An Approach for Researching the Relationship Between Physical Design Characteristics Through Eye Tracking and Kansei Evaluation of Products

by

Junyi Shen

A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Industrial Design

Auburn, Alabama
May 04, 2019

Keywords: Kansei Engineering, Product Design, Kansei Evaluation, Eye-tracking,

Approved by

Tin-Man Lau, Chair, Professor of Industrial Design
Shea Tillman, Associate Professor of Industrial Design
Jerrod Windham, Associate Professor of Industrial Design

Abstract

Kansei engineering is widely used to explore the relationship between design elements and consumer Kansei, however, the methodology of conducting Kansei research and developing new design is still needed to be completed.

This thesis proposes an approach to do research on human Kansei and conduct new product design based on Kansei research. A capsule coffee machine will be used as the object of the study. Different techniques and research tools will be applied in the research. Eye-tracking testing will also be applied to discover the consumer's concentration areas of a specific product. A semantic differential experiment will be conducted to evaluate human Kansei towards different product samples. A series of statistical analysis methods will also be used to determine the relationship between design categories and consumer's Kansei.

Some positive results may be obtained, which can be reasonable support for further research. Many significant correlations were also found in the development of a new capsule coffee machine design, which has predictable Kansei value.

Acknowledgements

I would like to thank my major professor Tin-Man Lau for his kindness and support throughout my master's study. You are not only a great teacher and a brilliant designer, but also a humorous friend and an outstanding philosopher. I learnt a lot during our conversations, either about design or life.

The experience of working on this thesis is just like a wonderful journey. I meet knowledge, challenges and friendship. Life always brings much more than I expect. Professor Wang helps me to apply for the IRB approval and teaches me how to conduct eye-tracking experiment without reservation. I meet so many friends in Auburn, and we have a good time together. My roommate Yang Sun helps me a lot in my life and study. My friend Tianyu Cui Helps me overcome challenges time after time. All of you are nice people.

Past history behind, life is way for apart. Wherever I am, I will always remember your kindness.

Table of Contents

List of Figures

Chapter 1 Introduction

1.1 Problem Statement

There are abundant numbers of products around us, and the complexity of these products has increased considerably. To make products attractive to win the market is an important problem in modern society. The industrial age is changing from “a product-out concept” to “a market-in concept” regarding new product development (Nagamachi,1999). The “product-out” philosophy implies the manufacturer provides technology and design specifications according to decision making of the manufacturer’s side. However, most consumers desire consumer-oriented product design which focuses on the user’s preference and enhances user experience.

Design is a comprehensive creative activity between an individual and surrounding factors, and it should include both the logical and intuitive behaviors of consumers. It is important to find a reliable method to help designers and companies develop attractive products efficiently with clear logic and reasonable analysis. Most designers choose to freely create product concepts that have a high potential to fail in market. Designers concentrate on user-centered design but the processes to do user research are frequently fuzzy. Furthermore, when the designer tries to generate new design from the result of user research, there is often no clear design method to follow. Many designers have problems in managing design under the user-centered concept.

Kansei engineering provides a new way to conduct user research and product design, which aims to develop the product people want to have that is deep in their mind. Kansei

engineering is able to draw out the user's feelings and by using statistical methods, these feelings can be transferred to specific design features. Designers can use this methodology to conduct design and generate attractive products.

1.2 Need for Study

People's aesthetic tendencies and the popular products in the market are constantly interacting with each other. Due to the mere exposure effect and other consumer psychology, a user's aesthetic preference is changing and affected by the environment constantly. There is no immutable rule to create a satisfactory product because of the changeable preferences of consumers. In this case, it is unwise to use user data for an extended period because it loses its timeliness, and relies on incorrect data statistics having the potential to lead to failure of the entire design.

A product design which lacks user research has a high risk of deviating from the market demand and losing consumers' interest. Whether it is a new product development or the re-design of existing products, positive and negative features can be discovered and used as a powerful reference during the design process.

There is no doubt that people's taste and aesthetic preferences for specific products in the short term can be discovered through research and analysis methods. After acknowledging the user 's aesthetic tendencies, designers can have clear information, which aids them in designing the characteristic and feature in the design. An approach using the Kansei engineering process can help the designer do research based on reliable, valid user data. Kansei engineering can be

used to quantify the user's emotion and feelings of a product, and this kind of information can be a useful reference to conduct product development.

Comprehensive and reliable user research is essential to successful product design. However, a complete user experience analysis for each product can be a complex process. Often, the product design cycle is too long and costs many more resources. An efficient way to conduct user surveys as well as analyze the data and design the product needs to be developed to help designers to understand the user's preference and create reasonable products with strong support from data. This thesis is aiming to develop several research tools based on Kansei engineering to realize these needs.

1.3 Objective of Study

- To study the theory and research method of Kansei engineering.
- To define and study product application based on Kansei engineering.
- To define and study semantic differential method.
- To define and study eye-tracking experiment.
- To study the statistical method in Kansei design processes.
- To determine the relationship between physical design characteristic and specific Kansei engineering process for customers.
- To develop a research based on Kansei engineering and develop new product design according to the research.

1.4 Definition of Terms

Electroencephalogram (EEG) - An electrophysiological monitoring method to record electrical activity of the brain.

Electromyography (EMG) - A basic strategy to record specific responses evoked by particular stimulation from external environment.

Eye-tracking - A technique whereby an individual's eye movements are measured so that researchers know both where a person is looking at any given time and the sequence in which the person's eyes are shifting from one location to another (Poole & Ball, 2006).

Kansei engineering - A kind of technology that translate the customer's feeling into design specifications (Nagamachi & Lokman, 2010).

Kansei- Sensitivity of a sensory organ where sensation or perception takes place in answer to stimuli from the external world (Nagasawa, 2001). Kansei is a subjective and unexplainable function. Kansei, besides its innate nature, consists of the cognitive expression of acquired knowledge and experience. Kansei is the interaction of intuition and intelligent activity. Kansei is the ability of reacting and evaluating external features intuitively. Kansei is a mental function creating images (Zhang, 1998).

1.5 Assumptions of Study

It is assumed that all the research, approaches, methods and data gathered are correct. It is assumed that people do care about the appearance of products. It is assumed that the customers have different feelings of different products. It is assumed that people's preference and taste are

changing constantly.

1.6 Scope and Limitations

Though user research is an efficient way to help designers to create attractive products and enhance user experience, the data that designers collect is often limited and the research typically does not include all the population and groups. When selecting user groups and analyzing data, a specific and reasonable scope should be ensured before the experiment and design process. By using questionnaires, researchers can choose the correct test group. In this case, detailed limitations of different users to achieve equal effect of the experiment for each user group. The primary limitation of the user groups defined is the design for the average preference of the majority of members in each user group.

1.7 Procedures and Methodology

Procedure 1: Study the concepts of Kansei and Kansei engineering.

• Studying online publications, dictionaries, articles and library resources.

• Analyzing existing products in market that utilize KE.

Procedure 2: Study the theories of Kansei engineering and Kansei methods.

- Studying online publications, dictionaries, articles and library resources.
- Sorting and analyze research.

Procedure 3: Study current Kansei techniques and statistical methods related to Kansei engineering.

- Studying online publications, dictionaries, articles and library resources.

- Sorting and analyze research.

Procedure 4: Design the research procedure.

- Collecting relevant research methods.
- Analyzing reliable research approaches.
- Extract research guideline.

Procedure 5: Conduct eye-tracking experiment.

- Designing the eye-tracking experiment.
- Applying for IRB approval.
- Conducting the experiment.
- Analyzing and illustrating the data.

Procedure 6: Conduct semantic differential experiment.

- Designing the questionnaire.
- Applying for the IRB approval.
- Conducting the experiment.

Procedure 7: Statistical Analysis.

- Designing elements classification.
- Principal component analysis.
- Linear regression analysis.

Procedure 8: Product design.

- Concept creation.

- Data-based design.

1.8 Anticipated Outcomes

The outcome of this research includes the whole procedure and methods that can be used in Kansei engineering-based user research and product design. This approach will help designers conduct user research to find out the relationship between user's feelings and specific design characteristics. This study can provide an approach to conduct Kansei research and analyze the results. By using Kansei methods, designers can transfer Kansei values to attractive product design.

Chapter 2 Literature Review

2.1 Introduction of Kansei

The feelings and impressions of the product are important for the customer's decision for purchasing it. Integrating these emotional or affective values into product design requires the appropriate approaches to investigate the consumer's decision-making processes. To understand Kansei engineering, first Kansei and its history must be introduced.

The Japanese word Kansei (感性) means sensitivity or sensibility and always is used to describe the consumer's psychological perception and imagination of a new product. This term expresses the feelings collected through sight, hearing, smell, and taste. When a consumer wants to buy something, he has an image of the product, such as "elegant, warm and lovely" (Nagamachi, 1999). Positive feelings generally mean that a consumer is more willing to purchase the product.

Regarding historical understanding of Kansei, the terminology of Kansei began to be used as a perceptual translation in Japanese by Amane Nishi in 1857. This term was re-applied to the translation of Sinnlichkeit, an equivalent Kantian term, in T. Amano's work, 1935. Kansei is the process of intuitive understanding prior to Verstand, which is a German word to describe the understanding towards an object. Kansei includes both sensibility and understanding. Therefore, all sensory data received through human body sensors must pass through an innate subjective innate filter. Because people have different backgrounds and experiences, they have different Kansei or feelings towards the same object. This innate subjective filter clarifies the most

confusing points, which is why various Kansei exist in individuals, and this lead us to Kansei research clearly (Kim & Cho, 2014).

2.1.1 Definition of Kansei

Kansei is a Japanese term with a broad interpretation, including

1. Sense, sensitivity, sensitiveness, sensibility.
2. Feeling, image, affection, emotion, want, need.

Kansei refers to the feelings felt by the receiver of stimuli contained in the atmosphere of a situation. If the receiver is rich with emotions, he or she will have feelings that match the stimuli. If the receiver lacks emotions or resistance, he or she can only respond to a part of the stimulus.

Sensitivity refers to the ability to understand consumers by perceiving what they want from their eyes, facial expression, spoken words, etc. This sensitivity or Kansei can be acquired by anybody through training. Through research and analysis of customer's Kansei, it is possible to develop new products that will attract customers (Nagamachi, 2015).

According to Toshimasa Yamanaka (2008), Kansei is usually described as a mental function, and more precisely as being a higher function of the brain. The literature indicates that:

- **Kansei process** gathers the functions related to emotions, sensitivity, feelings, experience, and intuition… (i.e. sensory quality-related functions), including interactions between them.
- **Kansei means** are all the senses (sight, hearing, taste, smell, touch, balance,

recognition…) and – probably – other "internal factors" (such as personality, mood, experience, and so on).

- **Kansei results** are the fruit of Kansei process (i.e. of these function processes and of their interactions). It appears to be a unified perception providing a qualitative meaning and value of one's direct environment. Therefore, a Kansei result is a synthesis of sensory qualities (Levy, 2008).

2.1.1.1 Dictionary definition

The appearance of the term Kansei in Japanese literature goes back at least to the 17th century, a period of the classical literature of Japan, especially for poetic styles (Levy, 2015).

Kansei is a Japanese multi-facetted expression that is not readily translated to other languages. This is the result of the close connection with Japanese culture (Schütte, 2002). *Kansei* was used for the same meaning as feelings in Japanese classical literature in old times. In Ukiyozoshi's *Ten-Inch-Diameter Mirror of Homoerotism*, the following phrase is found: "A piece of *waka (*thirty-one-syllable verse) makes your heart abate and *Kansei,* which is a virtue of *waka*." It is said that "to *Kansei*" in the phrase means "to feel to the core" (Nagasawa, 2002).

There is no proper English translation of the word "Kansei". Kansei affirmation is related to several related concepts, including sensitivity, impression, feeling and emotion (Levy, 2007). According to the Dainihon Dictionary of Japanese (1915), Kansei is obviously the abbreviation of the word "kanjusei", which translated into English means "sensibility". In addition, the dictionary provides a more precise definition:

Kansei: Sensitivity of a sensory organ where sensation or perception takes place in answer to stimuli from the external world.

As in the description above, many dictionaries today define Kansei as “sensitivity.” In addition to the fact that Kansei had the same meaning as sentiment in classical Japanese literature in old days, Kansei contains a hint of sentiment, using the word today (Nagasawa, 2002).

2.1.1.2 Philosophical definition

The first Japanese to use Kansei as a philosophical term was Amane Nishi (1829-1897). When he introduced western philosophy to Japan, he coined many philosophical terms in Japanese. He uses Kansei as the translation of "sensibility" in English. However, the word "Kansei" is not made up by Amane Nishi, because it has been used in Japanese classical literature.

In 1921, Teiyu Amano translated *Critique of Pure Reason*, a famous philosophical book by Kant, into Japanese. He used the word "Kansei" as a translation of Sinclair's philosophical term, thus "Kansei" was established as a philosophical term.

According to a study written by Shinya Nagasawa (2004), Kant called the ability to receive an image of an object that cannot be grasped only by reason, in the manner triggered by the object, Sinnlichkeit, which is an equivalent Kantian term. He believes that when the human subject is in contact with the outside world, Kansei plays a very important role. He appraised the

function of Kansei in cognition of an object, and imparted an ability to understand to the term Kansei.

Therefore, *Kansei* is originally a philosophical notion, and Kansei was frequently used to criticize modern rationalism. Some philosophers have observed that Kansei is a basic function directly related to life or living. And that is linked up with religions and aims to live for, and ultimately being, or life and death (Nagasawa, 2004).

2.1.1.3 Psychological definition

The word "Kansei" itself did not appear in Japanese psychology until recent years. It is associated with accepted psychological terms such as sensation, perception and cognition. (Schütte, 2005).

The word Kansei can not be found in the subject books of psychology, and it is seldom mentioned in the books of psychology. Therefore, psychology does not have a professional term of perception. However, in recent years, books dealing with Kansei in psychology have been published.

Since the 1960s, it has been generally believed that the process of sensation, perception and cognition is a continuous process. Sensation and perception are aspects of the whole cognitive activity, which may be emphasized or may not depend on the object of the cognitive activity (Nagamachi, 2011).

2.1.1.4 The nature of Kansei

Kansei can be described as a holistic, concrete and open perceptual field of human sensory psychological model. Therefore, the model does interact well with the model, including human and human activities (knowledge, preferences, communication, design, etc.). These themes are often considered in the themes of perceptual research. (Levy, 2008). Kansei is an individual's subjective impression from a certain artifact, environment or situation using all the sense of sight, hearing, feeling, smell, taste as well as recognition (Nagamachi, 2001).

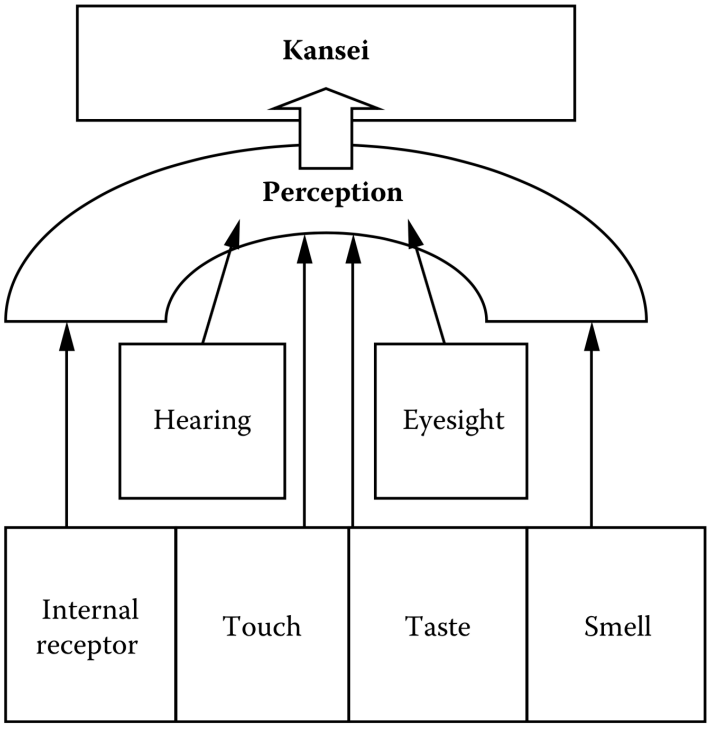

Figure 1

Kansei expressed after information from the six senses passes through the perception function （Nagamachi, 2011）.

All emotions through touch, taste and smell are perceived as emotions supported by people's everyday experience. Compound emotions combined with sensation, especially vision, which accounts for 70-80% of sensory stimulation, greatly affect perception (Nagamachi, 2015). In this thesis, the visual behavior of consumers will be the focus of the Kansei research.

2.1.2 Routes to reach the Kansei

Before conducting product design based on Kansei engineering, doing survey to understand consumer's Kansei is very important requirement. The customer's Kansei has a diversity of expressions, from psychological to psychophysiological measurement, and each measure also has a variety of emergence, as shown in Figure 2. The Kansei researcher who wants to create a new product design should choose the most appropriate route to reach the correct customer Kansei. Designers can achieve a Kansei product design successfully by using electroencephalogram (EEG), attitudes or words.

Kansei researchers should observe customer's behavior and check which route is the best way to reach customer's Kansei. The appropriate route is not always single and it could be a combination of several routes (Nagamachi, 2011). Through the five routes shown in Figure 2, the human Kansei can be evaluated and collected in different data types. In this process, Kansei is translated from human behavior data and by collecting different types of consumer behavior data, the analysis will be different in the same time.

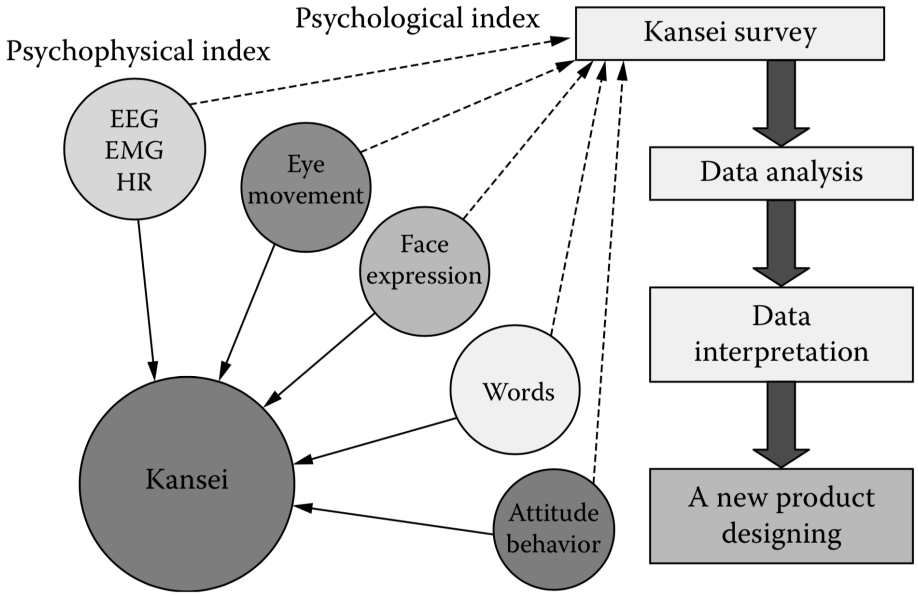

Figure 2

Routes to reach Kansei (Nagamachi, 2011).

2.1.2.1 Psychological phase of Kansei

Kansei is the outcome of cognition and human senses. Cognitive function includes memory, judgment, interpretation and thinking. Kansei is produced through some processes of cognition by different senses, which can be found from consumer behavior.

Kansei is the complex feelings of human, and can be divided to different axis. For example, a customer feels warm, lovely, clean, luxury, to a product. Since the Kansei towards a product is so complex, when a product designer wants to generate a new design based on customer's Kansei, he or she should think what Kansei is related to the new product and how to obtain the customer's Kansei.

2.1.2.2 Psychophysiological phase of Kansei

Mitsuo Nagamachi (2011) proposed the view that brain waves (EEG) are stimulated when with high motivation, but idle and repetitive work increases the worker's feeling f boredom. When using a very soft mattress, customers could feel uncomfortable if they have high body pressure. These are examples of a kind of Kansei shown as psychophysiological Kansei.

2.2 Introduction of Kansei Engineering

Kansei Engineering (KE) is a consumer-oriented technology to help designers in the process of new product development. It translates customers' emotions (Kansei) according to product characteristics by evaluating human senses (including vision, hearing, taste, smell and touch) and generates design specifications accordingly (Ismail, 2014).

