



A Study of Emotional Communication of Emoticon Based on Russell's Circumplex Model of Affect

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Abstract. With the rapid spread of the Internet, there are more and more people being fond of using emoticons to convey emotions on the Internet. However, due to the high abstraction of real things and expressions and the arbitrariness in the production of emoticons, many misunderstandings have happened. At the same time, more and more emoticons emerge in endlessly, people even do not know how to choose and use appropriate emoticons, which seriously affects the efficiency and the experience. This research tried to purpose an approach to verify and optimize the effectiveness of emoticons in emotional communication based on Russell's Circumplex Model of Affect. This research used emoticons in Wechat, which is the most widely used application in China, as an example to construct a quantitative coordinates of emotional cognition system based on Russell's Circumplex Model of Affect, through variable control, perceptual map, cluster analysis and statistical data analysis to verify and improve the present emoticons. The results of verification experiment indicated that it is practical and effective for emoticons classify and use. On the basis of these results, then we can tag the emoticons more effectively and apply it to the recommendation system to further improve the experience and efficiency in the process of using the emoticons. It is foreseeable that the theory of this research can be applied to other things related to emotional communication. Meanwhile, the research methods and results not only provide a new way of thinking for the application of Russell's Circumplex Model of Affect in the Internet era, but also can be applied to psychology, sociology re-search and other specific areas, playing a guiding and testing role.

Keywords: Emoticon · Emotional communication · Russell's Circumplex Model of Affect · Emotional cognitive

1 Introduction

With the increasing popularity and rapid development of computers and the Internet, network communication has become one of the main ways of communication in modern society. This new way of communication also promotes the development and wide application of network symbolic language, especially the emoticon. However, in

the context of the Internet era has gradually changed from the information technology age to the current data technology age, the use of emoticon has highlighted the inconsistency of user perception and the cumbersome use of traditional methods.

Therefore, this paper took the emotional communication of emoticon as the entry point, after deeply studying the emotional theory and personalized recommendation system, based on Russell's Circumplex Model of Affect, the effectiveness and completeness of emotional communication of emoticon were studied by means of user perception positioning experiment and user perception experiment. Based on the results of the research, the optimized design were put forward, and the optimized design was verified better by a series of experiments.

After research and verification, the emoticon optimization design ideas and schemes obtained by the research can greatly improve the user's cognitive efficiency and the production efficiency of the emoticon, and improve the effectiveness and completeness of emotional communication in the process of using emoticon. Research ideas and results can also be applied to personalized recommendation systems to further improve user efficiency and optimize user experience.

The innovative design and verification scheme based on Russell's Circumplex Model of Affect proposed in this study has the following advantages:

- The emoticon (or even images) can be studied in a quantitative way on emotional communication to arrive at quantitative data results.
- Quantitative analysis and verification of the effectiveness and completeness of online expressions in emotional communication, and the experimental method is highly feasible, which can be used to optimize the design of network expressions.
- Design ideas and methods have high scalability and follow-up research space. For example, "emotion" can be used as an intermediate connection point to implement personalized recommendations for web expressions.

The rest of the paper is organized as follows. In the second part, a general description and desktop study of Russell's Circumplex Model of Affect, personalized recommendation system, and emotions will be made. The third part will conduct a series of quantitative experiments on the most used emoticon in China, the emoticon of the application software WeChat. The fourth part will produce the optimal design ideas and schemes of the emoticon based on the experimental results, and verify its effectiveness and completeness in emotional communication through experiments. The fifth part will give an example of applying the optimized design ideas and schemes obtained in this study and applying it to the personalized recommendation system. The sixth part is the summary and expectations.

2 Desktop Research

Emotion. Emotion refers to the subjective feelings or experiences of the individual [1]. Emotional experience refers to the individual subjective experience of emotion [2]. Emotion is a part of attitude. It is in harmony with the introverted feelings and intentions in attitude. It is a more complex and stable physiological evaluation and experience of physiology [3, 4]. And for the same thing, each person always has a different emotional feedback and experience [5].

Russell’s Circumplex Model of Affect. Early psychologists believe that basic emotions should be discrete and have a fixed expression of nerves and bodily functions to correspond to corresponding emotional expressions and feelings [6–9]. However, later scholars found that emotions and emotions are not simple and simply in a discrete state. There is actually a certain relationship between emotions and emotions, and dimension classification can be performed. In such a situation and background, the theory of emotional dimension has emerged [10] (Fig. 1).

