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A Statistical and Scientific Approach to Deriving an Attractive Exterior Vehicle Design Concept for Indifferent Customers

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Abstract: *New-vehicle sales in Japan have gradually decreased, and young people there have recently lost interest in vehicles. Thus, an exterior vehicle design that attracts indifferent customers is required. This study proposes an exterior vehicle design that is attractive to indifferent customers; this design is derived through the use of statistical and scientific approaches. First, we confirm the importance of exterior vehicle design to indifferent customers' preferences. We then try to identify those vehicle design characteristics that influence indifferent customers' impressions, by executing questionnaires and analyzing questionnaire data by means of cluster analysis and text network analysis. Furthermore, we identify the parts of a vehicle to which indifferent customers pay attention when they do feel an impression, by using an eye-tracker to analyze eye movement. Based on the results of our analysis, we propose four vehicle design concepts. Following these concepts, a designer then generates a vehicle design. The effectiveness of the designs on indifferent customers is verified by measuring the change in customers' beta waves when viewing our vehicle designs. While creating a vehicle design today generally depends on designers' implicit knowledge, this study demonstrates the effectiveness and importance of taking a statistical and scientific approach in undertaking design.*

Keywords: *exterior vehicle design, indifferent customers, sensory words*

I. Introduction

New-vehicle sales in Japan peaked in 1990, and they have gradually been in decline ever since. If they wish to maintain their profits, car manufacturers must address this trend. Furthermore, a trend has been seen in recent years, wherein young Japanese people are losing an interest in vehicles [1]. Under such circumstances, it is important to generate an exterior vehicle design that attracts customers who are otherwise not interested in vehicles.

The development of a customer science approach that is capable of identifying customer desires for the purpose of market creation has become increasingly important [2]. In addition, it is important to use in design work statistics as a means of scientifically representing customers' unspoken senses (i.e., customer preferences) [3]. Taking a statistical approach is absolutely essential to successfully creating attractive vehicles [4]. Thus, attempts have been made to propose an exterior vehicle design that is attractive to indifferent customers, by using statistical and scientific approaches.

In section II, we confirm the importance of exterior vehicle design to indifferent customers' preferences. In section III, we identify those vehicle design characteristics that influence indifferent customers' impressions. In section IV, to develop a specific design concept, we identify those parts of a vehicle to which indifferent customers pay attention when they do feel an impression. In section V, we propose specific vehicle designs and evaluate them. Finally, in section VI, we briefly summarize our findings and provide some suggestions for future research.

II. Indifferent Customers' Preferences

To confirm the importance of exterior vehicle design on indifferent customers' preferences, we conducted a questionnaire survey. We asked 76 individuals—all of whom were over 18 years of age and had previous stated that they did not have an interest in vehicles—the following question: "When you buy a vehicle, how much importance do you place on each of the following items?" A list of 23 items (**Table 1**) was then shown to them; these items had been selected based on information in an existing study [5] and interviews with major automobile dealers.

They assessed each item on a seven-point scale anchored by 1 ("strongly unimportant") and 7 ("strongly important"). The average score for each item is shown in **Table 1**. These results indicate that, among indifferent customers, exterior design is the most important factor.

Table 1 List of Question Items: Customer Preferences

Category	Question items	Score (average)
Advertising	Brand	4.62
	Television commercial	4.54
	Enrichment of website	3.14
Cost	Fuel cost	5.07
	Sales price of vehicle	4.84
	Maintenance fee (insurance, inspection)	4.62
Dealership	Business hours	4.66
	Response to an emergency	4.40
	Appearance and interior of store	4.24
	Location	4.22
	Periodic contacts	3.35
	Automobile inspection service	3.11
Design	Exterior design	5.13
	Color	5.04
	Interior design	4.12
Performance	Safety	5.01
	Fuel efficacy	4.76
	Stability	4.54
	Silent operation sound	4.50
	Interior space	4.30
	Ease of handling	4.13
Other	Status	4.17
	Hobby	4.08

III. Design Characteristics Influencing Indifferent Customers' Impressions

We sought to identify those vehicle design characteristics that influence indifferent customers' impressions of a vehicle. We showed pictures of various vehicles (Mazda Atenza, Porsche Cayman, Volvo v40, MINI Paceman, and Fiat Panda) to the 67 subjects, 30 of whom had said they were indifferent to vehicles. They answered their impressions of the vehicles to sensory words, on a seven-point scale anchored by 1 ("strongly disagree") and 7 ("strongly agree"); they also provided the reason why they felt that way (i.e., free description). We used the 18 words listed in **Table 2**, in line with existing research [6]. In the following analysis in this section, we used the data of 30 subjects who were indifferent to vehicles.

