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# Exploring the Visual Cognitive Features on the Design of Car Based on the Theory of Eye-Tracking Technology

*Abstract. Along with the evolution of values and culture, there is different representative car design in each era. This representative design contains the image, style and mainstream value at that time. Therefore, new design of car has always been the main concern of car manufacturers for their annual facelift program. Because of this reason, this study will utilize the front appearance of cars to analyze the main area of interest of consumers at the time they see the front appearance of a car without logo attached. The forms of car appearance are summarized in Kansei words using Kansei Engineering analysis method and used as the substantial basis of analysis. Questionnaires are widely used in analyzing the like or dislike of an appearance. When a consumer response to a questionnaire, the corresponding Kansei words are usually summarized indirectly after the texts and graphics in the questionnaire are understood and processed in the brain. It could not directly reveals the subconscious desire of the consumer after first impression, but buying car is a consumer behavior to meet his own needs. For this reason, a newly developed assessment mechanism, Eye-Tracking technology, is employed in this research to track the actual interest of the consumers on the elements of a car. The misunderstanding and bias brought by texts in questionnaire are eliminated, and it is combined with Kansei Engineering to summarize the visual imageries and Kansei words of the consumers. Then, the results could be provided to car designers as a reference in designing their new products.*

*Streszczenie: Oczekiwania dotyczące wyglądu samochodu zmieniają się wraz ze zmianami kultury i wartości obowiązujących w danym czasie. Przy projektowaniu nowych modeli należy te oczekiwania spełnić. W prezentowanym opracowaniu analizuje się oczekiwania na podstawie wyglądu maski samochodu z usuniętym logo. Przeprowadzona została zbiorcza analiza wyników badań w postaci słów Kansei metodą inżynierii Kansei. Badania obejmują analizę na podstawie kwestionariuszy oraz nowego mechanizmu badań śledzenia ruchów gałki ocznej (okulografii). Wynikiem badań jest określenie istotnych obszarów oczekiwań użytkowników, co może służyć jako wskazówki dla projektanta wyglądu nowego modelu samochodu. **Badania wizualnej percepcji projektu samochodu na podstawie teorii technologii okulografii***

**Keywords:** Car design, Eye-Tracking Technology, Kansei Engineering, Kansei words.
**Słowa kluczowe:** Projektowanie samochodu, Technologia okulografii, Inżynieria Kansei, Słowa Kansei

## Introduction

How to effectively and accurately grasp the feeling of the consumers through their visual search on a product while respecting their psychological and emotional demands is very important. Among the researches regarding this matter, Kansei Engineering studies the relationship between consumers and products. However, in the process, the appearance of the product should be defined beforehand, and combined with the results of product image survey to summarize the characteristic factors which influence consumer's impression on product appearance. Therefore, in the characteristic factors extraction process, the characteristic point is obtained indirectly from the result of survey, not directly from the consumer through their visual search on the product features.

For this reason, this research uses the Eye-tracking technology to extract the intuition and objective feelings of the consumer looking at the front appearance of cars with different styles. Without going through the process of thinking or influenced by lifestyle and past experiences, the most direct feelings and responses of the consumer are then obtained through a scientific and quantitative method.

## Related Works
## Kansei Engineering

Kansei Engineering was first proposed in Japan. The word "Kansei" itself is directly translated from Japanese vocabulary, which represents "perception", "feeling", "impression" or a presentation of some kind of emotion. Mitsuo Nagamichi describes Kansei Engineering as the method of translating the emotional feelings and image perceptions of people into physical design parameters by a specific design technique; a connection between emotional feelings and engineering, analyzing the emotions of people and converting them into products design by engineering point of view, creating joy and satisfaction; etc (Nagamachi, 1995; Miyazaki et.al., 1993; Matsubara et. al., 1997) [8] [7] [6].

In other words, Kansei Engineering is a method to explore the human factors, and it is mainly focused on the psychological side. In practice, it is mainly used in the design of consumer-oriented products, such as car exterior[3], office chairs [4], and car interior[9]. It is also used in costume collocation, house interior design, product color collocation, or the other design issues.

## The Features for Product Form Recognition

Through a procedural method, the abstract image perceptions existed within consumer's mind are surveyed and analyzed moderately, and then they are converted into imagery features of an object. The whole process has its own advantages but it is susceptible to the differences in perception and expression caused by different ethnic groups or backgrounds, which could cause conversion problems within the process.

A product acts as a message carrying medium. The message transmitted by its appearance is not only limited to visual sense of beauty, but also carries a lot of meaning, such as: value judgment, etc [2]. This research is studying the front appearance of cars. Usually, the representative model in each era certain images and style. Today, the automotive manufacturing technology has reached a mature stage, and there are numerous kinds of car model available. Each model has its own image emphasis which could bring different feelings to people.