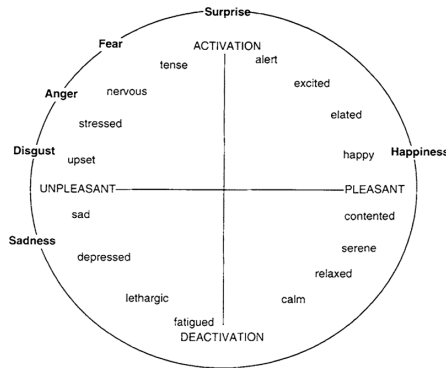


Fig. 1. Russell’s Circumplex Model of Affect

Russell’s Circumplex Model of Affect is a classic theoretical model in the theory of emotional dimension. He believes that there is a certain correlation or opposition between emotions. Therefore, eight emotional words are extracted from the previous literature: happy and excited, amazement, disappointment, misery, depression, fatigue, satisfaction, in the case of these eight emotional keywords as a benchmark, through a certain experimental approach he proposed two dimensions to classify emotions: pleasant and activation [11] (Fig. 2).

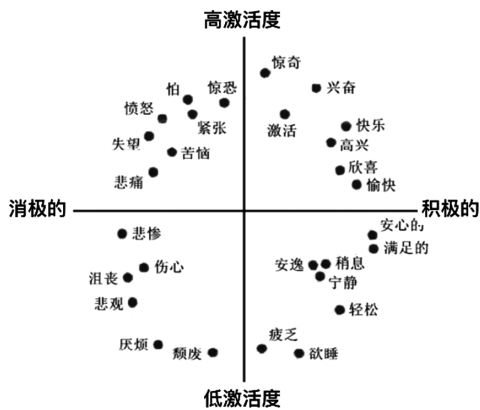


Fig. 2. Russell’s Circumplex Model of Affect in Chinese

Recommendation System. Recommendation system is a subclass of information filtering system that seeks to predict the “rating” or “preference” that a user would give to an item [12, 13]. In the era of big data in the Internet, users can label resources in the form of tags [14]. Users may be contributing resources, or they may be collecting resources for subsequent use, or they may be personally commenting on them [15]. However, no matter what kind of interaction behavior, the user exposes his preference for some of the items through the form of labels, which can be used as a clue to realize the personalized recommendation of the project [15] (Fig. 3).

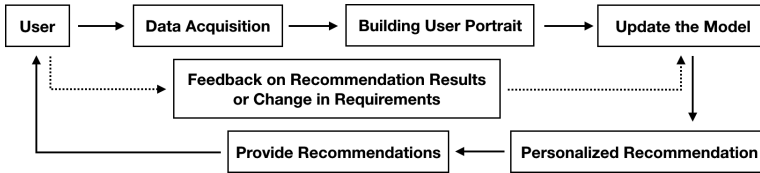


Fig. 3. Recommendation system

Emoticon. The emoticon is different from the language symbol in origin. It is a non-verbal symbol, which is the result of non-verbal rework design such as expressions or shapes used in daily life. It fuses emotions (emotion) with small icons (icon), and is responsible for non-verbal communication, which is a graphical symbol in network non-verbal communication. It is a new graphical language used by users on the Internet to communicate and interact. Its function is to create, enhance or attenuate, adjust and supplement the semantic information and emotional emotions that users want to express [16] (Fig. 4).

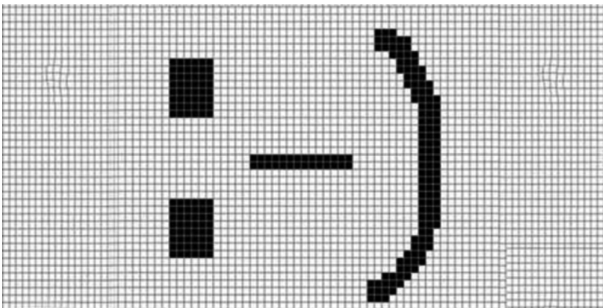


Fig. 4. The first emoticon: ASCII Code :-)

The emergence of online expressions simplifies the process of understanding and interpreting language in communication and interaction, and improves the efficiency of communication and expression of information between people on the Internet. Therefore, it is favored especially by the younger generation [17]. In the process of using a large number of online expressions, the following two problems are highlighted:

- Different users have cognitive biases in the interpretation of online expressions [18, 19].
- Excessive emoticon and reduced user productivity [20].

Therefore, this paper selected the most used emoticon in China - the application WeChat's own emoticon as the research and optimization design object, based on the model to conduct a series of quantitative experiments, proposed optimized design and solutions to solve the two problems mentioned above, and provide guidance and ideas for future emoticon design.

3 Exploratory Research

This part of the research firstly designed a user perceptual positioning experiment based on the Russell's Circumplex Model of Affect in the form of the Likert 5-point scale [21] to explore the validity and completeness of the research object in emotional communication. And then through user cognition, experiments were conducted to explore the clustering and correlation of research objects.

3.1 Data Collection

This paper selected the most used emoticon as the sample of research objects: the application software: WeChat's own emoticon, the version number of the application is the latest version of October 2018 - version 6.7.3, extracted all the emoticons that come with this version, a total of 99. And the 99 emoticons are numbered in the order of natural arrangement: 1-99. As shown below (Fig. 5).