Table 2 List of Sensory Words

Refined	Roundish	Individual	Stylish	Advanced	Compact
Practical	Orthodox	Eye-catching	Traditional	Square	Showy
Calm	Luxurious	Feeling of oppression	Sporty	Cool	Modern

First, to identify the characteristics of customers' impressions, we conducted cluster analysis using each person's score for each sensory word. As a result, 18 sensory words were classified into four groups, as demonstrated in **Fig 1**. We named the groups (A) Advanced, (B) Powerful, (C) Progress, and (D) Elegant.

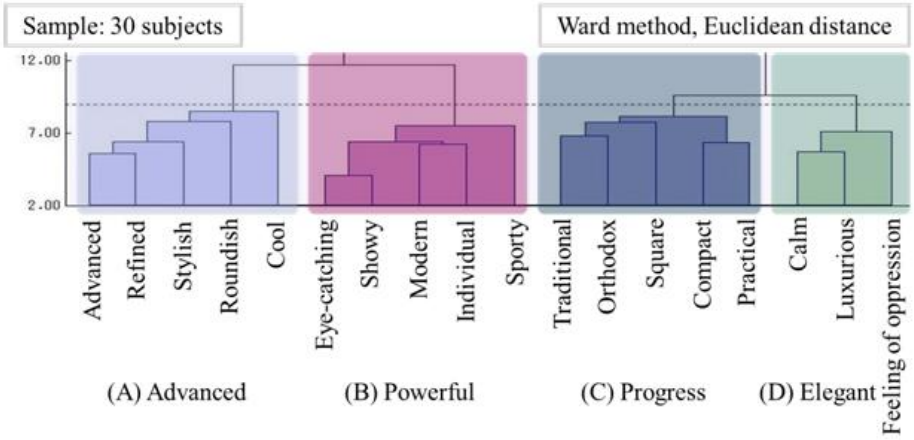

Fig. 1. Results of cluster analysis

Next, with the aim of identifying vehicle design characteristics that influence indifferent customers' impressions of each sensory word, we conducted text network analysis, using text data drawn from the free descriptions in the questionnaire answers. An example of the results is demonstrated in **Fig 2**.

