



# Relationship between eye fixation patterns and Kansei evaluation of 3D chair forms <sup>☆</sup>



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## ABSTRACT

Understanding how to induce Kansei (emotion or affect) in consumers through form is critical in product design and development. Conventional Kansei evaluations, which involve subjectively evaluating the overall form of a product, do not clarify the effects of the individual parts of a product on people's Kansei evaluation. A microscale analysis of eye movement of people looking at product form may redeem this flaw in subjective evaluation. However, simultaneously recording eye movement when people making Kansei evaluation is challenging, previous studies have typically investigated either the relationship between form and eye movement or the relationship between form and Kansei separately. The eye movement of people while performing Kansei evaluations on product forms still has not been clarified. To address this issue, the present study used an eye tracking system to analyze the changes in the fixation points of people performing various Kansei evaluations. Twenty participants were recruited for 8 Kansei evaluations on the form of 16 chairs by using the semantic differential (SD) rating, while their eye movements on these evaluations were tracked simultaneously. Through factor analysis on the data of Kansei evaluations, two principal factors, valence (pleasure) and arousal, were extracted from the 8 Kansei scales to constitute a Kansei plane which is compatible to Russell's circumplex model (plane) of affect. By adopting the factor scores of the 16 chairs as coordinates, the 16 chairs were mapped into the Kansei plane. Further analysis on the eye fixation on the chairs located in this plane concluded the following results: (a) Pleasure had a more significant effect on the participants' visual attention compared to arousal; the participants required more fixation points when evaluating the chair form that induced displeasure. (b) The participants typically fixated on two parts of the chairs during their Kansei evaluations, namely the seat and the backrest, indicating that seats and backrests are the two primary features people consider when evaluating chairs. The results clarify the effect of various Kansei on eye movements; thereby enable predicting people's Kansei evaluations of product forms through analyzing their eye movement.

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## 1. Introduction

Kansei engineering is a consumer-oriented product development technique, proposed by Japanese scholar, for creating suitable product forms to satisfy consumers' affective need. For this purpose, applying Kansei engineering have typically adopted subjective evaluation methods (termed as Kansei evaluation), such as the semantic differential (SD) method, to understand the consumer affective feelings on products, firstly [1,2]. In recent years, with the rapid rise of electronic commerce markets (such as Amazon and other online shopping websites), understand consumers' Kansei and eye movement while they're looking product online

becomes a very important issue. With technological advancements, studies have investigated consumer preferences through objective physiological examinations such as eye tracking and brainwave measurements [3]. In such studies, participants have been requested to read images or articles while their eye movements are recorded by an eye tracking system, which enables researchers to analyze where people focus their visual attention when observing product form [4,5]. The problems currently requiring discussion are listed as follows:

1. Analyzing eye movement and Kansei evaluations simultaneously is challenging and time-consuming. Previous studies investigating the relationships between form and eye movement [6–8] and between form and Kansei evaluations [9,10] have examined Kansei evaluations and eye movement separately before analyzing them together. However, no study has

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clarified the eye movement patterns of people performing a Kansei evaluation. Accordingly, the present study used an eye tracking system to record the eye movement of people while they performed Kansei evaluations.

2. Kansei evaluation involves evaluating an entire image. However, it is not possible to clarify which product features influenced people's Kansei evaluations. An objective eye tracking approach can overcome this flaw in subjective evaluations. Therefore, this study aims to analyze the differences among the participants' fixation points while performing various Kansei evaluation processes. Accordingly, the influence of Kansei product features on eye movement can be used to predict Kansei evaluations on the basis of eye movement.
3. In reference to Takahashi [1], Fann, Chuang, and Hsu [11] used redrawn Kansei abstract images as stimuli and applied the SD evaluation, basic content analysis, and eye tracking in an experiment. The results of the experiment based on the circumplex model of affect by Russell [12], revealed the corresponding relationship between the participants' eye movements and the forms of positive or negative Kansei evaluation stimuli. However, it remains unclear whether evaluations of abstract 2D product forms would be the same as those of 3D product forms. To address these problems, this study set the following goals:
  - (1) Explore the primary Kansei dimensions affecting consumer evaluations of chair forms, and investigate changes in the fixation points and length of fixation times through evaluating various Kansei words.
  - (2) Analyze the crucial product features that affect the visual attentions of the participants performing the bipolar Kansei evaluations.
  - (3) Compare the analysis results with the results reported by previous studies investigating abstract 2D forms.