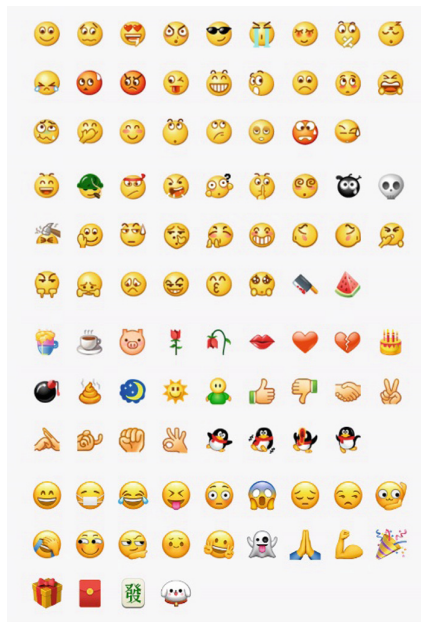


Fig. 5. All emoticon in WeChat 6.7.3

3.2 User Perception Positioning Experiment

A total of 20 volunteers were recruited for the experiment. All of them were citizens of the People’s Republic of China and their first language was Chinese.

The experiment firstly took the form of Likert 5-point scale [21] and asked the subjects to score the above 99 emoticon samples on the two dimensions of pleasant degree and activation degree respectively. In order to avoid the basic cognitive difference between the two dimensions of scoring, the user was trained to establish the basic cognitive consensus of the two dimensions through a simple Russell’s Circumplex Model of Affect diagram before the specific experiment starts (Fig. 6).

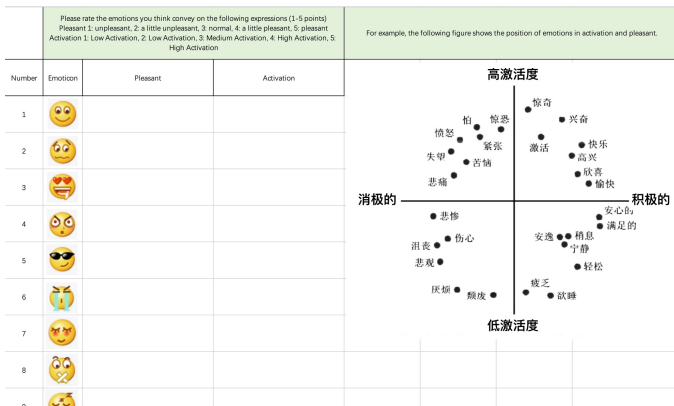


Fig. 6. A screenshot of the experiment for 99 initial emoticon

According to the scoring result, the expression samples with different cognitive differences between different users are first removed.

At this stage, the study used quadratic variance to measure the results of the questionnaire. In the specific study, 20 volunteers scored 99 emoticon samples in the two dimensions of pleasant and activation. Then, 20 results of 99 emoticons in each dimension can be obtained. If the number of times the same emoticon sample is hit at the same time on all the scores of the two dimensions is lower than a specified value, it will be regarded as a emoticon with large cognitive differences and will be washed away. This stipulation here we took 12 (i.e. $p < 5\%$, using a significant level of sampling commonly used in biology). With such a standard value, it can be guaranteed that the error in the experiment could be accepted by most people (95%) [22].

Some of the results of the experiment are shown in Fig. 7. Among them, especially the 32nd emoticon in the figure, although the scores of the pleasant 3 (normal) and the activation 3 (medium activation) are more than 12 times (all 13 times), but according to the Russell Circumplex Model of Affect, which says that such emotions are meaningless [11], because emotions need to be biased, so such emoticons need to be washed away.



Fig. 7. Part of the experiment results

After cleaning, 29 emoticons conforming to the user’s cognitive consistency were finally obtained. Form a new sample of emoticons, as shown below (Fig. 8):



Fig. 8. 29 emoticons after cleaning

At this time, 29 emoticons were positioned into the model coordinates in combination with the Russell’s Circumplex Model of Affect. We got the following intuitive graph (Fig. 9):

According to the research of user perception positioning experiment, we could find the sample of emoticon selected: on the one hand, there are a lot of ambiguities in user perception, on the other hand, the emoticons composed of these more consistent expressions are conveyed in the emotion. There is also a large incompleteness in the reception and reception.

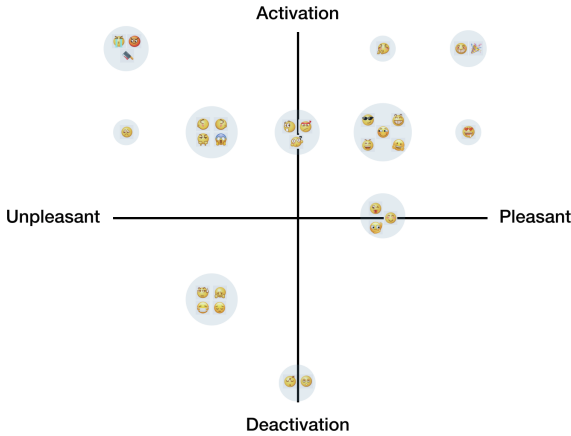


Fig. 9. The position map of 29 emoticons in Russell’s Circumplex Model of Affect

3.3 User Cognition Experiment

Subsequently, professional researchers used the 29 expressions obtained above as stimulus, the distance between the 29 expressions was defined by the Euclidean distance (1) using the user cognitive experiment. Based on the relevance coefficient in the matrix to build N-dimensional space, the Euclidean distance formula (1) can be used to calculate the spatial distance of two samples. The closer, the more similar samples can be considered.

