

# Difference evaluation between plant dyed and industrial dyed cotton fabrics based on perceptual factors

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**Abstract:** Combined with the basic theoretical knowledge of Kansei Engineering and clothing materials, the perceptual cognition of consumers for different dyed fabrics was studied, and the perceptual evaluation of dyed fabrics of different materials was compared. SPSS software was used for statistical analysis of the survey data in order to find the characteristics of dyed cotton fabric. The perceptual evaluation results of plant dyed fabric and industrial dyed fabric were discussed. The relationship between the preferences of consumers towards plant dyed and industrial dyed cotton fabrics and the perceptual evaluation were analyzed through regression analysis.

## 1. Introduction

Plant dyeing is a method of dyed fabrics with natural plant pigments, which has a long history in China. In recent years, with the continuous impact of social development and the concept of green environmental protection, people pay more and more attention to the improvement of quality of life, followed by the high quality requirements of textile and clothing products, and the pursuit of a more green, comfortable and healthy wearing experience. Compared with industrial dyed fabrics, natural plant dyed fabrics are healthy and environmentally friendly, and there are obvious differences in vision, touch and smell between natural plant dyed fabrics and industrial dyed fabrics. This study took the perceptual engineering as the theoretical basis, systematically studied the views and methods related to different dyed cotton fabric elements, which were considered to be qualitative, unquantifiable and illogical in the past.<sup>[1][2]</sup> By means of sampling experiment and statistical analysis, this paper studied the perceptual evaluation and cognition of plant dyed and industrial dyed cotton fabrics, explored the perceptual characteristics of these dyed cotton fabrics and found the relationship between the preference of consumers towards plant dyed and industrial dyed cotton fabrics and the perceptual evaluation. This study will provide reference for the development and design of plant dyed fabrics.

## 2. The theoretical basis of perceptual evaluation

From the perspective of human cognition, sensibility is the objective attribute of things, and perceptual cognition is the cognition of objective things based on psychology and physiology.<sup>[3]</sup> The perceptual cognition of the differences between plant dyed fabrics and industrial dyed fabrics is that people have different feelings of various information obtained in the process of wearing or choosing different clothing materials. There are three types of perceptual cognition of fabrics: tactile, vision and olfactory.



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Tactile cognition is to judge things by transmitting information from skin to brain. In this case, it mainly refers to the cognition of material handle and skin touch. <sup>[4]</sup> Visual cognition is the result of visual light stimulating the retina, which is to observe the information of objects through the eyes, such as the material's surface characteristics, such as luster, hardness, softness, etc. Olfactory cognition is the nerve impulse produced by olfactory cells stimulated by some volatile substances. The impulse is transmitted to the cerebral cortex along the olfactory nerve and causes olfaction. Here, it mainly refers to the different psychological feelings produced by different fabrics due to different dyed materials. The whole cognitive process can be divided into three levels from low level to high level, namely: perception stage (feeling and perception), perceptual cognition stage (concept and impression) and rational cognition stage (concept and theory). <sup>[5]</sup>

### 3. Construction of fabric perceptual differentiation evaluation system

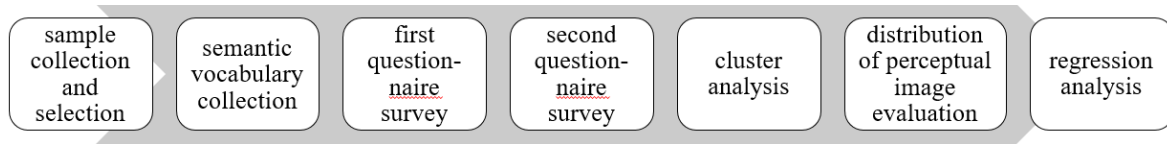
Fabric experience is that people touch the surface of the fabric, watch the texture of the fabric surface, smell the odor of the fabric, perceive all aspects of the fabric by the brain, and evaluate the texture, smoothness, softness, hardness, odor and other attributes of the fabric, which is a process based on the perceptual experience. Taking the perceptual experience test of plant dyed fabric and industrial dyed fabric as an example, firstly, the tester can directly perceive the surface texture of plant dyed fabric and industrial dyed fabric through finger skin. At the same time, combined with the memory effect of fabric vision, the tester perceived the visual, touching and olfactory information of the fabric to the brain through the nerve, and the brain classified the fabric perception dimensions. Combined with the memory and experience of the past visual, touch and smell feelings, the fabric experience was evaluated. Because people's evaluation and feeling of things are relatively vague, in psychology, we can measure the attitude and evaluation of the test person's perception experience through psychological scales (such as Likert scale, semantic difference scale, etc.). The perceptual cognition of plant dyed fabric and industrial dyed fabric mainly includes tactile, visual and olfactory types, as shown in Table 1.