In the 21st century, consumers not only want products to work well and meet their needs, they also want products to attract them. When customers are asked what they want, they usually generate a list of requirements, which usually involves functions. Designers and engineers can translate customer needs into technical parameters to enable products to meet these needs. However, customers can't clearly explain their needs and preferences, possibly because they do not realize them or can not tell what they are. In this case, Kansei engineering is needed to help designers achieve user needs and create attractive designs because Kansei engineering helps designers understand more clearly customer needs and preferences.

The goal of Kansei engineering is to realize the products which meets customer's desire and preference. Kansei engineering is a user-centered thinking, and Kansei researchers choose to stand on user's side to create successful products (Nagashima, 2013).

2.2.1 Definition of Kansei Engineering

Kansei engineering is a kind of technology that translates the customer's feelings into design specifications (Nagamachi & Lokman, 2010). For nearly 40 years, Kansei engineering has been developed as a productive research discipline, which is highly connected to the industrial world and claims numerous innovations and successes in market (Lévy, 2013).

Kansei Engineering is an important method of product development. It transforms consumers' impressions, feelings and requirements of existing products or concepts into design solutions and specific design parameters. Meanwhile, Kansei engineering shows how to translate Kansei into design (Schütte, 2002). Mitsuo Nagamachi (2011) proposed that the process of Kansei engineering should include the following scheme:

1. Who are the customers?
2. What do they want and need? What is their Kansei?
3. How to evaluate the customer's Kansei?
4. Analyze the Kansei data using statistical analysis or psychophysiological measurement.
5. Transfer the analyzed data to the design domain.

2.2.2 History of Kansei Engineering

In the 1970s. the term *emotional engineering* was already used to bring strong emotions like grief and pressure to customers through products. And then, Professor Nagamachi was advised to use the more suitable Japanese term: Kansei. In 1986, Nagamachi received the information that Kenichi Yamamoto, who was the president of Mazda, gave a special lecture titled "Kansei engineering" at the University of Michigan. The term Kansei engineering came into use and now is popular around the world (Nagamachi, 2011).

The main purpose of Kansei engineering is discovering the technical parameters of a product to elicit the chosen emotion or feeling. The founder of Kansei engineering, Mitsuo Nagamachi, has devoted himself to building Kansei engineering methods and assisted in the development of no less than 50 new products. In the 1980's and 1990's, Professor Nagamachi and his team collaborated with some companies including Mazda, Nissan, Wacoal, Goldwin, Sanyo, Sharp, Fuji, Canon and Shiseido (Marco, 2011).

Mazda, a Japanese automaker, first applied Kansei Engineering to the development of a new car called the Miata. Since then, Kansei has been used in automobile, construction machinery, textile, office machinery, housing construction, clothing and cosmetics industries. Nowadays, Kansei engineering has been extended all over the world, and it is popular in many countries. Many researchers have developed many new products that are the result of the application of Kansei engineering pertaining to emotions (Lokman, 2011).

2.3 Product Design Based on Kansei Engineering

In the 1970s, manufacturers produced a volume of products and people bought them. Since then, the industrial age has changed from “a product-out concept” to “a market-in concept” regarding new product development. Kansei engineering is a scientific method to develop new products from the analysis of customers' Kansei. Because the new product is based on the customer's Kansei data, the new product will be well received by customers, thus becoming a profitable product. We can also analyze what kind of merchandise display customers like or what kind of service they prefer from the data of customers visiting stores. Through stronger participation in the early steps of user experience creation, the Kansei design approach moves the focus closer to the user; it includes not only inspiration methods in the field of Kansei engineering, but also user-centered design and emotional design research fields (Gentner, 2012).

2.3.1 Kansei and Product Development

In a design context, Kansei highlights the designer’s imagery skills: the power to produce a mental image and use this in the creative process. It means when a designer creates a new shape, he or she should enhance the impressions gathered in the process. Generally, people wish to get pleasant feelings from products. Kansei researchers attempt to explore a new approach concerning Kansei in the early phase of design, which would be one of the solution to improve the feeling of pleasure in design (Lee, 2002).

Several factors, both internal and external influences, would affect the consumer’s decision to buy the product, and a consumer’s cognitive evaluation is produced through the

formation of preferences. All the emotions and feelings can affect customer's decision and user experience. This is important in product design. Kansei engineering provides a way to harness those feelings to make more effective products.

The process of design involves Kansei consideration, which is the motivation of Kansei research from the beginning. Indeed, the companies Dentsu and Mazda (followed by many Japanese companies) have Kansei interest in generating new design and marketing methods for their development. The first notable event in the design of Kansei engineering is the creation of Kansei engineering in the 1970s. Since then, many projects using Kansei engineering have been successful internationally. In addition, other research fields on Kansei have been created to expand Kansei knowledge and the potential of Kansei in industrial and commercial activities. At present, a new design method based on Kansei, called Kansei design, is being developed (Pierre, 2007). Ben Salem (2006) proposed the use of Kansei aesthetics as an effective way to convey rich and positive emotions. Kansei aesthetics deals with the aesthetic aspects of properties and attributes. Kansei engineering could be used to study the consumer's aesthetics of feeling and impression, therefore allowing the designer to create products consumers are more willing to purchase.

2.3.2 Applications in Kansei engineering

Kansei engineering has a wide range of applications in industrial and commercial fields. Some Japanese companies use Kansei Engineering to improve their products in different business areas, applying Kansei engineering from the automobile industry to packaging design,

to fabric and furniture manufacturers. Even Kansei engineering applications in residential and plane concepts have strengthened the industrial record of Kansei engineering (Schütte, 2002). This section will explore these applications in more detail.

2.3.2.1 Automotive Industry

In the automotive industry, many companies including Mazda, Ford, Nissan and Honda have already worked on projects based on Kansei engineering. Jindo and Hirasago (1997) conducted a project on vehicle front-end design. Subjective evaluations were carried out by semantic differential methods and analyzed through multivariate analyses. Researchers gathered the results concerning the relationship between characteristics and impression of styling to generate a list of desired feelings of the product.

Mazda implements Kansei engineering in interior design "Persona". In this case, Mazda introduces the concept of "interiorism" in interior design. This means realizing the atmosphere of the reception room inside the car. Secondly, Mazda tried to implement the complete technology and method of Kansei engineering in the development of "Miyata," or the Miata (Ishihara, 2015).

The implementation of Kansei engineering in automotive production, starting from the Cima, through Presia by Nissan Motor Company, has led to innovation and new automotive design. Outside Japan, Italian Fiat and American Ford are very interested in the study of Kansei Engineering. Ford used this technology in the Taurus model, and Fiat has also begun to change the style of the latest car. Porsche, the popular German automaker, has also begun to study

Kansei engineering. In Korea, Hyundai Automobile and Samsung Electronics have made considerable advances in Kansei research (Nagamachi, 2015).

2.3.2.2 Electronic Devices

One of the greatest success stories about Kansei engineering is the change of the traditional heavy camcorder. From characteristics drawn from research into customer Kansei, an innovative recording equipment with an image storage system and a liquid crystal has been created. The LCD view cam became smaller and finally evolved into a digital camera (Nagamachi, 2011).

2.3.2.3 Household appliances

In the field of household equipment, in order to establish Kansei engineering system (KES) for kitchen design, several studies have been carried out. In 1978, Sharp asked Nagamachi to develop a new type of refrigerator design based on Kansei engineering. Sharp was successful in redesigning from Nagamachi's suggestion and all refrigerators in Japan changed to a new style, with the freezer to the bottom and vegetables to the top area (Nagamachi, 2007). Kansei research indicated that consumers desired this change.

Professor Nagamachi conducted Kansei research concerning bras and designed the Wacoal Good –up Bra, which is very popular among ladies and brought a new era to bra design for other companies to follow. The new product used the Kansei experiment and analysis to understand and therefore fulfill the female's needs of being elegant (Nagamachi, 2011).

Ergonomic sense has been added to Kansei research to create a successful toilet design aiming to provide comfortable experience to users. In this research, ergonomics sense is needed to achieve the comfortable feeling; the resulting process is called Kansei Ergonomics.

An experiment was conducted to understand the effectiveness of the handrail presence at Onomichi City University. Matsushita Electric Works incorporated the concepts of universal design and Kansei engineering very early and has been pursuing a variety of new development products. The Kansei engineering philosophy is adopted in most products, such as tile roof, drainage ditch, wall (panel), external structure, bathroom, toilet, kitchen, storage room, lighting, floor heating, etc. (Nagamachi, 2011). Understanding customer desires through Kansei research allowed designers to create building and infrastructure design that consumers better appreciate.

2.3.2.4 Architecture

In addition, KES has been utilized in architectural designs. In 1974, a human living system based on Kansei engineering was applied in the interior design of a live studio. In 1998, a series of different studies involve bridges and surrounding landscapes which calculated the emotional differences of the situation of bridges came into being.

2.3.2.5 Package Design

In mid-November 2007, Nagamachi (2011) prepared a mock-up sample to show the final result of the new package design for Nestle and achieve success. Nestle recommends using Kansei engineering for new product development and creating a Kansei manual for implementation. Through KES, Nestle has created several new products.

2.4 Kansei Engineering Methods

Several kinds of methods have been used in research, and this chapter will classify them in different ways. Kansei engineering methods depends on the thing on which the exposure of emotion is based, and the type of emotion could be different for different people. It is important to consistently understand the Kansei method, where the goal is the design. To do this, we need to collect Kansei data and analyze these data using psychological, physiological, engineering, and statistical analyses to produce useful information (Nagamachi, 2015).

Kansei Engineering (KE) consists of two stages. First, researchers discover the image existing in the customer's mind, and secondly convert the image into design attributes or features. KE is the process of collecting user's perception, determining the relationship between KE and product design, and then generating a database or set of rules (Widodo, 2018).

Mitsuo Nagamachi (2016) proposed that Kansei engineering attempts to produce a new product based on the consumer’s feeling and demand. There are four points concerning this technology:

1. Grasp the consumer’s Kansei about the products in terms of ergonomic and psychological estimation.
2. Identify the design characteristics of the product from the consumer’s Kansei.
3. Build Kansei engineering system as an ergonomic technology.
4. Adjust the product design to the current societal change in people’s preferences.

Mitsuo Nagamachi (2011) proposed that there are two points in product development and customer Kansei utilization. First, when customers see a new product, they feel attracted to the product, and then they touch it and check whether it affects their feelings. When they touch without feeling the impact, it means that the opportunities for contact with customers are not developed, and there is low opportunity to buy products. The attractive elements of product appearance include the shape and color, which hold an attractiveness characteristic and attract the eye to the product. The effectiveness of this attractive feature is the result of Kansei analysis, which must be considered in design.

Secondly, when customers feel attraction, they will also feel the impulse to buy and try products. Unexpectedly, their faces sparkles. Feeling attraction on the face is called the *Primary first moment of truth* (*FMOT*). When attraction comes after purchase, it is called *Secondary FMOT*. If designers can create a new product with this characteristic, it will be a great success.

So far, according to Kansei research, the first element of creating attractiveness is the structure of color, which represents 70-80% of attraction. The second factor is shape, and roundness design is greatly affected. Designers can use Kansei analysis to get the weight of factors and conduct new design based on the analysis (Nagamachi, 2011).

2.4.1 Psychological Methods

Kansei is a psychological phenomenon. In order to use Kansei to develop and improve products by using Kansei engineering method, it is necessary to measure and analyze Kansei in terms of psychology.

In the psychology area, there are two main methods of sensation measurement: magnitude estimation and category method. Magnitude estimation examines the senses ratios between two stimuli. Category method tests the related categories or differences of different stimuli. The stimuli in Kansei research includes all the external stimuli including light, voice, smell, which could have effect on human Kansei. The Likert scale is a category method, most commonly used in different fields of psychology and Kansei engineering to quantify human Kansei.

2.4.1.1 Semantic Differential

One of the most frequently used psychological methods is the semantic differential (SD) experiment. In the mid-1950s, a social political psychologist, Charles E. Osgood, developed semantic differentials, which is the measurement method for connotative meaning of objects (Osgood, Suci, & Tannenbaum, 1957). To test the difference in semantic meaning between terms, the method employs pairs of words at opposite ends of a continuum. The choice implies judgment and evaluation of those terms, as well as the association among words.

Theoretical thoughts of semantic differentials are established as these three issues (Osgood & Suci, 1955):

1. A continuum is defined by an evaluation word pair which has opposite meanings. The description, judgment and evaluation process can be situated on the continuum.

2. The continuum is equivalent to judgment and evaluation. Different continuums which have similar responses and meanings can be merged.
3. Semantic space can be defined from association structure. Semantic space is proposed in a series of factor analysis studies by Osgood. Some pairs of words are strongly correlated, while others are negatively correlated.

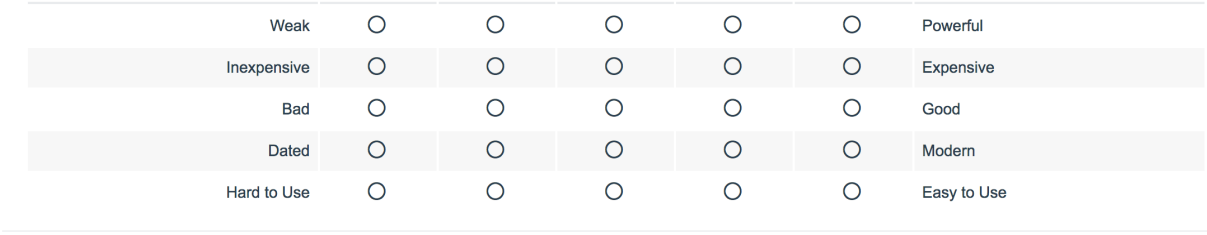

Figure 3

An example of semantic differential questionnaire

Osgood used differentiated antonyms like *soft—hard*. In Kansei engineering research, Nagamachi proposed that it's better to use denial words like *soft—not soft* instead of antonyms. In Kansei engineering, adjectives, nouns, technical terms, and jargon are often used for SD evaluation and these Kansei words are regarded as evaluation words in SD experiment.

Although some people criticize that psychological measurement cannot be objective because of the arbitrariness of responses, if the method of preparing questionnaires and the method of implementing measurements are proper, the arbitrariness of responses can be eliminated considerably (Nagasawa, 2000). In this case, it is important to ensure the

questionnaire used in an SD experiment is reliable so that Kansei researchers can employ the chosen characteristics are employed in design systematically.

Mamaghani, Rahimian and Mortezaei (2014) conducted Kansei research on ketchup sauce bottle design, and a semantic differential experiment was employed during this research. During this study, 8 types of sauce bottles and 31 Kansei words were selected. All of the 47 participants were in Tehran, including 23 males and 24 females. Researchers used 5-point semantic differential scale to determine the relationships between products' features and adjectives. It is the typical SD test procedure. Finally, the data was analyzed by SPSS software through multivariate statistical techniques. The consequence of the experiment could support consumer's preference of appearance of sauce bottles, and this data can be a useful reference to designers in following product production.

2.4.2 Physiological Methods

The Kansei process assembles functions related to emotions, sensation, feelings, experience, intuition, and interactions between them. Kansei is a complex psychological process that cannot be measured directly even with intrusive methods such as Functional Magnetic Resonance Imaging (FMRI). Therefore, Kansei can be measured indirectly by measuring human physiological and behavioral responses.

The consumer's physiological responses (e.g. electroencephalogram, functional brain imaging, heart rate, eye gaze movements, electromyography (EMG), etc.) are correlated with user's Kansei. Kansei researchers often use the physiological methods to physiologically

quantify the amount of feelings produced by outside stimuli using autonomic nervous reflexes and brain waves. With the development of technology, the range of techniques researchers use has widened. There are several methods widely used, including EMG Measurement, EEG Measurement, Musculoskeletal Model and Eye-tracking technology.

2.4.2.1 EMG Measurement

The electromyogram (EMG) measurement is a basic strategy to record specific responses evoked by particular stimuli from external environment. EMG technology has been used in Kansei research to find physical phenomena related to environmental stimuli, and this method can help designers to measure user's experience in a reliable way.

Nagamachi (2011) examined two types of shavers using EMG measurements to make a comparison of the voltages to the muscles from these shavers. Additionally, a piezo pressure sensor was used to measure the pressure to the face of each shaver. As shown in Figure 4, after conducting EMG experiment to test pressure the face experienced during usage of the shaver, the statistical tests had been conducted. Researchers found that the new pen-grip shaver reduced 22% of the forearm EMG and decreased 85% pressure to the face, which provided better Kansei

such as comfortable and relaxing to customers.

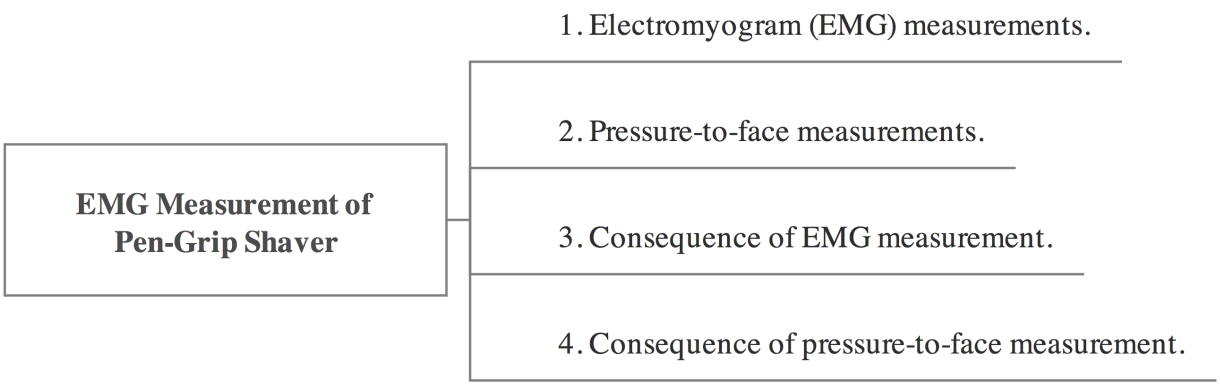

Figure 4

The Process of EMG Measurement of Pen-Grip Shaver.

The effectiveness of physiological method relies on the result of experiments. In order to obtain the best results, physiological experiments should be planned to keep the conditions unchanged, and the fluctuation factors including individual differences should be excluded by taking inbred animals as an example (Ozaki & Iwamoto, 2006). Ensuring stability of conditions and factors makes results more reliable and valid, which increases their usefulness in Kansei research, thereby ensuring chosen design characteristics elicit intended responses in customers.

2.4.2.2 EEG Measurement

In Kansei engineering area, Professor Yoshida pioneered the use of EEG (electroencephalogram) measurement and analysis techniques to measure frequency and quantity of alpha wave (8 to 13Hz) from the frontal lobe. Yoshida (2000) discovered alpha wave fluctuation relates not only to comfort, but also enjoyment. His innovations are based on massive measurements and statistical considerations of the wider frequency

range of alpha fluctuation. Through exploring the alpha waves of humans, the relation between consumer Kansei and products will be more clear.

In the study that Yoto et al (2013) conducted, memory task performance was explored. Researchers examined the user's central nervous activity after they smelled two kinds of Japanese green tea to find out the differences of user's feelings of these two kinds of green tea, including physical and psychological responses. During this experiment, EEG was recorded before and after smelling the test samples, and 4 frequency bands (alpha 1, alpha 2, beta 1 and beta 2) have been taken into consideration.

A cognitive type of brain-machine interface (BMI) system is being developed by Ryohei P. Hasegawa (2017) and other researchers. This system is an EEG-based communication aid for people with severe motor disabilities, which can analyze an event-related potential (ERP) to consecutively flashed pictograms to signify a desired significance, and even predict the user's choice in the brain. Such an interface would allow Kansei research to be extended to include more people with a wider range of abilities, thereby helping researchers employ these methods to make design more universal as well as attractive.

Nakanishi, Baba and Li (2011) proposed that brain waves indicate unconscious brain activity, which can be collected as biometric data, and doing so enables constant or on-demand verification what is effective in user research. In the authors' study, the authentication performance of the brain was evaluated by using a simplified driving simulator and the α-β band

was divided to several partitions. Now, α-β band is regarded as essential brain behavior to measure in Kansei engineering research.