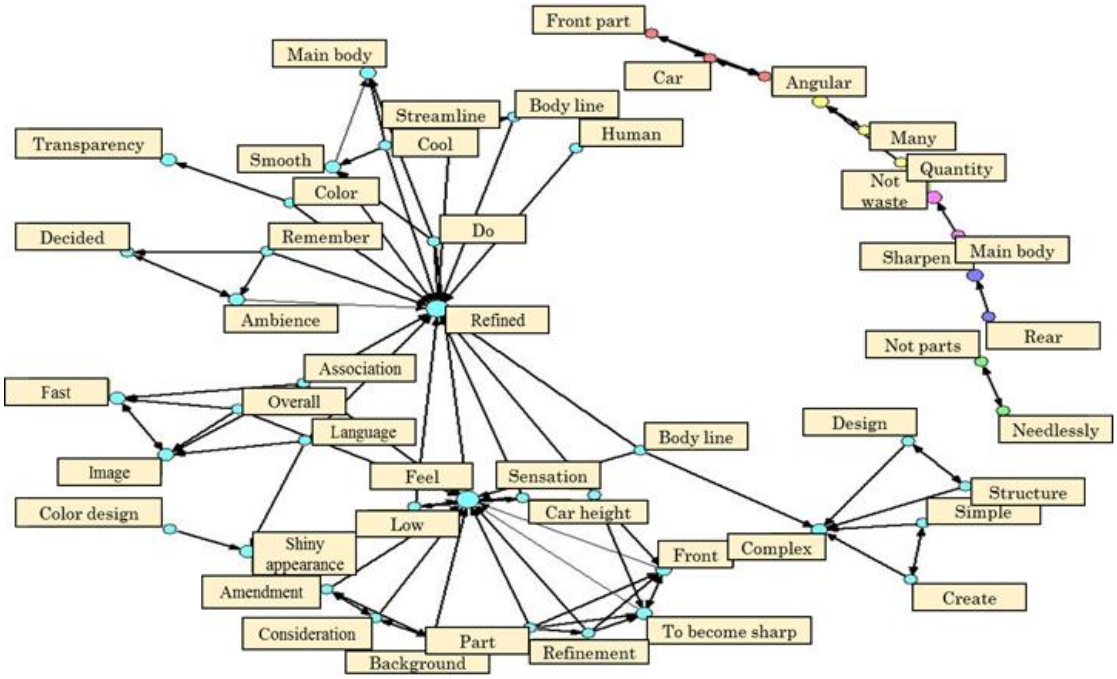

Fig. 2. An example of text network analysis

Table 3 summarizes, by group type, the relationships between the impressions of sensory words and the design characteristics, based on the results of the text network analysis. In this way, we were able to identify those vehicle design characteristics that influence indifferent customers' impressions of a vehicle.

Table 3 Relationships between the Impression of Sensory Words and Design Characteristics

Group	Sensory word	Design characteristics
(A) Advanced	Refined	Sharp front, smooth body
	Cool	Smooth body, small mirror
	Roundish	Streamlined, roundish body
	Stylish	Thin headlight, taillight, and wheel spoke
	Advanced	Streamlined, smooth body
(B) Powerful	Eye-catching	Sharpness, sharp line
	Showy	Tire is special
	Sporty	Smooth headlight, streamlined
	Modern	Image of the sports car
	Individual	Body is thin
(C) Progress	Practical	Big door, SUV type
	Orthodox	Four door, sharp body
	Compact	Hatchback type
	Traditional	Straight line
	Square	Square body
(D) Elegant	Calm	Big tire
	Luxurious	Small number of lines
	Feeling of oppression	Car height is low, roundish mirror

IV. Parts of a Vehicle to Which Indifferent Customers Pay Attention

To generate a specific design concept, we needed to identify those vehicle factors to which indifferent customers pay attention when they feel an impression. To clarify this relationship, we showed 3D images of several vehicles to the subjects as they wore an eye-tracker, and we asked them to evaluate their impressions of the vehicles in relation to the sensory words. The eye-tracker was used to analyze line of sight and pinpoint those areas that had caught indifferent customers' attention. We measured those factors to which indifferent customers paid attention as they provided answers about their impressions.

We showed 3D images of various vehicles (Lexus GS 350, Legacy B4, Chrysler 300, Cadillac CTS, Mercedes-Benz E65, BMW M5, and Audi S4) to 16 subjects. Each wore an eye-tracker and matched the impressions of the vehicle to each sensory word. The areas viewed by the subjects were compiled into a heat map (**Fig 3**), thus providing quantitative information on where on the picture the subjects were looking.

Fig. 3. Eye-tracker heat map

Using the heat-map data for those items for which subjects gave a high score (>5) to each sensory word, we were able to identify the relationships between customers' impressions and what had captured their attention. Using these results and the data in **Table 3**, we were able to complete a design concept (**Table 4**).

Table 4 Proposed Vehicle Design Concepts

Type	Sensory words	Attention part	Design characteristics
(A) Advanced	Refined	Front, body	Sharp front, smooth body
	Cool	Side mirror	Smooth body, small mirror
	Roundish	Body	Streamlined, roundish body
	Stylish	Light, wheel	Thin headlight, taillight, and wheel spoke
	Advanced	Fender	Streamlined, smooth body
(B) Powerful	Eye-catching	Front	Sharpness, sharp line
	Showy	Tire	Tire is special
	Sporty	Headlight	Smooth headlight, streamlined
	Modern	Body	Image of the sports car
	Individual	Body	A body is thin
(C) Progress	Practical	Door, body	Big door, SUV type
	Orthodox	Door, front	Four door, sharp body
	Compact	Body	Hatchback type
	Traditional	Front	Straight line
	Square	Body	Square body
(D) Elegant	Calm	Tire	Big tire
	Luxurious	Body	Small number of lines
	Feeling of oppression	Body, mirror	Car height is low, roundish mirror

