Effects of Design Factors of the Instrument Cluster Panel on Consumers' Affection

Gahun Jung, Seong M. Kim, Sung Y. Kim, Eui S. Jung, Sungjoon Park

***Abstract*— It is known from consumer surveys that the interior design of cars greatly influences on consumers' affection. Most notably, the instrument panel which occupies the driver's attention while driving would be one of the main components that affect consumer's affection, but the designer does not often put due importance to this design component. The purpose of this study is to define consumers' affection on the instrument cluster panel in terms of its design factors: color of panel lighting and layout of meters as independent factors as well as subjects' gender. Semantic differentials or affective adjectives that are related to the instrument panel were first derived from surveys, existing studies and the available literature. Then, representative affective factors were drawn using factor analysis and multi-dimensional scaling (MDS). Evaluation of the instrument panel was performed and analyzed by Taguchi's parameter design to provide more robust results under various noise factors involved. The result of this study may provide not only a guideline for the instrument panel design but also a basis of understanding underlying consumer's affection in terms of user-centered design.**

***Index Terms*— Consumer affection, Instrument panel, Kansei engineering, Taguchi's parameter design.**

I. Introduction

As most functional aspects of passenger car design meet consumer needs, consumer demand on cars has shifted from functional aspects to consumer affection such as total ambience, styling, etc. (Jindo and Hirasago, 1997). So, these functional aspects are no longer competitive factors, Instead, consumers' affection for colors, materials, and conveniences take the place as main design factors (White, 2001). As the consumer spends more and more time in cars, manufactures are currently developing interior design requirements or considerations to improve consumers' affection (Cho, 2005). Especially, the instrument panel is one of two major design components which most influence on consumers' affection with the center fascia.

There are several existing studies on the design of instrument panel. Kim(1999) reported the driver's cognitive characteristics for the arrangement of instrument panel, Nam(2007) applied work domain analysis for the development of a vehicle control display, and Tanoue(1997) studied on the perceived images of vehicle interior. Also, studies are available on the application of Kansei engineering to car interior (Jindo and Hirasago, 1997).

However, those existing studies are mostly about functional and cognitive aspects, not about consumers' affection. Although there are a few studies on consumers' affection to the car interior, no specific mentions were found on the instrument panel considering consider various conditions that have influence on consumers' affection.

The purpose of this study is to define affective factors of consumers on the instrument panel by varying two design factors: color of panel lighting and layout of meters. Evaluation of the instrument panel was performed and analyzed by Taguchi's parameter design to provide more robust results under varying experimental conditions.

II. Method

A. Defining representative affective factors

In this study, we defined representative affective factors for evaluating the instrument panel. Semantic differentials or affective adjectives that are related to the instrument panel were first identified from a consumer survey. Then, representative affective factors were drawn using factor analysis and multi-dimensional scaling (MDS). A total of 30 participants were recruited as volunteers, who were 22 males and 8 females. The average age of the participants was 33.6, ranging from 28 to 37. All participants had a driving experience for an average of five years.

B. Affective factors

We collected 121 affective adjectives that are related to car interior from literature, research and automobile magazines. Based on these adjectives, a customer survey was conducted to derive adjective related to instrument panel. Table 1 shows these 31 adjectives related to the instrument panel.

To derive affective factors, subjects were asked to evaluate various images of instrument panels. Subjects were asked to assign a numerical value to each of 31 adjectives in 9-point scale. A factor analysis was then performed on the scores

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assigned to each evaluation of adjectives. Among 31 adjectives, 21 adjectives were chosen to be meaningful from the factor analysis since 10 adjectives that were eliminated had multiple loading. Five factors were then extracted and defined as unique, luxurious, dynamic, charming and visible from a focus group interview. These results were shown in Table 2 and Table 3.

