2018 User-Centered Design Methodologies
Project Report

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1. Design Concept

Clock is the machine to tell people time. But nowadays it mean more than timing but also collection. In this case, we look forward to producing clocks more freshness. Of course, we shouldn't forget the main of a successful clock is easy to read.

2. Samples

Now we already own 5*3 types of clocks. It is easy to find there is some common features between them. To multiply the features, I design 6 evaluation samples by PC software in Fig. 6.

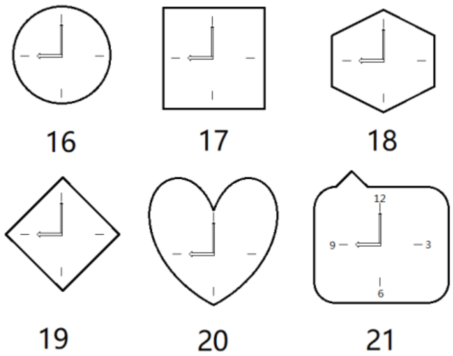

Fig. 1 My clock samples by drawing software.

In this experiment, 6 participants give scores of Fig. 2 .

		very	some what	neutral	some what	very	
		1	2	3	4	5	
1	unnatural						natural
2	traditional						modern
3	ugly						stylish
4	unique						ordinary
5	cold						warm
6	complicated						simple
7	uncomfortable						comfortable
8	difficult-to-read						easy-to-read

Fig. 2 Observed variables.

After get these scores, we average the scores for each sample's observed variables. The result is follow.

Table 1 Average evaluation score.

		Sample No.									
		1	2	3	⋯	16	17	18	19	20	21
Adjective Pair No.	1	3.83	3.17	2.50	⋯	4.50	4.67	4.50	4.33	3.17	2.67
	2	2.83	3.33	2.67	⋯	1.83	2.00	3.17	2.83	4.17	4.33
	3	3.17	3.17	3.17	⋯	3.50	4.00	3.83	3.33	4.17	4.17
	4	4.17	3.33	2.50	⋯	4.67	4.83	3.50	3.67	2.33	1.67
	5	2.33	3.83	1.67	⋯	4.00	3.83	3.00	3.17	4.17	3.67
	6	4.33	4.33	3.83	⋯	5.00	4.83	4.33	4.17	3.50	3.50
	7	3.17	4.00	3.00	⋯	4.83	4.33	4.67	4.17	5.00	4.50
	8	4.50	2.67	2.17	⋯	4.67	4.50	4.33	4.67	3.33	4.67

In this case, there is 8 pairs, 21 samples.

3. Factor analysis

3.1 Method

3.1.1 Factor estimation methods

Estimation of communality:

The diagonal component of the correlation matrix is replaced with the initial estimate of the communality of each variable (such as the square multiple correlation coefficient (SMC)).

3.1.2 Determing the number of factors

Draw scree plot using VSS.scree in psych package in Fig. 3. According to Kaiser-Guttman rule (extracts factors where the eigenvalue is greater than 1.0), number of factors equal to 2 in this case.

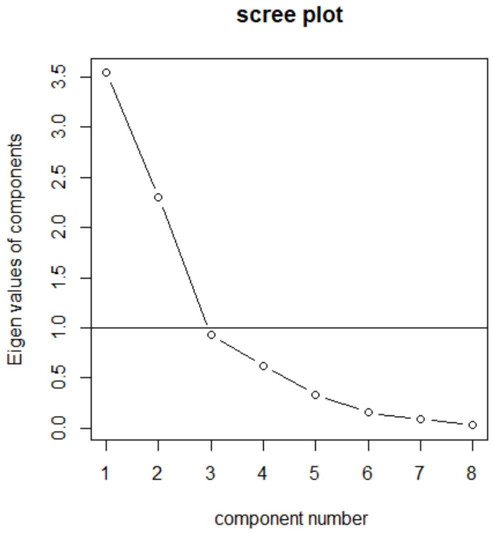

Fig. 3　Scree plot.

3.1.3 Methods of factors rotation

Rotation method:

Varimax rotation, an example of Orthogonal rotation (rotates the axes with maintaining the orthogonality under the assumption that there is no correlation among factors).

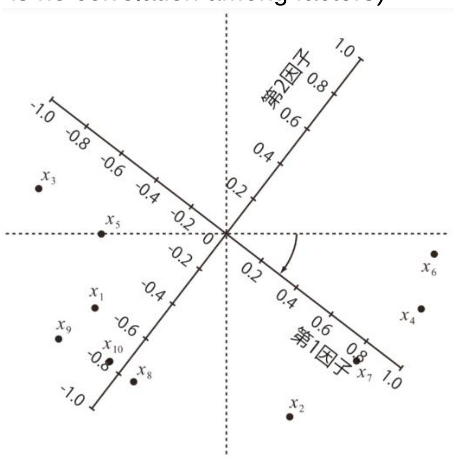

Fig. 4　Concept of Orthogonal rotation

Factoring method:

Principal factor solution.

