The Study of the Double Color Matching of the Elderly Assistive Products Based on the Kansei Engineering

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Abstract

The purpose of this research is to study the cognitive preference of the old people in the color matching of assistive products. First of all, the elderly assistive products color matching was analyzed. Based on this point, the double color samples color matching software was designed, and there are 858 valid two Color harmony pictures were obtained. Secondly, there were 50 pairs of Kansei words were obtained through investigation and research. Using Multidimensional scaling method and Clustering analysis method, there were 5 pairs of representative Kansei words were "Traditional-modern", "Emotional-rational", extracted: "Natural-technological". "Massive-leggiere", "Rigid-soft". According to above, were aimed to give score to 20 subjects (Contains the elderly group and young group) through the E-prime software, using the Likert scale to grade 858 valid two Color harmony pictures. The perceptual evaluation value of 5 pairs of representative Kansei words with 858 valid two Color harmony pictures were obtained. Finally, the different cognitive preference of double color matching for assistive products of the old people was obtained through the statistical analysis. The results can not only provide reasonable color recommendations, but also shorten the production cycle.

Keywords: Color harmony; the elderly assistive products; Color recommendations; Kansei Engineering

1. Introduction

With the acceleration of the aging process in China, it is more important that to study the old people's life and psychological problems. And how to satisfy the old people's needs is one of the urgent problems to be solved at present [1].

However, most of the existing elderly assistive products were designed in order to satisfy the physiological needs of the old people. For example, the elderly assistant seats, was designed by WANG Jianguang, which is aimed at the knee joint torque compensation [2]. ZHANG Hongliang used SAC force servo hybrid control method to design the exoskeleton walking auxiliary device for the elderly [3]. FU Xiaoyun *et al.* used the Kansei engineering to establish the perceptual correlation between Kansei words and the design elements of the car shape, and take the correlation to guide the product design. Finally, there were 2 electric scooter were designed which can satisfy the demands of the elderly [4].

At present, there are many color harmony researches about electrical appliances, shoes and other mass consumer products. For example, Shieh M *et al.* studied the color matching of shoes, and provided the reasonable color recommendations [5]. Under different cultural background, Ou L C *et al.* studied the differences of people's cognitive of double color harmony [6].

The elderly assistive products not only need to help the elderly obstacle-free living independently, but also need to satisfy the perceptual demands of the old people. Thus, it is important to find the color harmony laws about the assistant products which conform to

the cognitive preference of the old people. The color harmony laws will help the designers to design the elderly assistive products which can satisfy the physiological and psychological needs of the old people.

This paper will study the elderly assistive products color matching cognitive preference which can provide the reasonable color recommendations for designers.

2. Methods

2.1. Kansei Engineering

Kansei engineering is a technical support of the product development, which is based on ergonomics with the consumer orientation. The technology can transfer people's ambiguity perceptual demands and images into the shape elements of the products design [7].

2.2. Statistical Analysis

2.2.1. Multidimensional Scaling

Multidimensional Scaling analysis is a multivariate statistical analysis method to analyze the similarities or differences of the object which can reflect the degree of similarity or difference between multiple research objects. Express the degree of similarity or difference through the distance between point and point with proper dimension reduction method. And it can identify those potential factors that influence the similarity between things [9].

2.2.2. K- Mean Clustering Analysis

Clustering analysis is a kind of multivariate statistical analysis methods which is aimed to classifying index or samples. Each object is similar in the class [10], but it is different from other objects. The Clustering analysis includes the system clustering, K-mean clustering *etc*. This study adopts K-mean clustering analysis method [11]. The coordinate of Kansei words of the elderly assistive products were obtained through multidimensional scaling analysis. The final lexical coordinates of these Kansei words can be divided into initial group randomly. The sample coordinates of each group in the average value is set to the center of each group, the Kansei words pairs which are the nearest to the coordinates of the group center are the most representative words pairs.

2.2.3. Likert Scale

Likert scale is improved by American social psychologist Likert based on original summated rating scales in 1932 [12]. This paper will adopt the form of 5 Likert subscales through the E-prime Psychology experiment software. The score are divided into 5 kinds of degrees, such as "Strongly disagree", "disagree", "uncertainty", "agree". And 1to 5 is marked as 5 kinds of answer score respectively.