Zhang et al. (2006) succeeded in connecting comfortableness and brain wave fluctuation. According to research in the automobile industry field, the extent of comfortableness could be extracted from the EEG measurements. As a result of finding this relationship, it was determined that the changes in wave fluctuation respond to changes in psychological conditions. Through the spectrum analysis of fluctuations wave, Zhang determined that the frequency fluctuation of waves shows a moderate rhythm (characteristic close to 1/f) when in a relaxed condition, while such characteristics decrease when in uncomfortable condition. Being aware of such physiological changes helps researchers to identify not only what customers are saying, but also their subconscious responses, which aid in guiding design decisions.

2.4.2.3 Eye-tracking technology

Human eye movement delivers strong evidence for the location of meaningful content in an image or scene. When the position of the meaningful content changes, eye movements change accordingly. This basic fact about human vision explains the need for algorithms that simply quantify the focus area of the observer. These methods are not only effective and time-saving tools for conducting psychological research on eye movements, but also an essential component of human-machine interfaces using eye tracking technology (Santella & DeCarlo, 2004).

Eye tracking studies on how subjects deal with multiple-choice questions show that unsuccessful subjects are less able to distinguish irrelevant information when solving scientific

questions, and successful subjects spend more time examining relevant information than irrelevant information (Tsai, Hou, Lai, Liu, & Yang, 2012). Image viewing behavior depends on the characteristics of the image itself, people's expectation of where to find information, and the current task or information needs. The picture of products can be considered as specific types of images (Wieser, 2009). Eye movement may also be part of the stimulus, not just the response. The gaze-contingent display is a technique in which the stimulus changes depending on the people's viewing position (Feng, 2011). From the result of these studies, it can be indicated that people pay more time gazing at the part which the brain regards as meaningful information.

Kim (2014) proposed that the eye movement behavior has several implications for understanding search behavior. The more attention paid to a particular area, the more important the information there is than that in other areas (Poole & Ball, 2006). Longer average fixation duration is also an indication of task complexity (Just & Carpenter, 1976).

Based on the eye-mind theory, the eye tracking technology is usually used to detect human visual attention (Just & Carpenter, 1980). Generally, gaze position reflects attention, while gaze duration reflects processing difficulty and attention (the longer the information is gazed at, the more complex it is or the deeper it is processed). Additionally, the gazing time varies depending on the type of information and the type of task (Hyönä, Lorch & Kaakinen, 2002). Furthermore, the scanning path pattern shows the cognitive strategies used by individuals in goal-oriented tasks (Gandini, Lemaire & Dufau, 2008).

The eye-tracking method has been successfully applied in reading and information processing research, arithmetic problem solving, human–computer interactions and emergent literacy. Within these studies, researchers are particularly interested in how students solve problems in science (Tsai, 2012). This research can provide evidence of the human cognitive science, which is important reference of Kansei study.

Some limitations of eye-tracking methodology cannot be ignored. Although eye movement analysis reveals which parts of information have been noticed, including when, how long and in what order, it does not explain why these parts of information have been noticed and focused on. In addition, there is ambiguity in the interpretation of eye movement measurement: long gaze time may indicate that focused information is interesting for the tester, but it may also indicate that it is confusing or problematic for the tester (Holsanova et al, 2009).

Another possible limitation is the fuzziness of associating eye movement data with concepts. Eye tracking provides data about perception and cognitive processes through visual attention allocation, but it does not show what receivers think and feeling. Researchers cannot judge which aspects and attributes of image elements have been paid attention to, or at what level of abstraction, just from eye movement protocols. Some frames of reference are still needed to conclude the ideas corresponding to these gaze points (Holsanova, 2013). In this case, a tool called semantic differential method can be used to explain the meaning of human visual behavior. In fact, different measurements can be combined together to achieve different results.

2.4.3 Types of Kansei Engineering Techniques

As mentioned earlier, today's Kansei engineering is widely spread to many areas of industry. Many researchers work in this field and have contributed to the development of Kansei engineering. In addition, Kansei engineering is expanding in many new areas, including new innovative tools added to the original methodology. As a single methodology, Kansei engineering has become more and more complex due to its diversity of applications.

Nagamachi (1997) collected many applications related to Kansei engineering and grouped them according to the methods included. From these groups, he identified these tools as types of Kansei engineering. Six types of KE techniques have been developed which include Category Classification, KE computer system, KE modeling, Hybrid KE system, Virtual KE, and Collaborative KE. While the initial KE technique (type one) used some qualitative techniques, later techniques began to use more sophisticated quantitative and computer-based methods.

2.4.3.1 Kansei Engineering Type I - Category Classification

The first category of Kansei engineering is the easiest to understand and introduce. This method decomposes the concept of target product into more detailed concepts and extends them to multiple levels. At the same time, it will be interpreted according to the physical characteristics of product design. The steps to implement this method can be described as follows.

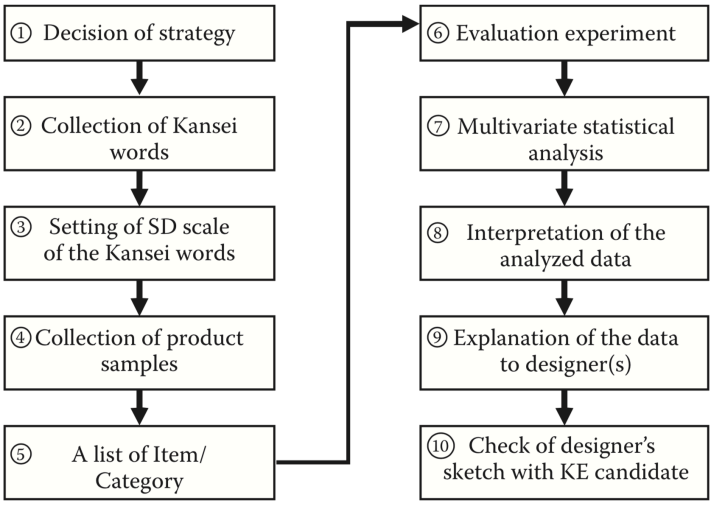

Figure 5

The Process of Kansei Engineering Type I (Nagamachi, 2011)

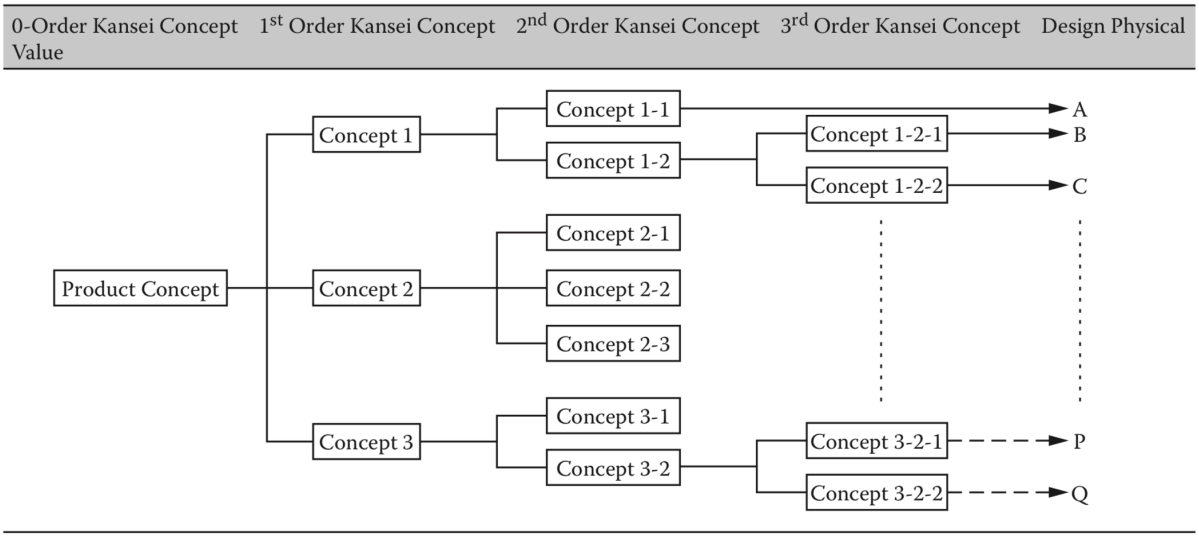

Figure 6

Conceptual map of Kansei engineering method Type I (Nagamachi, 2011).

Category classification is a method of decomposing Kansei categories into tree structures to obtain design details. In type I of Kansei engineering, product strategy and market

segmentation are identified and developed into a tree structure to identify customers' emotional needs. These emotional needs or Kansei are manually connected to product attributes.

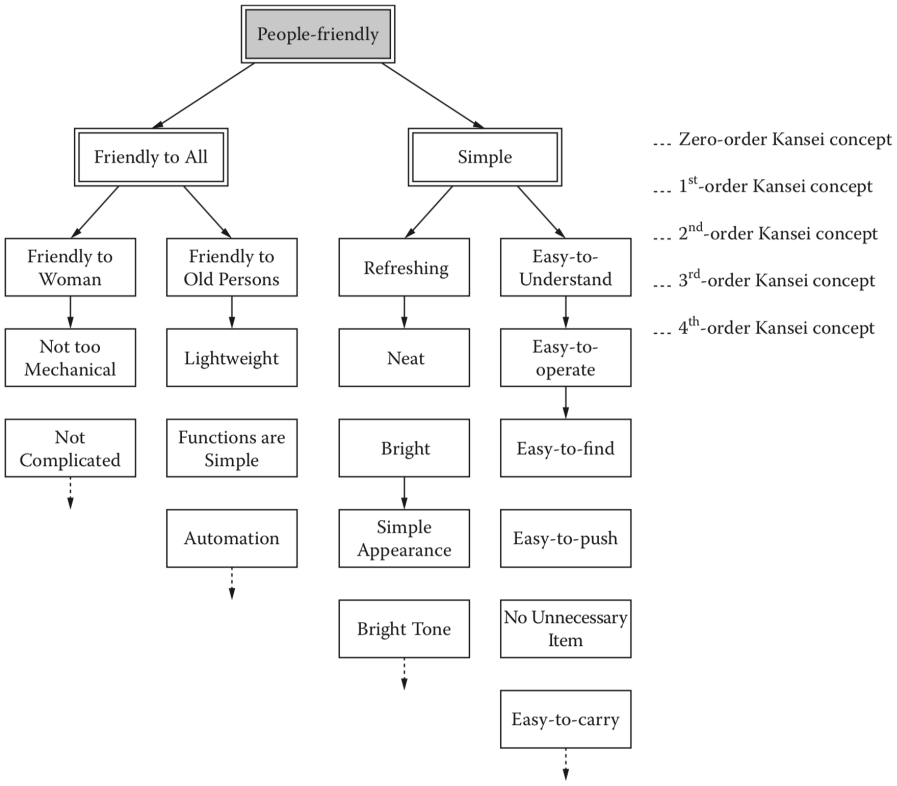

Figure 7

An example of deep order Kansei concept (Nagamachi, 2011).

Nagamachi (2011) proposed the process of Kansei engineering type I as follows:

1. Identify the target market group includes determining the range of customers and how to handle those people's Kansei.
2. Decide what kind of product concept should be incorporated into the new product development.
3. Break down the product concept into several levels so that physical design

characteristic can be properly assigned.

4. Deploy physical design characteristics to a deeper Kansei level. Different levels of Kansei concepts will define the Kansei need more clearly and accurately as shown in Figure 7.
5. Translate characteristics into technical specifications in the new product design.

2.4.3.2 Kansei Engineering Type II - Kansei Engineering System

Kansei Engineering Type II is a technology that transforms the feelings regarding an image or Kansei of products held in consumers' minds into tangible product design elements. The order for the Kansei engineering Type I begins with the decomposition of concepts and reflect them into the physical characteristics of design. Then the physical characteristics are transformed into technical specifications. Kansei engineering Type II is similar to Type I, and they both start from Kansei concepts. However, the difference between Type I and Type II is that the Kansei concepts are transformed into physical design characteristics using Kansei engineering technique (or *translation technique*).

Nagamachi (2011) proposed that the essential elements for the Kansei engineering Type II as shown in Figure 8 are the following three main points:

1. Cover all the Kansei consumers hold in their minds regarding the object, and establish the database that consists of all these Kansei.
2. Establish the design database that consists of all the design specifications related to the product.

3. Develop an inference function capable of connecting the Kansei and design specification.

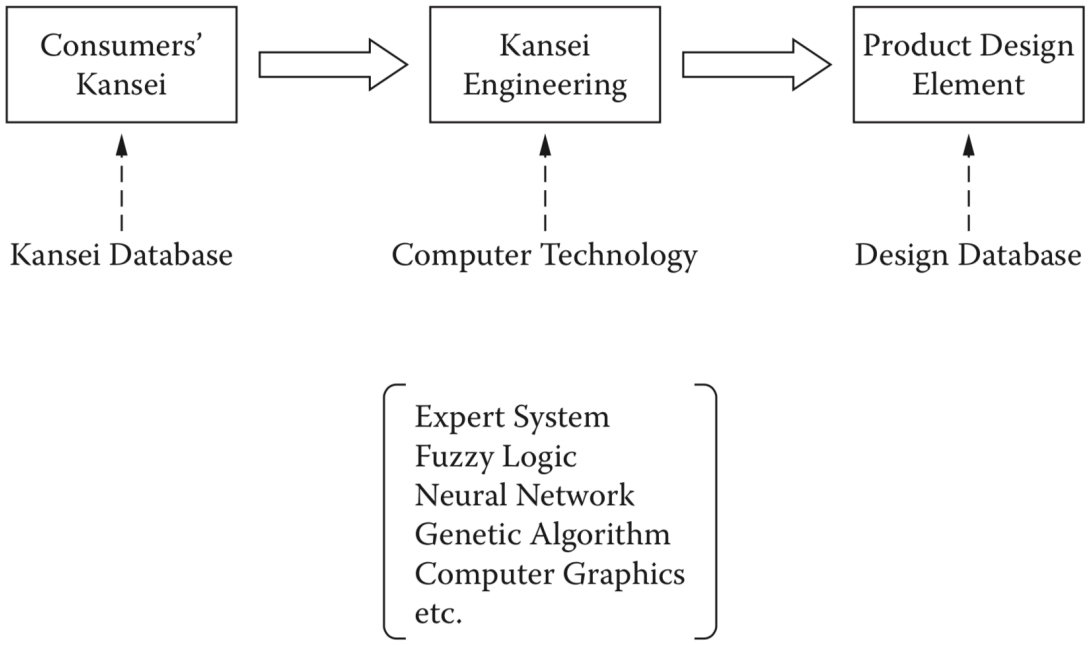

Figure 8

Translation process in Kansei engineering Type II (Nagamachi, 2011).

Kansei engineering II and computer techniques are used to build this kind of intelligent system. An expert system, neural network, genetic algorithm and other technologies related to computer science are employed in building intelligent systems. Fuzzy logic can also be used if necessary. At present, Kansei engineering Type II is the most widely used application of Kansei engineering in computer technology (Nagamachi, 2011).

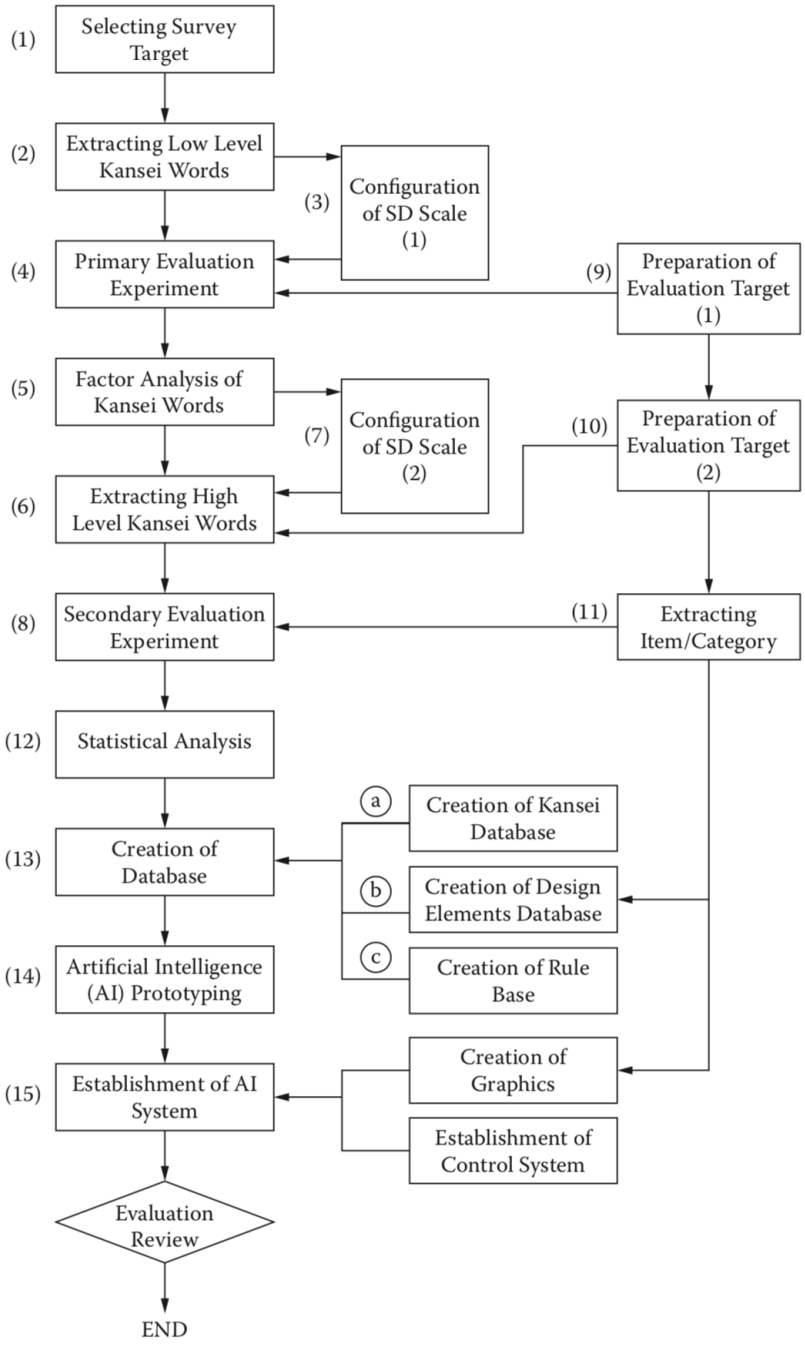

Figure 9

Kansei engineering Type II procedure (Nagamachi, 2011).

A consumer decision-making system and designer support system have been developed based on Kansei engineering, and the Kansei engineering system can be roughly divided into

these two systems. This thesis will concentrate on the designer support system by conducting Kansei research.

Nagamachi (2011) proposed that consumer decision-making system helps people make purchase decisions when choosing products by matching consumers' Kansei. Designer Support System (DSS) is a system that is applied as a reference for designers when designers create new products by matching the Kansei of the target product. At the same time, the system could identify how close the design is to the expected Kansei.

2.4.3.3 Kansei Engineering Type III - Hybrid Kansei Engineering System

Nagamachi (2011) proposed that a hybrid Kansei engineering system includes both forward Kansei engineering system and backward Kansei engineering system into computer.

The advantages of hybrid Kansei engineering system are as follows:

1. Designer can create the concept of the new product and input it into the forward engineering system to get a rough idea of the design.

2. Designers can not only add their own creative guides, but also sketch the product according to the idea from the system, and then use the backward Kansei Engineering system to recognize the types and specifications of new concepts.

3. Through continuous use of forward and backward systems, designers can design products that match consumer's Kansei and add designer's creativity.

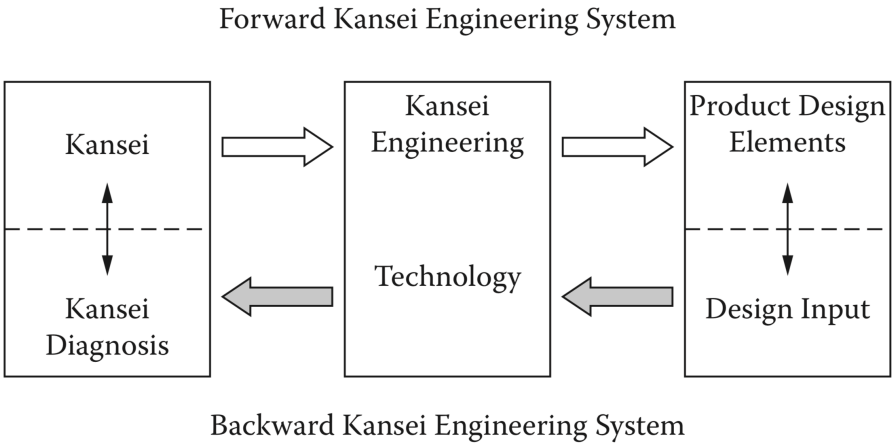

Figure 10

Schematic diagram of hybrid Kansei engineering system (Nagamachi, 2011).

