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User Knowledge Acquisition in Automobile Engineering Styling Design

Xiang YAO^{a*}, Hong-yan HU^b, Jia LI^c^{a,b}Wuhan University of Technology, Wuhan, 430070, China

Abstract

This paper analyzed the main characteristics and role of qualitative and quantitative research in user research. Take Automobile Engineering design for example, probed how to get accurate description words of car styling image, using factor analysis, cluster analysis and other statistical methods, and verified the application methods and value of quantitative research applied in user knowledge acquisition.

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1. Introduction

To retrieve experience and study life-style in UCD (user-centered design) method are collectively known as user research^[1]. User research is an ideal method to match the user's goals and needs to market demand. Its primary purpose is to help enterprise define the target business users of products, clear and detail product concept, and through study on the operating characteristics of user's tasks, perceived characteristics, characteristics of cognitive psychology, taking the actual needs of users to product design-oriented, and eventually make the product more in line with the user's habits, experience and expectations.

"User knowledge" mainly refers to the learning and problem-solving experience during the product using process^[2]. User research is essentially the access, expression and conversion application process to user knowledge. User knowledge exists in the population using the product. Users can understand the meaning, functions, features and operation mode of products. More importantly, the products reflect the user's life quality and certain cultural meaning. User awareness and the whole process of learning to use the product will produce implicit and explicit knowledge. The main tasks of user research are as follows: ① mining user needs particularly implicit needs; ② identifying valuable user knowledge; ③ matching user knowledge to product design features.

2. Qualitative and quantitative research

* Corresponding author. Tel.: 86-18971609986; fax: 86-027-87219181.

E-mail address: yaoxiang0102@126.com.

Qualitative research and quantitative research are the primary user research methods. Quantitative methods, including questionnaire, experiment, AHP and correlation analysis, etc.; qualitative research methods often refers to all those methods which different to quantitative methods such as questionnaire. Therefore, any non-digital, non-quantitative analysis methods are to be known as qualitative research ones, such as target-system method, field-research method, interviews and card methods^[11].

Qualitative research is a method of discovering new things from small sample. User interviews and usability testing fall into this category, with a few users (10 to 20) interactions to get new ideas or expose previously unknown issues. Qualitative research does not prove anything, but is very valuable for mining new insight; researchers can verify and test the results at the next step. From this sense, qualitative research is open; often reveal some of the unknown. Quantitative research is the way to use a large number of samples to test and prove certain things. Questionnaire is a typical quantitative research method. Through hundreds of pieces of data, researchers can find a statistically significant trend, which can more accurately reflect the real situation of all users. Quantitative research can help validate the hypothesis which the qualitative research found. Popular to say, the relationship of “qualitative” to “quantitative” is “what people say” to “actually do”^[13].

3. The main methods and significance of quantitative research

In recent years, due to the impact of sociological, anthropological and cognitive science, the role of quantitative research increasingly highlights in user research. There are three main reasons. The first is that quantitative research study more experienced users than qualitative research. Qualitative research is a small sample study; the researchers always worry about if the study result can give a scientific and objective reflection of the true situation, quantitative research providing a large number of users for research, and thus more convincing. The second is that quantitative research can better determine the importance and priority; which is difficult for qualitative research. Such as product design, through qualitative research we can get which features are important in styling-design, but the relationship between these characteristics needed to achieve by statistical analysis of quantitative research. Thirdly, because number instead text in quantitative research, it can adapt to more different situations, and can be linked to digital information from other groups for comparative analysis, relative to the conclusion from qualitative study, quantitative data can gives us a more complete user impression.

Upon completion of the appropriate survey research, the main task of quantitative research is data mining and conversion. Data mining is to obtain invisible user knowledge and laws from the data. The process of data mining, also known as knowledge discovery process, which is a new branch of wide-ranging and cross-disciplinary science, involving databases, artificial intelligence, statistics, visualization, parallel computing and other fields. Data mining is a new information processing technology, its main feature is to extract, transform and analyze the large amount of data in the database, and extract the key decision support data^[4]. Presently, correlation analysis, artificial neural networks, decision trees and genetic algorithms are widely used in data mining applications. In the process of access to user knowledge, according to the specific research needs, a variety of methods for cross-applications, such as YANG Jie^[5] using wavelet neural network algorithm for identification and evaluation of user knowledge sources, TAN Hao, ZHAO Jiang-hong^[6] use genetic algorithms to establish quantitative model for car styling features and so on.

4. Case study

In this paper, we take obtaining image words of automotive styling design for example, firstly, acquiring user perceptual image on car through surveys, and then obtaining effective user knowledge through mathematical statistics, making a comprehensive exposition of the application process of data mining and conversion in quantitative research. Research can be divided into four stages.