$$\text{Euclid}(1, 2) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2} \tag{1}$$

After this step, the distance matrix between the emoticons could be obtained. By SPSS analysis software the data results obtained can be further observe the problems in emotional transmission and reception of these 29 emoticons by the multidimensional scaling analysis and the clustering method after the data sample reliability verification (Fig. 10).

	😄	😎	🙌	😂	😭	😬	😁	😏	😊	😇	😘	🙄	😜	😈	😋	😏	😁	😊	😋	😏	😁	😊	😋	😏	😁	😊	😋	😏	
😄	1	2	9	9	9	2	2	7	3	9	2	8	8	9	3	2	9	9	9	9	9	9	9	9	9	9	9	9	9
😎	2	1	9	9	9	2	2	7	2	9	2	8	7	9	3	2	9	9	9	9	9	9	9	9	9	9	9	9	9
🙌	9	9	1	9	5	9	9	5	9	9	9	8	8	7	9	9	3	3	5	2	9	9	9	9	9	9	9	9	9
😂	9	9	9	1	9	9	9	9	9	1	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
😭	9	9	9	9	1	9	9	7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
😬	2	2	9	9	9	1	2	7	2	9	2	8	7	8	2	1	9	9	9	9	9	9	9	9	9	9	9	9	9
😁	7	7	5	9	7	7	7	1	8	9	5	8	2	8	6	9	9	8	8	8	8	8	8	8	8	8	8	8	8
😊	3	2	9	9	9	2	2	8	1	9	2	8	7	9	2	2	9	9	9	9	9	9	9	9	9	9	9	9	9
😇	9	9	9	1	9	9	9	9	9	1	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
😋	2	2	9	9	9	2	2	6	2	9	1	8	8	9	2	2	9	9	9	9	9	9	9	9	9	9	9	9	9
😏	8	8	9	9	9	8	8	8	8	9	9	1	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8

Fig. 10. Partial screenshots of distance matrix of 29 emoticon samples

Firstly, the reliability of the obtained data was verified. According to the analysis of the results, the AIPha value of the obtained sample distance matrix data was 0.937, and the sample reliability was relatively high, which can be used as a follow-up multidimensional scaling analysis and clustering analysis for 29 emoticon samples.

A multidimensional scaling analysis of the experimental data of the sample could be obtained as shown in Fig. 11. Through the multidimensional scaling analysis of the location map, we could visually see the two-dimensional plan with the distance correlation between the emoticon samples as the analysis standard, which could intuitively display the distance and cluster relationship between the emoticon samples from another dimension, which helped the researchers to intuitively the spatial distribution of these 29 emoticon samples was observed.

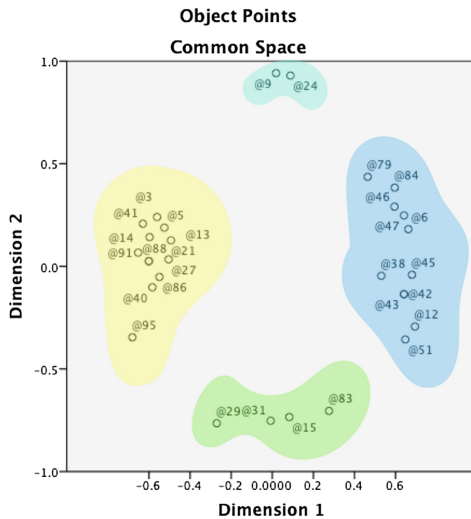


Fig. 11. The 29 emoticons' positioning map of multidimensional scaling analysis

The clustering analysis was performed on the sample data to obtain a cluster analysis tree. The cluster analysis tree could clearly and intuitively show the results of clustering induction of these 29 emoticon samples. As shown in Fig. 12, 29 emoticons were clustered into 4 groups of expressions, meaning that in 4 groups, there was little difference in emotion communication between emoticons and emoticons.