## 2. Literature review

### 2.1. Kansei engineering

Kansei engineering, proposed by Japanese scholar Nagamachi, is defined as a technique that transforms consumers' feelings and imagery induced by a product into design elements. *Kansei* is the Japanese pronunciation of Chinese character “感性 (affective).” Although the meaning of the Japanese term *kansei* is similar to the English words, *emotion* or *affect*, Japanese scholars have argued that Kansei involves relatively extensive and subtle meanings [13,14]. Since this study was originally based on the concept of Kansei engineering, we kept use the term of Kansei evaluation, rather than affective evaluation, in this paper. However, Kansei was considered to almost be the synonym of affect in this study. Kansei can be measured using subjective and objective approaches [15,16]. Currently, a common subjective approach to measure Kansei is the SD survey, whereas objective methods measure Kansei through analyzing recorded physiological reactions, such as brainwaves.

According to the finding in Chan [17], after crucial form elements were identified, by arranging, adding, or removing the elements in a product form based on certain parameters, designers can enable viewers to easily perceive the Kansei set by them. Chuang & Chen [18] demonstrated that Kansei can truly be measured and operated. Boucharde et al. [19] argued that studies in Kansei Engineering have described Kansei by using semantic expressions and examined the Kansei reactions of products through the semantic differential (SD) method. A Kansei database or expert system can be constructed using a data analysis, and automatic form analysis algorithms applicable to various designs may be subsequently used for calculations.

### 2.2. Emotion-circumplex

In emotion science, psychologists have attempted to identify the main dimensions characterizing core emotional experiences. The most common model is the one by Russell [12] who proposed the circumplex model of affect, which is composed of the axes of pleasure (P) and arousal (A). The P axis signifies the positive or negative Kansei perceived by people, and the A axis indicates the degree of arousal of Kansei induced by stimuli. The two axes were used to establish a psychological space (called the P–A Kansei space in this study) which can effectively explain human affections. Russell [12] identified the location of 28 basic emotions in the circumplex model (the P–A Kansei space), as shown in Fig. 1. The P–A Kansei space comprised four quadrants for Kansei evaluation, namely pleasure and arousal, pleasure and sleepiness, displeasure and arousal, and displeasure and sleepiness. Fontaine [20] further proposed the four dimensions of Kansei space, and these dimensions are evaluation pleasantness, potency-control, activation-arousal, and unpredictability. They were identified on the basis of the applicability of 144 features representing the six components of emotions: (a) appraisals of events, (b) psychophysiological changes, (c) motor expressions, (d) action tendencies, (e) subjective experiences, and (f) emotion regulation [20]. Yik, Russell, and Steiger [21] extended the concept of the circumplex model of affect, analyzing and exploring a wider variety of distributions in a pleasure–arousal (P–A) Kansei space.

### 2.3. Feature recognition

To recognize or evaluate things in the living environment, people identify and categorize the new object, image, or word that they encounter. Specifically, they perceive the form and meaning of an object, compare the new information with a prototype in memory, and then categorize this object. This process is called feature recognition. In cognitive psychology, feature recognition requires two conditions. First, a feature stimulus is generated from the external world. Second, previous knowledge and experiences regarding the feature stimulus should be obtained, and people can tolerate a certain level of physical variation in feature recognition [22]. Reid, MacDonald, and Du [23] used computer sketches and realistic renderings as research stimuli and employed an eye-tracking system to conduct a Kansei evaluation. The results indicated that presenting the same object as a realistic rendering or a computer sketch did not affect the subjects' evaluations. Additionally, when evaluating the same product, the subjects' point of gaze was centered on same features in both images. Karjalainen [24] used images of cars as a research sample to study visual brand identification, determining that identifying the key features of form facilitated successful brand identification. Chuang and Chen [25] selected railings as a research sample to examine how people visually evaluate stimuli in a short amount of time. Their results showed that the subjects classified stimuli based on the key features of the forms in the sample. Overall, the results in the literature suggest that identifying the Kansei of key product features is critical for designers in order to present effective Kansei for consumers. Understanding the key features of a product form is crucial for designers to convey the desired Kansei to consumers through product design.

### 2.4. Composition

Previous studies have revealed that all senses are interconnected, and that external sensory stimuli and internal cognition form a complex transmission network. Stimuli inducing Kansei through the visual senses is similar to excitation of the other senses and is referred to as visual synesthesia. Numerous studies

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