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Research on User Mental Model Based on Website Classification System

Yuntao Yang*
Department of Information Management
Nanjing University of Science and Technology
Nanjing, China
317241235@qq.com

Jinbing Ha
Department of Information Management
Nanjing University of Science and Technology
Nanjing, China
sdnuyyt@126.com

Abstract—A good design of a website is user-friendly. It means users can understand its content easily, which needs to be considered from the user's perspective. No matter what kind of website, their goal is to deliver effect message easily for users. The mental model is used to reflect user's inner thinking mode. Only in line with the user's way of thinking can website has further development. This paper used the method, Pathfinder network, to analyze the relationship between user mental model and information acquisition, and estimated which factors will affect user mental model in the process of information acquisition via the partial catalogue of JD Shopping Website.

Keywords—mental model, information interaction, website catalog, Pathfinder network

I. INTRODUCTION

Information acquisition behavior occurs when users interact with an environment. From the perspective of praxeology, information-acquisition is inevitably dominated by demand and motivation. In this sense, information demand is the raw impetus of information acquisition behavior, and it belongs to the category of individual psychological activity. The acquisition of information has a strong connection with the individual's mental model. The mental model contains the individual's understanding of the world. When people encounter a new thing, the mental model will guide the individual to adopt a certain understanding. Therefore, information acquisition and pleasant user experience can only be obtained if the mental model of the individual is consistent with the design of product.

Therefore, this article studies how the user's mental model works during the information acquisition process via the partial catalogue of JD Shopping Website, and judge which catalogue is more suitable for the user's mental model by comparing the website directory of the PC side and the phone side. This article will address the following issues:

- What are the factors that influence the individual mental model in the process of information acquisition?
- Does the website's catalogue match the mental model of most users?
- Which of the phone side and the PC side is more suitable for the user's mental model?

II. INFORMATION ACQUISITION AND MENTAL MODEL

A. Mental Model

The concept of the mental model was first proposed by Kenneth Craik, the Scottish psychologist, in 1943 [1]. But what really made this concept popular was Johnson-Laird's detailed discussion of mental model in his book [2]. He interpreted the mental model as a simpler world in people's minds when they understood the objective world. Since then, mental models have been widely applied to various discipline areas. Peter Senge introduced the concept of mental model into the management field through his book The Fifth Practice. He believes that mental model is a series of assumptions, ideas, images or impressions that ingrained in the mind, affecting how we understand the world, and how we take action on [3]. Donald Norman introduced the mental model into the design field. In his book, Norman divided the mental model into three interaction-related models: design model, user model and system model [4]. To put it simply, a mental model is a unique way of understanding which formed in the process of interacting with the world, and at the same time applies this way of understanding to the next things. The mental model can be seen as a way to mine user needs.

B. Information Acquisition

Individuals always do something with a certain purpose or goal. Therefore, most of the information acquisition is full of some purposes. In the network environment, the user's target-guided information acquisition methods mainly include information retrieval, information browsing with certain target, and information interaction [5].

Information search behavior belongs to information acquisition behavior, and information acquisition behavior also is a process in information behavior [6]. For example, when a user browses a shopping website, he wants to find a basketball, and then he searches for information according to the target until a given result is found, which is a process of information acquisition. As time and technology changed, the information environment we are living in has also undergone a large change. Modern society is an era of information explosion, which makes our information acquisition relatively difficult.

C. Relationship between Information Acquisition and Mental Model

Psychologically, information acquisition behavior has always been related to people's psychological activities. From the beginning to the end, information acquisition is not only a

single physical behavior, but a complicated process which physical behavior interweaves with psychological factors such as cognition and even emotion [7]. A series of behaviors in the interaction process of new things can be said to be information acquisition behaviors, and the time and quality of information acquisition are closely related to the individual's mental model. If the individual's mental model makes a mistake in a certain step, the time for information acquisition will increase.

III. Recording And Measurement Of Mental Models

A. Method of Recording Mental Model

The recording methods of mental models can be divided into two types: subjective recording method and objective recording method. This paper used the method of card sorting, which belongs to objective recording method. Card Sorting is originated from George Kelly's Personal Construct Theory. Later, it is applied to the classification of information in the network environment, which can be used to construct various mental models in the process of searching information. There are two types of Card Sorting:

- Open-card Sorting: It is completely determined by the user to divide the cards into groups, and the user decide how many cards are in each group. Finally, the user needs to name those groups.
- Closed-card Sorting: When organizing information on a website, the researcher determines the number of global navigation in advance, and identifies the name of the global navigation, so that the users can assign each card to a different global navigation according to their expectations.