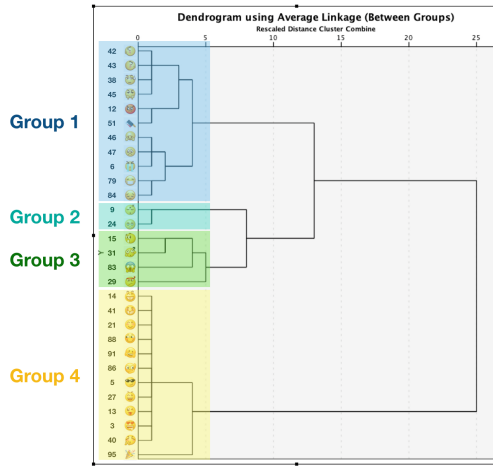


Fig. 12. The 29 emoticons' dendrogram of cluster analysis

3.4 Research Conclusion

According to the above experiment results, we could get current the most used emoticon in China - the application WeChat's own emoticon with the following three basic conditions:

1. A large number of emoticons are ambiguous in emotional expression. Only a small amount (about one-third) of emoticons have a good consistency in user perception of emotional communication and reception, and the rest of the emoticons have certain ambiguities in emotional communication;
2. The completeness of emotional expression is insufficient. Based on the positioning of Russell's Circumplex Model of Affect, these emoticons that can achieve higher user cognition consistency still have large deficiencies in the completeness of emotional expression and reception.
3. The clustering is too concentrated, and the gap between emoticons is not obvious. According to clustering and correlation analysis, it was found that there was a high correlation between some emoticons, there is not much cognitive difference between some emoticons and emoticons in emotional transmission and reception, which will cause certain damage to the efficiency of emoticons use and production.

4 Optimized Design and Experimental Verification

4.1 Design Thinking

According to the research and analysis results of the original emoticon described above, the core ideas of the optimized design are as follows:

1. Add text elements as part of the icon to solve the problem of inconsistent user perception of the emoticon.

2. Orienting new and optimized emoticons based on the Russell’s Circumplex Model of Affect.
3. In the specific design of the expression, use appropriate exaggeration and other micro-improvement techniques to widen the difference between the icons.
4. Simplify the design of the icon to improve the efficiency of the transmission of emotions and key information.
5. Extract and retain the excellent design points in the original emoticon, such as the yellow color that is more in line with the Chinese cognition.

4.2 Design Scheme

Under the five core optimized design ideas mentioned above, and after some experimental feedback and design iteration, the emoticon scheme of the final optimized design of the output is shown in Fig. 13. The final optimized design consists of 42 emoticons.

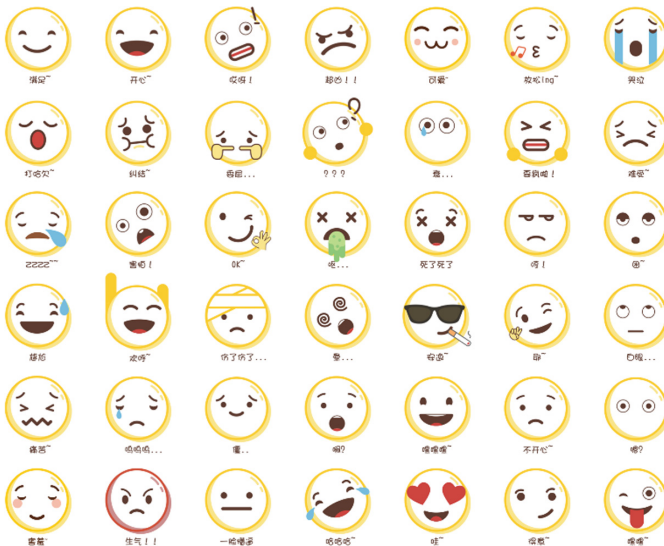


Fig. 13. Optimized design of the emoticons

From the perspective of visual expression, the optimized design not only retains the excellent design points in the original emoticon, but also adopts a flat design style, which simplifies the design content, thereby improving the communication efficiency of emotions and key information. And each emoticon has a corresponding Chinese text as part of the pattern to improve the accuracy of the user’s cognition.

In addition, the optimized design scheme also adopts exaggerated design methods to open the gap between emoticons and emoticons, and hopes to cover the Russell’s Circumplex Model of Affect more, so as to improve its emotional expression completeness.

4.3 Experimental Verification

The researchers designed and performed a user-perceived positioning experiment based on the Russell’s Circumplex Model of Affect, the emoticon sample cleaning, and certain cluster analysis and correlation analysis.

First, the 42 emoticons of the optimized design were numbered as sample objects. Also taking the form of the Likert 5-point scale [21], 20 volunteers scored 42 samples in both the pleasant and activation dimensions (Fig. 14).

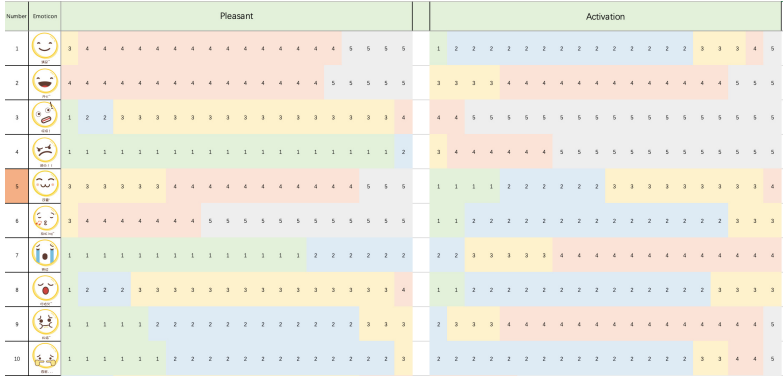


Fig. 14. Partial screenshots of the experimental statistics

According to the experimental statistical results, the emoticon samples with inconsistent emotional cognition were cleaned by the sampling level of the commonly used biology, and 35 emoticon samples with high user cognition in emotional expression are obtained. The agreement rate is 83.3%, which is much higher than the original emoticon of 34.3%.