3. Research Process

There were four major stages in this study. First of all, the elderly assistive products color matching was analyzed. Based on this point, the double color sample color matching software was designed. And the two Color harmony pictures were obtained. Secondly, there were 5 pairs of representative Kansei words were obtained through Multidimensional scaling method and Clustering analysis method. Following this, the subjects were aimed to give score to two Color harmony pictures through the E-prime software and Likert scale. The perceptual evaluation value of representative Kansei words

with valid two colors harmony pictures were obtained .Finally, the different cognitive preference of double color matching for assistive products of the old people was obtained through the statistical analysis (See Figure 1).





3.1. Obtaining the Double Color Matching Pictures

Through the network research, there were 50 pictures of assistive products were obtained, 30 representative assistive products pictures were screened. Through analyzing the double color area ratio of assistive products, the area ratio of 1:3 reached to 70% of the total number of products. Based on this point, the software of double color samples color matching based on RGB was designed through the visual basic software.

By setting the initial values is 0, the step length of the inner sample and the outer sample are 51, double color sample matching software could select the color sample. Finally, there were 858 valid pictures were obtained, as shown in Figure 2.



Figure 2. The Double Color Sample Color Matching Software Parameters Settings and Two Color Harmony Pictures

3.2. Obtaining the Representative Kansei Words of the Elderly Assistive Products

3.2.1. Collection and Preliminary Screening the Kansei Words

There were 50 pairs of Kansei words about the color of the elderly assistive products from books, internet and magazines were collected.

Through selecting 10 graduate students and 10 elder people who were investigated on the network questionnaire to choose the most suitable kansei words pairs of the colors of the the elderly assistive products. Through voting, the top 20 Kansei words pairs were chosen as shown in Table 1.

Serial number	Kansei words	Serial number	Kansei words
1	flamboyant-Restraine	11	Warm - cool
2	elegant-ornate	12	Orderly - random
3	masculine-feminine	13	Popular - personality
4	portable-heavy	14	Sedate - animated
5	spiculate-mellow	15	Passionate - calm
6	Plain - grand	16	complex - simple
7	Open- conservative	17	friendly-grim
8	Emotional- rational	18	Hard-soft
9	Natural - technological	19	Traditional - modern
10	Rigid - soft	20	Monotonous - abundant

Table 1. 20 Pairs of Kansei Words of the Elderly Assistive Products

3.2.2. Obtaining the Representative Kansei Words

(1) The semantic clustering questionnaire of the elderly assistive products

There were 20 people who were the subjects, including 10 the elderly (aged 65 ± 3 , male female ratio 1:1), 10 graduate students, (aged 25 ± 3 , male female ratio 1:1). And these 20 subjects were invited to categorize the 20 words in Table 1 according to character. The similar words would be filled in the same group. In each group, the number of words can be different, but all words must be filled in the group and cannot be repeated. Putting the frequency statistics of two words in the same group to a Similar frequency matrix of 20×20 , using A=(Xi,j)(i,j=1,2,...,20)to express as shown in formula 1.

 $A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1j} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2j} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} & \cdots & a_{ij} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix}$ (1)

(2) Foreordain grouping of the Kansei words pairs

Using the SPSS (Statistical Product and Service Solutions) software for multidimensional analysis of the Similar frequency matrix of Aij, Stress=0.01066 was calculated. The calculation results are shown in Table 2.

