (analytic hierarchy process) takes the decision object as a system and decomposes it into multiple elements or criteria, and calculates the single-level ranking and total ranking through the fuzzy quantification method of qualitative indicators, which is used as a multi-plan optimization decision system approach. While maintaining the connection of elements in the system, AHP quantifies the degree of influence of each factor on the results, and emphasizes qualitative analysis and judgment than general quantitative methods. Combined with the interface design perception

which is generally based on the user's subjective experience, AHP has been widely used in design decision making.

In this paper, we used the kano model to help the AHP to extract the subjective experience indicators of user emotions. To a certain extent, it compensates for the problem of insufficient quantitative data in the index screening process, which affects the accuracy of the overall evaluation results. In the current application research of kano model, the better-worse algorithm is generally used to obtain factor priorities.. But in order to strengthen the design expertise on the basis of user research, and to facilitate the comprehensive evaluation of the subsequent emotional impact on the interface. According to the principle of AHP analysis method, if the total number of categories of M, O and A are not more than 8 factors, the expert evaluation method and AHP analysis method can be used to first sort the importance of each factor more accurately to guide subsequent interface optimization. Then, the optimized interface schemes are compared according to the index weights, and the optimal scheme of information emotional stimulation design in the interface is selected.

V. Analysis to Verify

A. Kano model analysis

In the current research on interface design, the extraction of interface elements is generally classified and extracted according to design principles, but this type of index extraction first has a certain degree of repetition, and there will also be inconsistencies in index dimensions. Therefore, from the perspective of design, this paper will extract and classify interface visual elements mainly based on color and shape. Combining the above emotional dimension theory, this article firstly extracts the factors in an *Office System* interface (Fig.4) based on the color matching, comparison, and marking information levels. The modeling aspect is mainly based on the rhythm and balance of the layout. As well as the style expression of individual design elements, we extracted about 21 factors. Due to the relatively large number of indicators, in order to reduce the boredom caused by the large number of questions when responding to the questionnaire, this article and 6 experts in the field of interactive interface design screened and merged the questionnaire indicators based on the frequency of interface factors, and finally reduced them. The 13 questionnaire indicators (Tab.II) form the kano questionnaire for the final interface emotional stimulation element evaluation.

Fig.4. The sample of Decision System interface.

TABLE II. Kano Quality Factor Classification.

Kano questionnaire indicator set			
Code	***Indicator***	***Code***	***Indicator***
C1	Comfortable color of interface	***C8***	Strong guiding of Information color
C2	Layout rhythm	***C9***	simplicity words
C3	Key information has advantage position	***C10***	Clear emotional expression in pictures
C4	Size of the information box is arranged according to the information hierarchy	***C11***	Icon conforms to cognitive habits
C5	Design language consistency	***C12***	Clear chart information
C6	Clear hierarchy of information logic	***C13***	Prompt information saliently
C7	Highlight key information in contrast		

The form of the questionnaire basically follows the basic structure of kano. The question items are composed of two positive and negative questions corresponding to the indicators. There are 26 question items in total (the problem design is shown in the Tab.III) to ensure that the questionnaire fills out the questionnaire before they have a certain understanding of the interface. On the questionnaire, a simple introduction to the questionnaire and a picture display of the interface were carried out to make sure that users can answer the questions after browsing the interface for more than 20 seconds. In order to ensure that the questionnaire indicator selection is professional, students who have studied some interaction design for more than 2 years are invited to participate in the questionnaire survey. And the tested students are invited to experience the interface demo before the test, so as to be more familiar with the interface structure. This part of the test is accounted for about 26% of the total questionnaire.

TABLE III. The Questionnaire Sample.

Option / ***Question category***		***Like***	***Must be***	***No differ-ence***	***Can bear***	***Heat***
Positive problem	If the overall information color contrast is soft in this interface design, how do you feel when browsing the interface?					
Reverse problem	If the overall information color contrast is not soft in this interface design, how do you feel when browsing the interface?					