Finally, 35 emoticon samples to be analyzed and verified in the next experiment are shown in Fig. 15 The results of these 35 emoticon samples positioned in the Russell’s Circumplex Model of Affect are shown in Fig. 16.

Next, we used the user cognition experiment again to define the distance relationship between the 35 emoticon samples by Euclidean distance, and used the SPSS analysis software to score the data results. Firstly, the reliability of the obtained data matrix was verified. It was found that the AIPha value of the obtained sample distance matrix data is 0.911, and the sample reliability is high. It could be used as a follow-up multidimensional scaling analysis and cluster analysis for 35 emoticon samples. The specific results are shown in Figs. 17 and 18.

Therefore, from the above verification experimental data, the optimized design of the emoticon scheme based on the Russell’s Circumplex Model of Affect has a significant improvement in user perception consistency, completeness and effectiveness in emotional expression, achieving the intended purpose.

The logic of the optimized design idea and verification scheme of the final specific output of this study is shown in Fig. 19.

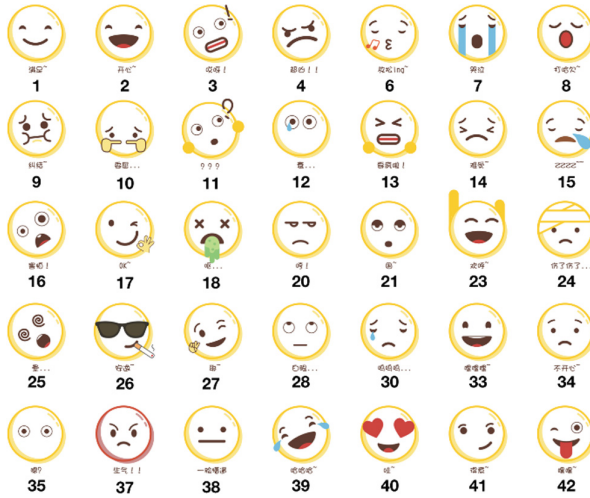


Fig. 15. 35 emoticons after cleaning

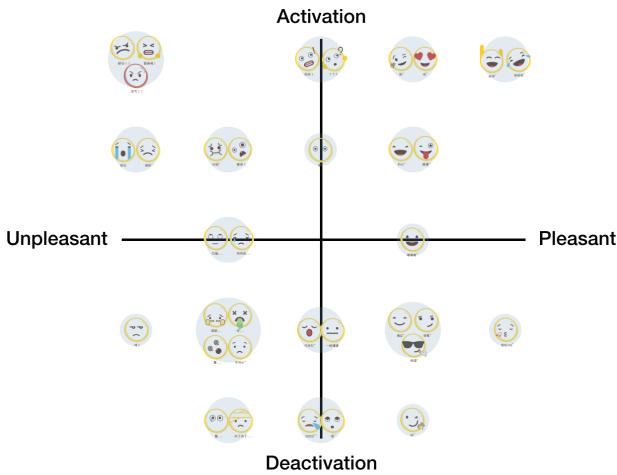


Fig. 16. The position map of 35 emoticons in Russell's Circumplex Model of Affect

It can be foreseen that the emoticon optimized design ideas and verification methods based on the Russell's Circumplex Model of Affect proposed in this study can be applied to more design scenarios and verification of design results, so as to improve the user experience and efficiency. And this paper would give an example in the next chapter.

