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Product Cognitive Style Based on Kansei Engineering and Visual Track Experiments

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Abstract: Based on the form of fuel tankers, the eye tracking experiment was adopted to measure the users' perception sequence of accessories. The weight value between accessories and holistic style was calculated. The key features that affected the cognitive style were extracted with the experiment of Kansei engineering. Combined with the methods of expert interviews, questionnaires and image scales, the relationship between the accessories style and the product form features was explored to structure the model of product cognitive style. The adjectives of tanker form were obtained and the image space of tanker form was build. The method of tanker form design for style image could enhance the production continuous innovation and maintain the sustainable development of enterprises.

Key words: Product cognitive style, kansei engineering, eyes track experiment, tanker form features

INTRODUCTION

Establishing an attractive vehicle exterior, however, often depends on design choices made far beneath the polished surface of the vehicle (Luo *et al*., 2012). Many accessories may be considered by automobile designers and engineers when designing a fuel tanker and, according to gestalt theory, the inner relationship of these accessories greatly influences users' perceptions of the final image of the product (Amendt-Lyon, 2001). Focusing only on diversity may reduce usability if the manufacturers do not consider consistency (Park *et al*., 2011). The resulting disharmonious design elicits elaborate cognitive processing and reduces consumers' perception of quality.

Most studies have mainly focused on the car in its entirety (Lai *et al*., 2005) or, alternatively, on individual accessories, such as the front mask (Shen *et al*., 2000), car bodyline (McCormack *et al*., 2004), or an amalgamation of its disparate features (Herriotts, 2005). Few existing studies in the field of vehicle design have examined whether accessories are well-suited to the vehicles' integrity or their influence on users' perceptions.

The current fuel tanker industry lacks matching rules between accessories and tanker types; given the multitude of potential combinations between these two fuel tanker accessories, it is often difficult for manufacturers to confirm that their selected design is truly the most appropriate for and harmonious with a given tanker.

METHODS

There are many types of fuel tanker accessories. In new product development, designers always do design work depending on their subjective preference and experience difficulty in judging whether their selection is truly appropriate. The accessories are generally regarded as an important part of a tanker, especially from the side or back view. However, there rarely exist matching rules for choosing accessories for a particular fuel tanker. There is a risk that the well-designed accessories are not actually suitable for the tanker body.

To investigate the relationship between entirety and accessories of one product design, Kansei Engineering theory (Nagamachi, 2002) provides a methodology to build mapping model to translate the consumer perceptions about the overall image of product form into separate design elements (Poirson *et al*., 2010). However, many existing approaches mainly discussed choosing various statistics methods to build the model (Demirtas *et al*., 2009; Llinares and Page, 2011). The mathematics method could not exactly predict the design quality from aesthetics.

Product Semantics (Krippendorff, 2006), a consumer-oriented method from Kansei engineering was employed to acquire users' subjective impressions from evaluation data. If it is verified that the Kansei image has a strong relationship with the matching quality, we can identify representative design solutions of accessories based on the design style of the fuel tanker, thereby assisting tangible design procedures.

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In order to investigate the relation based on users' perceptual feedback, a participatory experiment was conducted that involved users in the research process and while increasing direct communication between them and product developers (Lindgaard and Caple, 2001).

Subjects were invited to participate in a three-task experiment: Task 1 was an eyes tracking experiment to measure the consumers' reaction caused by the tankers' form; task 2 was a Kansei engineering experiment to determine relevant Kansei attributes between accessories and tanker types; task 3 was a Semantic Differential (SD) evaluation task that gathered subjects' Kansei evaluations of the accessories to illustrate their form design styles. Table 1 shows a detailed summary of each task, including the purpose, methods and results.

The methods can be implemented in four phases, as shown in Fig. 1:

- **Stage 1: Preparation:** From the oral report, a total of 40 distinct Kansei descriptions were established. The questionnaires of tanker style imagery were prepared for the tests
- **Second stage: Experiment:** Design experiments to determine the cognition sequence of accessories and establish the holistic style image space
- **Third stage: Evaluation:** The tankers' style image was evaluated quantitatively and the cognitive style was extracted, the information of tanker accessories was represented quantitatively
- **Fourth stage: Generation:** The image style combination between accessories and holistic body was evaluated; the new product form could be generated finally