The questionnaires were distributed mainly through online platforms, including offline questionnaires. A total of 243 copies were issued, and 187 valid questionnaires were recovered, with a recovery rate of 77%. The valid questionnaires were tested (Tab.IV), and the Cronbach α coefficients of the forward and reverse questions were 0.759 and 0.871, respectively, which were both greater than 0.75, indicating good internal consistency. And the KMO values were 0.741 and 0.866, respectively, greater than 0.7. Therefore, the overall reliability and validity of the

questionnaire is good, and it can be used for Kano model analysis.

TABLE IV. RELIABILITY AND VALIDITY TEST.

	Cronbach's α	KMO	Bartlett's test
Positive problem	0.759	0.741	198.715
Reverse problem	0.871	0.866	280.878
Kano model	0.889	0.789	632.316

After all valid questionnaires are collected, each element needs to be classified finally. After sorting out the answers to the questionnaire, perform frequency statistics, and get the index classification results shown in the following table （Tab.V）.

TABLE V. INDEX CLASSIFICATION RESULTS.

Category	Factors
***M* (2)**	C1, C13
***O* (2)**	C5, C6
***A* (1)**	C2
***I* (8)**	C3, C4, C7, C8, C9, C10, C11, C12

B. AHP analysis

According to the above-mentioned kano model's extraction of interface emotion influence factors, 6 factors from "M" "O" "A" category, which have the greatest influence on the perception of user emotion needs, can be obtained as the index layer of the stratification analysis method. So, according to the analytic hierarchy process, the index level A is assigned, and the index factors are respectively recorded as： Comfortable color of interface $(\boldsymbol{a_1})$, Prompt information saliently $(\boldsymbol{a_2})$, Layout rhythm $(\boldsymbol{a_3})$, Design language consistency $(\boldsymbol{a_4})$, Clear hierarchy of information logic $(\boldsymbol{a_5})$. Then, using the expert analysis method to comprehensively analyze the weight of the evaluation index importance. For that, 3 user research experts who have been engaged in interaction design for more than 3 years were invited. So, it was possible to compare the importance of the indicators, and then take their average assignment as the final importance evaluation index to obtain the index-level judgment matrix $A = (a_{ij})_{n\times n}$, $a_{ij} > 0$

$$\boldsymbol{A} = \begin{Bmatrix} 1 & 0.33 & 5 & 3 & 3 \\ 3 & 1 & 7 & 3 & 5 \\ 0.2 & 0.14 & 1 & 0.2 & 0.33 \\ 0.33 & 0.33 & 5 & 1 & 3 \\ 0.33 & 0.2 & 3 & 0.33 & 1 \end{Bmatrix}$$

Then, the normalizing processing for the matrix $\boldsymbol{A}$. The eigenvectors of each column are calculated, and the sum of the rows can be obtained by: $\overline{\boldsymbol{w}}_{\boldsymbol{i}} = \sum_{j=1}^{n} \overline{w}_{ij}$. The eigenvector has to be normalized in order to obtain the weight vector $\boldsymbol{w}$, $\boldsymbol{w} = \{w_1, w_2, w_3, w_4, w_5\}^T$

By using the square root method, the elements in the matrix are processed, that is, and then the importance vector $\boldsymbol{A}\overline{\boldsymbol{w}}_{\boldsymbol{i}} = \left(\prod_{j=1}^{n} aij\right)^{\frac{1}{n}} w_i = \overline{w}_i / \sum_{i=1}^{n} \overline{w}_i$, get the importance vector $\boldsymbol{W}$.

$$\boldsymbol{W} = \{0.25, 0.45, ,0.04, 0.17, 0.09\}^T$$

The importance degree between feature vectors can be obtained as: $a_2 > a_1 > a_4 > a_5 > a_3$. The ranking is basically the same as the ranking of the factors in the Kano model.

VI. EXAMPLE VERIFICATION

Considering the human-computer interaction interface, especially the design of the complex information human-computer interaction interface, the visual elements and information composition have certain complexity. Different information stimulus performance will have different degrees of impact on interface ergonomics. Therefore, in order to verify the indicators more accurately, this article analyzes the prototype framework of the information decision system interface as described above, extracts the information frames such as pictures, charts, and icons in the interface, and optimizes the interface in combination with the priority of the above emotional impact indicators - The analysis structure is shown as (Fig.5）, and obtains two Interface plan (Fig.6). Evaluating two optimized schemes（P_2, P_3） and the original scheme (P_1) according to the above-mentioned AHP index layer importance vector.