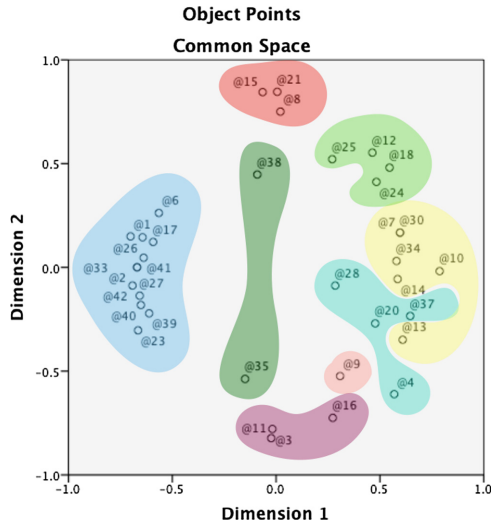


Fig. 17. The 35 emoticons' positioning map of multidimensional scaling analysis

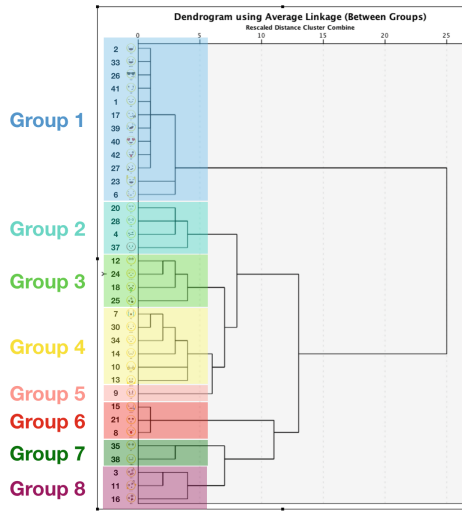


Fig. 18. The 35 emoticons' dendrogram of cluster analysis

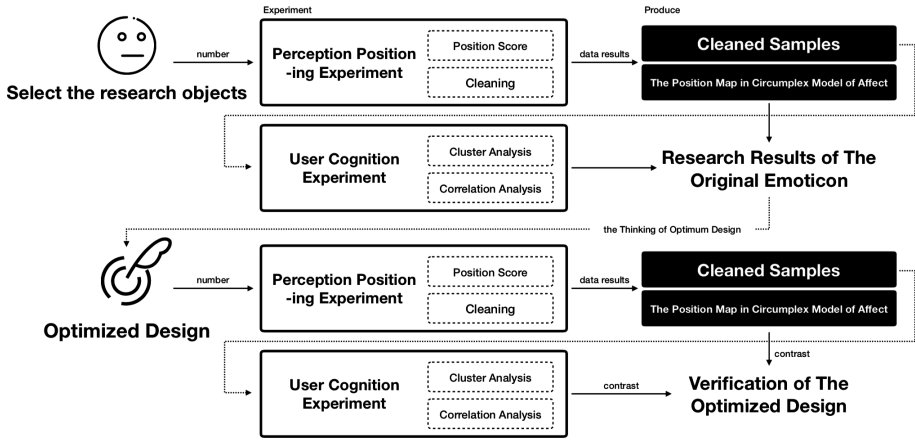


Fig. 19. The thinking of the research and design

5 Application Example: Recommendation System of Emoticon

Based on the above research, we could get the relationship between “emoticons” and “user emotions”, so combined with the relationship between “user emotions” and “emotional words” in existing research, relying on neural network and other technologies. We could build a personalized recommendation system for emoticons [23, 24]. The specific logical framework is shown in Fig. 20.

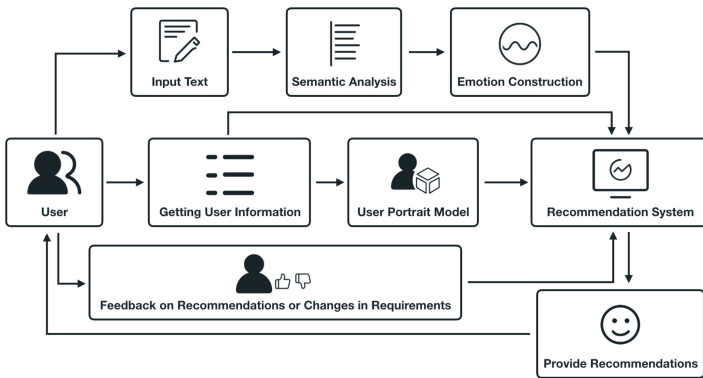


Fig. 20. Recommendation system of emoticon

The Jieba word segmentation algorithm can realize the word segmentation calculation of the user input text, and then realize the word frequency and weight calculation of the word segmentation result of the user input text through the TF-IDF technical principle, and realize the word vectorization. The corresponding semantic analysis of

the text input by the user is completed. At this time, through the neural network algorithm and the collaborative filtering method, the logical correspondence between the “emotional words” - “user emotions” - “emoticons” can be realized.

The core of these is neural network computing, neural network is a processing system with strong self-learning, self-organization and self-adaptation capabilities. The basic neural network has three levels of input layer, hidden layer and output layer, as shown in Fig. 21.

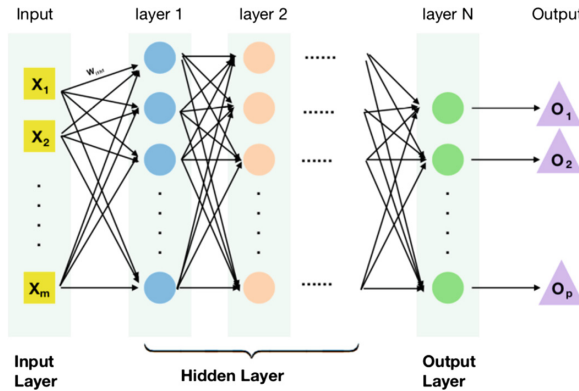


Fig. 21. Basic neural network hierarchy

In the neural network operation, firstly we input the words matrix to the neural network input layer, and the formula is shown in (2).

$$I_m = \begin{bmatrix} x_1 \\ x_2 \\ \dots \\ x_m \end{bmatrix} \tag{2}$$

Where I_m represents the input system words matrix, and m represents the number of words.