Table 1: Detailed information of 3 tasks

Parameters	T1: Eyes-tracking	T2: Kansei attributes	T3: SD evaluation
Purpose	To measure the consumers' reaction caused by fuel tanker exterior style	To identify Kansei semantic space for the evaluation of tanker form design	To illustrate Kansei image between accessories and holistic style
Methods	Eyes-tracking	Oral report and questionnaire	7-level Likert scale
Results	Sequence of visual rognition	Kansei semantic space	SD evaluation scores

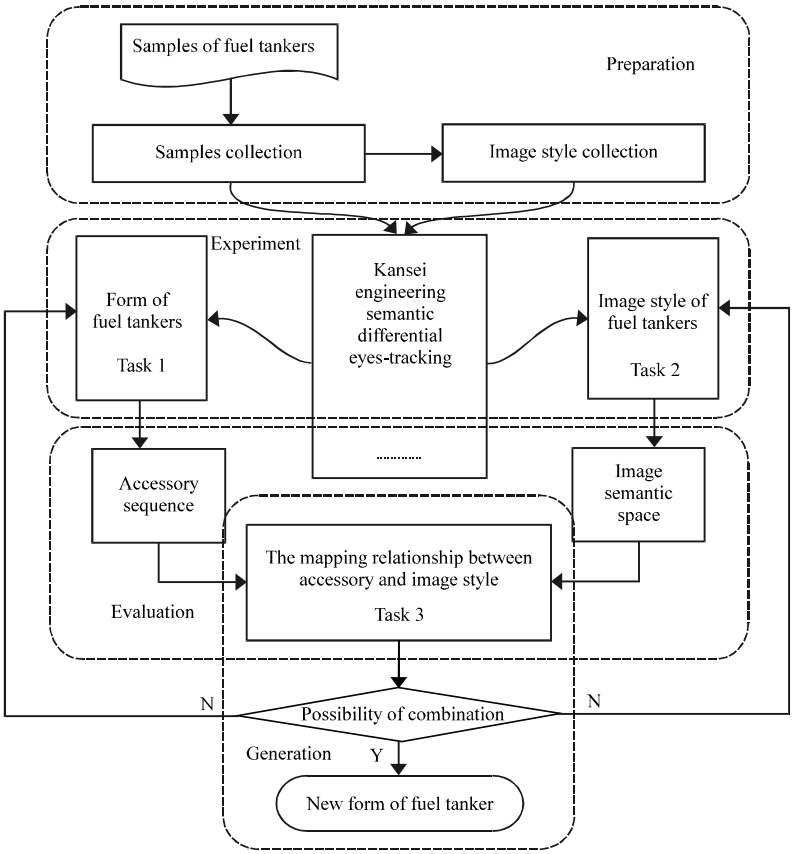

Fig. 1: New product generation process based on eyes-tracking and kansei experiments

EXPERIMENTS

Purpose: The eye-tracking experiment aimed to measure the consumers' reaction caused by fuel tanker exterior style.

Devices: The device in this experiment was eye-tracking 6000 helmet systems produced by Applied Science Laboratory (ASL).

Materials: A total of 24 fuel tankers of 6 manufacturers leading the world market were collected, as shown in Fig. 2. Five senior designers from large local tanker manufacturers were invited as expert panel to define the tanker types as the stimuli for the study. Twenty participants in Guangdong (14 males and 6 females averaging 30 years of age, 5 industrial design internal students, 5 marketing staff, 5 engineers, 5 workers) were invited as subjects. The 24 samples of fuel tanker were eliminated the unwanted influence of elements irrelevant to the shape, such as brand and model number and thus assessed subjects' feelings solely with respect to the tankers' shapes.

Procedure: Firstly, the participants should read the guidance and operate the devices in practice, then they were asked to sequentially browse the 24 tanker samples using eyes-tracking 6000 and they were completely involved in the experiment according to personal preference. Each participant testing process took about 10 min or so.

When they gazed the tanker samples, the Eyes-tracking device would record the important parameters automatically, such as fixation duration, fixation transition rate and the number of fixation. The data results were processed by Gaze Track and SPSSWIN software package. The fixation duration and number of fixation were shown as Fig. 3, the data statistic were shown as Table 2.

Data analysis: The obtained sequence reflected the levels of the visual cognition of the fuel tankers. This sequence provided necessary materials for subsequent research on perceive relations.