V. Proposed Vehicle Designs, and Their Evaluation

Based on the results of our analysis (summarized in **Table 3**), we created vehicle design concepts and proposed them to a designer. Following our concepts, a designer created four vehicle designs—namely, (A) Advanced type, (B) Powerful type, (C) Progress type, and (D) Elegant type—as demonstrated in **Fig 4**. **Fig 5**, **6**, and **7** demonstrate the relationship between vehicle design and the concept in the (A) Advanced type, (C) Progress type, and (D) Elegant type, respectively. (As the (B) Powerful type deviated too much from current vehicle designs, we verified the effectiveness of only the three other vehicle designs.)

Fig. 4. Proposed vehicle designs

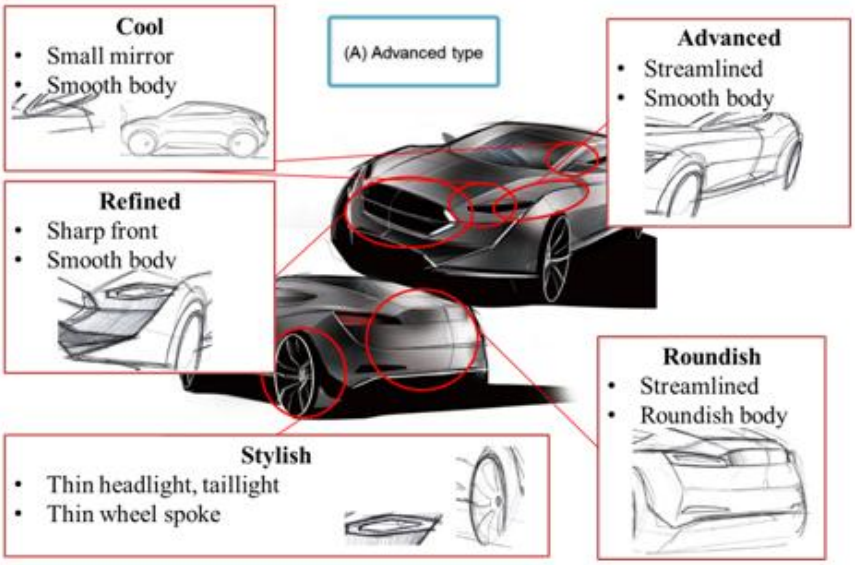

Fig. 5. Design concept type A

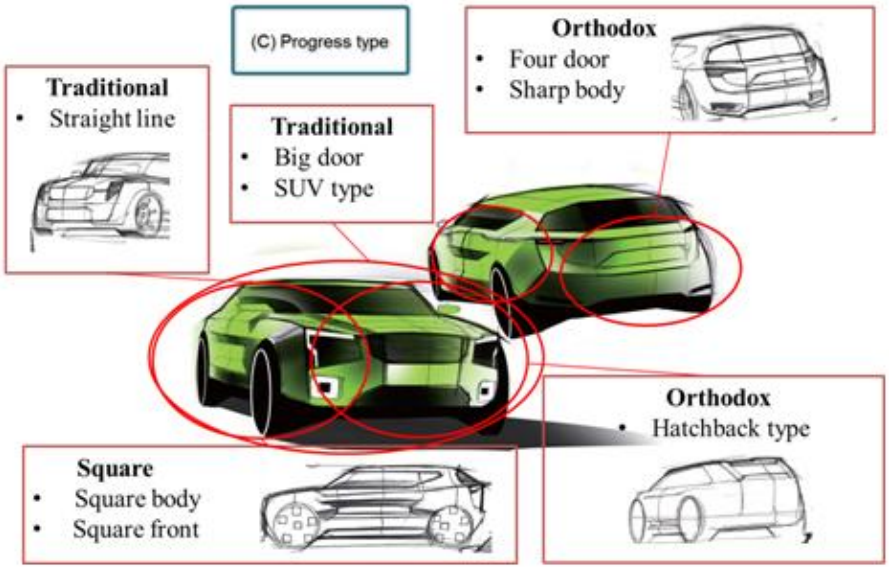

Fig. 6. Design concept type C

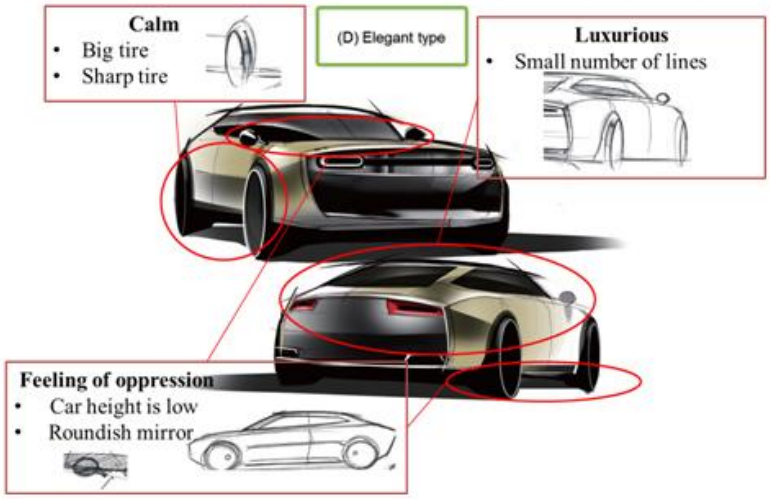

Fig. 7. Design concept type D

We showed some current vehicle designs and one of our proposed vehicle designs randomly for 10 s each, to 16 persons who had previously voiced an indifference to vehicles. They wore an electroencephalography (EEG) equipment so that we could measure their beta waves—a physiological response that is associated with concentration. **Fig 8** shows an example of beta wave trends in the current study.