## The Application of Visual Trajectory to Measure Visual Characteristics

People get in touch with a large number of things and images every day, therefore their visual system is continuously processing the information coming from the surroundings. It is mentioned that a lot of information could be obtained by observing the eye movements of a person [1]. The eye movements instantly reflect the image viewing process, so the area or point of interest of a person could be understood through this observation.

When a person is looking at a scene, the gaze point distribution is not randomly presented, but it is regionally concentrated or dispersed to different locations [5]. Therefore, the area of interest of a person while looking at

an image could be understood by analyzing the frequency and density of the gaze points on each part of the image.

Eye movement trajectory is not a new technology as it had been used in psychology experiments as early as half century ago. Besides, it is also applied in aircraft, transportation, characters, treatment, and advertising industry. However, this technology is relatively less applied in design related researches. If the eye movement trajectory is used in a design related research to understand the most attractive part of a product, it could build the communication bridge between the designers and the users.

## Research Methods and Analysis

In this research, two dimensional figures of front-viewed cars are used to probe for the form features of the car which are visually affecting people's feelings. Eye-Tracking technology is used to track the gaze point density to obtain the variable values for the analysis.

## Screening of Research Sample

Given the large number of car models in recent years, this study will focus on sedans to limit the scope of research. One of the sample car photos is as shown in Fig. 1. Factors such as logo and color are removed to avoid unwanted effects on the feature analysis, as illustrated in Fig. 2. Then, the front appearance of the cars is drawn into line art which is to be used in follow-up experiments.



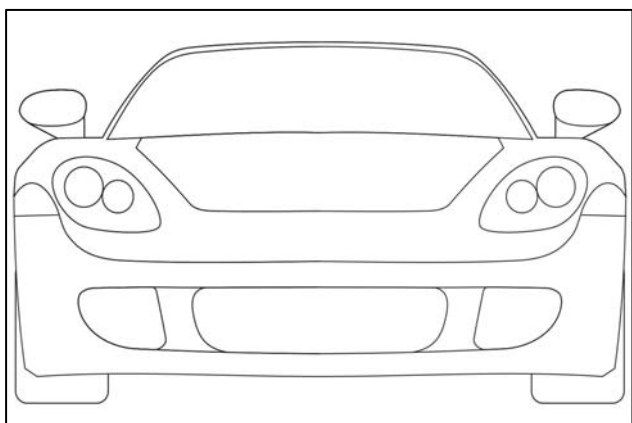Fig.1. One of the sample car photos in this study.



Fig.2. The sample car photo which is removed logo and color.

## Screening of Research Words

Related catalogs, advertisement, magazines and other promotional materials are collected to search for the Kansei words. Screening process of the words is done through focus group discussion, followed by rating the words against each representative samples. In the end, the words selected are: classy, hi-tech, luxurious, stylish, and fast.

## Extraction of Product Form Features

In this research, the eye tracking devices are used by 20 subjects to evaluate the form of displayed products, as shown in Fig.3. The snapshot of the eye tracking device is as shown in Fig. 4. The viewing time for each figure is 1 minute before the next figure is displayed automatically. After the evaluation is completed, the subjects are requested to fill a questionnaire which will be used as the basis of analysis on the key elements of form features of Kansei Engineering products.
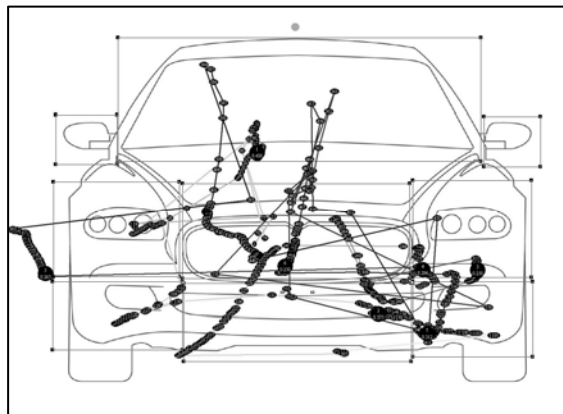


Fig.3. Gaze point distribution and the gaze trail of a subject.

According to the gaze trail and feature points, the front-viewed car can be partitioned into eight partial features, which include windshield, left rearview mirror, right rearview mirror, left headlight, right headlight, left fog lamp, right fog lamp and grille, to analyze which positions is the major gaze points of the subjects.
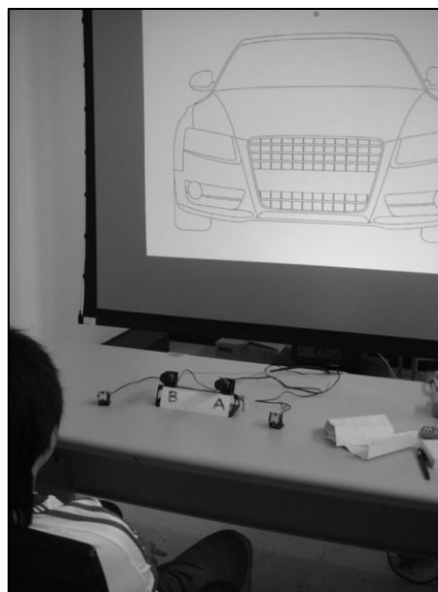


Fig.4. The snapshot of eye-tracking experimental environment.