In Table 2, among all the accessories of fuel tanker, the side fence got the highest ranking of visual perception and played the best performance in fixation duration and numbers of fixation. This indicated that participants generally thought the form of side fence was the main factors that affected the holistic style and the features of side fence could directly affect the consumers for imagery cognition of holistic style. By the same token, the ranks of

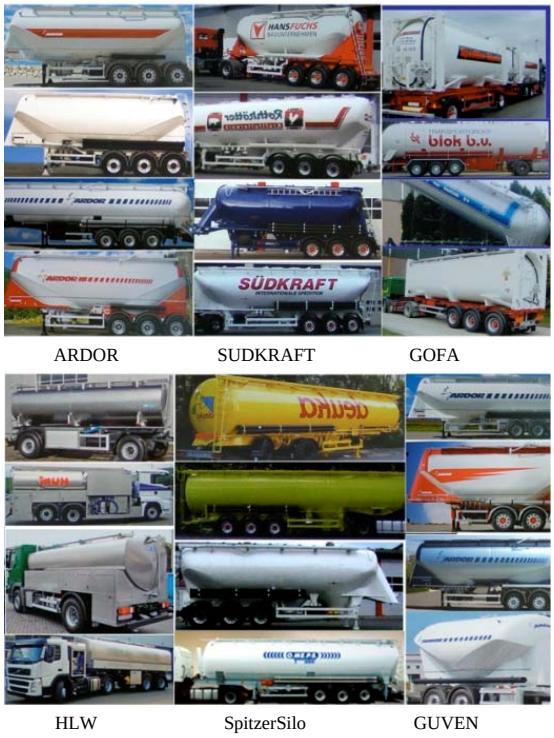

Fig. 2: Twenty four fuel tankers of 6 manufacturers

Table 2: Index of eyes tracking in different AOI

	Index of eyes tracking (average value)			
Accessory	Fixation duration	Transition rate	Fixation No.	Rank
Side fence	4.23	12.80	7.94	1
Hose locker	0.86	2.70	1.93	7
Tool box	1.48	4.20	2.84	5
Ladder	2.68	8.85	5.01	3
Bumper	1.03	3.04	1.95	6
Fender	2.97	9.02	5.38	2
Platform	1.54	5.84	3.07	4

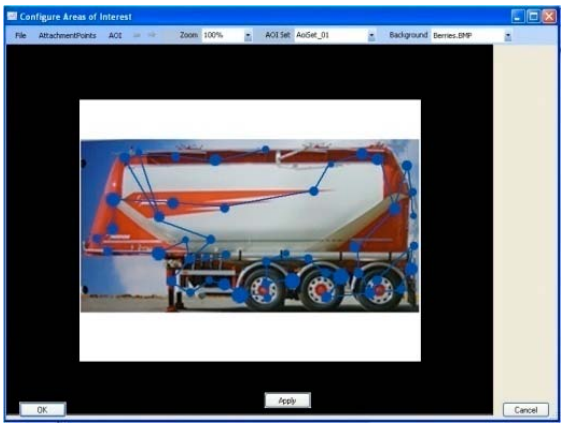

Fig. 3: Fixation duration of fuel tanker

the other accessories also represent the order to influence the holistic style. The hose locker ranked second, the tool box ranked third, the ladder ranked fourth, the bumper ranked fifth, the fender ranked sixth, the platform ranked last in all 7 accessories.

According to the brand of manufacturer, all the samples of tanker were classified. The attraction of all accessories from different manufacturer was codified in eyes-tracking data, as shown in Table 3. PCT means the percentage of all samples for the holistic style that the participants were interested in. Specific value of accessories indicates that the percentage of every brand fuel tankers for each accessory. S stands for the "Side fence" style of tanker, H stands for the "Hose locker" style, T stands for the "Tool box" style, L stands for the "Ladder" style, B stands for the "Bumper" style, F stands for the "Fender" style, P stands for the "Platform" style of the tanker.

Obviously, the fenders of brand A got the longest fixation duration (37.62%) that was to say, the form feature of fender was most attractive among all the accessories of brand A. Further, the form feature of fender would inevitable affect the holistic style cognition of brand A. Similarly, fender of brand B was also the most attractive one among its holistic style cognition, the fixation rate was 26.89%. Among the accessories of brand C, the fixation specific value of side fence, bumper and fender was adjacent in around twenty percent, they three affected the holistic style of tanker together. In brand D, tool box and side fence were the main factors to influence the holistic style, their fixation rate were, respectively 31.69 and 28.17%. In brand E, platform was most notable accessory that was not the same as any other brand of tanker and its fixation rate was 34.48%. Finally, in brand F, fender and platform had outstanding performance in attractive appearance, both of them got nearby 20% fixation duration.