The schematic diagram of hybrid Kansei engineering system shows that, by using a hybrid Kansei Engineering System, designers can obtain design specifications from Kansei words through forward Kansei engineering. From the consequence of the system display, the designer can receive the suggestions supported by the system and develop new product designs. Then, the designer inputs his or her new sketch of the product into the system, and the backward Kansei engineering identifies the designer's sketch through the image recognition system. Finally, the system analyzes the inputted sketch by referring to the Kansei database, which helps the designer to evaluate the Kansei value of the new design concept. This process can be regarded as a kind of positive feedback loop and designers can use this system to develop and complete designs.

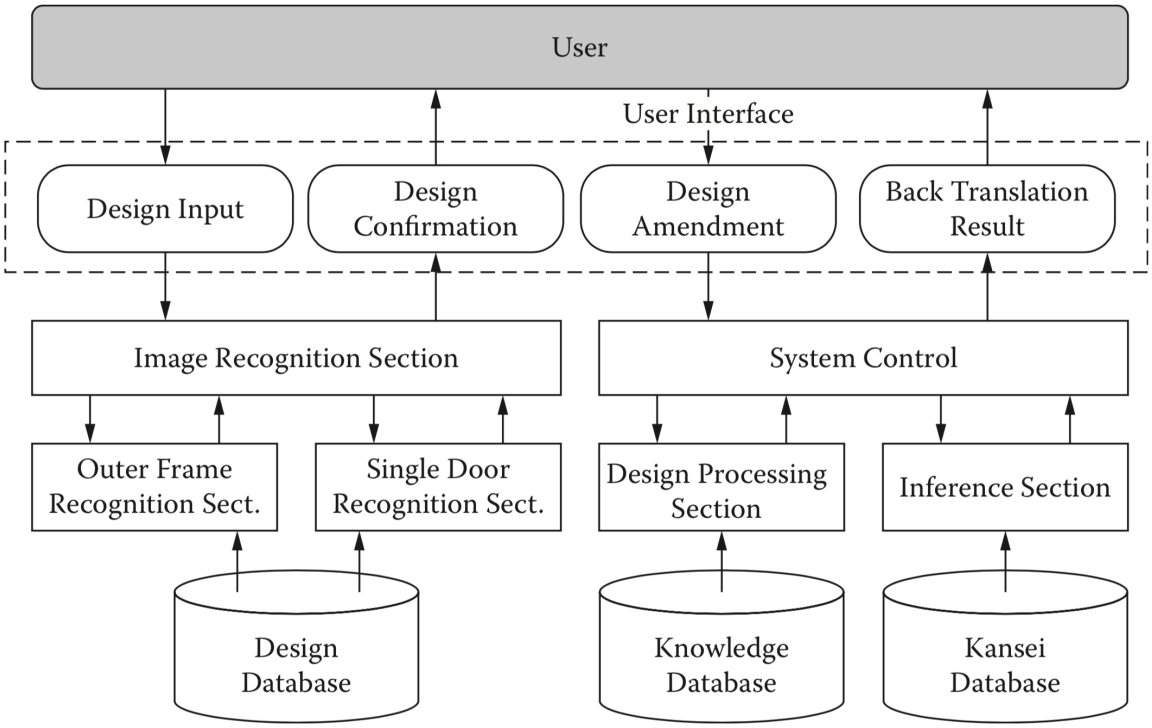

Figure 11

The Hybrid Kansei Engineering System structure (Nagamachi, 2011).

2.4.3.4 Kansei Engineering Type IV - Kansei Engineering Modelling

In this type of KE, a mathematical model is built to predict the Kansei response of consumers and this model is called Kansei Engineering IV, which utilizes the mathematical model built in a computerized system. In this technology, a mathematical model is a logic like a rule base.

Starting from Kansei research, the process reflected in physical design characteristics is the same in type III of Kansei engineering. The difference is that in type IV, the mathematical model is mediated by researchers and the relationship between input and output (physical characteristics) is established by looking for coefficient values.

Ishihara (2015) proposed that Sanyo Electric tries to realize Kansei fuzzy logic as machine intelligence in color printers. An intelligent color printer is composed of a camera, computer and color printer system with fuzzy logic. This printer can diagnose the color of original image and print more beautiful color image according to fuzzy logic. Nagamachi (1999) developed a computer diagnosis system for Japanese language sense by using fuzzy integral and fuzzy measure logic. This is used to diagnose brand sensation, and some Japanese companies use this system to determine the name of the good feeling of a new brand product.

From the point of view of the transformation from Kansei to product design elements and the system of Kansei diagnosis from design input, the type IV system is an effective way to support designers to develop new designs.

2.4.3.5 Kansei Engineering Type V - Virtual Kansei Engineering

Virtual Kansei engineering can be used in urban planning or landscape design, as well as in testing the exterior and interior design of buildings. Nagamachi (2011) proposed that virtual Kansei engineering is a combination of virtual reality technology and Kansei engineering technology. This type replaces the presentation of real products with VR representations. A joint project of Matsushima Electric Works Ltd (MEW) and Hiroshima University applied VR Kansei Engineering technology to kitchen design.

Virtual Kansei engineering is the first technology in the world that integrates Kansei engineering and virtual reality. This system has been used to provide products that can satisfy user's needs in a MEW custom kitchen. People can virtually walk through the room design

developed by designers by means of a head mounted display (HMD), and the consumer's Kansei evaluation towards the design can be collected for designers to conduct deeper analysis and research (Ishihara, 2015). In Kansei research, it is expensive to create a real house to conduct a test, but it is important to know the customer's Kansei desire. In this case, the virtual reality technology can be used as an efficient tool to build a virtual house to conduct Kansei research and to ascertain user's Kansei demand.

The procedure of virtual Kansei engineering is similar to the traditional experiment, but virtual reality technology has been added to the Kansei test to help customer to select samples. Nowadays, VR technology plays an important part in customer decision-making process.

2.4.3.6 Kansei Engineering Type VI - Collaborative Kansei Engineering Designing

Since an expert system (a type of artificial intelligence) in a computer can display the images that match each Kansei, the Kansei database needs to be created. Collaborative Kansei Engineering Designing is Kansei Engineering Type VI, a type in which the Kansei database is accessible through the internet. Collaborative Kansei Engineering Design or Internet Kansei Design System (IKDS) is an Internet-supported Kansei Engineering System. This kind of design tool is used to conduct Kansei Engineering studies with software and databases through the internet.

KES can be assessed publicly by using the Internet, which provides an opportunity to combine the views of customers and designers. This system can shorten and simplify the early development phase. Although IKDS has not been developed completely, it could provide many

positive outcomes, such as collaborative work of participants, efficiency of product development speed, effective dialogue between consumers and producers。

2.4.4 Statistical Analysis for Kansei Engineering

Statistical analysis plays an important role in Kansei engineering research, and it is used to find potential relationships between various designs and user feelings. Hayashi's Quantification Theory Type I theory is used to discover Kansei design information from Kansei experimental data. This method is a variant of linear multivariate regression analysis, and the nominal scale values can be treated as explanatory variables. The most commonly used multivariate prediction technology in behavioral science is linear multivariate regression, which could indicate some linear relations between x value and y value. For example, when x value changes, y value changes linearly.

Nagamachi (2011) proposed that multivariate analysis is commonly used in Kansei engineering because Kansei is multidimensional in nature. When using multivariate analysis in Kansei Engineering, the following steps are usually taken:

1. Use principal component analysis (PCA) to obtain Kansei structures, multidimensional scaling method and factor analysis.

2. Use cluster analysis to classify samples into groups with evaluation similarity and get the sample clusters, each of which has different decisive design structures. Compared with the traditional clustering algorithm, the clustering algorithm based on neural network has higher clustering accuracy.

3. In order to obtain the relationship between Kansei and design details, several analyses will be tested to determine the appearance and functional types of Kansei information generation.

4. In the statistical model, the local regression method is used to consider the non-linear relationship between design elements and perceptual evaluation. This is a convenient tool for visual investigation of uneven local relations between design elements and Kansei evaluation.

5. Use correspondence analysis to map different design elements to visualize the results. Furthermore, use local regression method with these analyses to provide three-dimensional representations of relations between design and Kansei evaluation.

2.4.4.1 Principal Component Analysis

Human Kansei is very complex, so multiple measures are needed to analyze it. Many Kansei vocabulary measurements used in semantic differential experiment produce multidimensional evaluation data. Kansei researchers use lower dimensions or variables to describe the characteristics of the evaluation data so that the result of Kansei research can be understood readily. The dimensions are compressed to get the data structure through the statistical process of dimension reduction. This is why principal component analysis (PCA) is used in Kansei engineering. Factor analysis and PCA are calculated through similar procedures, and their results are presented in similar ways. Even though these two analyses involve similar calculations, they involve opposite premises.

Researchers should be aware that the software SPSS – one of the most commonly used in KE studies – only has factor analysis as a menu option, but when conducting the analysis with all

options by default (principal components extraction, no rotation) it is in fact doing a principal component analysis. Researchers can use PCA measurement to find the principal components which are shared by all variables, while factor analysis represents data with common factors shared by all variables and unique factors that are particular to a variable. The unique factor corresponds to the residual of the linear model (Nagamachi, 2011).

One method of factor extraction in PCA is using principal components. In this case, factors are the same as in a principal component analysis. If only two factors are selected, these two factors are exactly the same as the first two principal components. But other methods of factor extraction are available; a common one is maximum likelihood. In this case, if only two factors are selected, they will be different from the first two principal components (and different from selecting three factors or just one).

Principle components can be used to conduct factor extraction in factor analysis. If there are only two factors, these two factors can be regarded as the same as the first two principle components. While there are other methods to extract factors, the most common one is the maximum likelihood method. In this case, if there are only two factors are selected, they have different meaning from the first two main components.

2.4.4.2 Linear Regression Analysis

Linear regression analysis has been intensively used in Kansei engineering studies. This type of statistical method is convenient to show how one independent value has influence on

another dependent variable. In the case of two explanatory variables, a multiple linear regression model is as follows:

$y_i = a_1 x_{1i} + a_2 x_{2i} + b$

x1, x2, ... np are called explanatory variables (independent variables), and y is called an objective variable (dependent variable). Commonly, the task of multiple regression analysis is to find out a_1 and a_2, and the weights for variables x_1 and x_2 by using all samples respectively.

If the weight a_1 is positive and a_2 is negative, it means x_1 has positive effect on y and x_2 has positive effect on y. If the absolute value of a_1 is larger than a_2, it means the change of x_1 can affect y more strongly. This feature of regression analysis can be used to Figure out the relationship between design elements and user's Kansei.

2.4.4.3 Partial Least Squares Regression

Partial least squares (PLS) was developed in the mid-1970s by the Swedish econometrician Herman Wold and his colleagues. The most popular applications of PLS have been applied in the chemometries field since 1990s. In these studies, the number of instances of x may be up to several hundred, with a very high degree of correlation between the x and y variables. Furthermore, the y variable is a measured value. PLS is gaining importance in many fields of chemistry; analytical, physical, clinical chemistry and industrial process control can benefit from the use of the method.

By using PLS analysis, researchers can obtain the precise numerical model of the relationship between design elements and user's Kansei. In other words, the PLS results reflect a small deviation from the sample. Even though PLS is reliable, it is important to assess whether the results accurately reflect consumer trends or are distorted by a particular sample (Matsubara, 2011). Failure to do so may result in design characteristics being chosen that do not reflect actual customer Kansei.

In the multiple regression model, when the number of variables exceeds the number of samples, the simultaneous equation can not be solved. In many cases of Kansei engineering, the number of design variables is larger than the number of samples. Then, the analyst must divide the design variables for analysis. The other defect is the interaction between X variables. If the interaction between X variables is very heavy, the analysis results will be distorted (Nagamachi, 2011).

2.4.4.4 Quantification theory type I (QT1)

Quantification theory type I is one of the most commonly used methods in KE studies and it attempts to quantify the relationship between the user's Kansei and the design elements. It is merely a multiple regression model, but with some smart features.

An item of a product is a design element (variable) that is supposed to contribute to Kansei. This could be a color or shape. Properties, usually called design factors in the field of factorial designs, are here named items. Marco-Almagro (2011) proposed that each item has

several categories or levels. All regressors in the equation will consequently be qualitative, while the response is quantitative (the mean of all participants' ratings to a Kansei word).

Multiple linear regression analysis deals with interval or scale explanatory variables. However, design elements such as color selection, functionality, the presence of illustrations cannot be expressed in quantity or order. QT1 is a development of the multiple linear regression analysis which deals with nominal scaled explanatory variables and an interval or a proportionally scaled objective variable. In other words, each variation of a design element can be assigned to a nominal scaled explanatory variable and then researcher can perform multiple linear regression analysis. In the quantification theory, a design element is regarded as an item, and each level or type of a design element is a category (Nagamachi, 2011). QT1 is an effective tool for Kansei analysis to find out relationship between design element and user's Kansei. By using the results of QT1 analysis of customers and designers, a considerable amount of Kansei design knowledge and many successful products have been created.

2.5 Perspectives on Kansei Engineering

Nowadays, product design is becoming more and more comprehensive since the customers are becoming more intelligent and the choices are increasing constantly. The success of a product not only depends on competitor analysis and on its quality, but also relies on the consideration of customer's feeling towards product.

Traditional product development is based on business case logic. Although some people believe that products must be market-oriented or customer-centered, products are still designed

from the company's perspective. At this time, products based on company strategy are far from Kansei concept. Therefore, introducing a proper tool to the process of new product development to measure customer feelings is important. Kansei Engineering is such a tool that captures and transfer customer feelings about a product into specific design parameters (Rajaseker & Karunasena, 2013).

In the view of the trend of development of technology including big data application in design process, Kansei engineering has the potential to realize wonderful success in industry field. In recent years, "Kansei' has been noticeably taken up by academic conferences and academic societies, as well as at the Japanese governmental level (Nagasawa, 2004).

With the development of technology, more advanced tools have been created that have the possibility to be used in Kansei research. Thus, we can broaden our perspective and try to use new techniques to conduct Kansei experiments and gain more correct and deeper analysis of customer's Kansei. All these methods, including SD test, EEG measurement, eye-tracking experiment, can contribute to a successful design procedure.

Chapter 3 Research Approach

3.1 The Overview

This study will explore an application and development of Kansei research based on eye-tracking technology, including conducting a semantic differential experiment. The main feature of this research approach is that the design characteristic classification is based on the result of an eye-tracking experiment of product samples. Furthermore, a data based design method will be proposed to make the best use of all the experiment's results. The process of the Kansei research is as follows.

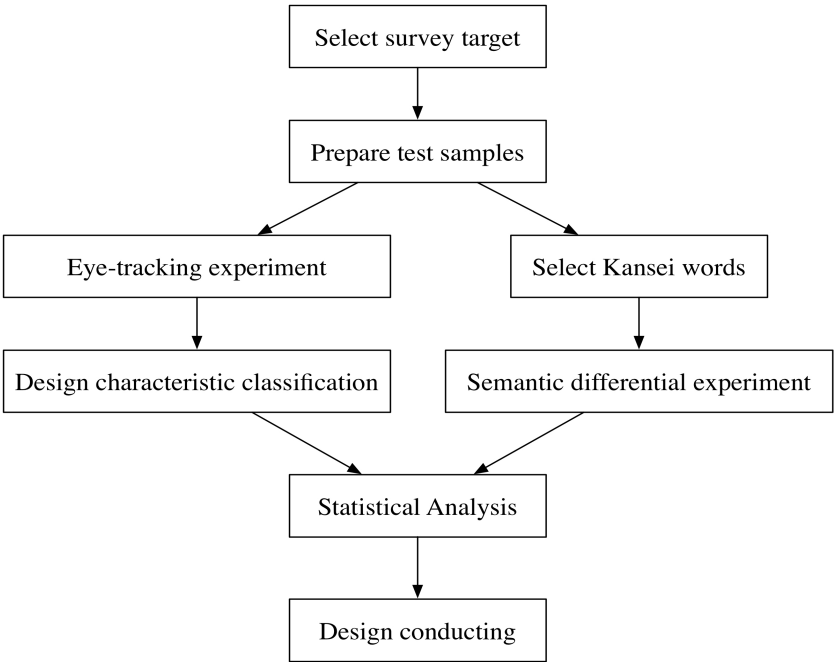

Figure 12

Process of the eye-tracking-based Kansei research

In this research process, after selecting the target product and selecting test samples in specific ways, researchers can begin eye-tracking experiments and selecting Kansei words at the

same time. Eye-tracking experiments can support evidence about user's concentration and interest, which can be used as strong references for designers to classify categories, while an SD experiment can quantify user's feelings in detail through questionnaires. Thus, the eye-tracking experiment and semantic differential (SD) experiment are both essential processes to conduct statistical analysis.

The main purpose of this research method is to combine a combination of eye-tracking experiment and SD experiment to find out how different design elements affect customer's Kansei. With categories of different items, linear regression analysis is used to Figure out the relationships between design characteristics and customer's Kansei. Finally, a new design can be developed according to specific results of this research.

3.2 Selecting Survey Target

The kind of product that will be designed in the Kansei research is named "survey target", which could include various products. However, some rules and limitations should be recognized to help designers to select proper products in Kansei design. This study proposes the following requirement of selecting the survey target:

1. Different types of this product should have significant appearance features and can be distinguished from others easily.
2. There are many types of this product so that there are enough test samples that can be used in following experiment.
3. There is a large population who have experienced using this product. In this case, it

will be easier to find enough participants to take part in the SD experiment and data could be more exact.

4. Making sure of the appearance of this kind of product is an important factor in customer purchasing process; otherwise, the result of the research will be insignificant.
5. The product whose structure is too small for customers to see clearly is not proper for this research.

All the limitations of collecting survey target process are aimed to ensure the research can produce reasonable and meaningful results. Not all kinds of product can be used as target product in this type of Kansei research, and using improper products could result in failure.

3.3 Preparation of Evaluation Samples

The samples used in eye-tracking experiment and SD experiment are selected by designers. However, due to the different preferences of designers, some principles of selecting samples should be set to make sure the products types are chosen randomly, and the samples include the majority of types of this kind of product.

Due to the limitations of the resources and environment, sometimes there are not enough real products to be used as samples in the experiment. In this case, VR technology can be used to provide a 720-degree view of the product by making 3D models on the computer. Additionally, the images of products can be used in some situations. This study supports some references of selecting evaluation samples for Kansei research in this study:

1. Choose a wide range of brands' products to avoid the consequence that samples share

the similar design style.

2. Choose products which do not have strange and unique characteristics, since strange look will result in a gaze without meaning in the eye-tracking experiment. Furthermore, a unique design will produce more problems in analysis process.
3. When selecting samples from many products, delete those who have the same look and leave only one sample from them. If many samples with the same appearance are selected, it will result in over-representation when conducting analysis, which can skew results.
4. If images are used in the experiment, make sure all the pictures are the same size, in the same view and in HD. If necessary, images can be edited by software.
5. If the number of samples is too small, the category classification will be affected strongly. Commonly, the more complex the product is, the more samples are needed because the categories of this product will increase with the increase of the complexity of the product.
6. The differences of actual dimension of samples cannot be too large. Since the image cannot show the dimensions of products, it is better to choose samples which have similar size.

If there are additional requirements of samples and research, designers can revise the principles of choosing proper samples. It is sufficient to collect 10 to 20 samples in most cases.

3.4 Selecting Kansei Words

In the semantic differential experiment, proper Kansei words are essential for designing the questionnaire. Kansei words, including adjectives or descriptions can be collected; adjectives can be more easily understood. Nagamachi (2011) proposed several methods to collect Kansei words related to the survey target:

1. Record dialogues between customers and marketing staff where selected products are sold, and write down the Kansei words related to consumer's discussions.
2. Look for descriptions of the product from related catalogs, magazines and books. Then list all the Kansei phrases and words.
3. Search for Kansei words in dictionary and select proper words for this specific product.
4. Ask product designers for product descriptions, and obtain Kansei words from these descriptions.

All the steps of selecting Kansei words above are aimed to collect many Kansei words. Then, designers could begin narrow down the list to the most important ones. Commonly, the number of the Kansei words finally selected is smaller than 20. Since designers are sensitive about these words related to products, it is efficient to ask designers in order to get useful Kansei words.