Most scholars used the closed-card sorting method when using the card sorting method to study the user's mental model. The user is assigned some cards and required to classify each card according to his own inner knowledge structure. This method can avoid confusing classification results due to individual differences.

B. Method of Measuring Mental Model

There are three kinds of mental model measurement methods: Pathfinder network, Multidimensional scaling, and clustering. This article used Pathfinder network method.

The Pathfinder network was proposed by Schvaneveldt, a leader of the computational research laboratory at the state university of new Mexico, based on semantic network theory and graphics theory [8]. The researchers can analyze some network graphs via pathfinder network.

The Pathfinder network visualizes some psychological processes of the user in the form of a network diagram. It transforms the similarity assessment matrix into a concept map composed of nodes and lines to reflect the relationship between the concept elements. The Pathfinder network consists of nodes and limes, where nodes are used to represent concepts, lines are represented as distances between concepts, Weight assignments on lines represent the degree of association between two concepts, where the shortest distance is taken as the final distance between two nodes. We can use the Pathfinder network to measure the similarity of two concept maps. The GTD (Graph-theoretic Distance), PRX (Proximity Index) and C (Closeness Index) are commonly used as quantitative indexes to measure the similarity between the subjects and the designer's mental model [9]. This paper choose the Pathfinder network based on GTD index to calculate the global correlation of two network graphs.

The Pathfinder network is based on the graph theory and calculates the global correlation coefficient based on the path distance of the network graph. For items with special requirements, a signal concept also can calculate correlation coefficient. The specific steps are as follows:

- Firstly, researchers should convert website catalog into a Pathfinder map, and then convert the map into an upper triangular matrix.
- Secondly, participant's map also should be transformed an upper triangular matrix.
- Converting those upper triangular matrices into corresponding vectors.
- Calculating the global correlation index of the two vectors finally.

The Pathfinder network is expressed in the form of distance matrix, where the values represent the distance between the corresponding nodes. And the distance matrix can be represented by a vector of length(n-n2)/2. where n is the number of nodes, covering all pairs of nodes. Once the distance vector of each map is determined, the similarities and dissimilarities between the network graphs can be compared by calculating the global correlation coefficient and the local correlation coefficient.

An example is as follows: There is a concept map of a website's catalog contains 7 nodes, and Fig. 1 is the Pathfinder network :

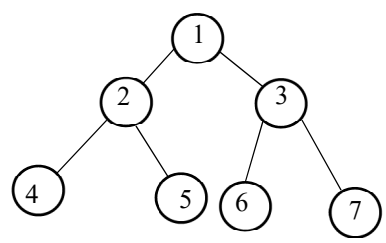

Fig. 1. Pathfinder network of website

Table I shows the corresponding upper triangular matrix：

TABLE I. Website Concept Distance Matrix

nodes	1	2	3	4	5	6	7
1	-	1	1	2	2	2	2
2	-	-	2	1	1	3	3
3	-	-	-	3	3	1	1
4	-	-	-	-	2	4	4
5	-	-	-	-	-	4	4
6	-	-	-	-	-	-	2
7	-	-	-	-	-	-	-

Based on this distance matrix can generate distance vector A= (1,1,2,2,2,2,2,1,1,3,3,3,3,1,1,2,4,4,4,4,2).

Fig. 2 shows a Pathfinder network of a participant:

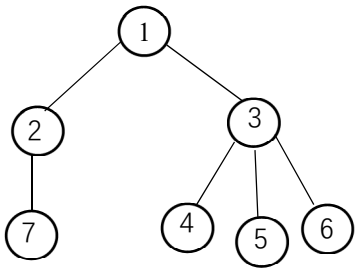

Fig. 2. Pathfinder Network of participant

Table II shows the participant`s matrix:

TABLE II. PARTICIPANT`S MATRIX

nodes	1	2	3	4	5	6	7
1	-	1	1	2	2	2	2
2	-	-	2	3	3	3	1
3	-	-	-	1	1	1	3
4	-	-	-	-	2	2	4
5	-	-	-	-	-	2	4
6	-	-	-	-	-	-	4
7	-	-	-	-	-	-	-

Similarly, distance vector B= (1,1,2,2,2,2,2,3,3,3,1,1,1,1,3,2,2,4,2,4,4).

