A Quantitative Approach to the Design of the Center Console of Automobiles*

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Abstract

We consider a statistical approach to design the center console of automobiles. The design of the center console is an important part in the sense that it has a strong effect on user satisfaction. From this standpoint, the center console should be adequately designed. However, the design process usually relies on a trial and error approach, which consumes lots of time. If the relationships between usability and physical specifications are revealed, we may design the center console with higher user satisfaction in a shorter time. For this purpose, we carry out a questionnaire survey. The results show several interesting relationships.

1 Introduction

Dials and switches are major components of center consoles of automobiles. Since the usability of such components has a strong effect on user satisfaction, it is very important to pay attention how to design each dial and switch within a center console. So far, we don't have any quantitative relationships between the usability and the physical specifications of dials and switches. If we have some information about the relationship in advance, it will be a useful tool to reduce the design time.

Our first target is to obtain the relationships between the usability and the physical specifications by statistical methods. We prepared 12 samples of center consoles for our analysis, which are all commercially offered. We made a survey questionnaire for a sensory test and measured each component of the 12 samples to know the specifications of each of them, such as dimensions, stroke, friction and so on. We also made a statistical analysis of the survey data and the physical data.

We used the principal component analysis for both the survey data and the physical data [1, 2]. We also simply calculated correlation coefficients between each item of the survey data and each item of the physical data. There was partially strong correlation between the survey data and the physical

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data. For example, the sense of heaviness for temperature control dial has a strong correlation to the range of its rotation angle.

This paper is organized as follows. In Section 2, we describe the survey questionnaire in detail. In Section 3, we briefly mention the specifications of each center console. In Section 4, we show the results of the statistical data analysis. Finally, we will conclude the paper in Section 5.

2 Survey questionnaire

We carried out a questionnaire survey (sensory test) using the 12 samples by 10 respondents. Each sample has the following 7 different switches.

- Air Conditioner On-Off
- Air Conditioner Auto-Manual
- Temperature Control
- Mode of Cabin Air Duct
- Air Circulation Internal-External
- Rear Defroster
- Front Defroster :

We asked the following 4 questions for each switch.

- How do you feel the click when you touch the switch?
- How do you feel about the heaviness when you turn on or turn off the switch?
- How do you feel about the stroke of the switch?
- How easily do you recognize what the switch is for?

Each question has five choices:
1. very good, 2. good, 3. fair, 4. bad and 5. very bad. In addition to these 28 questions, we asked the respondents the following 2 overall questions.

- Is it easy to operate the console?
  1. very easy, 2. easy, 3. fair, 4. somewhat difficult, 5. difficult.
- Do you feel satisfaction with the design of this sample?
  1. very satisfied, 2. satisfied, 3. fair, 4. somewhat dissatisfied, 5. dissatisfied.

Thus the survey questionnaire consists of 30 questions. Moreover, we asked the respondents about their personal data including driving experience, driving distance per day, and the frequency of operating each switch in the center console of their own cars.

Figure 1: Testing Work

Figure 2: Rotational Dials

Before the survey, we prepared experimental apparatus to set pseudo driving environment so as to make respondents to feel as if they were driving a car during the test (See Figures 1 and 2). The respondents sit on the driving seat and operated each switch on the sample and answered the questions. It took about one hour to answer all questions of the 12 samples for a respondent. The age of the respondents is distributed from twenties to sixties. Six out of ten respondents are female.

3 Physical specifications of the switches

In order to get the specifications of the 12 samples, we measured each component of each sample. There are 59 items to measure. Table 1 shows a part of the results. The measured items are the dimension of center console, the types of switches, the dimensions of switch and the other physical data like stroke and friction of the switch. We have three types of switches. They are rotational dial

type, lid dial type (knob type) and rectangular push type. We incorporate dummy 0-1 variables to distinguish the types of switches.

Table 1: Physical specifications

		No.	1	2	3	4	5	6	7	8	9	10	11	12
Dimensions of center console (mm)		Vertical	95	84.5	120	95	66.6	195	137	270	135	144	60	96
		Horizontal	230	205	330	240	187	264	264	370	310	240	188	200
		Depth	80	96	65	150	82.1	163	143	150	75	215	46.6	81.3
Temp. control switch	Switch type	Rotational dial	1	0	1	1	0	0	1	1	0	0	0	0
		Lid dial	0	1	0	0	1	1	0	0	0	0	0	0
		Rect. push	0	0	0	0	0	0	0	0	1	1	1	1
	Dimensions (mm)	Vertical	60.4	35	48.3	44.7	36.4	41.5	53.1	55.3	33.5	32.6	41	25.8
		Horizontal	60.4	35	48.3	44.7	24.4	41.5	53.1	55.3	24.6	31	22.1	25.8
		Height	10.5	27	15	10.2	11.6	12.2	11.6	22.2	15.1	15.1	15.1	14.5
	Physical data	Stroke	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.72	0.66	0.95	1.17
		Friction	2.2	1.2	2.75	2	3.5	1.7	2.5	2.8	3.2	1.94	3.6	2.38
		Rotation range	180	250	220	220	290	180	210	250	223	223	223	223
		Dial pitch	12.4	10	13.5	7.5	24.8	17.4	10	7.8	13.6	13.6	13.6	13.6

