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# Kansei Innovation:
# Practical Design Applications for Product and Service Development
# A sampler

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# Contents




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# 1

# *What Is Kansei?*

## 1.1 Everybody Has Kansei

When we run across a beautiful woman, our feelings say, "What a pretty woman!" When we see a woman in appropriate, graceful (not flashy) makeup and elegantly dressed, we feel that she has been raised in a good environment and has a sense of elegance. We make inferences about the person's gentle character, privileged home environment, and so forth. This kind of feeling is called Kansei. Kansei is the feeling felt by the receiver of stimuli contained in the atmosphere of a situation. If the receiver is rich with emotions, a feeling that matches the stimuli will come out, but if the receiver is lacking in emotions or being defiant, he or she can only respond to a portion of the stimuli, and the feeling will be distorted. When a child who loves animals finds a puppy on a roadside, he or she will hug the puppy with sparkling eyes, but another child who has no such emotion will chase the puppy around with a stick. Even if the stimuli from the environment is the same, the emotion created by the stimuli, which is Kansei, may be different.

Different employees show different responses to customers, even though they receive the same new employee training and corporate education; some of them are very much liked by customers, while others very frequently cause trouble with customers. This difference is related to whether the person who received the education or training really understands the philosophy of the company. Therefore, there is a need for training that is easy to understand and has much practical work incorporated into it. In corporations that are recognized by the public as providers of excellent service, there is a training system that focuses on employees' emotions and values and nurtures their incorporation into the work process—this is Kansei education.

The functions that are the basis for Kansei are the five senses—eyesight, hearing, taste, touch, and smell—plus the deep sensation we get that is related to, for example, the ride quality of a car. Eyesight is the sense when something is visible to the eyes, and it is related to shape, color, tone, light, etc. These stimuli pass through the eyeball to touch the retina; the signals then reach the occipital lobe and pass through a few other regions before being processed as Kansei at the prefrontal cortex. Something that has

a good shape will be interpreted as a beautiful or well-balanced feeling, and something that has colors and is well balanced will be sensed as an attractive thing. We do not sense it merely as a result of physiological processes, but this kind of Kansei is generated in combination with past experiences and memory (hippocampus) information. Therefore, Kansei that feels the beauty or attractiveness through eyesight alone will not be as meaningful to a person who does not have good experiences to incorporate in that feeling. The same thing for hearing; if we just sensuously feel the sound streaming from a CD, it will be merely a sound, but to a person who is familiar with classical music, he or she will surely be captivated by *Pastoral,* a symphony conducted by Furtwangler and composed by Beethoven. If the person's life philosophy and in-depth knowledge are incorporated in the physiological sensation, then a deep Kansei (savoring) related to symphony will come along.

Visual emotion is the external stimulation that passes through the eyes to the occipital lobe, interpreted as shape, tone, motion, etc., and the memories, knowledge, and experiences that were previously stored are added before the emotion reaches the prefrontal lobe. When a scene enters one's eyes, the person's accumulated visual database is added to the visual information; thus, he or she will see "delicious-looking food" or a "kindly person." The same thing applies to auditory stimulation. Sound stimulation enters the ears, which are sensory organs. While the stimulation is a mere physical sound wave, it is processed and flavored by the person's life experience, and by the time it reaches the prefrontal lobe, it will be heard as a "beautiful birdsong." All emotions through touch, taste, and smell are felt as the emotions supported by the person's daily life experiences. Composite emotions that combine sensations (sensory modalities), especially eyesight, which dominates 70%–80% of sensory stimulation, greatly impact Kansei; for example, eyesight + taste or eyesight + touch. The pain from being pinched by someone special will not be felt as a pain, and a photo of delicious-looking food is sufficient to make us sense how good it would taste. In addition to the five senses described above, there is the internal receptor, which gives us a composite sensation about something, for example, the ride quality of a car, but cannot be associated with a specific sensory organ.

Figure 1.1 shows how taste information received by taste buds inside our mouth (taste receptors) passes through a few pathways and is processed before the information that reaches the primary and secondary gustatory cortexes is interpreted into various tastes at the prefrontal cortex. As shown in the figure, sweetness, astringency, and other tastes pass through a complex pathway, intricately processed into taste sensation. At the same time, the experience information for the taste is added to the chemical information in the interpretation process. Emotions such as "Japanese plum tastes sour," "green tomato is not sweet," etc., will be generated and recorded into the long-term memory. Similarly, eyesight, hearing, smell, touch, etc., pass through a complex pathway before reaching the prefrontal cortex, together with respective emotions. Figure 1.2 shows the simplified neural pathways for eyesight and hearing.