There are several ways to narrow down the Kansei words and designer can choose to perform the primary evaluation experiment and conduct factor analysis for Kansei words. This is

a reasonable way to select Kansei words for the actual experiment. However, this study proposes a more efficient method to narrow down the Kansei words:

1. Arrange Kansei words and divide them into different types according to their dictionary explanation.
2. Select one typical word from each type of words.
3. Delete the words which are far away from the features of selected evaluation samples.
4. Delete the words which have negative meaning. Positive words are easier for customers when answering the questionnaire.
5. Delete the Kansei words that can describe all the samples with this word.

Though there is a risk of missing important Kansei words by using this simplified selection method, this process can decrease significantly the effort of the pre-test. Furthermore, if the aim of research does not include researching all design factors of a product but only to increase several aspects of a product's Kansei, this method is a good choice.

3.5 Semantic Differential Experiment

Semantic differential experiment is necessary for the whole research, and the key of SD method is the SD questionnaire. There are different ways to get answers of questionnaires. Researchers can ask participants to fill out the questionnaire for the answers of all the questions.

Since the eye-tracking experiment and SD experiment are separate, and the results of both experiments are used at the same time when doing analysis, there is no specific need to ensure

the participants of both experiments are all the same people. However, the range of target customers will limit the range of participants of both experiments.

3.5.1 Questionnaire designing

After collecting the proper Kansei words, the work of designing the SD questionnaire is clear. The rating scale is used to rate each Kansei of the image of the sample or real the product.

Nagamachi (2011) proposed that a pair of proper Kansei words are like *elegant-inelegant,* but not *elegant-crude*, since the later one is more likely to create confusion. Moreover, Nagamachi cited research indicating that results of survey using 3-level scale and 11-level scale are the same. It doesn't matter how many levels the scale has, and 5 to 7 levels are usually used in research. Figure 13 shows the rating scale that allows participants to rate the degree with one word or another.

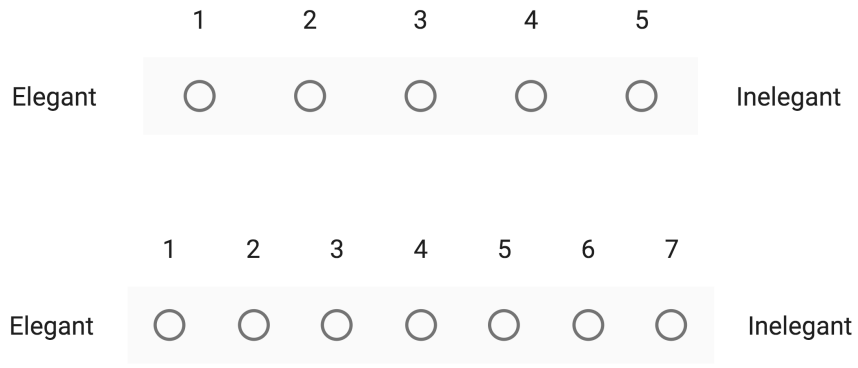

Figure 13

An example of the rating scale questionnaire.

The range of the population who have the potential to take this survey should be considered before creating the questionnaire. Usually, the target customers are the population

who will take this survey. If there is any other private information that researchers want to get, it should be designed in a proper way so that the data is easy to deal with. An introduction of this survey should be shown to all participants before they answer the questionnaire. All the questions should protect the private information of participants and be approved by IRB.

3.5.2 Conducting the SD Experiment

According to the limitation of target customers decided before, the participants should be limited in the same way. The amount of participants should be more than five times the number of Kansei words. However, it is not easy to recruit so many people in reality, and an online survey is convenient for researchers, so conducting online research is a good choice.

If the online survey is open to anyone, some additional demographic questions should be added into the survey to classify the target population. Before collecting the data of the online survey, a pre-test is needed to ensure the questionnaire has no error. During the period of collecting data from an online survey, all private information including IP dress and location should be protected. The researcher should make sure all procedures meet IRB requirements.

3.6 Eye-tracking Experiment

The purpose of the eye-tracking experiment in this research is to find the interest point of consumers when they look at the product samples. The samples have been selected and the process of conducting the eye-tracking experiment is not complicated. Commonly, there are some rules to obey when doing eye-tracking experiment.

The population limitation of participants is same as the target customers selected before. Researchers should also make sure the participants have normal eyesight. The number of the participants is related to what kind of products is the survey target and the number of Kansei words chosen. The more subjects are recruited, the more data can be collected, which will increase the validity of the consequence of the research. Before the test start, a gaze point pre-test should be done to examine subjects' eyesight. Gaze point is the focus of human eye-movement and the heat map can show the duration of looking at different parts of a product. If the accuracy of subject's gaze point test is too low, this participant is not proper to take the test.

During the test duration, the subject should sit down in a comfortable situation and keep his or her body stable, concentrating on the samples. If evaluation samples are images of products, proper space between screen and subject's eyes is important to the accuracy of the test results. It is recommended to do a pre-test so the participant can Figure out proper hardware techniques and the researcher can refine all test conditions. The research should keep silent and not interrupt subjects when they are taking the test. Finally, the researcher should prepare a relaxing environment for all participants to take the eye-tracking test, to mimic shopping and discovering products they want to purchase.

Since eye-tracking technique is strange to the majority of people, it's necessary to introduce the use and effect of this test. An introduction letter should be shown to each subject before everything starts. An IRB approval must be identified if the research is conducted for academic purpose in the U.S.A. Though no negative influence on people of eye-tracking method

has been found, all steps in the research that includes humans should be conducted seriously and ethically.

3.7 Design Characteristic Classification

Category classification is a necessary analysis procedure of the eye-tracking experiment, which can provide reasonable evidence of the interest of customers towards a specific part of the product. Although we can not identify what kind of Kansei is related to the element, the more time customers spend on the element, the more influence produced on the customer Kansei and final purchasing decision.

If the gaze accuracy is above 80%, the original data can be selected as valid data for the later measurement. According to most gaze analysis software, when the subject looks at one part for long time, the color of this area will change from blue to red. Commonly, the heat map is clear, and it is easy to point out the element which attracts more concentration of customers. Each heat map should be worked out by using the gaze analysis software related to the eye-tracking technique. Then, the researcher should calculate locations of heat points and contrast test samples to determine the parts which customers spend more time looking at.

From the Figure extracted by the gaze software, some heat points indicate the essential elements of the target product. After listing all these essential elements, designers need to divide each element to different items. For example, the bottom of the television attracts much gaze and has been selected as an important element. In this case, several categories can be extracted from different evaluation samples, including: round, square, oval, rectangle. These four different

shapes of bottom of television are four categories, and the bottom shape is one item. If bottoms of different televisions also have different sizes, the size can be listed as another item, and categories under this item can be classified according to the dimensions.

Designers' experiences can also be used as a reference in the category classification process. After extracting categories and items from the eye-tracking experiment and analysis of the heat map, designers can suggest some other design factors of the product. Because the comprehensive shapes or features of a product are not always shown on the heat map, there is still potential to miss important design characteristics. Combining data-based analysis and designer's thinking could increase the reliability of the consequence of the category classification.

Additionally, Nagamachi (2011) proposed some general guidelines for extracting items and categories. More categories mean less possibility of important design elements being left out. The most important principle is keeping the perspective of user's viewpoint on the design. If the classification is created only from designer's viewpoint, it will turn out to be merely unit division. If only one sample has the feature of the category A, it means category A is not proper for the following statistical analysis. In this case, category A should be deleted. Otherwise, this category has the potential to be an influential point in regression analysis and skew results.

Category Classification of Electric Kettles

	1	2	3	4	5
1. Height	20-23 cm	23-26 cm	26-29 cm	29-32 cm	32-35 cm
2. Width	13-15 cm	15-17 cm	17-19 cm		
3. Body shape	Round	Oval			
4. Lid size	1-3 cm	3-5 cm			
5. Lid shape	Round	Sharp			
6. Handle size	5-7 cm	7-9 cm	9-11 cm		

Figure 14

Example of Item/Category for Electric Kettles.

Orthogonal Array (OA) is a highly fractional orthogonal table which is used to consider a selected subset of combinations of multiple factors at multiple levels (Yang & Haik, 2008). Kansei researchers should use OA in order to prepare results for statistical analysis. Survey results exported from the online program cannot be used by the statistical analysis program. After gathering all items, categories and related samples will be listed in the orthogonal table so that the following statistical work can use the table directly.

3.8 Statistical Analysis

The statistical analysis of all the data collected through the previously discussed processes is an important reference of creating the final design. In this research, regression analysis is applied to find the relationship between categories and specific customer Kansei. SPSS (Statistical Package for Social Sciences) is a convenient software to do common statistic research.

The first step of handling the data of the SD experiment is to delete invalid data and arrange the data. For example, if the survey answers of a participant are all the same, those answers can be considered invalid data and removed. The online survey could export the result of the SD questionnaire, but the document cannot be used directly in SPSS. Thus, it's necessary to arrange the data according to the orthogonal table of different categories. Then, the researcher should check whether the amount of the data is enough. The amount of records should be no less than 20 times of the number categories to ensure statistical results are reliable and significant. If the data is not enough, the result of analysis may be far away from the reality.

After all the data has been inputted to SPSS, the linear regression analysis can be used to confirm the *P*-value is smaller than 0.05. According to the explanation of *p*-value by Rumsey (2016), the *p*-value is a number between 0 and 1 and interpreted in the following way:

a) A small *p*-value (typically $\leq$ 0.05) indicates strong evidence against the null hypothesis, so you reject the null hypothesis.

b) A large *p*-value ($>$ 0.05) indicates weak evidence against the null hypothesis, so you

fail to reject the null hypothesis.

c) *p*-values very close to the cutoff (0.05) are considered to be marginal (could go either way). Always report the *p*-value so your readers can draw their own conclusions.

If the p-value is much larger than 0.05, it means this data cannot be used to do further analysis, so the researcher should delete the data related to this specific item.

The key point is using the chart to show statistically significant relations ($p < 0.05$) between design elements and Kansei values. Several tools can be used in this process, including line charts, area charts and scatter/dot charts in SPSS. The researcher should examine the analysis of each item and Kansei evaluation to Figure out the relationships between them. Normally, there will be some positive results such as: with the increase of the length of the product, the product will be more pretty.

After all the data has been analyzed, researcher could draw a conclusion about the results of the statistical analysis. Then, designers can deeply analyze these results for use in product design. To make the results of Kansei research useful in product development, the analysis can be shown by charts and tables.

3.9 Conducting Design Based on Kansei Analysis

Although there are many researchers doing research to evaluate product's Kansei, the methodology to use the data and Kansei analysis are not familiar to many designers. This thesis will propose a product design method to combine Kansei design and designer's creativity. Initially, there is no limitation of how an original concept is created, so the statistical analysis of

previous Kansei research can be used as tips and references during the whole product development process. If a designer just wants to make the new product have a strong emotion or Kansei value of “modern”, he or she can get much useful information from the results of Kansei analysis. He or she has a clear guide of how modern the design is in the view of customers. He or she can also add some specific characteristics to the new product to make it more attractive. To confirm the Kansei value of the new product, a SD experiment can be conducted based on the new product. This is a positive feedback loop in product development.

Since not all elements are considered factors in Kansei research, there is enough freedom for designers to express their ideas and concepts based on the Kansei design theory. This design method is not used dogmatically but can be developed and extended in the future.

Chapter 4 Application of This Research Approach

In this chapter, a specific product, a capsule espresso machine, will be selected as a target product and redesigned using the Kansei approach. All details and procedures are generated from the research approach proposed in Chapter 3. By conducting each process of Kansei research, the analysis result will be illustrated, and a new capsule espresso machine design will be developed.

This chapter will show the completed procedures of a Kansei research of a specific product. All the details of eye-tracking, SD experiment, statistical analysis and design conducting will be shown. This is a concrete practice of the research and design guideline.

4.1 Selecting Target - Capsule Espresso Machine

When selecting the target product, it's important to focus on a well known type of product that most people have used and the need to purchase. There are many choices in purchasing products, including furniture, electronic products, household appliances, cars and so on. Because this research is conducted in the U.S.A, the lifestyle of American people should also be considered in the target selecting process. If the product is closely associated with American people's life, it will be easier to find proper participants and get reliable results of experiments.

According to the instructions indicated in Chapter 3.2, capsule espresso machine has been selected as the research objective. Firstly, coffee machines have been produced for a long term, and there are a lot of types of coffee machines in market. The fierce competition requires a superior design to win the market. However, the technological gap of coffee key differentiate makers between different producers is not large, so the appearance of the product has become a

main point when designing the coffee machine. Capsule coffee machines have been available for over ten yeas, and are becoming more and more popular among population.

Secondly, the complexity level of coffee machines is ideal for Kansei research. If a product is too complex, the accuracy of eye-tracking experiment will decrease, and the difficulty of category classification will increase. The capsule coffee machine mainly consists of the following elements: coffee outlet, capsule container, coffee buttons, drip tray, drip grid, water tank. Many of these elements show significant differences among different types of coffee machines. In this case, the capsule coffee machine is a proper product to be the object in the Kansei research.

In addition, the target population using the capsule coffee machine is needed to be considered in both the eye-tracking experiment and SD test. The range of participants in both experiments is the same as the target population. In this research, the target user of the capsule coffee machine is the general population, over 19 years of age, living in the United States. The general population is the entire population of individuals who share a common characteristic, such as age, gender, or education background. There is no specific requirement for target users.

4.2 Selecting Samples

In this research, the images of capsule coffee machines are used as test samples. The capsule coffee maker is a common product in people's life and there are many different types of capsule coffee machines in the market. To start the process, over 150 types of capsule coffee machines have been collected and then all the images of these capsule coffee machines should be

selected according to principles proposed in Chapter 3.3. The concrete procedures of selecting test samples will be stated as follows.

Figure 15

Grayscale images of different capsule coffee machines.

The first step is to decide the view of coffee machines, and then, all pictures collected from the internet should be photographed from the same view. By this approach, it is easier to select appropriate pictures in the following work. Secondly, small size pictures which will not be clear enough when shown on the screen of 27-inch iMac should be deleted. Thirdly, all pictures should

be changed to grayscale JPGs to decrease the influence of colors and textures of different coffee makers as shown in Figure 15. And then, the coffee makers which share a similar appearance should be deleted, only keeping one representative image. In this step, the researcher should ensure diversity of brand types. Up to this step, many coffee machines have been deleted but there are still over 40 pictures of capsule coffee machines left. Following this, a further method should be used to select samples.

Figure 16

Classification of coffee machines according to elevation shape.

From the pictures of capsule coffee machines, some different types of elevation views of these coffee machines can be determined. Based on the shape differences of coffee machines, all the images can be divided into different types. Figure 16 illustrates that all coffee makers are classified by different normal section shapes. It's clear that four types of shapes mostly appear in

this Figure. Some unique shapes, such as types B, C, E, G, and I, have fewer than 5 samples, which are not sufficient for further research. Thus, final test samples should be selected from types A, D, F, and H.

As mentioned in Chapter 3.3, the randomness of test samples should be ensured, so 4 samples are collected from each type A, D, F, and H. Finally, 16 test samples have been selected and the images adjusted to make sure all the 16 pictures show as a similar size on the screen.

Figure 17

Selected capsule coffee machine samples

All the selected images of capsule coffee machines are grayscale and share similar size. Each sample can be distinguished from others easily. These 16 pictures of capsule coffee machines (shown in Figure 17) will be used in both the SD experiment and eye-tracking test.

4.3 Eye-tracking Experiment

By conducting an eye-tracking experiment in the research, researchers can determine a consumer's concentration when looking at capsule coffee machines. The heat map of a user's eye movement can be used as a reference in the category classification process. According to the guideline proposed in Chapter 3.6, the eye-tracking experiment related to capsule coffee machine has been conducted.

Since the survey target should be the same as the user target decided in Chapter 4.1, the subjects that take part in the eye-tracking experiment are members of general population. There is no specific requirement for them. The test samples are images of capsule coffee machines (shown in Figure 17). All the pictures are supposed to show on the screen of 27-inch iMac to subjects.

This study is focused on determining the main physical design factors of a capsule espresso machine through the use of eye-tracking devices. After receiving the approval from IRB (Appendix A), the eye-tracking experiment was conducted as follows.

The usability test was conducted in the User Experience Lab at the School of Industrial and Graphic Design. A group of randomly selected twenty (20) students were recruited from AU main campus via e-mail invitation from the PI. Participants were asked to wear a pair of Tobii Pro Glasses, the world's leading eye-tracker, and watch a four-minute video on a provided computer. This video shows 16 different images of Capsule Espresso Machines and each image lasts 15 seconds. According to the pre-test result, the average time each subject looks at the

image is about 15 seconds, so showing each image for 15 seconds is a proper way to get valid result. Participants could look through all the features of a capsule coffee machine and avoid spending useless time.

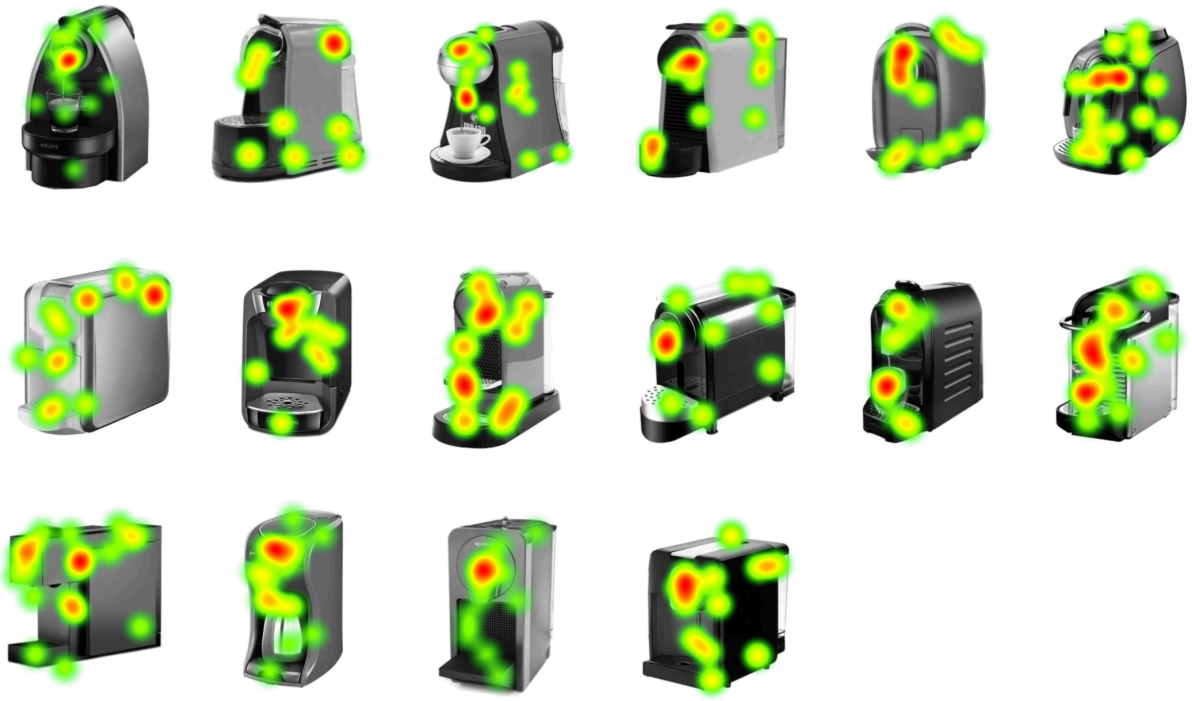

Figure 18

An example of heat map.

To protect the human right of all participants, no identifiable individual data were collected. Fist-person perspective recording videos are stored on the computers in the User Experience Lab at the School of Industrial and Graphic Design. These commercially available eye-tracking devices do not meet the definition of "electronic product radiation", and they are not subject to the provisions of FDA. PI has prior knowledge on using Tobii Pro Glasses and analysis software. A total of three pairs of Tobii Pro Glasses will be used for this research study.

Finally, by using the analysis software related to Tobii Pro Glasses, many heat maps can be developed. Figure 18 is an example of a heat map, which includes all 16 images on one picture. It's a clear way to show consumer's gazing focus of different images of products.