3.2 Results and remarks

Table 2 Displaying 2 factors loading.

	PA1	PA2
x_1	0.81	0.47
x_2	-0.68	0.26
x_4	0.99	-0.07
x_6	0.65	0.18
x_3	-0.18	0.63
x_5	0.23	0.81
x_7	0.12	0.95
x_8	0.45	0.39
SS loadings	2.82	2.44
Proportion Var	0.35	0.31
Cumulative Var	0.35	0.66

Only 66% of the target product impression can be expressed with the space of these 2 factors. And x_8's factor loadings get some problems. By analysing, I think it is due to the small number of factors. And I try 3 factors, and get the following result.

Table 3 Displaying 3 factors loading.

	PA2	PA1	PA3
x_3	0.554	-0.281	0.161
x_5	0.783	0.152	0.218
x_7	1.082	0.086	0.096
x_2	0.180	-0.766	-0.037
x_4	-0.077	0.857	0.443
x_6	0.259	0.720	0.101
x_1	0.345	0.542	0.722
x_8	0.206	0.097	0.890
SS loadings	2.358	2.251	1.605
Proportion Var	0.295	0.281	0.201
Cumulative Var	0.295	0.576	0.777

In this case, target product impression is improved to 77% . To plot samples using factor scores.

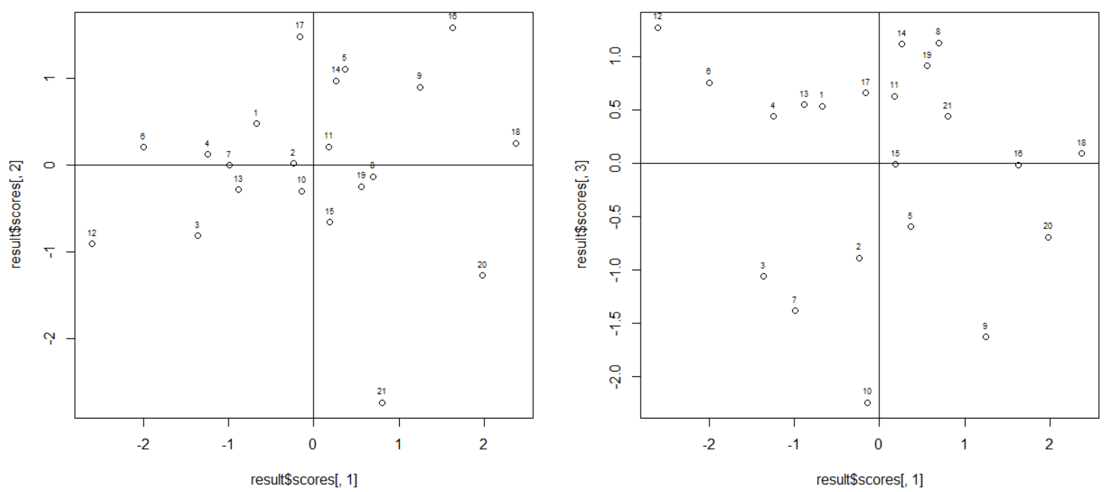

Fig. 5 Factor scores

4. Relationship between Design Elements and Impressions

4.1 Items and categories

The item / category classification is used in Fig. 6.