**Table 1.** Perceptual evaluation system

Touch	Vision	Smell
Smoothness, roughness, texture	luster, hardness, softness,	irritation, gentleness and naturalness

### 4. Experimental methods of perceptual differentiation evaluation

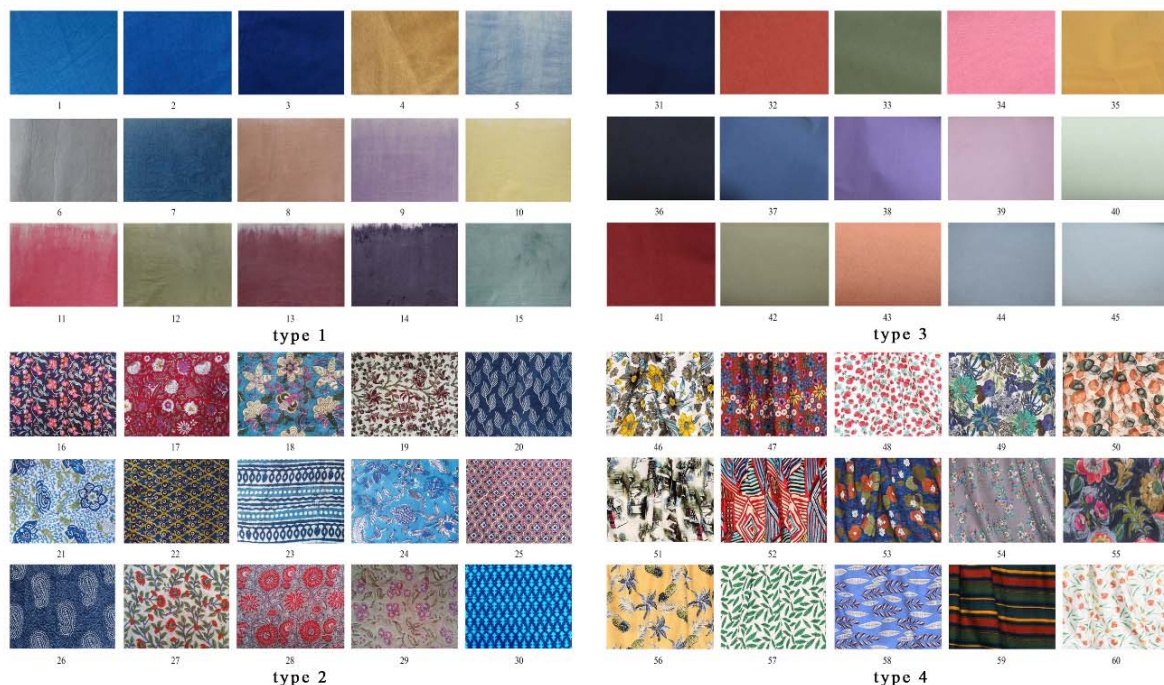
The research process shown in figure 1 was roughly divided into five steps: (1) sample collection and selection; (2) semantic vocabulary collection; (3) questionnaire survey to determine the image semantic space; (4) the second questionnaire survey to obtain the evaluation, preference and other information; (5) cluster analysis to divide the image word pairs into groups and extract the representative image words; (6) analysis of the distribution of perceptual image evaluation of different dyed methods; (7) regression analysis to study the relationship between the preferences of four types of fabrics and image words. In the stage of statistical analysis, IBM SPSS 22 software was used to analyze the survey data. The semantic difference method was used to design the questionnaire and carry out the investigation. The semantic difference method is a commonly used subjective evaluation method. It uses several adjective pairs related to an evaluation object as the scale to measure the subjective response of the subject after being stimulated by the object.