In the experiment, different subjects may have different gaze trails even watch the same photos. These gaze trails can be classified as focused viewing and glance viewing. The gaze situations can be summarized as four types, which include (1) focused viewing of feature block, (2) partial glance viewing and then focused viewing of feature block, (3) partial glance and then focused right side viewing, and (4) glance viewing and then focused down side viewing, as shown in Fig. 5, Fig. 6, Fig.7 and Fig. 8, respectively.
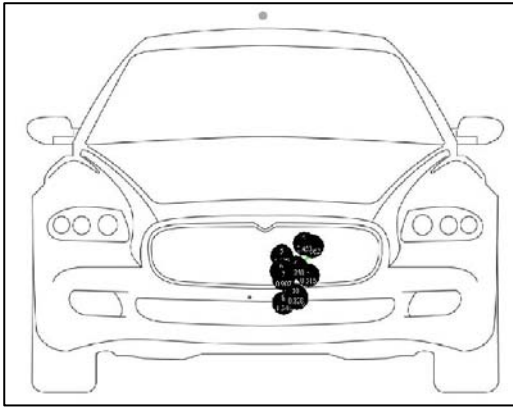
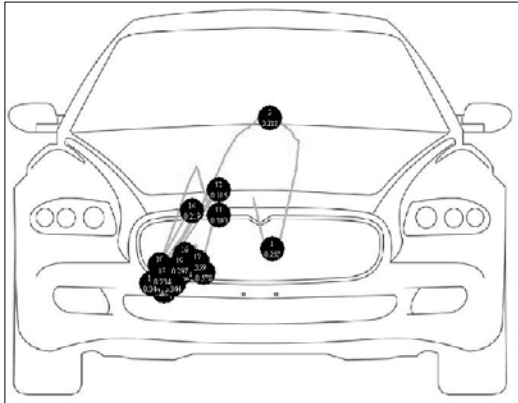Fig.5. The gaze trail of focused viewing of feature block.



Fig.6. The gaze trail of partial glance viewing and then focused viewing of feature block.
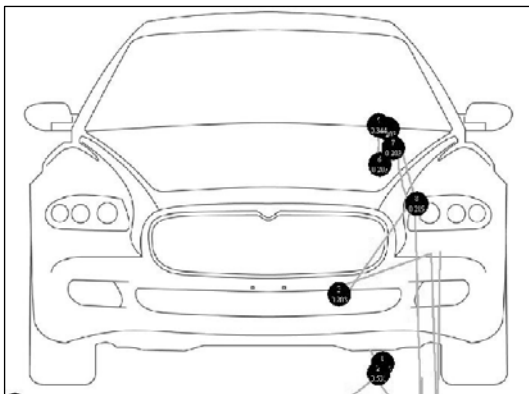


Fig.7. The gaze trail of partial glance and then focused right side viewing.
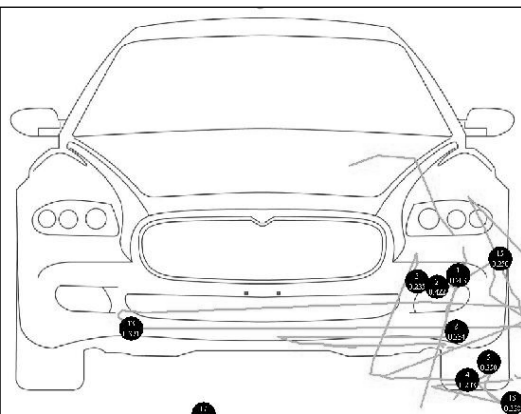


Fig.8. The gaze trail of glance viewing and then focused down side viewing.

**Experiment Analysis**

Regression Analysis is a kind of quantitative prediction method which is mainly used to establish regression equation between variables. The established regression equation is then used as the predictive model.

**The Influence of Subject'S Background in Feeling Car Features**

In this section, eye tracking devices are used to evaluate whether subject's background bring differences in their perception on the features of a car. The time ratio of viewing duration for each area is then used in ANOVA analysis, as listed in Table 1.