4 Data Analysis

We made a principal component analysis for both the survey data and the physical data. In the survey data, the respondents grade one of five choices in each question for each sample. In principal component analysis of the survey data, we analyzed the two way data of 120 observations (responses by 10 respondents for the 12 samples) by 30 variables (questionnaires). Figure 3 shows a scatterplot of the mean scores for the 12 samples with 95 % bootstrap confidence ellipses with respect to the first and second principal component scores. The cumulative proportion up to the third component is about 56 % and up to the fourth component is about 63 %. The first component can be interpreted as heaviness and click feelings, although the meanings of other components are not so clear. Figure 4 shows a scatterplot of the 1st and 2nd principal components of the physical data. We can also see three groups. The cumulative proportion up to the third component is 69 % and up to the fourth component is 78 % . Each component can be interpreted as follows:
the first component: the type of switch is rotational dial and the dimension is bigger; the second component: the type of switch is rectangular push and the stroke and the friction is light; the third component: the type of switch is lid dial or round push and the height of the switch and the range of dial rotation angle are both big.

Next, we simply calculated correlation coefficients between each item of the survey data and each item of the physical data. This simple analysis provided several interesting relationships between the user preferences and the physical specifications of the center console. The results are as follows:

- Dimension of the center console should be bigger.
- Dimension of the switches should be bigger.

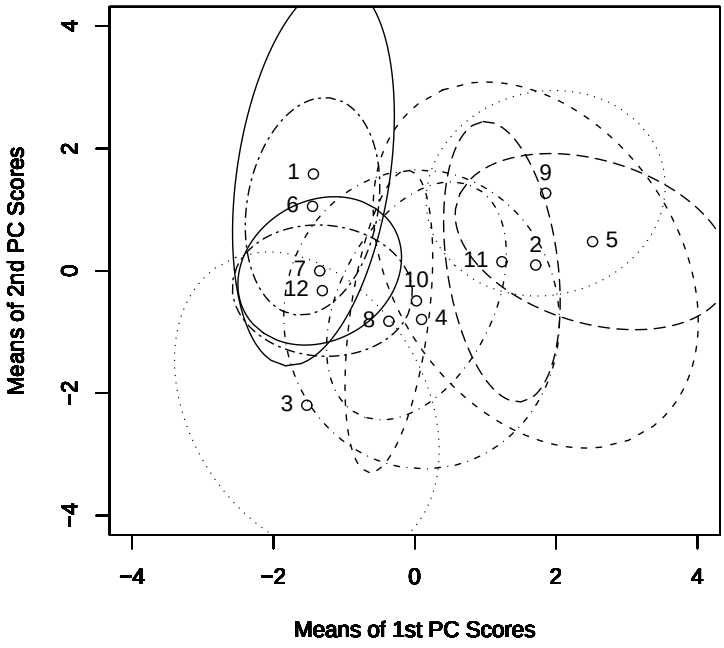

Figure 3: Scatterplot of the mean scores for the 12 samples with 95 % bootstrap confidence ellipses

- Rotational dial switch is the best.
- Stroke of the switch should be short.
- Range of the dial rotation angle should be small.
- There is no relationships between the user satisfaction of the design of center console and feelings of operation.
- Click feeling, friction and stroke of the switches have strong correlation to feelings of operation.

5 Concluding remarks

We made a simple experimental analysis to obtain the relationships between the survey (sensory test) results and the physical specifications of the center console. We used the principal component analysis, which brought some interesting features We also got some useful results from the correlation coefficients between each item of the survey questionnaire and the physical specifications. We could have obtained better results if we had made the survey by more samples. Other possible matters to find better results are that we take into account the nonlinearity of the data and examine the

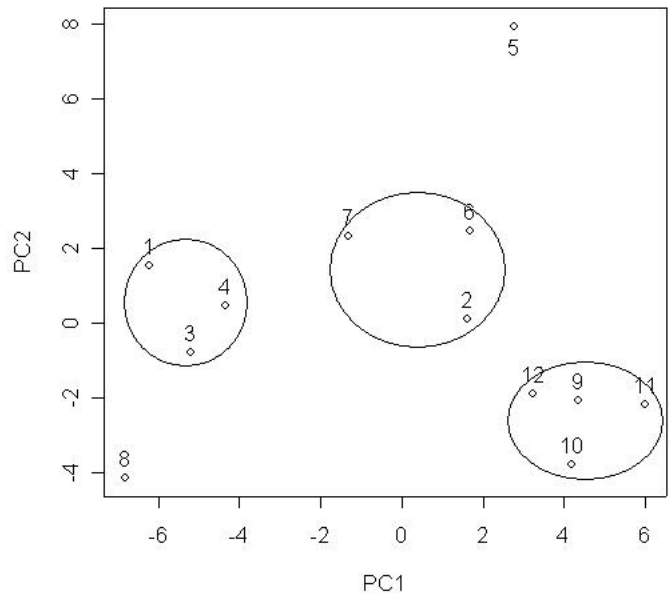

Figure 4: Scatterplot of the 1st and 2nd principal components of the physical data

experiments in themselves whether they are suitably designed for our purpose of extracting the relationships.

Although our strategy of the experiments and the analysis is still in a preliminary stage, we got some useful results and made a prototype of the center console based on the results. Further research for sophisticated strategy to design a center console will be a necessary future topic. For this purpose, we need to reconsider how to design the experiments and enlarge the questionnaire survey. We also should check the lineality of the data. These efforts will enable us to establish a useful integrated strategy to design a center console with higher user satisfaction in a shorter time.

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