**Figure 1.** Research process

#### 4.1. Sample preparation

From the collected plant dyed cotton fabrics, 15 kinds of monochromatic fabric samples and 15 pattern fabric samples in different colors were selected. From the collected industrial dyed cotton fabrics, 15 kinds of monochromatic fabric samples and 15 pattern fabric samples in different colors were selected. In order to exclude the influence of different fabric materials, fabrics with similar gram number, count and physical properties were selected.



**Figure 2.** Four types of dyed cotton fabric samples

#### 4.2. Perceptual vocabulary extraction

In order to describe the tester's perceptual evaluation standardly, understand and master the relationship and factors among the various perceptual characteristics, and provide the statistical basis for establishing the relationship model between the perceptual image and the fabric characteristics, we used many methods to confirm the perceptual vocabulary. Through dictionaries, magazines, fabric exhibitions, product catalogues, market research and related websites, emotional image words were widely collected, and fabric experts, fashion designers and fabric designers were interviewed to preliminarily screen the collected words and remove words with similar meanings. Then, the image words were further screened by questionnaire to find out the proper evaluation words and group them to ensure the representativeness and comprehensiveness. Finally, 60 groups of words which were most suitable to describe the emotional image of fabric samples were selected which were shown in Table 2.

**Table 2.** A preliminary table of perceptual image words for sample fabrics

Sequence number(SN)	Perceptual image word pair	Sequence number(SN)	Perceptual image word pair
1	unique - common	31	pleasant - disgusting
2	delicate - rough	32	modern - traditional
3	simple - complex	33	mild - stimulating
4	handmade - industrial	34	smooth - pleated
5	elegant - unsophisticated	35	smooth - stiff
6	safe - moldy	36	individual - public
7	pure - dirty	37	fresh - old
8	natural - artificial	38	fragrant - smelly
9	environmental - polluting	39	casual - formal
10	popular - outdated	40	cheap - expensive
11	healthy - unhealthy	41	bright - sober
12	high end - low grade	42	tasteless - strong
13	bright - dim	43	decolorized - firm
14	gorgeous - plain	44	dull - multifariouss
15	fancy - plain	45	gray - showy
16	uniform - uneven	46	soft - hard
17	clean - messy	47	high level - low level
18	luxurious - simple	48	shining - faint
19	straight - supple	49	concise—complicated
20	elegant - flowery	50	elastic - inelastic
21	clean - turbid	51	bold - conservative
22	flat - concave convex	52	trendy - nostalgic
23	cool - warm	53	natural - rigid
24	tight - loose	54	dry - wet
25	monotonous - diverse	55	light - heavy
26	wrinkle resistant - non wrinkle resistant	56	fresh - dirty
27	healthy - hazardous	57	practical - fancy
28	elegant - heavy	58	beautiful - ugly
29	exquisite - rustic	59	durable - not durable
30	fine - vulgar	60	concrete - abstract

#### 4.3. Questionnaire design and data collection

In this experiment, in order to get the real feedback from the subjects as much as possible, the survey was equipped with real fabric samples of  $16 \times 16$  cm. The subjects were required to feel the fabric samples through eye observation and hand touch at the same time, and the image score was scored according to the comprehensive feeling, with the score ranging from -2 to +2, reflecting the degree of aesthetic image felt by the subjects. The evaluation experiment was carried out in the laboratory with the temperature of  $(20 \pm 2)^\circ\text{C}$  and relative humidity of  $(60 \pm 3)\%$ . Each subject conducted the

experiment independently, and the duration of each experiment was about 5-10 minutes. The differences between the perceptual images of plant dyed and industrial dyed cotton fabrics were obtained through questionnaire survey and data analysis. Questionnaire design and specific operation were as follows.

*4.3.1. The first questionnaire survey.* 100 students and teachers aged 20-50 were invited to fill in the questionnaire. The subjects were asked to select no less than 20 groups of adjective pairs from 60 given semantic word pairs of perceptual image for the fabrics. A total of 100 questionnaires were distributed and 106 questionnaires were collected, including 97 valid questionnaires.