The number of Kansei	The 5 dimensions of space coordinates						
words	1	2	3	4	5		
V1	0.1973	0.1993	-0.0762	1.3650	-0.0609		
V2	0.0216	0.3416	-0.0359	0.9177	0.3547		
V3	0.0058	0.3761	0.0080	0.8517	0.3935		
V4	-0.1173	-0.0557	0.1977	0.5714	0.2268		
V5	-2.0763	0.5496	-0.3743	0.4863	-1.5075		
V6	-0.0728	-0.0876	0.0015	-1.4502	-0.0005		
V7	0.6133	-1.6168	1.6930	0.4577	1.2161		
V8	0.6836	-1.2294	0.1493	0.9072	-1.6490		
V9	-1.8814	0.2431	0.7798	0.3823	1.6146		
V10	2.4838	0.3573	0.1702	0.2747	0.5494		
V11	0.1372	1.1300	1.9725	0.6180	-0.4702		
V12	-1.5936	0.7145	-0.7490	0.5768	-1.1591		
V13	-0.1558	-0.4970	0.3703	-1.5920	-0.1799		
V14	1.0900	1.7903	-0.6591	-0.6059	-1.5579		
V15	1.0152	-0.2764	-0.5674	0.9350	0.4572		
V16	-1.4223	-1.5525	-1.9422	-0.0433	0.6867		
V17	0.3442	1.9499	-0.1913	-0.9877	1.6027		
V18	0.7006	-0.2472	0.7010	-2.0327	-0.2166		
V19	-0.6140	-2.4440	0.8692	-0.1355	-0.0758		
V20	0.6408	0.3549	-2.3172	-1.1965	-0.2243		

Table 2. The 5 Dimensions of Space Coordinates Using the Software ofSPSS

The relationship between fit degree and pressure coefficient in multidimensional scaling analysis is shown in Table 3. Stress is the Kruskal, to represent the fit of the observation distance and the actual distance [10] .the smaller of the stress, the better of the fitting degree. The kruskal is 0.01066, the fit degree is perfect that 20 Kansei words are divided into five dimensions.

Table 3. The Relationship between Fitting Degree and Pressure Coefficient
in Multidimensional Scaling Analysis

Kruskal	Fit degree
0.200	Poor
0.100	Ordinary
0.050	Good
0.025	Excellent
0.000	Perfect

(3)To obtain the representative Kansei words pairs

According to the experiments of 20 pairs of Kansei words on the five dimensions of space coordinates, using SPSS software on Kansei words pair of the colors of the elderly assistive products to clustering analysis, the result is shown in Table 4:

NO.1group	NO.2 group	NO.3 group	NO.4 group	NO.5group
V1	V2	V3	V4	$V_{12}(1, 126*)$
(0.367)	(1.095*)	(1.460*)	(2.061)	V12(1.120**)
V(0, 217*)	V6	V5	V7	V16
V8(0.517*)	(2.273)	(2.118)	(2.082)	(1.596)
	V9	V15	V11	
	(1.511)	(1.599)	(1.281)	
	V10		V17(0 410*)	
	(2.225)		V1/(0.419 ^{**})	
	V13		V18	
	(2.158)		(0.658)	
	V14		V19	
	(1.423)		(0.686)	
			V20	
			(0.597)	

First of all, to select the Kansei words pairs which are the closest to zero as the representative Kansei words pairs. The representative Kansei words pairs in group5, as shown in Table 5.

 Table 5. 5 Pairs of Representative Kansei Words

V8	V2	V3	V17	V12
Emotional-	Traditional-	Natural-	Massive-	Rigid-
rational	modern	technological	leggiere	soft

3.2.3. The Experiment of Color Samples Matching With Perceptual Image

(1) Experimental simples

There are 858 valid two Color harmony pictures were obtained from 3.1.

(2) Experimental subjects

There are 20 subjects, including 10 the elderly (aged 65 ± 3 , male female ratio 1:1), 10 graduate students, (aged 25 ± 3 , male female ratio 1:1).

(3) Experimental program

Experiments are conducted on the computer and program, using the E-Prime2.0 software establishment to evaluate the preference of the Kansei words of double color matching samples. To have three times rest among the testing, and the length of time to rest which were controlled by the subjects themselves, the process of the rest will play the landscape pictures in random. For example, "Traditional - fashion", as formal experiment, 858 color collocation images appeared in a random way in the middle of the computer monitor alone. Screen background was 10% gray. The subjects' fixation point was "+", the rendering disappeared after 500 ms, and then a picture of the double color collocation appeared on the screen. When the subjects buttons 1, 2, 3, 4, 5, which are represent "very traditional" "traditional" "uncertainty" "fashion" "very fashionable" .The picture was disappeared. The stimulus presentation sequence is shown in Figure 3.