Then, the weight matrices (3) and (4) from the input layer to the hidden layer and from the hidden layer to the output layer are respectively obtained through hidden layer operation.

$$w_{ih} = \begin{bmatrix} w_{i1h1} & \dots & w_{imh1} \\ \dots & \dots & \dots \\ w_{i1hn} & \dots & w_{imhn} \end{bmatrix} \tag{3}$$

w_{ih} represents the weight matrix of the trained input layer to the hidden layer.

$$w_{h0} = \begin{bmatrix} w_{h1o1} & \cdots & w_{hno1} \\ \cdots & \cdots & \cdots \\ w_{h1op} & \cdots & w_{hnop} \end{bmatrix} \quad (4)$$

w_{h0} represents the weight matrix of the trained hidden layer to the output layer.

The new emotional words are input into the trained neural network system, and the emoticons probability matrix of the output category can be obtained. The formula is shown in (5).

$$O_p = \begin{bmatrix} o_1 \\ o_2 \\ \cdots \\ o_p \end{bmatrix} \quad (5)$$

O_p represents a probability matrix that outputs emoticons, and p represents the number of emoticons.

To sum up, the output matrix of the hidden layer is calculated by $H = f(w_{ih} * I_m)$, that is the output layer of the input layer, and then the probability matrix of each emoticon is obtained by $O_p = f(w_{h0} * H)$. Finally, combined with some weights of other dimensions, the final recommended emoticon and its corresponding front-and-back order can be obtained through the collaborative filtering algorithm.

The initial data and preliminary correlation and weight relationship will be established based on the Russell's Circumplex Model of Affect, which come from the researchers' collation, and then continuously optimized and adjusted along with the data generated by the user's interaction.

In this paper, the researchers first sorted out 435 almost all Chinese emotional words related to emotional state, and then used the user perception positioning experiment to locate the emotional words into the Russell's Circumplex Model of Affect, and at the same time, the word meaning blur could be eliminated in the process of localization. That was the user's cognitive inconsistency and uncommon words, eventually got 201. At the same time, the Russell's Circumplex Model of Affect was divided into 8 regions during the experiment, and 201 emotional words are located in these 8 regions to obtain the number of emotional words contained in each partition [22], as shown in Fig. 22. The correspondence between these words and emotions, together with the relationship between emotions and emoticons, could be used as data for preliminary training of neural networks.

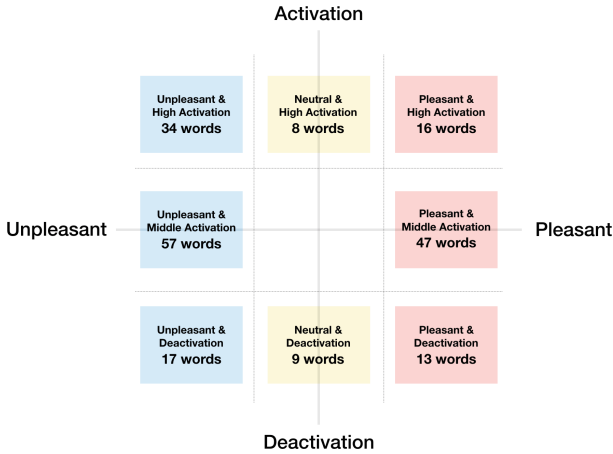


Fig. 22. Russell’s Circumplex Model of Affect after partition

6 Conclusion

This paper initially envisaged a emoticon optimization design ideas and verification schemes based on Russell’s Circumplex Model of Affect and a series of quantitative user perception positioning experiment and user cognitive experiments. Its core idea is to integrate the factors of user’s emotional expression and cognition to the original design of emoticon to optimize the design flow of emoticon.

At the same time, based on Russell’s Circumplex Model of Affect, we can get a lot of data feedback on the emotional communication of emoticons. An application example in the fifth section of this paper can also be seen that the emoticon optimized design and verification ideas obtained in this paper can be applied to more practical scenarios. Relying on Russell’s Circumplex Model of Affect to better quantify “user emotion” to optimize the design of emoticon, even the design of icons and patterns.

However, the emoticon optimized design and its verification scheme proposed in this paper still have great limitations. For example, in the user perception positioning experiment, because the use of the Likert 5-point scale type of scoring, the subdivision of the granularity is not enough, it is difficult to achieve a more rigorous level of quantification. Therefore, we actually need more samples of users and more subdivided quantitative indicators to get a more rigorous level of quantification.

It is foreseeable that the theory of this research can be applied to other things related to emotional communication. Meanwhile, the research methods and results not only provide a new way of thinking for the application of Russell’s Circumplex Model of Affect in the Internet era, but also can be applied to psychology, sociology research and other specific areas, playing a guiding and testing role.

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