Methods: semantic difference method <sup>[6]</sup> was used. Semantic difference method is a commonly used subjective evaluation method, which measures the subjective response of testers after being stimulated by the object. The semantic difference method consists of concept and several scales. Concept refers to the object used by the testers to evaluate, namely stimulus map. The scale was composed of two adjectives with opposite meanings. <sup>[7]</sup> From 60 groups of words, 20 perceptual image word pairs matched with representative samples were selected according to the results of the first survey. In the next experiments, these 20 word pairs would be used for subjective evaluation of four groups of cotton fabrics with two different dyed methods. The results are shown in Table 3.

**Table 3.** Confirmed perceptual semantic vocabulary

SN	Perceptual image word pair	SN	Perceptual image word pair
1	unique - common	21	clean - turbid
2	delicate - rough	27	healthy - hazardous
4	handmade - industrial	29	exquisite - rustic
5	elegant - unsophisticated	32	modern - traditional
6	safe - moldy	33	mild - excitative
8	natural - artificial	36	individual - public
9	environmental - polluting	38	fragrant - smelly
13	bright - dim	43	decolorized - firm
14	gorgeous - plain	45	gray - showy
16	uniform - uneven	49	concise—complicated

*4.3.2. The second questionnaire survey.* After examining the 60 fabric samples, 100 testers were asked to rate the 20 perceptual image words according to their feelings. A total of 100 questionnaires were distributed and 96 valid questionnaires were recovered.

Methods: 5-level Likert psychological scale was used. The scale was used to test people's evaluation of different dyed fabrics in different dimensions. Taking the perceptual vocabulary pair "concise - complicated" as an example, option 1 (- 2 points) means very concise; option 2 (- 1 points) means relatively simple; option 3 (0 points) means neither concise nor complicated; option 4 (1 point) means more complicated; option 5 (2 points) means very complicated.

In order to improve the accuracy of the experimental data, 100 subjects evaluated the semantic differences of four questions about the degree of preference: (1) you satisfied with the material of this fabric; (2) you are willing to wear the clothing made of this material; (3) you are willing to recommend this material to others; (4) you are willing to pay to buy clothing made of this material. <sup>[8]</sup>

## 5. Results and analysis

### 5.1. Cluster analysis

Research methods: through cluster analysis, the perceptual words were divided into five perceptual semantic groups with intrinsic clustering characteristics, and the word pair nearest to the center was taken as the representative of the group. [9] Through clustering, the complexity of subsequent analysis and the interference of related words were reduced.

The results of questionnaire analysis: through SPSS software, the total number of clustering cases was derived, which showed that all the 20 vocabulary categories were valid, and they were divided into five groups: the vision group included 7 samples, the tactile sensation group included 3 samples, the olfactory group included 4 samples, the health group included 3 samples, and the value group included 3 samples. According to the results of cluster analysis in Table 4, the distance between each sample and centroid point (CP) of the cluster can be seen. The word pair with the smallest distance to centroid point can be regarded as the representative image semantics of the cluster. The representative word pairs of each cluster are marked with “\*” in Table 4. The semantic classification is shown in Table 5.

**Table 4.** Results of clustering analysis of perceptual image word pair

SN	Perceptual image word pair	Cluster	Distance to CP	SN	Perceptual image word pair	Cluster	Distance to CP
1	unique - common	Olfactory	5.278	21	clean – turbid	Visual	4.451*
2	delicate - rough	Tactile sensation	5.533	27	healthy - hazardous	Health	5.973
4	handmade - industrial	Value	5.381	29	exquisite – rustic	Tactile sensation	4.472*
5	elegant - unsophisticated	Tactile sensation	5.824	32	modern - traditional	Value	4.833*
6	safe - moldy	Olfactory	4.762	33	mild - excitative	Olfactory	4.583*
8	natural - artificial	Health	5.242	36	individual - public	Value	5.325
9	environmental - polluting	Health	5.087*	38	fragrant - smelly	Olfactory	5.076
13	bright - dim	Vision	5.593	43	decolorized - firm	Vision	6.241
14	gorgeous - plain	Vision	5.094	45	gray - showy	Vision	5.711
16	uniform - uneven	Vision	5.995	49	concise - complicated	Vision	5.825

\* The representative word pairs of each cluster with the smallest distance to centroid point.