TABLE 1. 31 Affective Adjectives Related to Instrument Panel

Far-out, Unique, Distinctive, Innovative, Futuristic, High-tech, Creative, Elegant, Gleaming, Harmonious, Luxurious, Magnificent, Active, Powerful, Sporty, Dynamic, Chic, Fascinating, Sharp, Simple, Visible, Sophisticated, Spandy, Trendy, Classical, Modern, Cozy, Delicate, Strikingly new, Glamorous, Compact

TABLE 2. Factor Loading Matrix

	Factor				
	1	2	3	4	5
Far-out	.858	.172	.255	-.012	-.054
Unique	.799	.202	.102	.297	-.048
Distinct	.790	.076	.231	.256	.016
Innovat	.776	.324	.287	.080	-.058
Futurist	.763	.286	.096	.255	-.054
High-te	.750	.213	-.102	.305	.173
Creativ	.735	.254	.219	.202	-.040
Elegant	.414	.750	.012	-.072	.163
Gleami	.288	.741	.053	.092	.095
Harmon	.096	.741	-.088	.263	.177
Luxurio	.358	.602	.176	.409	.028
Magnifi	.180	.594	.242	.498	-.098
Active	.240	.005	.902	-.075	.011
Powerf	.092	-.074	.786	.402	-.010
Sporty	.423	.141	.669	-.034	.329
Dynami	.157	.320	.576	.479	.178
Chic	.315	.242	.082	.773	.002
Fascina	.438	.314	.273	.627	-.137
Sharp	.319	.046	-.038	.602	.490
Simple	.042	.186	-.001	.056	.900
Visible	-.208	.063	.193	-.037	.806

TABLE 3. Affective Factors Chosen to Represent Consumers' Affection

Unique	Far out, Unique, Distinctive, Innovative, Future-oriented, High-tech, Creative
Luxurious	Elegant, Gleaming, Harmonious, Luxurious, Magnificent
Dynamic	Active, Powerful, Sporty, Dynamic
Charming	Chic, Fascinating, Sharp
Visible	Simple, Visible

C. Representative affective factors

Subjects were asked to evaluate various images of the instrument panel with respect to five affective factors. They assigned a numerical value to each of 5 adjective factors in 9-point scale. A MDS was then performed on the scores assigned to each evaluation of these factors. The resulting positioning of the factors is shown in Figure 1.

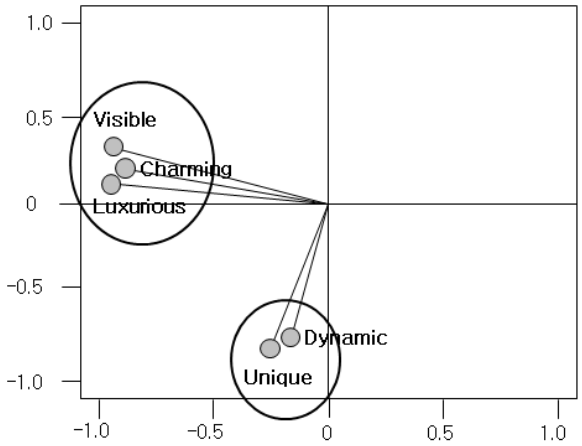

Fig.1. MDPREF mapping of affective factors.

The result showed that three factors of luxurious, charming and visible were grouped into one group and the rest of two factors into another group. So, two representative affective factors: unique and luxurious, each of which possesses the largest variance in each group, were defined to represent consumers' affection.

D. Evaluation of instrument panels

In this study, various simulated instrument panels that were shown on the computer screen were presented to subjects based on Taguchi's parameter design and evaluated on two representative affective factors.

E. Participants

A total of 18 participants were recruited as volunteers who were consisted of 9 males and 9 females. The average age of the participants was 32.3, ranging from 27 to 36. All participants had a driving experience for an average of six years.

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F. Experimental setup

Graphically simulated instrument panels presented were made by Illustrator CS3, Subjects evaluated these materials presented on LCD display as shown in Figure 2.

Fig.2. An experimental setup

G. Procedure

As mentioned, color of panel lighting and layout of meters were selected as independent variables. Each level of two independent variables was determined through a market research generally performed. Panel lighting color consists of three levels which were white, orange and blue and do did meter layout which were two, three and four circular meters. 9 combinations of the two factors were made and two samples that were consisted of gray and beige colors of car interior for each combination were made. A total of 18 instrument panel samples were created by computer graphics for subjective evaluation. The level of consumers' affection was measured in two representative affective factors as dependent variables. Subject gender and two colors of car interior which were gray and beige were used as noise variables.

The evaluation was performed by Taguchi's parameter design method to find the most robust design from noise factors. It was shown in Table 4. To reduce the variance of individuals, the evaluation was performed by a within subject design and the test order was made by Latin Square.