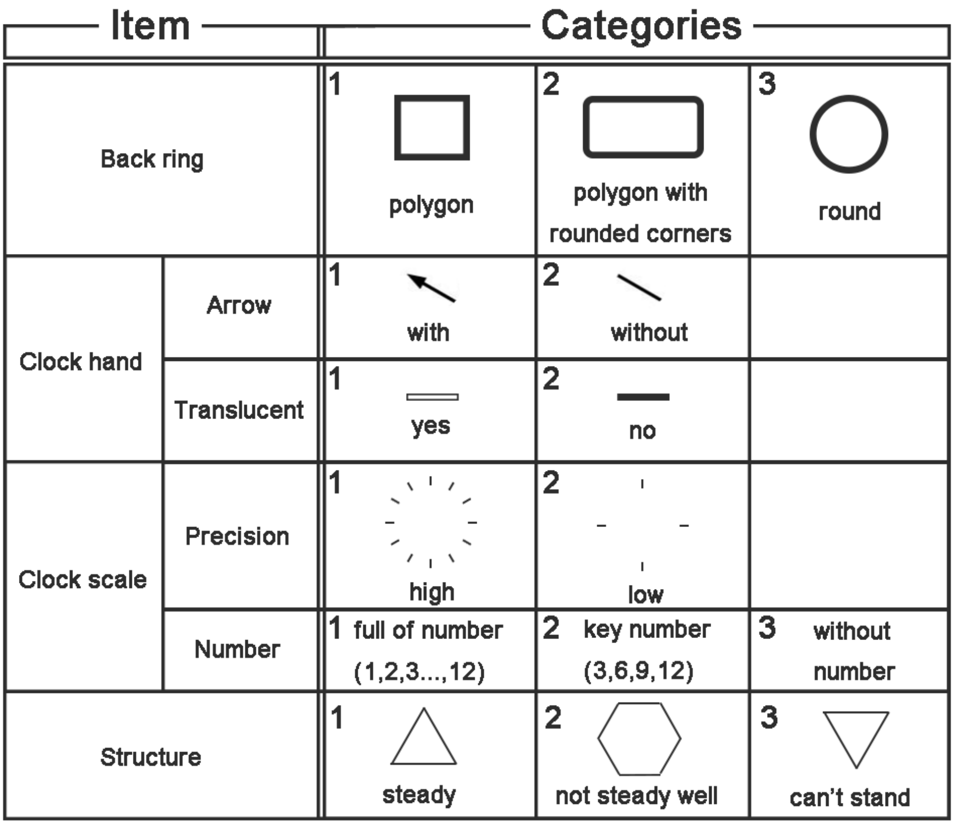

Fig. 6 Item / category classification

4.2 Analysis using Quantification Theory type I

4.2.1 Describe the data of category number

First, create a table of category number for each item according to each sample's features. Second, fill the data frame with category number of each sample with respect to each item in the arrangement of "clock samples" as follows:

Table 4 Category number

		Sample No.									
		1	2	3	…	16	17	18	19	20	21
Category.	BackRing	1	3	1	…	3	1	1	1	2	2
	ClockHand_Arrow	2	1	2	…	1	1	1	1	1	1
	ClockHand_Translucent	2	2	2	…	1	1	1	1	1	1
	ClockScale_Precision	1	1	1	…	2	2	2	2	2	2
	ClockScale_Number	1	3	3	…	3	3	3	3	3	2
	Structure	1	3	2	…	3	1	2	3	3	1

```
Code:
> categoryData<-data.frame(BackRing=c(1,3,1,1,1,1,1,3,3,1,3,1,1,3,1,3,1,1,1,2,2),
+ ClockHand_Arrow=c(2,1,2,1,2,2,1,1,2,1,1,1,1,2,2,1,1,1,1,1,1),
+ ClockHand_Translucent=c(2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,1,1,1,1,1,1),
+ ClockScale_Precision=c(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,2,2,2,2,2,2),
+ ClockScale_Number=c(1,3,3,2,2,2,3,1,3,3,2,1,2,1,1,3,3,3,3,3,2),
```

```
+ Structure=c(1,3,2,1,2,1,2,3,3,1,3,1,2,3,2,3,1,2,3,3,1)
+ )
```

From the data we find a problem : ClockHand_Translucent and ClockScale_Precision are completely the opposite which makes the matrix singular. So I choice only 5 categories (BackRing, ClockHand_Arrow, ClockHand_Translucent, ClockScale_Number, Structure) as the last.

```
> categoryData[,1:5]<-lapply(categoryData,factor)
```

4.2.2 Preparing vector of objective variables

According to the table 3, x_8(difficult-to-read & easy-to-read) is 89%. I choice it as observedData.

```
>observedData8<-
c(4.50,2.67,2.17,3.83,3.50,4.33,2.67,4.83,2.67,2.00,4.33,4.00,4.33,4.83,4.33,4.67,4.50,4.33,4.67,3.33,4.67)
```

4.2.3 Displaying observed values and predicted values

Table 5 Result of observed values and predicted values

	observed value	predicted value	residual
#1	4.5	4.315506	0.18449416
#2	2.67	2.680358	-0.0103577
#3	2.17	2.289116	-0.1191161
#4	3.83	3.961912	-0.1319117
#5	3.5	3.99748	-0.4974799
#6	4.33	3.954151	0.37584927
#7	2.67	2.296877	0.37312299
#8	4.83	4.750077	0.07992336
…	…	…	…
#20	3.33	3.317505	0.01249526
#21	4.67	4.682495	-0.0124953