4.1. Stage I: The collection of samples and image words

(1) The selection of image words

Vocabulary selection is to obtain the range of perceptual image on cars; the main steps are as follows:

First extraction: randomly selected 40 people to have interviews, including drivers, teachers, civil servants and the self-employed people, obtained general impression and psychological expectations on cars, and access to auto books, magazines and Web sites, organized 80 perceptual words. Second extract: make these 80 words a list, and send to 15 people for collection, including 10 people of 4S car-service staff and 5 customers, to find out which ones they think most appropriate adjective to describe cars, acquired 40 words. Third extract: take an interview to 20 graduate or undergraduate students, who are related to design education and received more than 3 years. Take the 40 pairs of emotional words to questionnaires. After subjective selection and statistical analysis by Excel, we have selected the final 13 pairs of representative image-words: young - aging, the high-speed - The slow, lively - rigid, modern - traditional, dynamic - static, male - female, avant-garde - conservative, creative - imitative, characteristic - common, rounded - sharp, masculine - feminine, friendliness - indifferent, geometric - unordered.

(2) The selection of product samples

Collect samples of car pictures from domestic and foreign professional automobiles website and automobile manufacturer website. Take morphological differences as a principle when collecting samples in order to ensure the completeness and correctness on research results. Research groups complete to collect the sample pictures around the world 10 brands and each brand 20 cars. Each sample should be with the front 45° view, the back 45° view and front-perspective view, a total of more than 600 pictures collected. Through expert evaluation, we selected 40 representative samples from the sample library.

4.2. Stage II: The selection of representative samples and image words

(1) The Filter of representative samples

In this study, make 40 sample images in the first stage a questionnaire, adopting Richter Scale method (Table 1), for clustering experiment, and then package into a compressed file, sent to each subjects through network, so as to ensure no interference between various subjects.

Invite 15 students majoring in industrial design from Wuhan University of Technology, 5 people with product design experience, a total of 20 for clustering experiments. Before the experiment, subjects were told to ignore the functionality and related factors of cars, only the feeling of form to clustering. Studies have shown that it is relatively easy to distinguish the sample if it is divided into 4-5 groups, when the sample is relatively large. According to the classification and the mean score, selected 5 representative samples from each type, a total of 20 representative samples.

Table 1. Clustering experiment questionnaire

								
young	-3 ()	-2 ()	-1 ()	0 ()	1 ()	2 ()	3 ()	aging
high-speed	-3 ()	-2 ()	-1 ()	0 ()	1 ()	2 ()	3 ()	slow
.....	-3 ()	-2 ()	-1 ()	0 ()	1 ()	2 ()	3 ()
friendliness	-3 ()	-2 ()	-1 ()	0 ()	1 ()	2 ()	3 ()	indifferent
geometric	-3 ()	-2 ()	-1 ()	0 ()	1 ()	2 ()	3 ()	unordered

1) Evaluation experimental of image words

Select eight representative bottle-samples from the 40 samples acquired at the first stage, and make them questionnaires. Invited subjects to judge based on personal subjective feelings. In this study, perceptual image is divided into 7 segments, the midpoint as a dividing point signed "0"; both ends of the scale image the strongest feelings. According to image extent, subjects score the sample with Likert scale. Take "young" for example, points

by: the extreme left means "oldest", namely, -3 points; the extreme right means "youngest", namely +3 points; no special feelings for the middle, namely, 0 point. The subjects have to judge each sample and record scores from -3 to +3. Invite 50 people of all, including 25 men and 25 women, to score each image word, statistics are shown in the table after finishing the average score (Table 2).

Table 2. The mean of Image-word statistic

	A06	A14	B07	B15	...	C17	D06	D09	E07
young- aging	0.24	-2.50	0.04	0.46		-1.70	-2.40	0.50	-1.78
high-speed- slow	-0.44	-2.50	-0.76	-0.16		-1.04	0.40	-0.34	-1.90
lively - rigid	0.56	-1.98	0.16	0.74		-1.10	-2.48	0.86	-1.08
...
masculine-feminine	-0.82	-1.34	-1.78	-1.42		-0.44	1.74	-0.80	-0.44
friendliness- indifferent	-0.06	0.74	-0.46	0.36		-0.66	-2.06	0.24	0.04
geometric - unordered	-0.66	-0.80	-0.64	-0.98		-0.64	-1.02	-0.54	-0.42

2) The selection of representative image words

Put the data in Table 2 into SPSS Statistics software; select the factor analysis method and the average orthogonal rotation method. In the factor analysis, the standard for the extraction is the eigenvalues should be greater than 1, get three semantic factors (Figure 1), and the cumulative variance reach 90.405% (Table 3), can more fully reflect all information. From Table 3, we can know 13 pairs of image words have been in the three factors, but the cumulative variance explanation is not 100%,means we can also increase image words, but may increase the complexity of the study words if we do so, thus ignore the remaining interpretation amount of 9.595%. Name the derived three factors as "creative" factor, "character" factor and "geometric" factor (Table 4).