4.4 Design characteristic classification

The classification of different elements of the capsule coffee machine was conducted by researchers, according to the result of eye-tracking experiment. By using analysis software related to Tobii Pro Glasses, 20 heat maps were developed. Then, several elements of capsule coffee machines were selected according to these heat maps. These elements were named "items" and each item includes several different categories. This research was conducted based on the method of design category classification is proposed in Chapter 3.7.

First of all, each item should have at least two different categories. Commonly, the more categories an item has, the more accurate the result will be. Secondly, each category should correspond to at least one coffee machine sample. The concrete process of category classification in this research includes several principles.

Because all 16 capsule coffee machines have different dimensions, the ratio of actual dimensions of each sample are used to divide them into different categories. Some features of coffee machine can not be accounted by numbers, such as shape. In this case, different shapes of an element can be divided into several types, and these types can be arranged in a gradient way. Doing so ensures the statistical analysis works well.

		a	b	c	d	e	f
1	Normal section shape						
2	Width-to-height ratio	4/10	5/10	6/10	7/10	9/10	
3	Height-to-length ratio	6/10	7/10	8/10	9/10	10/10	12/10
4	Radius size	0-5mm	5-10mm	10-15mm	15-20mm		
5	Proportion of spout	<1/11	2/7				
6	Spout shape						
7	Proportion of drip tray	<1/6	1/6	1/5	1/3		
8	Drip tray shape						

Figure 19

Item/Category chart of capsule coffee machine.

The result of category classification of capsule coffee machines is illustrated in Figure 19. The normal section shape, spout shape and drip tray shape are fuzzy descriptions, and other items are classified according to actual dimensions of the 16 capsule coffee machine samples. Since the overall size differences among capsule coffee machines are not distinct, radius size can account for their actual dimensions.

Finally, every capsule coffee machine used in this research was divided into 8 items, and only corresponded to one category in each item. The classification result was summarized in an Orthogonal Array (Figure 20).

Sample/Item	1	2	3	4	5	6	7	8
1	d	d	d	b	b	b	d	a
2	d	c	c	c	b	b	d	a
3	d	d	c	b	b	c	a	a
4	d	b	a	c	b	c	c	a
5	b	c	d	d	b	c	b	a
6	b	e	c	d	b	b	b	b
7	b	c	c	d	b	a	b	b
8	b	d	c	b	a	a	b	b
9	c	b	b	c	b	c	a	a
10	c	c	b	b	b	b	c	a
11	c	b	b	b	b	b	a	b
12	c	b	b	c	b	b	c	a
13	a	a	e	a	a	a	a	c
14	a	b	f	c	a	a	a	b
15	a	b	b	b	b	b	b	c
16	a	d	c	d	a	a	b	b

Figure 20

Orthogonal Array of Capsule coffee machine

4.5 Selecting Kansei words

In the process of Kansei words selection, over 200 Kansei words related to capsule coffee machine were collected. All these Kansei words were divided into different groups, which play important roles in the later selection process.

Keyword	Kansei Words
Elegant	Exquisite, exquisite, graceful, ladylike, chaste, noble, refined, sophisticated, arousing, charming, romantic, extraordinary, fantastic, thin, artistic, modest, beautiful, pure, fresh, orderly, neat, well-organized, compact, precise, unified.
Modern	Fashionable, radical, revolutionary, extreme, innovative, chic, concise, different, particular, contemporary, latest, recent, advance, distinguished, exceptional, impressive, smart, young, vogue, significant, special, technological, conceptual.
Approchable	Common, familiar, usual, regular, adequate, plain, general, normal, ordinary, acceptable, adaptable, affordable, balanced, cheap, suitable, satisfactory, considerate, moderate, adorable, economical, effective, thick, beneficial, practical, useful, gentle, manageable, safe, comforting, caring, reliable, firm, official, user friendly.
Luxury	Valuable, high quality, high level, grand, top, recognizable, important, sufficient, clear, delicate, deluxe, gallant, gorgeous, gracious, famous, sophisticated, precious, smooth, wonderful, individual, gaudy, highlighted.
Likable	Mild, appealing, attractive, captivating, desirable, lovely, presentable, pretty, shining, stimulating, cute, noticeable, excellent, fine, focus, talented, nice, warm, fascinating, sweet, soft, womanly, unisex, enjoyable, funny, fragrant, positive, good design, perfect, amazing.
Active	Bright, cheerful, pleasant, light, shiny, energetic, exposed, valiant, vigorous, outdoor, loose, motivating, encouraging, inspiring, witty, blooming, flourishing, changeable, elastic, lively, moving, amusing, bright, unstressed, powerful, clever, grown, vivid, colorful, decorative, fancy, popular, sparkling, sensual.

Figure 21

Classification of Kansei words

The initial Kansei words include potential user feelings, affections and emotions of capsule coffee machine. Kansei words were obtained from various sources such as the dictionary, magazines, target users as well as professional designers. The selection of Kansei words for this research should cover emotions or adjectives related to capsule coffee machine. All Kansei words were displayed on cards and sorted into groups. These groups were named

with key words. These key words include: approachable, elegant, likable, luxury, active and modern. The final selection of Kansei words were used in the SD experiment.

When deciding the final Kansei words used in this research, only positive words were selected. These six Kansei words were selected by designers based on their design experience and the main design purpose. Not all key words are necessary for this research, since the scale of experiment is limited. Therefore, six key words were selected to be included in the study to avoid subject fatigue.

4.6 Semantic Differential Experiment

This study is focused on determining user's feelings about different kinds of capsule coffee machines. An online survey is used to investigate what are the user's feelings about capsule coffee machines. The SD experiment is divided into two phases, which are 1) survey preparation phase, and 2) data collection phase. In the first phase, the survey preparation includes object selection of study, questionnaire design and participant recruitment. In the second phase, over 100 participants finished the online survey and survey data is collected. All collections in the semantic experiment was approved by the IRB committee (Appendix B).

The study uses Qualtrics Survey Software to create an online survey experiment in the form of an online multiple-choice questionnaire. A list of measures used in the study is included in Figure 22. The whole questionnaire is shown in Appendix C. An email attached with the link of this survey was sent to participants and it was made sure they are voluntarily participating and anonymous.

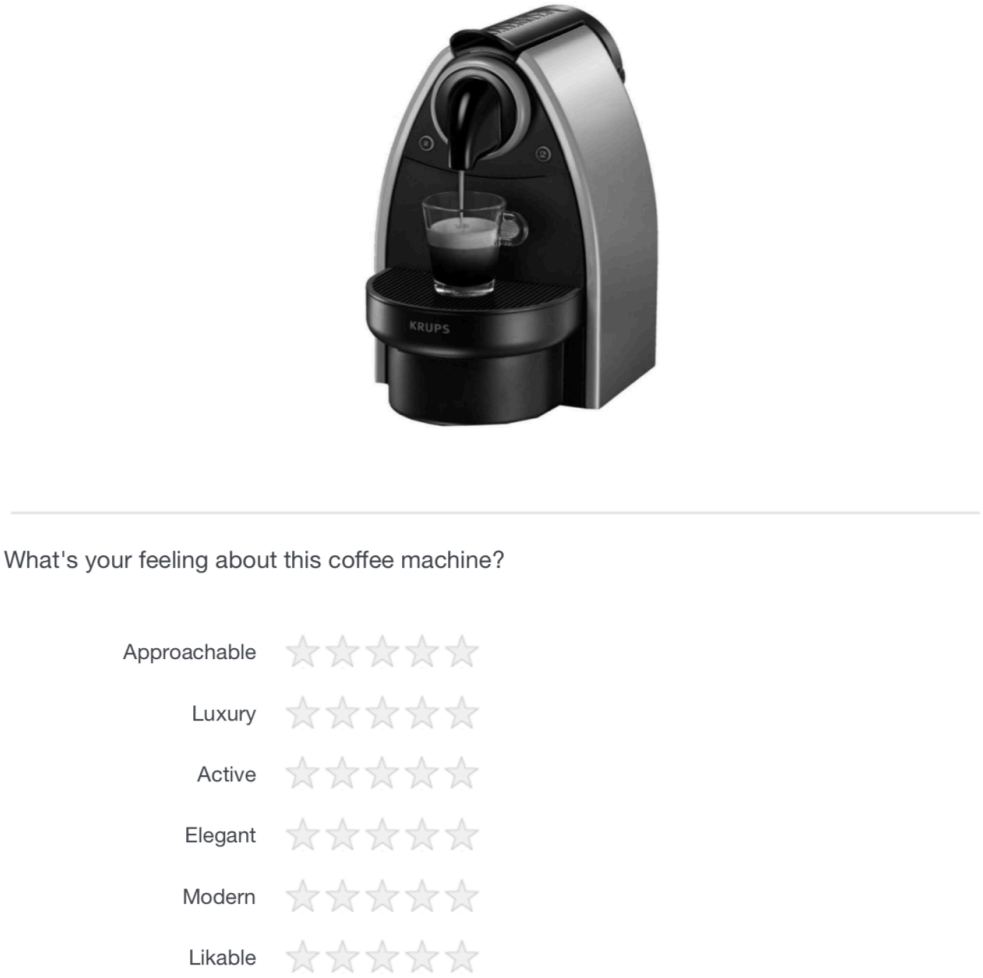

Figure 22

An example of semantic differential questionnaire

In the preparation phase, the questionnaire was designed and target participants were decided. This online survey showed 16 images of different coffee machines selected in the previous research. Kansei words were used as measuring sticks in the questionnaire. Participants can rate each Kansei evaluation on a scale of 1 to 5. The total time commitment will be approximately 7 minutes.

Participants were members of the general population over 19 living in the United States. The general population is the entire population of individuals who share a common characteristic, such as age, sex, or education background. There is no specific requirement for participants. In total, 102 participants finished the online survey and 65 results are valid.

4.7 Statistical Analysis

Statistical analysis plays an important role in Kansei Engineering research. Different analysis methods were used to find out relationships between design characteristics and consumer feelings. This section shows experimental results. First, consumers' Kansei values of different capsule coffee machines were explained. After that, relationships between design categories and user's Kansei are illustrated by diagram. Finally, further analysis of user's Kansei of capsule coffee machines is summarized.

From the results of online survey about consumer Kansei of capsule coffee machines, some significant correlations between design characteristics and human Kansei were found. To analyze human Kansei of different design characteristics of capsule coffee machines, different analysis methods were used in this research. By using SPSS software, analysis of variance (ANOVA), Correlation analysis and stepwise regression were conducted for each design item. Though the specific processes of different statistical analysis methods are not the same, they can contribute to generate a comprehensive result of the research.

4.7.1 ANOVA

Analysis of variance (ANOVA) can be used as an exploratory tool to explain observations in this research. Since the survey data was collected from random participants from the same population, ANOVA is suitable for this research. The results of ANOVA are shown in Figure 23.

Design factor/Kansei value	Approchable	Luxury	Active	Elegant	Modern	Likable
Normal section shape	F=2.64, P=0.05	F=13.76, P=0.00	F=6.36, P=0.00	F=6.05, P=0.00	F=5.56, P=0.00	F=5.44, P=0.00
Width-to-height ratio	F=7.33, P=0.00	F=15.682, P=0.00	F=11.53, P=0.00	F=11.12, P=0.00	F=9.75, P=0.00	F=13.17, P=0.00
Height-to-length ratio	F=10.21, P=0.00	F=9.09, P=0.00	F=5.23, P=0.00	F=9.66, P=0.00	F=6.13, P=0.00	F=8.68, P=0.00
Radius size	F=8.41, P=0.00	F=5.24, P=0.00	F=7.45, P=0.00	F=6.78, P=0.00	F=4.23, P=0.01	F=7.58, P=0.00
Proportion of spout	F=0.14, P=0.71	F=28.34, P=0.00	F=4.00, P=0.05	F=10.91, P=0.00	F=0.01, P=0.00	F=5.95, P=0.02
Spout shape	F=1.05, P=0.35	F=23.14, P=0.00	F=7.17, P=0.00	F=14.76, P=0.00	F=13.06, P=0.00	F=6.85, P=0.00
Proportion of drip tray	F=2.22, P=0.08	F=4.50, P=0.00	F=1.01, P=0.39	F=8.75, P=0.00	F=8.39, P=0.00	F=3.91, P=0.01
Drip tray shape	F=12.95, P=0.00	F=10.00, P=0.00	F=7.96, P=0.00	F=5.08, P=0.01	F=2.65, P=0.07	F=9.06, P=0.00

Figure 23

Variance analysis results

From the results of variance analysis, the majority of design items show considerable effect on six Kansei value ($p<0.05$), which means there are some relations between various design factors and specific consumer Kansei. To illustrate the trend of Kansei value of design items directly, the result of each design item is shown on a line chart. From former research, eight design characteristics were selected, including normal section shape, width-to-height ratio, height-to-length ratio, radius size, proportion of spout, spout shape, proportion of drip tray and drip tray shape. The results of each design factor above are shown in Figure 24 and Figure 25.

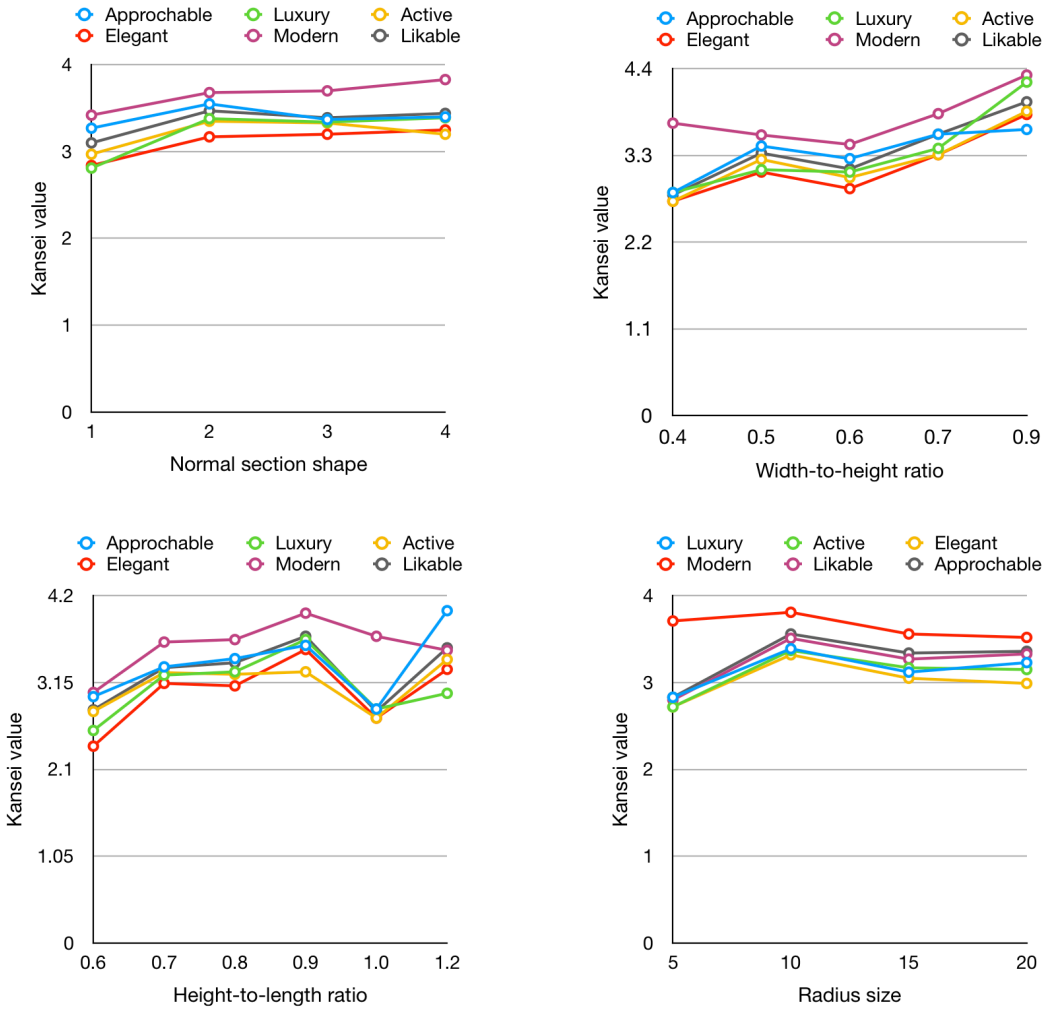

Figure 24

Kansei evaluation line chart A

Figure 24 illustrates how four design factors (normal section shape, width-to-height ratio, height-to-length ratio and radius size) have effect on all 6 Kansei values (approachable, luxury, active, elegant, modern and likable). Except “Modern”, other five Kansei evaluations of different normal section shapes reach the peak at shape 2 (rounded rectangle). All six Kansei values show fluctuated trends with the increase of width-to-height ratio, and hit the peak when width-to-height ratio is 0.9. There is a sharp decrease in several Kansei values when height-to-length ratio

is 1, then rise dramatically with the growth of height-to-length ratio. Most of the Kansei evaluations hit the peak when height-to-length ratio is 0.9. It can be seen from the chart that, all Kansei values reach the highest point when radius size of capsule coffee machine is 10 mm.

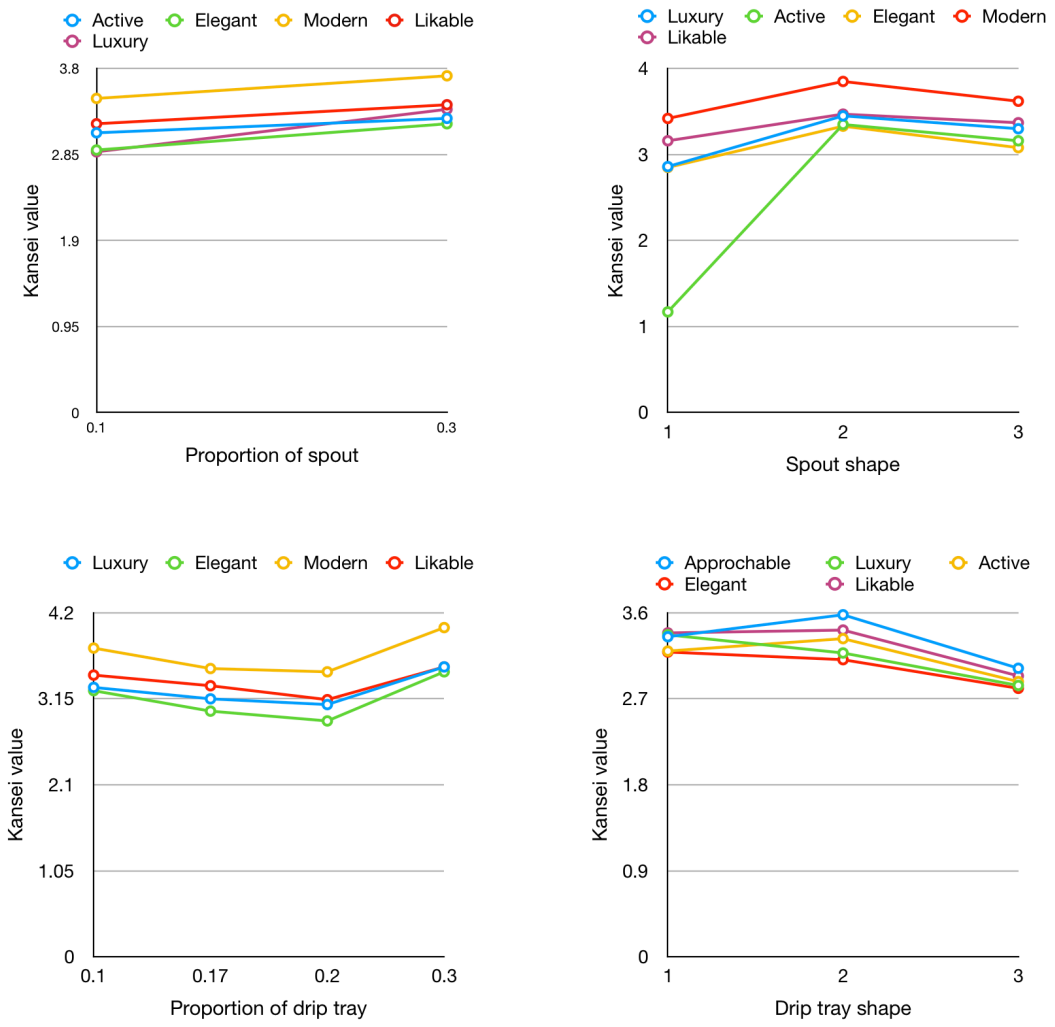

Figure 25

Kansei evaluation line chart B

Figure 25 shows the relations between other four design characteristics (proportion of spout, spout shape, proportion of drip tray and drip tray shape) and Kansei values. According to the chart, five Kansei evaluations experience a similar upward trend with the growth of spout

size. Kansei values reach the highest point around 3.8 when the capsule coffee machine has a drop shape (shape 2) spout. Whereas, the active rate of rounded rectangle (shape 1) spout is significantly lower than other spout shapes.