Table 1. Driving experience and viewing duration of test subjects

| Driving experience | Longest viewing duration | | Shortest viewing duration | |
|---|---|---|---|---|
| | area | time ratio | area | time ratio |
| less than 1 year (15 person) | logo | 28.57% | left rearview mirror | 0.57% |
| 1-3 years (2 person) | logo | 54.53% | right rearview mirror | 0.18% |
| 4-6 years (2 person) | logo | 26.82% | right rearview mirror | 0.04% |
| more than 6 years (1 person) | logo | 30.42% | left rearview mirror | 0% |

Table 2. Brand preferences and viewing duration of test subjects

| Brand preferences | Longest viewing duration | | Shortest viewing duration | |
|---|---|---|---|---|
| | area | time ratio | area | time ratio |
| yes (10 person) | logo | 27.78% | left rearview mirror | 0.22% |
| no (10 person) | logo | 34.39% | left rearview mirror | 0.70% |

In Table 2, driving experience and brand preferences brought a significant effect on the viewing duration of right headlight, but the longest viewing duration regardless the brand preferences was on the logo, which is related to the branding campaign in recent years, where brand is emphasized and the logo is made big to increase the visual effect. In contrary, the shortest viewing duration was on the left and right rearview mirrors.

**A Study on Visual Features of a Front-Viewed Car**

The study is officially started by dividing the front view of the cars to eight partial features. The awareness level of whether each partial feature suits each imagery word is investigated through the viewing ratio measured by eye-tracking devices used by 20 subjects with design background. The purpose of this test is to obtain the percentage of viewing duration for each partial feature, which is measured by the eye tracking devices when the subjects are looking at thirteen figures of front-viewed cars. The data obtained are processed together with the scores of the imagery words in multiple regression analysis to obtain the results shown in Table 3.

The partial correlation coefficients ($R^2$) for all imagery words shown in Table 3 are greater than 0.6, means the data obtained from the test could be sufficiently explained by analysis results. The overall regression model has reached a remarkable standard, and the eight partial features of the front-viewed cars are sufficient to explain the whole five imagery words.

Table 3. Partial features of the front-viewed car and the regression coefficients of words

| Words | Hi-tech | Stylish | Fast | Classy | Luxurious |
|---|---|---|---|---|---|
| Partial correlation coefficient（R2） | 0.6 | 0.7 | 0.7 | 0.8 | 0.7 |
| Windshield | -0.149 | -0.206 | -0.173 | -0.186 | -0.231 |
| Left rearview mirror | 0.604 | 0.895 | 1.475 | 1.351 | 0.889 |
| Right rearview mirror | 0.198 | 0.415 | -0.144 | -0.783 | -0.312 |
| Left headlight | -0.177 | -0.289 | -0.250 | -0.253 | -0.481 |
| Right headlight | 0.111 | 0.183 | 0.211 | 0.040 | 0.200 |
| Left fog lamp | 0.080 | 0.072 | 0.055 | -0.075 | 0.154 |
| Right fog lamp | -0.091 | -0.069 | 0.037 | 0.153 | -0.062 |
| Grille | 0.045 | 0.038 | 0.010 | -0.091 | -0.076 |
| Constants | 4.180 | 4.776 | 3.688 | 7.650 | 4.180 |

For the whole thirteen figures and five imagery words, the subjects were spending the longest viewing duration on the left rearview mirror. Thus, the form of left rearview mirror will be the most influencing variable to those five words. The second longest viewing duration for "hi-tech" and "stylish" was on the right rearview mirror; while for "fast" and "luxurious" it was on the left headlight; and for "classy", it was on the right fog lamp. The results show that rearview mirrors and lamps were strongly concerned by the subjects, breaking the myth of the importance of logo or grille.

**Conclusions**

From the standardized regression function of the partial features of front-viewed cars and the Kansei words, it could be observed that the left headlight has the largest influence between the features, but it is negatively correlated. Thus, it is speculated that the feeling brought by the front appearance of cars to the subjects is decreasing rapidly along with the increasing viewing duration on the left headlight. The sense of technology, style and luxury bring the largest positive correlation influence to the right headlamp, while it is the sense of speed and class which bring the largest positive correlation influence to the left rear-view mirror.

Overall, this study reveals whether driving experience influences the awareness of the logo and its positioning. It is also found that most people glance left to right when they are looking at the front side of a car, with the longest viewing duration on the left headlight.

In the past, many car manufacturers were prioritizing the design of the body, but now they are putting more attention to the front appearance of the car, especially to the logo. Car logo used to be small and it was often put in inconspicuous position. Now it is made bigger and integrated with the grille. The entire design of the front appearance of car also tends to mimic human expressions, with the headlights simulating joyful or vicious human eyes and grille simulating human nose as examples. Therefore, the design of the front expression of a car will be one of the consumer's concerns in the future, so it will directly influence its overall image and sales performance. This is an issue worth further discussion and research.

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