Figure 3. The Stimulus Presentation Sequence

4. The Experimental Results and Data Analysis

4.1. Experimental Results

These 20 subjects are aimed to give score to these 5 pairs of Kansei words which are the "Emotional-rational", "Traditional-modern", "Natural-technological", "Massive-leggiere", "Rigid-soft". After finishing the matching experiment, the 5% of the longest response time and the shortest reaction time was eliminated to reduce experimental error. The experiment adopted the sequential data, the average variation ratio is less than 40% through calculation, so the experimental data used mode as statistics. Getting valid data through sifting and processing data is shown in Table 6.

Table 6. The Evaluation Data of the Elderly Perceptual Image and Double
Color Matches Samples

	5 pairs of Representative Kansei Words					
The number of	Emotional-	Traditional-	Natural-	Massive-	Rigid-	
Kansei words	rational	modern	technologic	leggiere	soft	
			al			
1	4	3	3	2	1	
2	3	4	2	4	3	
3	2	3	4	2	3	
4	3	2	1	3	4	
5	5	3	4	1	2	
6	2	3	4	4	2	
7	3	1	3	3	1	
8	4	4	2	2	1	
9	1	4	1	2	5	
10	3	3	1	2	4	
11	2	2	4	3	3	
12	4	2	3	4	4	
13	2	1	2	1	5	
14	2	4	2	2	2	
15	3	3	2	3	3	
•••	•••		•••	•••	•••	
858	4	2	3	2	4	

4.2. Analysis of Experimental Results

Black and white is the dominant color or auxiliary color of 858 valid two Color harmony pictures. Thus, they were divided into G1, G2 and G3, G4 four groups. (Table 7)

Category	Dominant color	Auxiliary color
G_1	black	multicolor
G ₂	white	multicolor
G ₃	multicolor	black
G ₄	multicolor	white

Table 7. The	Category of Val	id Two Color	Harmony Pictures
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Take "Traditional-fashion" for instance, according to the Table 6 and Table 7 obtained the distribution circular diagram that is shown in Figure 4. The circular diagram consisted of four layers from the center to the outside: G1, G2, G3, G4, and the percentage of the different scores.



Figure 4. The Experiment Match Score Statistics Figure of "Traditional -Fashion" in the Elderly Group

The score of 1, representing the words group "very traditional". Therefore, the samples score of 1 respectively accounted for 46%,3%,5%,3% of the G1, G2, G3, G4. The samples score of 1 of G1 were picked up for subsequent analysis.

4.2.1. The Analysis of Experimental Results Based on HSB

HSB is a kind of color model based on human eyes, and also is a common color pattern of design software, in which H represents hue, S represents saturation, and B represents the brightness. In order to analyze the experimental results, the RGB should be transferred into HSB pattern.

The score of 1 in 99 samples of G1, can be converted to HSB color model.

Statistic the values of H,80% of the color is warm colors.65% of the values is $B \le 50$,and 75% of the value is $S \ge 50$. In short, a combination of the dominant color of black and the auxiliary color of warm colors with low saturation and high brightness gives the old people a sense of tradition. In the same way, the percentage of H,S,B in the perceptual evaluation value of 5 pairs of representative Kansei words with 858 valid two Color harmony pictures in the aged group were obtained. The results are shown in Table 8.

Category	Category of the group			group Category of HSB				
Kansei	G_1	G_1	G ₁	G_1	Cold	Warm	Saturatio	Brightnes
words					tone	tone	n	S
Traditional	80%*	5%	9%	6%	20%	80%	65%≤50	75%≥50
Modern	8%	26%	28%	38%*	75%	25%	70%≥50	78% <u>></u> 50

Table 8. Statistical Table of the Percentage the of H, S, B in the Aged Group

International Journal of Multimedia and Ubiquitous Engineering Vol.11, No.4 (2016)

Emotional	6%	12%	16%	66%*	22%	78%	70%≥50	75%≤50
Rational	14%	48%*	19%	19%	69%	31%	63%≤50	77%≥50
Rigid	61%*	18%	15%	6%	79%	21%	75%≤50	66% <u>≤</u> 50
Soft	0%	6%	1%	93%*	70%	30%	70%≤50	66%≤50
Leggiere	0%	73%*	3%	24%	76%	24%	80%≥50	75%≥50
Massive	66%*	3%	20%	11%	75%	25%	85%≤50	65% <u>≤</u> 50
Natural	11%	66%*	11%	12%	65%	35%	70%≥50	75%≥50
Technological	67%*	16%	9%	8%	82%	18%	60%≥50	70%≥50