**Table 5.** Perceptual image word pairs grouping table

SN	Vision	SN	Tactile sensation	SN	Olfactory	SN	Health	SN	Value
49	concise - complicated	2	delicate - rough	6	safe - moldy	27	healthy - hazardous	32	modern - traditional
13	bright - dim	5	elegant - unsophisticated	33	mild - excitative	9	environmental - polluting	36	individual - public
14	gorgeous - plain	29	exquisite - rustic	1	unique - common	8	natural - artificial	4	handmade - industrial
21	clean - turbid			38	fragrant - smelly				
45	gray - showy								
16	uniform - uneven								
43	decolorized - firm								

According to results of cluster analysis, vision group represents the tester's visual perception of the fabric; tactile sensation group represents the tester's tactile perception of the fabric; olfactory group represents the tester's olfactory perception of the fabric; health group represents the tester's feeling of health related features; and value group represents the fabric's value related features. According to the experimental data, the perceptual image of cotton fabrics with different dyed methods depends on five evaluation elements: visual perceptual evaluation, tactile perceptual evaluation, olfactory perceptual evaluation, health factor evaluation and value element evaluation. The first three are perceptual evaluation, which is based on the expression of human instinctive response. Perceptual element evaluation can stimulate people's pleasant feelings and positive emotions at the first time, and meet people's most basic, primitive and instinctive needs. It is the knowledge of people's perceptual cognition of fabrics. The evaluation of health elements and value elements is the recessive perceptual feeling of fabric materials, which can better reflect people's psychological and aesthetic needs at a deeper level.

In the perceptual evaluation process, the testers paid more attention to the clean or turbid state of the fabric for visual perception, the exquisite or simple degree of fabric products for tactile perception, and the mild or pungent smell of fabric products for olfactory perception. The evaluation of health elements includes three groups of word pairs, which are the internal needs mainly represented by health, nature and environmental protection. The fabric design based on nature is also the development target of fabric design in the future<sup>[10]</sup>. Fabrics with health elements can meet the health and safety needs of users and make the wearer feel safer and more comfortable. The evaluation of value elements is the symbolic meaning experienced by the testers, including personal self-consciousness, value judgment and cultural orientation, which belong to the highest level of spiritual needs of self-realization. As Maslow, the famous American social psychologist, said: "the satisfaction of high-level needs can lead to more desirable subjective effects, that is, a deeper sense of happiness, serenity and inner richness."<sup>[11]</sup> In the evaluation of value elements, "modern – traditional" was the evaluation word pair that testers pay more attention to, which was the most important value element in the test.

### 5.2. Distribution of perceptual image evaluation of different dyed methods

According to four types of samples (plant dyed monochromatic fabric, plant dyed pattern fabric, industrial dyed monochromatic fabric and industrial dyed pattern fabric), the perceptual image evaluation of dyed fabric samples was analyzed. The data are shown in Table 8. There were significant differences in perceptual image evaluation of four types of materials.

**Table 6.** Mean value of perceptual image evaluation scores

SN	type 1	type 2	type 3	type 4	SN	type 1	type 2	type 3	type 4
1	0.56	0.43	0.55	0.47	21	-0.22	-0.41	-0.94	-0.87
2	-0.34	-0.36	-0.4	-0.41	27	0.10	0.32	0.67	0.74
4	-0.15	-0.21	0.92	0.85	29	0.38	0.33	0.23	0.19
5	-0.25	-0.27	-0.33	-0.32	32	0.12	0.44	-0.15	-0.24
6	-0.23	-0.20	-0.18	-0.16	33	-0.67	-0.69	0.42	0.49
8	0.37	0.44	0.68	0.93	36	-0.55	-0.31	0.15	0.12
9	-0.53	-0.24	0.67	0.74	38	-0.33	-0.32	-0.10	-0.05
13	0.15	0.05	0.07	-0.11	43	0.56	0.23	0.78	0.59
14	0.86	0.13	0.45	0.03	45	-0.45	0.08	-0.33	0.32
16	-0.45	-0.13	-0.48	-0.09	49	-0.67	-0.11	-0.70	0.05