TABLE 4. Taguchi's Parameter Design

		male	male	female	female
color	layout	gray	beige	gray	beige
white	2	y_{11}	y_{12}	y_{13}	y_{14}
white	3	y_{21}	y_{22}	y_{23}	y_{24}
white	4	Y_{31}	y_{32}	y_{33}	y_{34}
blue	2	y_{41}	y_{42}	y_{43}	y_{44}
blue	3	y_{51}	y_{52}	y_{53}	y_{54}
blue	4	y_{61}	y_{62}	y_{63}	y_{64}
orange	2	y_{71}	y_{72}	y_{73}	y_{74}
orange	3	y_{81}	Y_{82}	y_{83}	y_{84}
orange	4	y_{91}	y_{92}	y_{93}	y_{94}

III. RESULT

Since two representative affective factors possess the characteristics of 'larger the better,' the following equation was used to calculate SN ratios.

$$SN_i = -10\log\{\frac{1}{n}\sum_{j=1}^{n}\frac{1}{y_{ij}^2}\} \qquad (1)$$

where yij is observed data in i-th row and j-th column, and n is the number of repetition in one experimental point.

Table 5 showed the result of SN ratios on two factors: luxurious and unique. To find variables that have an effect on dependent variables, the ANOVA was performed. Since ANOVA of SN ratios did not have any repetitions, the interaction factor of color and layout was pooled to the error term, then, p-values were calculated. The result of ANOVA was shown in Table 6. The results showed that only color of panel lighting had a significant effect on the affection of luxury (p-value=0.025<0.05) and only layout of meters did on the affection of uniqueness. (p-value=0.036<0.05)

TABLE 5. S/N ratios calculated for two factors

Luxury		male	male	female	female	S/N
color	layout	gray	beige	gray	beige	ratio
white	2	4.85	4.90	6.75	6.52	14.89
white	3	4.70	5.01	5.00	7.19	14.42
white	4	6.90	6.99	6.83	5.10	15.96
blue	2	3.27	1.74	5.34	4.24	8.91
blue	3	2.98	2.34	4.81	3.95	9.97
blue	4	3.67	3.46	5.38	4.14	12.03
orange	2	5.55	7.08	2.07	4.52	10.76
orange	3	6.05	5.61	5.08	6.71	15.22
orange	4	6.10	7.57	6.64	4.71	15.53

Uniqueness		male	male	female	female	S/N
color	layout	gray	beige	gray	beige	ratio
white	2	4.09	3.74	5.10	4.90	12.76
white	3	4.22	6.42	4.33	5.57	13.82
white	4	5.91	5.68	4.71	4.81	14.32
blue	2	3.55	4.18	6.33	5.86	13.22
blue	3	5.00	5.85	4.05	6.24	14.09
blue	4	5.36	6.09	5.10	6.24	15.01
orange	2	3.29	4.15	4.43	5.48	12.30
orange	3	6.14	5.22	4.24	6.62	14.50
orange	4	6.24	7.78	6.90	6.33	16.57

TABLE 6. ANOVA table of SN ratios

	Source	DF	SS	P - value
Luxury	color	2	36.96	0.025
	layout	2	13.41	0.119
Uniqueness	color	2	1.02	0.475
	layout	2	9.69	0.036

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Since the maximum of S/N ratio maximizes consumers' affection under various noises, the white panel lighting was derived as the most preferred one in terms of the affection of luxury, the layout with four meter clusters was derived as the best one in terms of the affection of uniqueness.

IV. Discussion

The purpose of this study was to define affective factors of consumers on the instrument panel and to suggest the most referred color of panel lighting and layout of meters that satisfy consumers' affection under noise factors.

It was found from an experiment that consumers had five affective factors on the instrument panel and luxurious, charming and visible affections are grouped into a factor that constitutes consumers' affection and unique and dynamic affections in another factor.

Evaluation of the instrument panel by Taguchi's parameter design revealed that the white color of panel lighting was the most preferred design in terms of the affection of luxury and the panel with four meters was the best one in terms of the affection of uniqueness.

In this study, the most robust design of the instrument panel was found by employing Taguchi's parameter design under various conditions in terms of customers' affection. More design and noise factors that have an effect on consumers' affection need to be considered in future research.

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