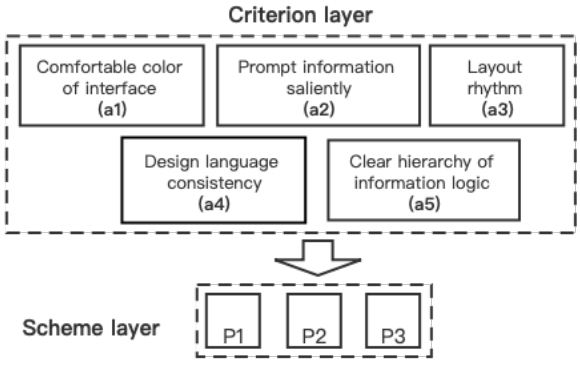

Fig.5. Feature extraction mode

(a) Interface plan 2

(b) Interface plan 3

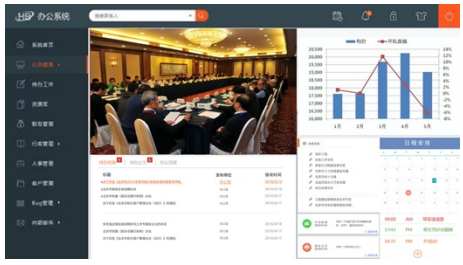

Fig.6. Optimized schemes of office system.

The plan of interface optimizations is represented as the level $\boldsymbol{P} = (\boldsymbol{p_n}, \boldsymbol{n}\boldsymbol{>}\boldsymbol{0})$, and each plan is calculated with the

index layer $\boldsymbol{A}$ as the criterion. 10 students were invited to compare and score the interface, obtaining the index layer's vector $\boldsymbol{w_n}$ of each index $\boldsymbol{A}$ of the $\boldsymbol{P}$.

$$w_1 = \{0.22, 0.41, 0.37\}^T;$$

$$w_2 = \{0.25, 0.54, 0.21\}^T;$$

$$w_3 = \{0.13, 0.46, 0.41, \}^T;$$

$$w_4 = \{0.09, 0.48, 0.51\}^T$$

$$w_5 = \{0.11, 0.51, 0.38\}^T.$$

By combining the weight vectors W_P:

$$W_P = \begin{Bmatrix} 0.22 & 0.25 & 0.13 & 0.09 & 0.11 \\ 0.41 & 0.54 & 0.46 & 0.48 & 0.51 \\ 0.37 & 0.21 & 0.41 & 0.51 & 0.38 \end{Bmatrix}$$

Multiply the exponential matrix $\boldsymbol{A}$ by the vector matrix $\boldsymbol{W_P}$:

$$W = W_A W_P \ = \{0.19, 0.49, 0.32\}$$

Therefore, we get the order of program dominance as: $\boldsymbol{p_2} > \boldsymbol{p_3} > \boldsymbol{p_1}$,

It can be seen that the Scheme 2 has more advantages in the performance of emotional information representation. In order to verify the evaluation results, voting was conducted among the user population of this office system. The voting ratio of the three schemes was 5:4:1, which was consistent with the above evaluation results.

In the evaluation process of this article, although the kano model and AHP analysis method are combined, the data source still mainly depends on the user's main observation evaluation. Because the process of emotional stimulation on users is usually unconscious, and the reaction time is short, this research method cannot measure deeper emotional perception behaviors, and the measurement results are still subjective. On the other hand, due to the wide application of information interaction interface, different fields and majors will put forward different interaction requirements for the system interface. Thus, the verification results obtained by testing this office system interface may not be universal.

We hope to combine physiological measurement methods as much as possible in subsequent research to explore more detailed emotional feelings of users in interface operations.

VII. SUMMARY

Design application strategies based on the emotional interface

A. Rational Use of Emotional Stimuli

Although the interface information with emotional characteristics has the advantage of capturing attention resources to some extent, it should avoid interfering with normal professional work due to information abuse. The use of emotional information design should aim at improving the cognitive efficacy of the interface and the ability of information recognition. Excessive use of emotionally expressed information not only weakens its function, but also causes anxiety and unnecessary cognitive load on the user.