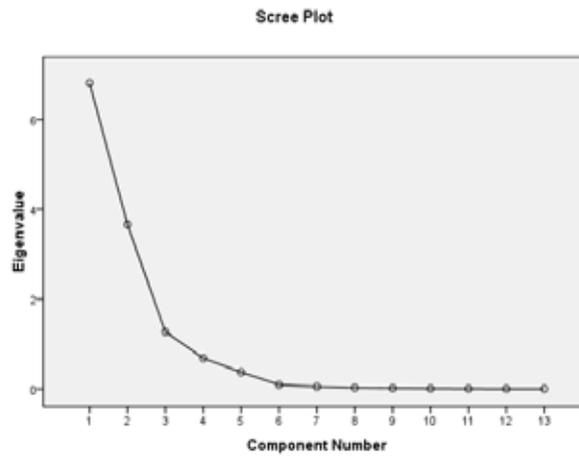


Figure 1. Factor eigenvalue slope figure

Table 3. Factor analysis results of the image words

Component	Extraction Sums of Squared Loadings
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	1	2	3	Total	% of Variance	Cumulative %
young - aging	.834	.357	-.369	6.821	52.466	52.466
high-speed - slow	.691	-.654	-.155			
modern - traditional	.451	.150	-.476			
dynamic - static	.921	-.260	-.246			
avant-garde – conservative	.988	.088	-.031			
creative - imitative	.971	.191	.074			
characteristic - common	.944	.271	.137			
male - female	-.137	-.886	.355	3.661	28.165	80.632
masculine – feminine	-.119	-.875	.370			
friendliness - indifferent	.245	.923	-.126			
lively – rigid	.411	.865	-.221			
rounded – sharp	.201	.071	.896	1.271	9.773	90.405
geometric - unordered	.033	-.196	.920			

Table 4 Classification of image words

"creative" factor	"character" factor	"geometric" factor
young – aging high-speed – slow modern – traditional dynamic – static creative – imitative characteristic - common avant-garde – conservative	male – female masculine – feminine friendliness - indifferent lively – rigid	rounded – sharp geometric - unordered

In order to be more careful selecting representative image words, we make the factor loading of the 13 image words in three dimensions as the coordinates of each image word in the three dimensions. By Ward method of Hierarchical cluster analysis, calculate the distance of each word in three dimensions, and select the words of each group nearest to the group center of gravity as the representation of image words. Through research, select out "high-speed, dynamic, lively, avant-garde, rounded" five image words (Table 5), then merger "high speed" and "dynamic " as "speed feeling " because the meaning are too close to each other. Thus, a total of 4 representative images obtained, namely “speedy - calmly, avant-garde-conservative, rounded – sharp, lively – rigid”, for the study of next stage. According to principal component analysis, we selected out the greatest contributed ones from a large number of image words, in fact, that is an effective dimension reduction process (figure 2).

Table 5 The cluster distance computation sheet of image words in the dimensions

	X-axis	Y-axis	Z-axis	Shortest distance
masculine	0.800	0.350	0.460	0.017
male	0.830	0.190	0.490	0.016
high-speed *	0.810	0.340	0.480	0.012
Group Center	0.818	0.331	0.476	
geometric	0.910	0.260	0.360	0.066
avant-garde *	0.910	0.210	0.350	0.013
characteristic	0.940	0.170	0.270	0.071
Group Center	0.916	0.190	0.340	

dynamic *	0.730	0.360	0.550	0.000
Group Center	0.730	0.360	0.550	
friendliness	0.020	0.980	0.030	0.067
rounded *	0.070	0.980	0.120	0.059
young	0.170	0.930	0.140	0.151
Group Center	0.051	0.949	0.066	
creative	0.910	0.210	0.340	0.015
modern	0.730	0.490	0.440	0.227
lively *	0.900	0.340	0.230	0.013
Group Center	0.845	0.347	0.346	

Note: *means the most representative image words

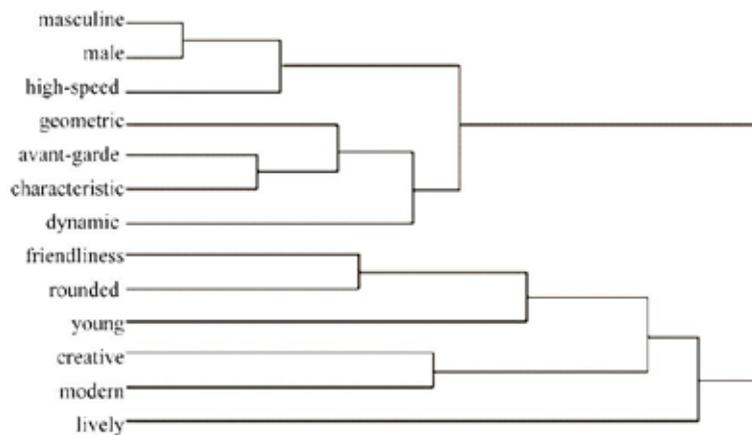


Figure 2 Cluster-tree map of image words

5. Conclusion

Quantitative research is an important means to user research, not only can provide data support for qualitative research, but also find the hidden law through the means of data mining which qualitative research cannot achieve. The fundamental purpose is to obtain valuable user information, and convert to design knowledge for product design and development. In the actual application process of user research, the two methods are often used interchangeably, in order to achieve the most reasonable application results.

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