Display observed values and predicted values using print function in Table 5. And Plot the relationship between the observed values and the predicted values using plot method in qt1 function as following:

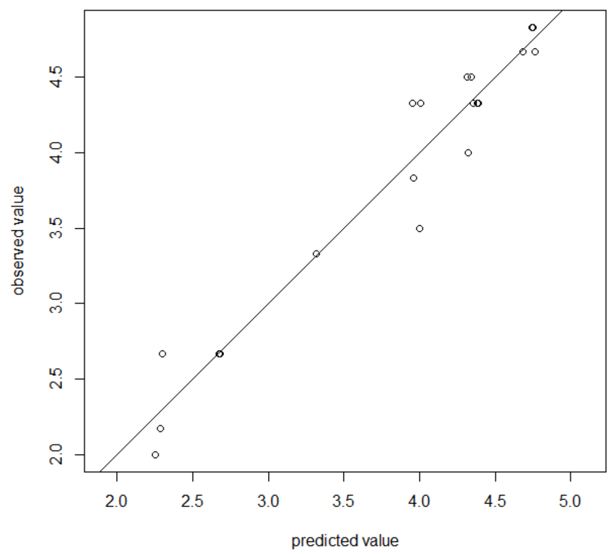

Fig. 7 Picture of observed values and predicted values

4.2.4 Correlation coefficients

Table 6 Multiple correlation coefficient.

	observed value	predicted value
observed value	1	0.9720384
predicted value	0.9720384	1

Table 6 is data of 1st and 2nd columns. And Table 7 show the result of partial correlation coefficients.

Table 7 Partial correlation coefficients.

	Partial correlation coefficient	t value	P value
BackRing	0.8497	6.2402	1.58E-05
ClockHand_Arrow	0.0155	0.0600	9.53E-01
ClockHand_Translucent	0.9525	12.120	3.77E-09
Number	0.9666	14.611	2.81E-10
Structure	0.5899	2.8297	1.27E-02

From Table 7, it shows items of "BackRing", "ClockHand_Translucent", "Number" strongly affect this impression. What's more, "ClockHand_Arrow" is weak to influence the result.

4.3 Discussion

4.3.1 The category scores

Table 8 Category scores.

Category	score
BackRing.1	0.106
BackRing.2	-1.259
BackRing.3	0.190
ClockHand_Arrow.1	0.003
ClockHand_Arrow.2	-0.005
ClockHand_Translucent.1	1.490
ClockHand_Translucent.2	-0.596
Number.1	1.089
Number.2	0.727
Number.3	-0.981
Structure.1	-0.143
Structure.2	-0.100
Structure.3	0.200
Constant term	3.865

According to Table 8, we can determine design based on the category scores. For each item, we select the category contributing to the design concept and items with high partial correlation coefficient. In this case, we can select BackRing.3 (round), ClockHand_Arrow.1 (with), ClockHand_Translucent.1 (yes), Number.1 (full of number), Structure.3 (can't stand) as new designs element.

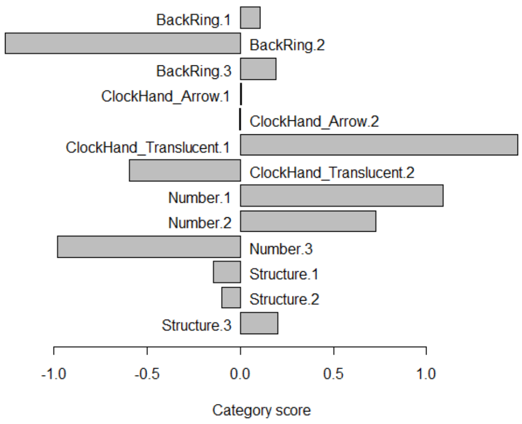

Fig. 8 Plotting category scores

From the plotting, it is easy to find clock hand's arrow (<u>with or without</u>) actually doesn't make value on design. It might not important in clock design.

5. New Clock Design

Present the drawing of new clock design based on the results obtained in Chapter 4:

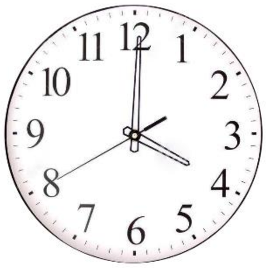

Fig. 9 New clock design

We select BackRing.3 (round), ClockHand_Arrow.2 (<u>without</u>), ClockHand_Translucent.1 (yes), Number.1 (full of number), Structure.3 (can't stand) as new designs element. By the way, this new clock design's goal is to make the design easy-to-read. According to different evaluation scale (adjective pairs), the result is totally different.