B. Pay Attention To The Diversified Stimuli of Different Emotions

In human-computer interaction interface design, the emotional guidance needs of users based on different information should also be adjusted according to the design function and purpose. In the general interface design, in order to attract user's attention, more visual stimulus is designed based on neutral emotion or positive emotion. But according to aforementioned features of the stimulating theory, the interface of plus or minus alternate emotional stimuli can not only extend the user's attention that the extension of time, but also be more conducive when expressing the information accurately

C. Ensure Consistency In The Emotional Language

Because stimulating information cognition itself will consume certain cognitive resources, to avoid this, it's necessary to keep the consistency of design expression. This is more conducive to reduce the useless consumption of cognitive resources and attention resources, and consequently, it improves the information cognition efficiency of human-computer interaction interface.

As one of the first sensing systems of perceptual communication, the influence of user emotion perception and application on human-computer interface is self-evident. Although the psychological research on emotional influence cognition is still controversial in many aspects. Generally speaking, the key point of the research is to accurately connect the user's emotion with the interface information expression, form the correct cognitive guidance for the user's subconscious level, so as to improve the ergonomics of the human-computer interface.

[1] Peter A. Ubel. "Free Market Madness.(Book). "Harvard Business Review Press. 2008-12-16.

[2] Reid Hastie, Robyn M. Dawes. "Rational Choice in an Uncertain World: The Psychology of Judgement and Decision Making (Book). " Journal of Economic Literature (2003).

[3] Verbruggen F , Houwer J D . Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm[J]. Cognition & Emotion, 2007, 21(2):391-403.

[4] Desimone R, Duncan J. "Neural mechanisms of selective visual attention. Annual Review of Neuroscience. "1995 ;18:193-222.

[5] Gawronski B , Deutsch R , Strack F . Approach/Avoidance‐Related Motor Actions and the Processing of Affective Stimuli: Incongruency Effects in Automatic Attention Allocation[J]. Social Cognition, 2005, 23(2):132-6.

[6] Nancy, Garon, Susan E , et al. Executive function in preschoolers: a review using an integrative framework.[J]. Psychological bulletin, 2008.

[7] Hsu S M , Pessoa L . Dissociable effects of bottom-up and top-down factors on the processing of unattended fearful faces[J]. Neuropsychologia, 2007, 45(13):3075-3086.

[8] Fátima Smith Erthal, Letícia de Oliveira, Mocaiber I , et al. Load-dependent modulation of affective picture processing[J]. Cognitive, Affective, & Behavioral Neuroence, 2005, 5(4):388-395.

[9] Richards J M , Gross J J . Emotion regulation and memory: the cognitive costs of keeping one's cool.[J]. Journal of Personality and Social Psychology, 2000, 79(3):410-424.

[10] Oatley K,Keltner D,Jenkins J M."Emotions and mental health in childhood.Understanding emotions(2th eds.) "[M]. Oxford,UK: Blackwell Publishing, 2006:321-383.

[11] Lang P J , Greenwald M K , Bradley M M , et al. Looking at pictures: affective,facial,visceral,andbehavioral reactions.[J]. Psychophysiology, (2010), 30(3):261-273.

[12] Gross J J . Emotion regulation: Affective, cognitive, and social consequences[J]. 2002, 39(3).:281-291.

[13] Gross, James J . The Emerging Field of Emotion Regulation: An Integrative Review[J]. Review of General Psychology, 1998, 2(3):271-299.

[14] Gross, James J . Antecedent- and response-focused emotion regulation: divergent consequences for experience, expression, and physiology.[J]. Journal of Personality and Social Psychology, 1998, 74(1):224-237.

[15] Brian Boxer Wachler MD. Perceptual Intelligence: The Brain's Secret to Seeing Past Illusion. New World Library. 2017-10-16

[16] Kotani, Y, Hiraku, et al. Effect of Positive and Negative Emotion on Stimulus-Preceding Negativity Prior to Feedback Stimuli[J]. PSYCHOPHYSIOLOGY, 2001.

[17] Su J , Duan D , Zhang X , et al. The effect of negative emotion on multiple object tracking task: An ERP study[J]. Neuroence Letters, 2017, 641:15-20.

[18] Fredrickson, Barbara L . The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions.[J]. 2001, 56(3):218-226.