It can be seen that, there is a very large difference in accessories designed in different brand of tanker and then it cause corresponding changes of perception sequence and the interest areas came from consumer. With the eyes-tracking experiment, the most attractive accessory of different brand can be found out scientifically. As a result, designers can carry on their design work with the targeted guidance.

Table 3: Specific value of accessories

	Specific value of accessories						
PCT	S	H	T	L	B	F	P
25	5.82	16.86	3.68	14.63	2.78	37.62	18.61
15	13.72	9.19	5.34	19.46	7.19	26.89	18.21
5	20.61	3.76	4.87	13.45	21.93	29.85	5.53
35	28.17	16.43	31.69	3.51	4.47	6.02	9.71
5	21.87	5.79	14.73	6.45	8.92	7.76	34.48
15	11.64	18.41	4.07	7.92	10.27	22.93	24.76

After the eyes-tracking experiment, the participants were asked to finish the supplement questionnaires, the relationship between accessories and holistic style in their mind was investigated.

EVALUATION

According to the results of data analysis in section 3, the accessories with high ranking and having similar style imagery can be collected. And then, designers match them together. The new product form is generated automatically.

Furthermore, one generation design should be evaluated through the SD method. And the limit of the paper length, the process of evaluation is omitted. The final generation design is shown in Fig. 4.

The purpose of this task was to elicit subjects' perceptions and impressions of the tankers with respect to their relevant Kansei attributes.

The open-ended questionnaires were adopted to ask the participants' image feeling about the accessories of the fuel tankers. Then, the extracted words were converted into Kansei attributes in the form of a pair of bipolar adjectives (Yan *et al*., 2008) that constituted the space of semantic cognition.

A questionnaire listing 7 Kansei attributes from task 1 was designed firstly, then the subjects were invited to evaluate the two groups of design samples based on a 5-level Likert scale, where "2" corresponded to consumer satisfaction, whereas "-2" corresponded to consumer dissatisfaction. The obtained SD evaluation scores were summed and averaged as the global rating data, as shown in Fig. 5.

In Fig. 5, red solid line represents the new generation design and the other dashlines represent the original holistic tanker style of six manufacturers. It can be seen

Fig. 4: Generation design of fuel tanker

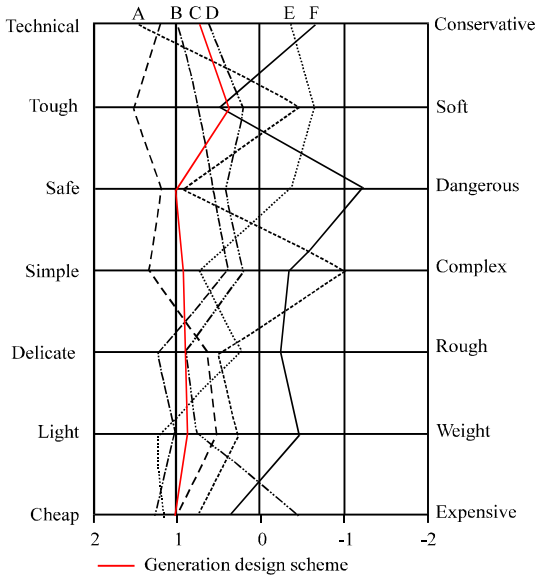

Fig. 5: 5-level Linkert scale between new generation and original style

that, the tanker of brand A has the most technical sense, the tanker of brand B has the sense of tough, softy and simple, the tanker of brand C is most delicate and the tanker of brand E is good at weight and value. Correspondingly, the new generation is not very prominent in a single aspect but its general performance is better than the most others.

CONCLUSION

For the purpose of providing guidelines for accessories selection, a case study on 6 manufacturers of tankers and 24 fuel tankers was presented and their cognitive styles were examined. The study accordingly proposed a methodology for evaluating the perceptual relationship between the two through a participatory experiment, the eyes-tracking and Kensei engineering experiments. Based on computing the correlations of SD evaluation value vectors between bodies and accessories, the visual cognition was verified to have a strong relationship with the similarity of the components' design style. With a subsequent correspondence analysis of ranking data, the obtained projection value explicitly reflected the strength of the association between accessories and corresponding tanker types. As a result, 7 positive representative design samples of accessories were obtained for each type of tanker. Accordingly, design solutions were recommended and the achievements can be readily employed by companies to propose appropriate designs that precisely meet market demands.

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