By putting two distance vectors into formula (1), the global correlation coefficient can be obtained:

$$GTDCC_{PAB} = \frac{\sum (a-\bar{a})(b-\bar{b})}{\sqrt{\sum (a-\bar{a})^2 (b-\bar{b})^2}} \quad (1)$$

In the expression above, a a is an element of vector A, and $\bar{a}$ is the average of all elements of vector A. In the same way, b is an element of vector B, and $\bar{b}$ is the average of all elements of vector B. The range of correlation coefficient is [-1, +1]. If the correlation coefficient is -1, it means the two maps are very different. On the contrary, it means the two maps are same if the value is 1. The smaller the value of correlation coefficient, the lower the similarity between the two maps. To prevent the value of denominator is 0, the correlation coefficient will be assign 0 when the value of $\sum(a-\bar{a})$ or $\sum(b-\bar{b})$ is 0.

The following heuristic rules are applied in the algorithm: if the value of correlation coefficient between network maps or nodes is lower than 0.4, it is considered that there is no similarity or low similarity. If the value is between 0.4 and 0.7, it is considered to be a moderate degree of similarity. If the value of correlation coefficient is greater than 0.7, which is considered to have greater similarity. The higher the coefficient, the more consistent the website's catalog design is with the user's mental model.

IV. EMPIRICAL RESEARCH

In the experiment, we selected partial catalogues of JD Shopping Website for case study, and conducted the survey by combining card classification and questionnaire. Finally, there were 35 valid questionnaires. The experiment tool is SPSS 22.0.

A. Experimental Hypotheses

According to the relevant theory, we put forward the following assumptions before the experiment:

- Hypothesis 1: Gender has an impact on the user's mental model of the website classification system.
- Hypothesis 2: Age has an impact on the user's mental model of the website classification system.
- Hypothesis 3: The PC side catalog of JD Shopping website is more in line with the user's mental model than the phone side.

B. Experimental Elements

We took JD Shopping website as the target website, and selected the classification of household appliances as the target system. Finally, we selected some representative nodes from each layer of the catalog as experiment cards. Fig. 3 and Fig. 4 are the specific design concepts that used in the experiment.. Meanwhile, we numbered each concept.

C. Experimental Results

We used the ANOVA to test the hypothesis. We performed the test of homogeneity of variances before ANOVA to eliminate the data differences within the group.

1) Gender factor: Hypothesis 1: Gender has an effect on the user's mental model.

Firstly, we analyzed the homogeneity of variance, taking the global similarity coefficient as a dependent variable and gender as a factor. Table III shows the result:

P (0.114)>0.05, This means it passed the Levene test for homogeneity of variances.

It can be seen from P (0.869) >0.05 in the Table IV that gender has little or no influence on user's mental model in information acquisition. The average of male similarity coefficient is about 0.60, the female`s similarity coefficient average is about 0.58. The male`s coefficient was slightly higher than the female but the difference is not significant. So, this assumption is invalid.

TABLE III. HOMOGENEITY OF VARIANCES

Levene Statistic	Df1	Df2	Sig
2.623	1	38	0.114

TABLE IV. HOMOGENEITY OF ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.001	1	0.001	0.028	0.869
Within Groups	0.971	36	0.027		
Total	0.971	37			