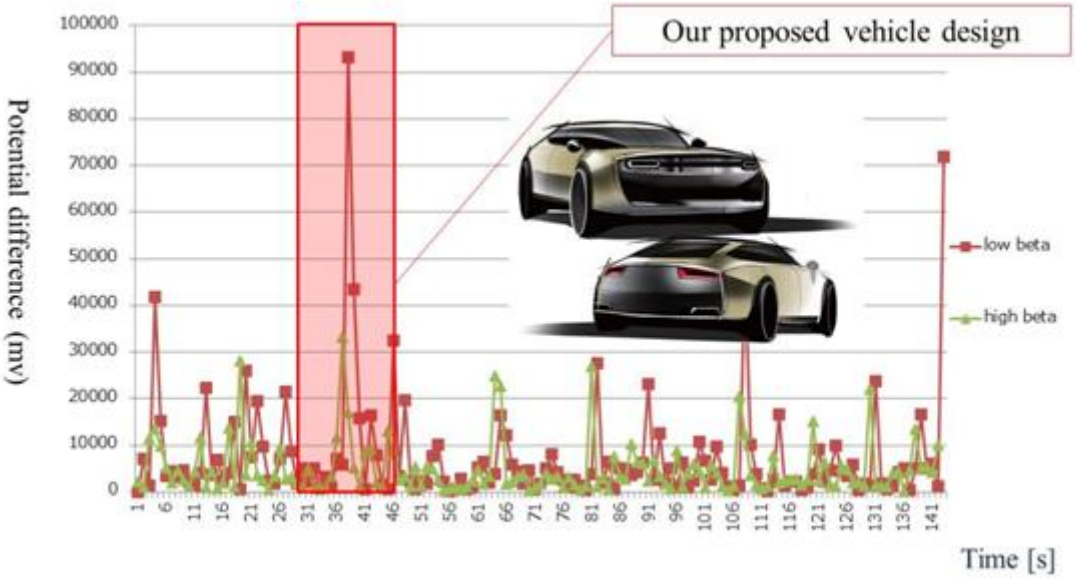

Fig. 8. An example of subject beta waves

The subjects' beta waves showed high levels only when the proposed vehicle design was shown; this suggested that the subjects had an interest in it. The results of the other subjects showed similar but lower trends. Thus, it was demonstrated that our proposed design is effective in creating vehicle designs that are interesting to customers who are otherwise indifferent to them.

VI. Conclusion

This study used a statistical approach to develop and propose a vehicle design that will attract otherwise indifferent customers; additionally, the attractiveness of our proposed vehicle design was scientifically verified. Although the creation of a vehicle design generally depends on designers' implicit knowledge, this study suggests that leveraging a statistical approach is effective. Future studies should consider vehicle designs that include additional factors, such as color elements.

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