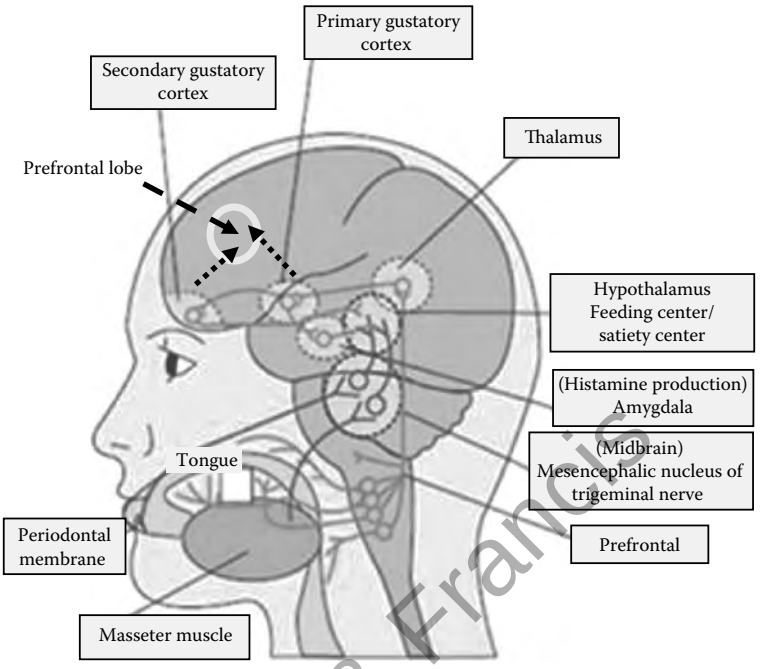


**FIGURE 1.1**
Pathway on which the taste sense is processed at the cerebral circuitry before arriving at the prefrontal cortex.

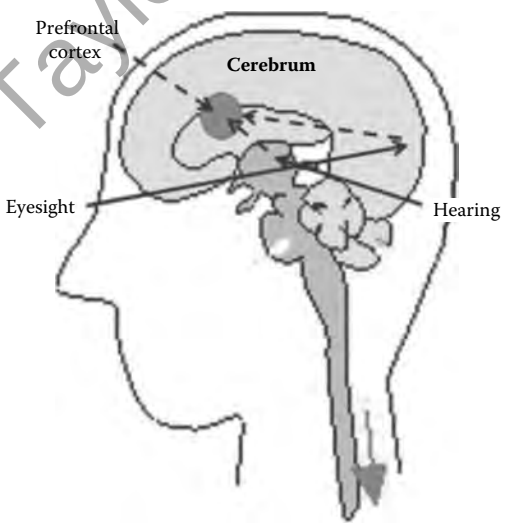


**FIGURE 1.2**
Information processing for eyesight and hearing is finally sensed as Kansei at the prefrontal cortex.

## 1.2 Let's Explore Kansei

Searching for what kind of product a customer wants from his facial expressions and motions, and judging whether a task is a heavy burden to a worker, or whether he or she is satisfied with his or her job based on his or her movements, are the Kansei issues dealt with in this book.

Mitsuo Nagamachi, the founder, has explained before that Kansei is composed of eyesight, hearing, smell, taste, touch, and an internal receptor. Respective sensory experiences are memorized together with the episode memory experienced at that time, and they are recorded as emotions. Something that is being memorized, decided, or judged as a certain value on top of these emotions by a function called *perception* will ooze out when a sensation similar to the previous ones is felt, and the prefrontal cortex will sense: "Ah, this one is very similar to the cooking that I have eaten before, so it will be delicious." The feeling of "how beautiful!" when a person saw the colored sunset described by Ken'ichiro Mogi in his book[1] is also a manifestation of a high-order function transmitted from eyesight (Figure 1.3).