As can be seen from the Figure 25, with the growth of drip tray ratio, four Kansei values show steady downward trend. However, there is a sudden increase when the proportion of drip tray is 0.3. When the drip tray shape is shape 1 (semicircle), the elegant and luxury evaluations reach the peak, while Kansei values of approachable, likable and active peak around 3.5 when the drip tray shape is shape 2 (rounded rectangle).

Overall, these line charts show how Kansei value increase and decrease with the change of design elements selected. A serious of remarkable results can be found. The analysis results plays a necessary role in following design conducting.

4.7.2 Correlation Analysis

To investigate potential relations between design elements of capsule coffee machine and consumer's Kansei, correlation analysis was performed on factor scores obtained along the principal axes of Kansei value and design characteristics. Compared to ANOVA, correlation analysis can show whether there are positive or negative relation between a design factor and a Kansei value.

Design factor/Kansei value	Approachable	Luxury	Active	Elegant	Modern	Likable	Approachable
Normal section shape	0.018	0.154**	0.064**	0.116**	0.118**	0.090**	0.154**
Width-to-height ratio	0.109**	0.214**	0.143**	0.159**	0.140**	0.177**	0.214**
Height-to-length ratio	0.113**	0.018	0.023	0.079**	0.062**	0.064**	0.018
Radius size	0.000	-0.008	-0.016	-0.051	-0.093**	0.055	-0.008
Proportion of spout	-0.012	0.163**	0.062**	0.102**	0.093**	0.075**	0.163**
Spout shape	-0.023	0.142**	0.043	0.081**	0.071**	0.072**	0.142**
Proportion of drip tray	-0.031	0.036	-0.034	0.023	0.032	0.000	0.036
Drip tray shape	-0.028	-0.135**	-0.047	-0.090**	-0.064**	-0.089**	-0.135**
** p<0.05, ** p<0.01*							

Figure 26

Correlation matrix for design characteristic and Kansei evaluation

Pink colored cells in Figure 26 indicate positive correlations, and blue colored cells indicate negative correlations. Kansei evaluation significantly correlated with some design factors ($r>0.15$, $p<0.05$). Notably, positive correlations were found between luxury and normal section shape, approachable and normal section shape, luxury and width-to-height ratio, elegant and width-to-height ratio, likable and width-to-height ratio, approachable and width-to-height, luxury and proportion of spout, approachable and proportion of spout.

4.7.3 Stepwise Regression

Although correlation analysis can provide some information of the correlation between design elements and Kansei evaluations, a more accurate general linear model is needed to be developed. Stepwise regression was performed in this research to build regression models to estimate the relationships among independent variable (design characteristics) and dependent variable (consumer Kansei). Forward selection approach was applied in this research and the result is shown in Figure 27.

Based on the result of regression analysis, a linear model can be generated. Each design item used in this research is named as $X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8$. Each Kansei evaluation is named as $Y_1, Y_2, Y_3, Y_4, Y_5, Y_6$.

$$Y_1=1.979+1.077X_2+0.964X_3$$

$$Y_2=0.482+2.873X_2+1.625X_3-0.044X_4+3.795X_5-2.201X_7-0.150X_8$$

$$Y_3=2.413+0.104X_1+1.589X_2-2.372X_7$$

$$Y_4=-0.052+2.168X_2+2.014X_3-0.045X_4+3.495X_5$$

$$Y_5=1.097+2.016X_2+1.647X_3-0.053X_4+3.028X_5$$

$$Y_6=1.251+2.264X_2+1.439X_3-0.029X_4+2.274X_5$$

		Y1	Y1	Y3	Y4	Y5	Y6
	Design factor/Kansei value	Approchable	Luxury	Active	Elegant	Modern	Likable
	Constant	1.979	0.482	2.413	-0.052	1.097	1.251
X1	Normal section shape			0.104			
X2	Width-to-height ratio	1.077	2.873	1.589	2.168	2.016	2.264
X3	Height-to-length ratio	0.964	1.625		2.014	1.647	1.439
X4	Radius size		-0.044		-0.045	-0.053	-0.029
X5	Proportion of spout		3.795		3.495	3.028	2.274
X6	Spout shape						
X7	Proportion of drip tray		-2.201	-2.372			
X8	drip tray shape		-0.150				

Figure 27

Result of stepwise regression

According to the linear model, several consumer Kansei of a specific capsule coffee machine can be predicted. Not all design elements are independent variables in this model, which means some selected design categories only have minor effect on these 6 types of human Kansei.

In conclusion, some significant linear relations between design characteristics and consumer Kansei have been found by performing a series of statistical analysis methods. The analysis result can provide a persuasive and reliable reference to designers who aim to design a capsule coffee machine with predictable consumer Kansei. This methodology of statistical analysis can also be applied in other Kansei researches, which may focus on different kinds of products.

4.8 Design Conducting

Capsule coffee machine is the subject of design conducting which is based on Kansei engineering research. The results of semantic differential experiment, eye-tracking experiment and statistical analysis are strong support of the design procedure of capsule coffee machine. From chapter 4.7, some phenomenon of consumer Kansei of capsule coffee machine can be concluded. To achieve high Kansei evaluations in six Kansei dimensions, some specific design items have been figured out. The selected design characteristics are listed as followed:

1) Normal section is rounded rectangle

2) Width-to-height ratio is 0.7

3) Height-to-length ratio is 0.9

4) Radius size is 10 mm

5) Proportion of spout is 0.3

6) Spout shape is drop shape

7) Proportion of drip tray is 0.1

8) Drip tray shape is rounded rectangle

According to these design features, some sketches are developed. New concepts of capsule coffee machine should follow the selected proportions and shapes. To up concave can make it convenient to hold the water pump. Since the capsule coffee machine should be suitable for common coffee cup, the distance between drip tray and spout should longer than 120 mm. However, a coffee machine with small volume is easy to transport and compact, the size of the coffee machine should not be very large. Finally, the height of capsule coffee machine is 267 mm, which is high enough to hold a 4-in-high coffee cup. The colors used in new capsule coffee machine are the gray and white, which are most popular colors in the coffee machine market.

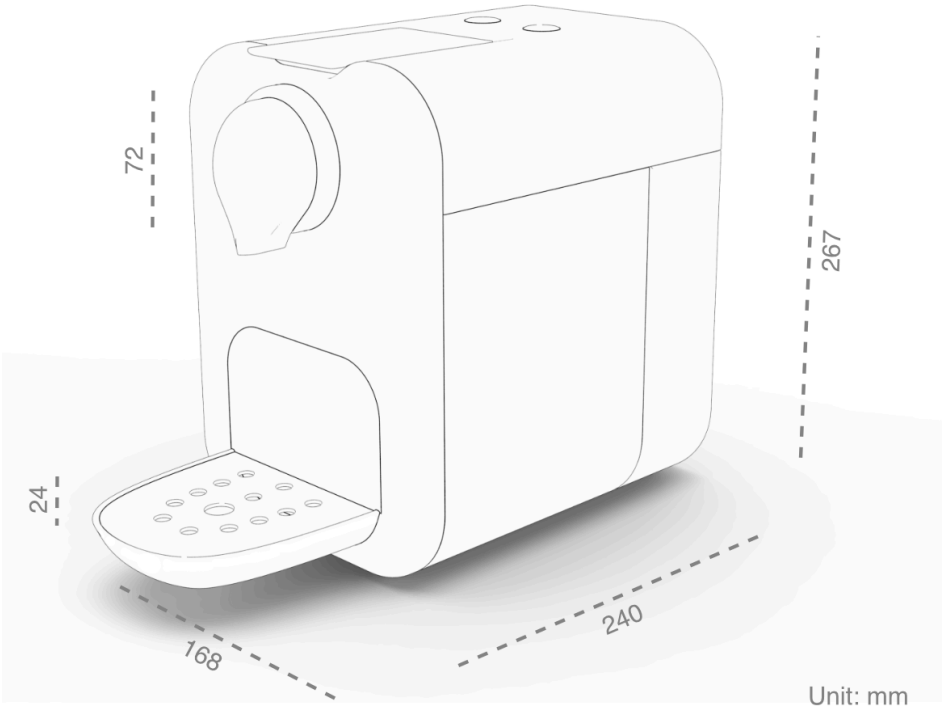

Figure 28

Dimension of new capsule coffee machine design

Figure 29

New coffee machine design rendering - 1

Figure 30

New coffee machine design rendering - 2

According to the multiple regression equations in chapter 4.7.3, the predicted Kansei evaluation of six Kansei dimensions are: approachable (3.82), luxury (4.71), active (3.81), elegant (4.41), modern (4.77), likable (4.98). The new design is predicted to be rated highly in elegant, modern and likable feeling.

Chapter 5 Conclusion

5.1 Conclusion

This thesis proposed a method to evaluate consumer Kansei, analyze the relationship between characteristics of product appearance and user's Kansei, and the product development method based on Kansei research.

Different techniques and research tools are applied in the Kansei research. Eye-tracking test is applied to find out consumer's concentration part of a specific kind of product. Semantic differential experiment is conducted to evaluate human Kansei towards different product samples. A series of statistical analysis methods also play important roles to figure out the correlation between design categories and consumer's Kansei. Capsule coffee machine is regarded as the object of study, and many positive results are obtained during the practice of the whole Kansei research. Since the effect of color and other characteristics of product are not included in the category classification process, this research is still needed to be completed. The participants of the eye tracking experiment are students at Auburn University around 25 years old, who are not uniform distribution of the target population. This would cause experimental errors in the research.

5.2 Further Development

Although some significant correlations have been found in the research around capsule coffee machine, there are still some issues with the research method. The items are not enough to describe the whole product, because color, texture and other design elements are not considered

in the analysis phase. Theoretically, experimental error can be declined if more design items are classified. The data collected is still limited for commercial application. With the development of techniques, some new ways to obtain user data could be created to increase the efficiency of Kansei research, such as capturing and analyzing facial expressions by using AI technology. Also, deep learning can be applied in the process of category classification. The approach for translating consumer Kansei to new product design could be expanded in the future.

Reference

Ahmady, A. (2008). Review and classification of Kansei Engineering and its applications. *In Proceedings: 4th Annual Symposium: Graduate Research and Scholarly Projects*. Wichita, KS: Wichita State University, 143-144.

Gan, Z. W. D., Kavis, B., & Harris, J. (2010). *Implementation of Kansei Engineering to product development-an empirical study*. DOI: 10.1109/ICINA.2010.5636750

Gandini, D., Lemaire, P. & Dufau, S. (2008). *Older and younger adults' strategies in approximate quantification*. DOI:10.1016/j.actpsy.2008.05.009.

Gentner, A, Bouchard C., Elizondo, D. E. & Favart, C. (2012). *Kansei design approaches for the new concept development process*. Retrieved from https://www.researchgate.net/publication/308414610_Kansei_design_approaches_for_the_new_concept_development_process

Hasegawa, R. P., Hasegawa, Y. & Nakamura, Y. (2017). *Development of neuroauthenticator: Feasibility of an EEG-based authentication*. DOI: 10.1109/ICBAKE.2017.8090618

Hisao S. & Ayako H. (2011). *Kansei/Affective Decision Making*. DOI: 10.1109/INCoS.2011.107

Holsanova, J. (2013). Reception of multimodality: *Applying eye-tracking methodology in multimodal research*. DOI: 10.13140/2.1.3790.3041.

Holsanova, J.,Holmberg, N. & Holmqvist, K.(2009). *Reading information graphics: The role of spatial contiguity and dual attentional guidance*. DOI: 10.1002/acp.1525.

Hyönä, J., Lorch, R. F., Jr., & Kaakinen, J. K. (2002). Individual differences in reading to summarize expository text: Evidence from eye fixation patterns. *Journal of Educational Psychology, 94(1),* 44-55. DOI: 10.1037/0022-0663.94.1.44.

Ishihara, S., Ishihara, K., & Nagamachi, M. (2015). *Finite Element Estimation of Pressure Distribution inside the Trunk on a Mattress*. DOI: 10.5875/ausmt.v5i4.949

Ismail, M. N., Lokman, A. M., & Abullah, N. A. S. (2014). *Formulating Kansei concept of assistive device for people with physical disabilities*. DOI: 10.1109/IUSER.2014.7002672

Just, M. A. & Carpenter, P. A. (1976). *Eye fixations and cognitive processes*. DOI: 10.1016/0010-0285(76)90015-3.

Just, M. A. & Carpenter, P. A. (1980). *A theory of reading: From eye fixations to comprehension*. DOI: 10.1037/0033-295X.87.4.329.

Kanda, N., Tadashi, O., Shinichi, O., Tsutomu, K., Shinya, N. & Kazuhiko, M. (2002). *Easy-To-Understand Version of the Seven Tools for Product Planning Series to Create Hit Products, Volume 2,* Taiwan Productivity Center, 257pp., 2002, ISBN957-8848-79-X (translated in Chinese)

Kim, S & Cho, Y. (2014). *An approach to enhanced Kansei engineering*. DOI: 10.1109/SMC.2014.6974587

Lee, S. (2002). *Pleasure with Products: Design based on Kansei*. DOI: 10.1201/9780203302279.ch16

Lee, S. (2002). *Pleasure with Products: Design based on Kansei*. DOI: 10.1201/9780203302279.ch16

Lévy, P. (2013). Beyond Kansei engineering: The emancipation of Kansei design. *International Journal of Design, 7(2)*, 83-94.

Lévy, P., Lee, S. & Yamanaka, T. (2007). *On Kansei and Kansei Design: A Description of a Japanese Design Approach*. Retrieved from https://pdfs.semanticscholar.org/be67/d26aade5dc9819b696221456b6648da274db.pdf

Lévy, P., Lee, S. & Yamanaka, T. (2007). *On Kansei and Kansei Design: A Description of a Japanese Design Approach*. Retrieved from https://www.researchgate.net/publication/228402358_On_Kansei_and_Kansei_Design_a_Description_of_a_Japanese_Design_Approach

Levy, P., Vakamori, S., & Yamanaka, T. (2008). *Explaining Kansei design studies*. In Proceedings from the 6th Conference on Design and Emotion 2008

Mamaghani, N.K., Rahimian, E. & Mortezaei, S.R. (2014). *Kansei Engineering Approach for Consumer's Perception of the Ketchup Sauce Bottle*. Retrieved from https://www.researchgate.net/publication/288003336_Kansei_Engineering_Approach_for_Consumer's_Perception_of_the_Ketchup_Sauce_Bottle/citations

Marco-Almagro, L., & Tort-Martorell, X. (2012). Statistical Methods in Kansei Engineering: A Case of Statistical Engineering. *Quality and Reliability Eng. Int., 28*, 563-573.

Matsubara, T. (2011). N*onlinear Perturbation Theory Integrated with Nonlocal Bias, Redshift-space Distortions, and Primordial Non-Gaussianity*. DOI: 10.1103/PhysRevD.83.083518.

Nagamachi, M. (1995). Kansei Engineering: A new ergonomic consumer-oriented technology for product development. *International Journal of Industrial Ergonomics*

Nagamachi, M. (1999). *Kansei Engineering; the Implication and Applications to Product Development*. DOI: 10.1109/ICSMC.1999.816563

Nagamachi, M. (2008). Perspectives and the new trend of Kansei/affective engineering. *The TQM Journal, Vol. 20 (4),* 290-298.

Nagamachi, M. (2010). *Kansei/Affective Engineering*. Boca Raton, Florida: CRC Press.

Nagamachi, M. & Lokman, A. M. (2010). *Innovations of Kansei Engineering*. Boca Raton, Florida: CRC Press.

Nagamachi, M. & Lokman, A. M. (2015). *Kansei Innovation: Practical Design Applications for Product and Service Development*. Boca Raton, Florida: CRC Press.

Nagasawa, S. (2002). *Kansei and business*. DOI: 10.5057/kei.3.3_3

Nagasawa, S. (2005). *Present state of Kansei engineering in Japan*. DOI: 10.1109/ICSMC.2004.1398319

Nagashima, T. (2013). *The Fundamentals of Kansei Engineering and a Methodological Problem: Human Internal Information and Empathy*. *D*OI: 10.1109/ICBAKE.2013.87

Nakanishi, I., Baba, S. & Li, S. (2011). *Evaluation of Brain Waves as Biometrics for Driver Authentication Using Simplified Driving Simulator*. DOI: 10.1109/ICBAKE.2011.27

Osgood, C. E., & Suci, G. J. (1955). Factor analysis of meaning, *Journal of Experimental Psychology, 50*, 325–338.

Osgood, C. E., Suci, G. J. & Tannenbaum, P. H. (1957). *The measurement of meaning*, University of Illinois Press: Urbana.

Ozaki, S. & Iwamoto, Y. (2006). CAN WE EVALUATE KANSEI BY PHYSIOLOGICAL MEASUREMENT. *Kansei Engineering International Vol.6 (2)*, 25-28.

Rajasekera, J. & Karunasena, H. (2013). *Apparel Design for Global Market: Kansei Engineering Perspective*. DOI: 10.1109/ICBAKE.2013.39.

Salem, B., Nakatsu, R. & Rauterberg, M. (2009). Kansei Experience: Aesthetic, Emotions and Inner Balance. *International Journal of Cognitive Informatics and Natural Intelligence 3(2)*, 18-36.

Santella, A. & DeCarlo, D. (2004). *Robust clustering of eye movement recordings for quantification of visual interest*. DOI: 10.1145/968363.968368

Schütte, S. (2002). *Designing Feelings into Products: Integrating Kansei Engineering Methodology in Product Development*. Retrieved from https://www.researchgate.net/publication/279441538_Designing_Feelings_into_Products_Integrating_Kansei_Engineering_Methodology_in_Product_Development

Schütte, S. (2005). *Engineering Emotional Values in Product Design: Kansei Engineering in Development (PhD dissertation)*. Retrieved from http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A20839&dswid=9903

Simeunovic, N., Gentner, A. Badoil, A., & Favart, C. (2018). Kansei Design approach applied to new concept development stage: Establishing communication between automated driving vehicles and their surroundings. *Proceedings of the 7th International Conference on Kansei Engineering and Emotion Research 2018*, 277-288.

Widodo, I. D., & Novibrilliwan, H. Z. (2018). *Wristwatch development based on Kansei engineering*. DOI: 10.1109/IEA.2018.8387140

Wieser, M. J., Pauli, P., Alpers, G. W. & Mühlberger, A. (2009). *Is eye to eye contact really threatening and avoided in social anxiety? An eye-tracking and psychophysiology study*. DOI: 10.1016/j.janxdis.2008.04.004.

Yoshida, T. & Iwaki, T. (2000). The study of early emotion processing in the frontal area using a two-dipole source model, *Japanese Psychological Research, 42(1)*, 54–68.

Yoto, A. (2013). *Effect of Smelling Green Tea Rich in Aroma Components on EEG Activity and Memory Task Performance*. DOI: 10.1109/ICBAKE.2013.15

Zhang, J., Lei, S., Harada, A., Yamanaka, T. (2006). Driver's comfortableness and vehicle's characteristics in linear movement, *KANSEI Eng. Int. Journal, vol. 6 (2)*, 51-60.

Appendixes

Appendix A

AUBURN UNIVERSITY INSTITUTIONAL REVIEW BOARD for RESEARCH INVOLVING HUMAN SUBJECTS

REQUEST FOR EXEMPT CATEGORY RESEARCH

For Information or help completing this form, contact: **THE OFFICE OF RESEARCH COMPLIANCE**, 115 Ramsay Hall
Phone: 334-844-5966 **e-mail:** IRBAdmin@auburn.edu **Web Address:** http://www.auburn.edu/research/vpr/ohs/index.htm

Revised 2/1/2014 **Submit completed form to IRBsubmit@auburn.edu or 115 Ramsay Hall, Auburn University 36849.**

Form must be populated using Adobe Acrobat /Pro 9 or greater standalone program (do not fill out in browser). Hand written forms will not be accepted.

Project activities may not begin until you have received approval from the Auburn University IRB.