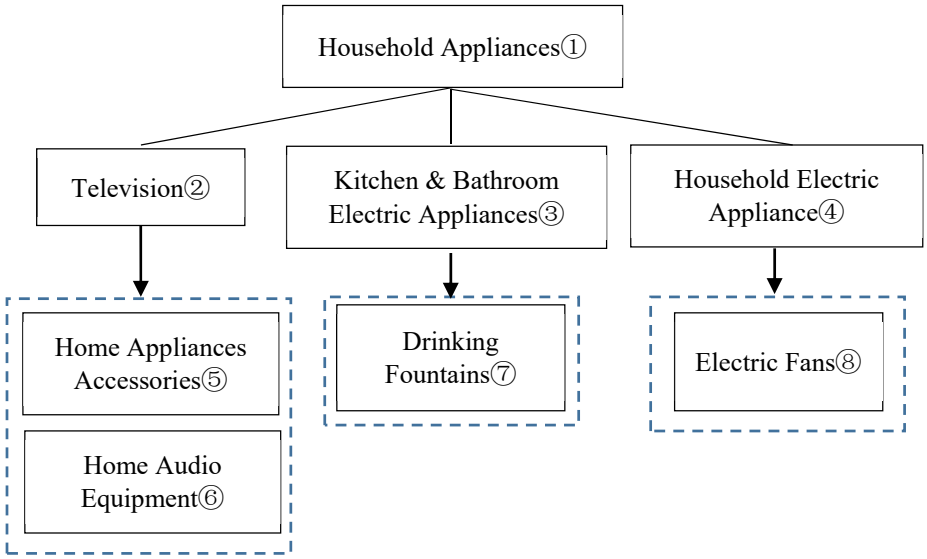

Fig. 3. PC side catalog

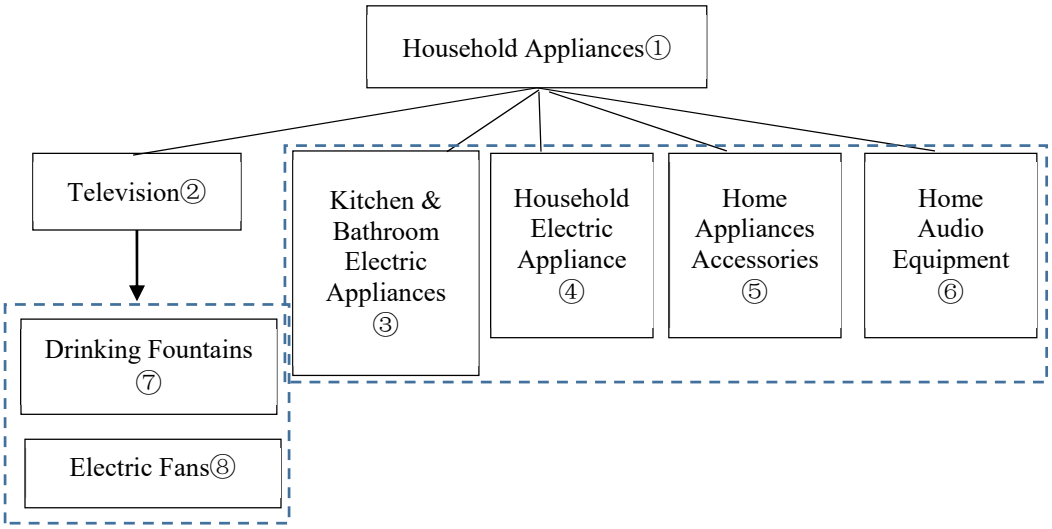

Fig. 4. The phone side catalog

2) Age factor: Hypothesis 2: Age has an impact on the user's mental model of the website classification system.

In this study, we divided the age of the participants into three groups.

In the Table V, P (0.456)>0.05. This means it passed the Levene test for homogeneity of variances.

TABLE V. HOMOGENEITY OF VARIANCES

Levene Statistic	Df1	Df2	Sig
0.803	2	38	0.456

It can be seen from P (0.127) >0.05 in the Table VI that age also has little or no influence on user's mental model in information acquisition. So, the hypothesis 2 is incorrect.

TABLE VI. HOMOGENEITY OF ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.108	2	0.054	2.186	0.127
Within Groups	0.863	35	0.025		
Total	0.971	37			

3) Device factor: Hypothesis 3: The PC side catalog of JD Shopping website is more in line with the user's mental than the phone side.

The result from the Table VII supported the hypothesis 3. This means The catalog of PC side is in line with user's mental models than the phone side.

TABLE VII. AVERAGE OF PC SIDE AND PHONE SIDE

Devices	Average
The PC side	0.65157
The phone side	0.438087

V. CONCLUSIONS

This paper took the classification system of household appliances as the research object, used the method of card sorting to record the user's mental model and used the Pathfinder network method to measure the mental model. Finally, we analyzed which factors will affect the mental model of users in the process of information acquisition in the website classification system. The results showed that gender and age had little or no influence on the user's mental model. And we found that the directory system on the PC side was more consistent with the user's mental model. Designers need to understand from the perspective of users when designing products, that is, they need to understand the mental model of users. Only in this way can the user feel happiness in the process of using the product.

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