Results of questionnaire analysis: from the experimental data, there are significant differences in the evaluation of some perceptual images between plant dyed and industrial dyed cotton fabrics. In the evaluation of the image of the experimental samples, there were great differences in the evaluation dimension of “clean - turbid”. In descending order of cleanliness, the four types were industrial dyed monochromatic fabric, industrial dyed pattern fabric, plant dyed pattern fabric and plant dyed monochromatic fabric. In the evaluation of “exquisite - rustic” image, the descending order of the four types was industrial dyed pattern fabric, industrial dyed monochromatic fabric, plant dyed pattern fabric and plant dyed monochromatic fabric. Among them, industrial dyed pattern fabric was the most exquisite, and plant dyed monochromatic fabric was the most rustic. In terms of perceptual images with significant differences in olfactory features, the cotton fabrics with plant dyed patterns were the least excitative, while those with industrial dyed patterns were the most excitative; in terms of perceptual evaluation of health related features, plant dyed monochromatic fabrics were rated as the most environmental and healthy, and industrial dyed pattern fabrics were rated as the most polluting and hazardous. In the perceptual evaluation of value related image, industrial dyed monochromatic fabric was the most industrial and popular; plant dyed pattern fabric was considered to be the most traditional and handmade; industrial dyed pattern fabric was considered to be the most modern and artificial. In addition, because the samples were all pure cotton fabrics with similar density and index, there was little difference in tactile evaluation from the testers. The results showed that different dyed methods had little impact on the tactile feeling of the fabric.

### 5.3. Regression analysis

Research methods: multiple linear regression analysis was used to investigate the relationship between the testers' preferences and image word pairs. Testers' preference served as dependent variable and the perceptual image word pairs served as independent variables. Multiple linear regression was performed with SPSS software. A higher standardized coefficients indicates a stronger effects that the independent variables influence the dependent variable. <sup>[12]</sup>

The image words related to preference of plant dyed monochromatic fabric samples were “natural - artificial” (coefficients = -0.259,  $p = 0.008$ ), “healthy -hazardous” (coefficients = -0.172,  $p = 0.042$ ) and “concise - complicated” (coefficients = -0.238,  $p = 0.007$ ). The image words related to preference of plant dyed pattern fabric samples were “handmade - industrial” (coefficients = -0.262,  $p = 0.005$ ) and “individual -public” (coefficients = 0.203,  $p = 0.018$ ). The image words related to preference of industrial dyed monochromatic cotton fabric samples were “uniform - uneven” (coefficients = -0.185,  $p = 0.029$ ) and “concise complex” (coefficients = -0.274,  $p = 0.006$ ). For industrial dyed pattern cotton fabric samples, the image words related to preference were “gorgeous - plain” (coefficients = -0.336,  $p = 0.001$ ) and “exquisite - rustic” (coefficients = -0.307,  $p = 0.012$ ).



## 6. Conclusion and discussion

Based on the theory of Kansei Engineering, this paper studies the representative fabric samples to investigate the perceptual image of consumers. 20 perceptual image word pairs were chosen from 60 word pairs based on the survey results. These word pairs were used to explore the perceptual characteristics of cotton fabrics dyed by plants and industrial dyes through cluster analysis, these word pairs were divided into five groups: vision, tactile sensation, olfactory, health and value. Through statistical analysis, the results showed that there were significant differences in the evaluation of some perceptual images between plant dyed and industrial dyed cotton fabrics. The results of regression analysis showed that some perceptual image word pairs had greater relationship to some type of dyed fabrics. Each type of dyed fabrics had the typical perceptual image evaluation from the testers. This study has research significance and deficiency listed below.

(1) This method can be used to establish a fabric evaluation system combining subjective image and index. The results showed that the five groups of perceptual image word pairs are feasible to this method can be used to establish the index relationship between specific consumers and the properties of dyed fabrics, and is helpful to identify consumers' preferences and which perceptual factors affect them.

2) Through data analysis, the difference between the selected cotton fabrics dyed by plants and those dyed by industry were successfully evaluated. But the overall evaluation score was only for the five main factors: vision, tactile sensation, olfactory, health and value related factors. The results did not include the influence of other factors. Therefore, this method is more suitable for the comparison of the overall properties of dyed cotton fabrics, and cannot fully cover all the indexes.

3) The perceptual images of different materials have different effects on preference evaluation, which can be expressed as image words related to preference. Grasping the perceptual information implied in different dyed fabrics and understanding consumers' psychological feelings are helpful for designers to develop new dyed fabrics according to the needs of users.

4) Due to time and funding reasons, this paper did not conduct cross research on the characteristics of the testers, such as gender, age, region, educational background and other variables, which will be included in the subsequent research for further research.

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