1. **PROJECT PERSONNEL & TRAINING**

PRINCIPAL INVESTIGATOR (PI):

Name Junyi Shen **Title** _____ **Dept./School** SIGD

Address 131 Wallace Hall **AU Email** jzs0160@auburn.edu

Phone 334.329.2345 **Dept. Head** Prof. Clark Lundell

FACULTY ADVISOR (if applicable):

Name Tinman Lau **Title** Professor **Dept./School** SIGD

Address 131 Wallace Hall

Phone 334.844.2373 **AU Email** lautinm@auburn.edu

KEY PERSONNEL: List Key Personnel (other than PI and FA). Additional personnel may be listed in an attachment.

Name	Title	Institution	Responsibilities

KEY PERSONNEL TRAINING: Have all Key Personnel completed CITI Human Research Training (including elective modules related to this research) within the last 3 years? ☑ YES ☐ NO

TRAINING CERTIFICATES: Please attach CITI completion certificates for all Key Personnel.

2. **PROJECT INFORMATION**

Title: Exploring the physical design factors of Capsule Espresso Machine with Wearable Eye -Tracking Technologies.

Source of Funding: ☑ Investigator ☑ Internal ☐ External

List External Agency & Grant Number: _____

List any contractors, sub-contractors, or other entities associate with this project.

_____

List any other IRBs associated with this project (including those involved with reviewing, deferring, or determinations).

_____

FOR ORC OFFICE USE ONLY

DATE RECEIVED IN ORC: _____ by _____ APPROVAL #
DATE OF IRB REVIEW: _____ by _____ APPROVAL CAT
DATE OF ORC REVIEW: _____ by _____ INTERVAL FOR C
DATE OF APPROVAL: _____ by _____
COMMENTS:

The Auburn University Institutional Review Board has approved this Document for use from
10/10/2018 to ---------
Protocol # 18-427 EX 1810

3. **PROJECT SUMMARY**

a. **Does the research involve any special populations?**

- ☐ YES ☑ NO **Minors (under age 19)**
- ☐ YES ☑ NO **Pregnant women, fetuses, or any products of conception**
- ☐ YES ☑ NO **Prisoners or Wards**
- ☐ YES ☑ NO **Individuals with compromised autonomy and/or decisional capacity**

b. **Does the research pose more than minimal risk to participants?** ☐ YES ☑ NO

Minimal risk means that the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests. 42 CFR 46.102(i)

c. **Does the study involve any of the following?**

- ☐ YES ☑ NO **Procedures subject to FDA Regulation** Ex. Drugs, biological products, medical devices, etc.
- ☐ YES ☑ NO **Use of school records of identifiable students or information from instructors about specific students**
- ☐ YES ☑ NO **Protected health or medical information when there is a direct or indirect link that could identify the participant**
- ☐ YES ☑ NO **Collection of sensitive aspects of the participant's own behavior, such as illegal conduct, drug use, sexual behavior or use of alcohol**
- ☐ YES ☑ NO **Deception of participants**

If you checked "YES" to any response in Question #3 STOP. It is likely that your study does not meet the "EXEMPT" requirements. Please complete a PROTOCOL FORM for Expedited or Full Board Review.
You may contact IRB Administration for more information. (Phone: 334-844-5966 or Email: IRBAdmin@auburn.edu)

4. **PROJECT DESCRIPTION**

a. **Subject Population** (Describe, include age, special population characteristics, etc.)

Adult Auburn University students on-campus, between 19 and 65 of age.

b. **Describe, step by step, all procedures and methods that will be used to consent participants.**

☐ **N/A (Existing data will be used)**

A recruiting email from the PI will be sent to all AU students, with a digital copy of the informed consent attached. If they are interested in possibly participating, they will be given the instruction on when and where the usability test will be conducted. Once the participants arrive, they will be given a hard copy of the informed consent to read. They will be given a chance to ask any questions and sign the consent if they wish to participate.

c. **Brief summary of project.** (Include the research question(s) and a brief description of the methodology, including recruitment and how data will be collected and protected.)

RESEARCH QUESTIONS: What are impressed physical design factors of Nespresso Machine.

METHODOLOGY: This study is going to find out the impressed physical design factors of Capsule Espresso Machine through the use of eye-tracking devices. The usability tests will be conducted in the User Experience Lab at the School of Industrial and Graphic Design. A group of randomly selected thirty (30) students will be recruited from AU main campus via e-mail invitation from the PI. Participants will be asked to wear a pair of Tobii Pro Glasses, the world's leading eye-tracker, and watch a four minutes video on a provided computer. This video shows 16 different images of Capsule Espresso Machines and each image lasts 15 seconds.

No identifiable individual data will be collected. Fist-person perspective recording videos will be stored on the computers in the User Experience Lab at the School of Industrial and Graphic Design. Participants will be offered the chance to win a $25 app store gift card, by providing their e-mail addresses. Upon the completion of the study, one e-mail address will be randomly drawn from the pool using an online tool such as randomresult.com. The winner has the choice between iTunes gift card or Google Play gift card. The gift card code will be sent to the winner via e-mail. These commercially available eye-tracking devices do not meet the definition of "electronic product radiation", and they are not subject to the provisions of FDA. PI has prior knowledge on using Tobii Pro Glasses and analyzing software. A total of three pairs of Tobii Pro Glasses will be used for this research study.

d. **Waivers. Check any waivers that apply and describe how the project meets the criteria for the waiver.**

- ☐ **Waiver of Consent (Including existing de-identified data)**
- ☐ **Waiver of Documentation of Consent (Use of Information Letter)**
- ☐ **Waiver of Parental Permission (for college students)**

e. **Attachments. Please attach Informed Consents, Information Letters, data collection instrument(s), advertisements/recruiting materials, or permission letters/site authorizations as appropriate.**

Signature of Investigator Junyi Shen Date 10/8/2018

Signature of Faculty Advisor Date 10/8/2018

Signature of Department Head (GPO) Date 10/8/2018

AUBURN UNIVERSITY
COLLEGE OF ARCHITECTURE, DESIGN AND CONSTRUCTION

SCHOOL OF INDUSTRIAL AND GRAPHIC DESIGN

(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

INFORMED CONSENT

for a Research Study entitled
"Exploring the design factors of Capsule Espresso Machine with Wearable Eye - Tracking Technologies. "

You are invited to participate in a research study to explore the most impressed physical design factors of Capsule Espresso Machine. The study is being conducted by Junyi Shen in the Auburn University School of Industrial and Graphic Design. You were selected as a possible participant because you are a student and age 19 or older. A total of 30 participants are needed for this study.

What will be involved if you participate? If you decide to participate in this research study, you will be asked to wear a pair of Tobii Pro Glasses, the world's leading eye-tracker, and watch a four minutes video on a provided computer. This video shows 16 types of Capsule Espresso Machines and each one lasts 15 seconds. All studies will be conducted at the User Experience Lab, which is located in Wallace Hall. Your total time commitment will be about 5-8 minutes.

Are there any risks or discomforts? The risks associated with participating in this study are minimal, possible eyestrain or dizziness. If, for any reason, participants feel uncomfortable, they may quite the experiment, with no repercussions.

Are there any benefits to yourself or others? If you participate in this study, you will have the experience of using the latest wearable eye-tracking technologies. The general population may benefit from this study as product designers may deliver more attractive Capsule Espresso Machine design with gteater understanding of the physical design facors of Capsule Espresso Machine.

Will you receive compensation for participating? Participants will be offered the chance to win a $25 app store gift card, by providing their e-mail addresses. Upon the completion of the study, one e-mail address will be randomly drawn from the pool using an online tool such as randomresult.com. The winner has the choice between iTune gift card or Google Play gift card. The gift card code will be sent to the winner via e-mail.

Participant's initials _____

Are there any costs? There is no cost for you to participate in this study.

If you change your mind about participating, you can withdraw at any time before your appointment by sending an e-mail to jzs0160@auburn.edu. If you choose to withdraw after the study, your data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University, the School of Industrial and Graphic Design.

Your privacy will be protected. Any information obtained in connection with this study will remain anonymous. Information obtained through your participation may be published in professional journals, and presented at professional meetings; however, no names will be included.

If you have questions about this study, please ask them now or contact Junyi Shen by phone (334)329-2345 or e-mail at jzs0160@auburn.edu. A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)844-5966 or e-mail at IRBadmin@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

_____	_____
Participant's signature Date	Investigator obtaining consent Date
_____	_____
Printed Name	Printed Name

The Auburn University Institutional Review Board has approved this Document for use from 10/10/2018 to ---------- Protocol # 18-427 EX 1810

E-mail Invitation Script

I am a student in the School of Industrial and Graphic Design at Auburn University.
I would like to invite you to participate in my research study to evaluate the impressed physical design factors of Capsule Espresso Machine. You may participate if you are a student over 19 at Auburn University.

As a participant, you will be asked to wear an eye-tracking device (Tobii Glasses) and watch a four minutes video on a provided computer. This video shows 16 types of Capsule Espresso Machines and each one lasts 15 seconds.Your total time commitment will be approximately 5 to 8 minutes. Participation is completely voluntary.

To thank you for your time you will be offered the chance to win a $25 iTunes or Google Play gift card.

More detailed information about participating this research project can be found in the attached “informed consent”.

If you would like to participate in this research study, please reply to this email directly.

Thank you for your consideration.

Appendix B

AUBURN UNIVERSITY INSTITUTIONAL REVIEW BOARD for RESEARCH INVOLVING HUMAN SUBJECTS

REQUEST FOR EXEMPT CATEGORY RESEARCH

For Information or help completing this form, contact: **THE OFFICE OF RESEARCH COMPLIANCE**, 115 Ramsay Hall
Phone: 334-844-5966 **e-mail:** IRBAdmin@auburn.edu **Web Address:** http://www.auburn.edu/research/vpr/ohs/index.htm

Revised 2/1/2014 **Submit completed form to IRBsubmit@auburn.edu or 115 Ramsay Hall, Auburn University 36849.**

Form must be populated using Adobe Acrobat / Pro 9 or greater standalone program (do not fill out in browser). Hand written forms will not be accepted.

Project activities may not begin until you have received approval from the Auburn University IRB.

1. **PROJECT PERSONNEL & TRAINING**

PRINCIPAL INVESTIGATOR (PI):

Name Junyi Shen **Title** Graduate student **Dept./School** SIGD

Address 131 Wallace Hall **AU Email** jzs0160@auburn.edu

Phone 334.329.2345 **Dept. Head** Prof. Clark Lundell

FACULTY ADVISOR (if applicable):

Name Tinman Lau **Title** Professor **Dept./School** SIGD

Address 131 Wallace Hall

Phone 334.844.2373 **AU Email** lautinm@auburn.edu

KEY PERSONNEL: List Key Personnel (other than PI and FA). Additional personnel may be listed in an attachment.

Name	Title	Institution	Responsibilities

KEY PERSONNEL TRAINING: Have all Key Personnel completed CITI Human Research Training (including elective modules related to this research) within the last 3 years? ☑ YES ☐ NO

TRAINING CERTIFICATES: Please attach CITI completion certificates for all Key Personnel.

2. **PROJECT INFORMATION**

Title: The online survey of Capsule Espresso Machine.

Source of Funding: ☑ Investigator ☑ Internal ☐ External

List External Agency & Grant Number:

List any contractors, sub-contractors, or other entities associate with this project.

List any other IRBs associated with this project (including those involved with reviewing, deferring, or determinations).

FOR ORC OFFICE USE ONLY

DATE RECEIVED IN ORC: _____ by _____ APPROVAL #
DATE OF IRB REVIEW: _____ by _____ APPROVAL CAT
DATE OF ORC REVIEW: _____ by _____ INTERVAL FOR
DATE OF APPROVAL: _____ by _____
COMMENTS:

The Auburn University Institutional Review Board has approved this Document for use from 11/26/2018 to ----------
Protocol # 18-470 EX 1811

3. **PROJECT SUMMARY**

a. **Does the research involve any special populations?**

- ☐ **YES** ☑ **NO** **Minors (under age 19)**
- ☐ **YES** ☑ **NO** **Pregnant women, fetuses, or any products of conception**
- ☐ **YES** ☑ **NO** **Prisoners or Wards**
- ☐ **YES** ☑ **NO** **Individuals with compromised autonomy and/or decisional capacity**

b. **Does the research pose more than minimal risk to participants?** ☐ **YES** ☑ **NO**

Minimal risk means that the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests. 42 CFR 46.102(i)

c. **Does the study involve any of the following?**

- ☐ **YES** ☑ **NO** **Procedures subject to FDA Regulation** Ex. Drugs, biological products, medical devices, etc.
- ☐ **YES** ☑ **NO** **Use of school records of identifiable students or information from instructors about specific students**
- ☐ **YES** ☑ **NO** **Protected health or medical information when there is a direct or indirect link that could identify the participant**
- ☐ **YES** ☑ **NO** **Collection of sensitive aspects of the participant's own behavior, such as illegal conduct, drug use, sexual behavior or use of alcohol**
- ☐ **YES** ☑ **NO** **Deception of participants**

If you checked "YES" to any response in Question #3 STOP. It is likely that your study does not meet the "EXEMPT" requirements. Please complete a PROTOCOL FORM for Expedited or Full Board Review.
You may contact IRB Administration for more information. (Phone: 334-844-5966 or Email: IRBAdmin@auburn.edu)

4. **PROJECT DESCRIPTION**

a. **Subject Population** (Describe, include age, special population characteristics, etc.)

Participants will be general population over 19 living in the United States. The general population is the entire population of individuals who share a common characteristic, such as age, sex, or health condition. There is no specific requirement for participants.

b. **Describe, step by step, all procedures and methods that will be used to consent participants.**

☐ **N/A (Existing data will be used)**

An email attached with the link of this online survey will be sent to AU students and faculties, with a digital copy of the informed consent attached. The email addresses can be found on Qualtrics, a survey website provided by Auburn University. If they are interested in this survey, they will click the link and answer some questions. Prior to the online survey, an information letter will be displayed, which will provide information about the study. The information letter will state that after having read the information provided, the participants can decide if they want to participate in this research study.

c. **Brief summary of project.** (Include the research question(s) and a brief description of the methodology, including recruitment and how data will be collected and protected.)

RESEARCH QUESTIONS: What's the user's feeling about Capsule Espresso Machine?

METHODOLOGY: This study is going to find out usr's feeling about different kinds of Capsule Espresso Machines. The purpose of this research is to investigate what's the user's feeling about the Capsule Espresso Machine.

The study will use Qualtrics Survey Software to create an online survey experiment in the form of an online multiple-choice questionnaire. A list of measures used in the study is included in Appendix C. An email attached with the link of this survey will be sent to general adults and participants are voluntarily and anonymous.

This online survey shows 16 images of different coffee machines. Participants need to evaluate these coffee machines with sliders. There are six measuring sticks: approachable, luxury, active, elegant, modern and likable. Participants can choose from 1 to 5. The total time commitment will be approximately 7 minutes.

Participants will be offered the chance to win a $25 app store gift card, by providing their e-mail addresses. Upon the completion of the study, one e-mail address will be randomly drawn from the pool using an online tool such as randomresult.com. The winner has the choice between iTune gift card or Google Play gift card. The gift card code will be sent to the winner via e-mail.

The desired sample size is 100 participants. Questionnaires will be coded for confidentiality and anonymity and will be stored in locked file cabinets within PI's office until such an event that the data is no longer needed. No identifiable individual data will be collected.

d. **Waivers. Check any waivers that apply and describe how the project meets the criteria for the waiver.**

- ☐ **Waiver of Consent (Including existing de-identified data)**
- ☑ **Waiver of Documentation of Consent (Use of Information Letter)**
- ☐ **Waiver of Parental Permission (for college students)**

Given that this research will be conducted with the use of an online survey which does not provide any risks or discomfort to participants, information letters will be used. Data of the study will be collected and analyzed as anonymous given that the name of the participants will not be recorded in the data collection.

e. **Attachments.** **Please attach Informed Consents, Information Letters, data collection instrument(s), advertisements/recruiting materials, or permission letters/site authorizations as appropriate.**

Signature of Investigator Junyi Shen Date 11/08/2018

Signature of Faculty Advisor [signature] Date 11/08/2018

Signature of Department Head [signature] GPO Date 11/08/2018

AUBURN UNIVERSITY
COLLEGE OF ARCHITECTURE, DESIGN AND CONSTRUCTION

SCHOOL OF
INDUSTRIAL AND
GRAPHIC DESIGN

(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

INFORMED CONSENT

for a Research Study entitled
"The online survey of Capsule Espresso Machine. "

You are invited to participate in a research study to evaluate the users' feeling about Capsule Espresso Machine. The study is being conducted by Junyi Shen in the Auburn University School of Industrial and Graphic Design. The advisor of this research is Pro. Lau Tinman who is instrumental in designing the online survey. You were selected as a possible participant because you are 19 or older. A total of 100 participants are needed for this study.

What will be involved if you participate? Your participation is completely voluntary. If you decide to participate in this research study, you will be asked to complete an online questionnaire. This survey includes 16 capsule espresso machine. Your total time commitment will be approximately 7 minutes.

Are there any risks or discomforts? The participation in this study would put you in no physical or psychological risks other than the minimal inconvenience of completing the questionnaire.

Are there any benefits to yourself or others? If you participate in this study, you will have the experience of evaluate capsule coffee machines which can help you choose a good cooffee maker. The general population may benefit from this study as product designers may deliver more attractive Capsule Espresso Machine design with gteater understanding of the users' feeling about Capsule Machine.

Will you receive compensation for participating? Participants will be offered the chance to win a $25 app store gift card, by providing their e-mail addresses. Upon the completion of the study, one e-mail address will be randomly drawn from the pool using an online tool such as randomresult.com. The winner has the choice between iTune gift card or Google Play gift card. The gift card code will be sent to the winner via e-mail.

The Auburn University Institutional Review Board has approved this Document for use from 11/26/2018 to ---------- Protocol # 18-470 EX 1811

Are there any costs? There is no cost for you to participate in this study.

If you change your mind about participating, you can withdraw at any time by closing your browser window. If you choose to withdraw after the study, your data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relation with Auburn University, the School of Industrial and Graphic Design.

Your privacy will be protected. Any information obtained in connection with this study will remain anonymous. Information obtained through your participation may be published in professional journals, and presented at professional meetings; however, no names will be included. We will protect your privacy and the data you provide by not collecting IP addresses from research participants.

If you have questions about this study, please ask them now or contact Junyi Shen by phone (334)329-2345 or e-mail at jzs0160@auburn.edu. A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)844-5966 or e-mail at IRBadmin@auburn.edu.

HAVING READ THE INFORMATION ABOVE, YOU MUST DECIDE IF YOU WANT TO PARTICIPATE IN THIS RESEARCH PROJECT. IF YOU DECIDE TO PARTICIPATE, PLEASE CLICK ON THE LINK BELOW. YOU MAY PRINT A COPY OF THIS LETTER TO KEEP.

Junyi Shen
Investigator Date: 11/21/2018

Tinman Lau
Faculty Advisor Date: 11/21/2018

Link to survey:
https://auburn.qualtrics.com/jfe/form/SV_aXy4UPMho9blkZT

The Auburn University Institutional Review Board has approved this Document for use from 11/26/2018 to ----------
Protocol # 18-470 EX 1811

Attached Consent Form

E-mail Invitation Script

I am Junyi Shen, a graduate student in the School of Industrial and Graphic Design at Auburn University. I would like to invite you to participate in my research study to find out user's feeling about Capsule Espresso Machine. You may participate if you are over 19.

As a participant, you will be asked to finish an online questionnaire. This online survey shows 16 images of different coffee machines. Participants need to evaluate these coffee machines with sliders. There are six measuring sticks: approachable, luxury, active, elegant, modern and likable. Participants can choose from 1 to 5. Your total time commitment will be approximately 7 minutes.

To thank you for your time you will be offered the chance to win a $25 iTunes or Google Play gift card.

More detailed information about participating this research project can be found in the attached “informed consent”.

If you would like to participate in this research study, please click this link:
https://auburn.qualtrics.com/jfe/form/SV_aXy4UPMho9blkZT

Thank you for your consideration.

The Auburn University Institutional Review Board has approved this Document for use from
11/26/2018 to ----------
Protocol # 18-470 EX 1811

Appendix C

List of Possible Scale Measurements

AUBURN UNIVERSITY

Default Question Block

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆

What's your feeling about this coffee machine?

Approachable	☆☆☆☆☆
Luxury	☆☆☆☆☆
Active	☆☆☆☆☆
Elegant	☆☆☆☆☆
Modern	☆☆☆☆☆
Likable	☆☆☆☆☆