Table 9. Statistica	Table of the	Multicolor Part o	f Color Matching	Pictures
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Kansei words	Tone	Saturation	Brightness
Traditional	Warm tone	Low saturation	High brightness
Modern	Cold tone	High saturation	High brightness
Emotional	Warm tone	High saturation	Low brightness
Rational	Cold tone	Low saturation	High brightness
Rigid	Cold tone	Low saturation	Low brightness
Soft	Cold tone	Low saturation	Low brightness
Leggiere	Cold tone	High saturation	High brightness
Massive	Cold tone	Low saturation	Low brightness
Natural	Cold tone	High saturation	High brightness
Technological	Cold tone	High saturation	High brightness

Table 10. The Relationship between Kansei Words and Two Color HarmonyPictures in the Elderly Group

Kansei words	Dominant color	Auxiliary color
Traditional	black	low saturation, high brightness, warm tone
Modern	High saturation, high brightness, cold tone	white
Emotional	High saturation, low brightness, warm tone	white
Rational	white	low saturation, high brightness, cold tone
Rigid	black	low saturation, low brightness, cold tone
Soft	low saturation, low brightness, cold tone	white
Leggiere	white	High saturation, high brightness, cold tone
Massive	black	low saturation, low brightness, cold tone
Natural	white	High saturation, high brightness, cold tone
Technological	black	High saturation, high brightness, cold tone

The relationship between Kansei words and two Color harmony pictures in the elderly group is shown in Table 10.

4.2.2. Differential Analysis of the Young Group and the Aged Group

The results show that there are some differences between the aged group and the youth group's cognition of the elderly assistive products color matching .Take "traditional-fashion" for instance, a combination of the dominant color of white and the auxiliary color of warm colors with low saturation and low brightness gives the young a sense of tradition. However, a combination the dominant color of black and the auxiliary color of cold colors with high saturation and high brightness gives the young a sense of fashion.

5. Discussion

As the vulnerable group, the old people have different psychological demands. From the experimental results, a combination of the dominant color of black and the auxiliary color of warm colors with low saturation and high brightness gives the old people a sense of tradition. And a combination of the dominant color of black and the auxiliary color of cold colors with low saturation and low brightness gives the old people a hard feeling. But a combination of the dominant color of black and the auxiliary color of cold colors with high saturation and high brightness shows the advanced technology to the old people.

The dominant color is white, the auxiliary color is cold color with low saturation and high brightness, can give the elderly the rational sense. The dominant color is white, the auxiliary color for high saturation and high brightness of cold color, can give the elderly leggiere and natural feeling.

A combination of the auxiliary color of white and the dominant color of cold tone with high saturation and high brightness gives the old people a sense of fashion. And a combination of the auxiliary color of white and the dominant color of warm tone with high saturation and low brightness gives the old people an Emotional feeling. But a combination of the auxiliary color of white and the dominant color of cold tone with low saturation and low brightness gives the old people a soft feeling.

The results show that there are some differences between the aged group and the youth group's cognition of the elderly assistive products color matching. Take "traditional-fashion" for instance, a combination of the dominant color of white and the auxiliary color of warm colors with low saturation and low brightness gives the young a sense of tradition. However, a combination the dominant color of black and the auxiliary color of cold colors with high saturation and high brightness gives the young a sense of fashion. The difference between the living environment and the cultural background of the old people and the young people may be the main reason for the differences. The old people are the users of the assistant products, but the young people may be the buyers, so the differences of the experimental results between the aged group and the youth group can also provide a reference for the designers.

Through a lot of research and experiment data statistics, it is concluded the cognitive preference of the old people in the color matching of assistive products, which can provide the color recommendations for the designers, and shorten the production cycle. But due to the huge color matching samples and the experimental works, the experiment adopts the single evaluation to evaluate the perceptual value. In follow-up studies, the experiment will adopt the two-two comparing ways to obtain the perceptual evaluation value and acquire more scientific experimental results.

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International Journal of Multimedia and Ubiquitous Engineering Vol.11, No.4 (2016)



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