The managerial staff of a company must include someone who understands the emotion of his or her subordinates toward the job by looking at their actions and expressions; a salesperson of a department store must have the ability to understand the emotion of visiting customers toward the lined-up merchandise by looking at their actions, facial expressions, and how they speak; and it is desirable for product development staff to accurately grasp social demands—what kinds of products are currently sought—from



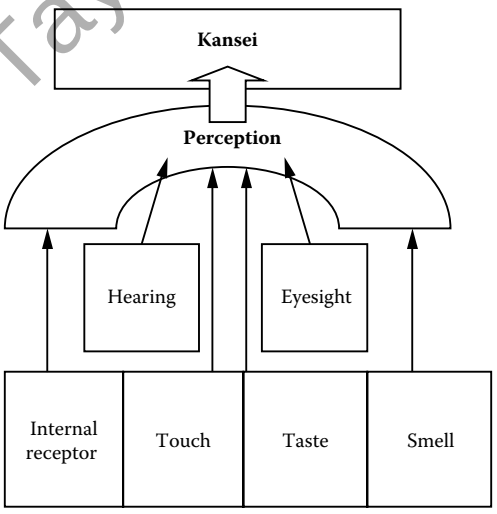


**FIGURE 1.3**
Kansei expressed after information from the six senses passes through the perception function.

customer information and develop an appreciated product. It is desirable for a schoolteacher to sense the symptoms of bullying early in the relationships between students and provide proper guidance. All these roles require figuring out concealed emotions and Kansei beneath the actions, expressions, spoken language, etc., of the persons they are dealing with. In order to do this, the managerial staff, customer service personnel, teacher, and so on, need to have rich and deep Kansei themselves, and have the ability to read Kansei of the persons they are dealing with.

## 1.3 Kansei Is Expressed in Various Forms and Shapes

Figure 1.4 shows how Kansei is represented in various forms and shapes. A person's emotional state can be measured physiologically. For example, if it is measured using brain waves or functional magnetic resonance imaging (fMRI), we can know the activity state of the cerebrum and the emotional state. We can check whether someone is performing an improperly tough job by measuring the state of the muscle using an electromyograph. A customer will definitely turn his eyes to the products that catch his interest, so we can measure his or her eyeball movement with an eye camera. We can know whether a food tastes good or bad by looking at the facial expression of the person who is eating the food. The difficulty of a job is proportional to the degree of hip bending and distance walked, and a worker's motivation can be sensed based on the energy that the worker exhibits. And when someone



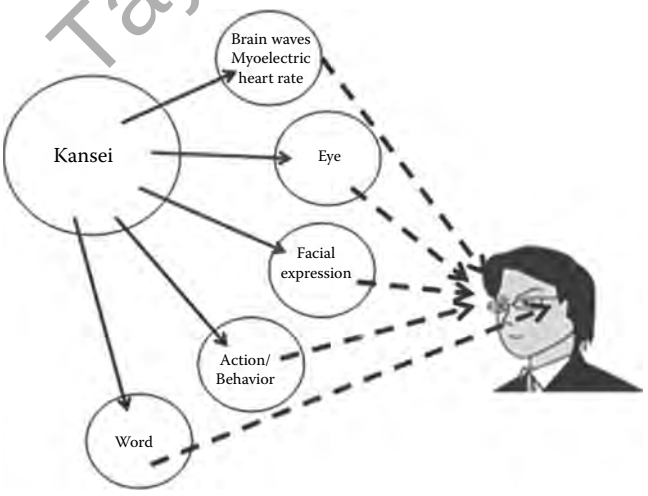


**FIGURE 1.4**
Various forms of Kansei expression.

is deeply moved, he or she will express it using words. He or she will utter something like "That's cool!" "It was so delicious!" or "That's uncool!" so we can know his or her Kansei conditions. By being alert to these kinds of expressions, we will be able to apply human Kansei to product development or work improvement.[2]

There are ergonomics and Kansei engineering methods to study human Kansei that should not be overlooked. In brief, they are as follows:

1. As a method for product development:
   a. Observational method. Observe customer actions for a while to search for certain characteristics in body and eye movements. As necessary, we may also need to count these movements. If a person looks at, sniffs, touches, or returns to a product a few times, we will know that he or she is attracted to something about that product.
   b. Kansei analysis. After we have grasped the overall interest level, we should conduct a Kansei survey and analysis of what captured his or her interest—is it shape, color, taste, or price? Depending on the first Kansei prehension, prepare a list of 40–60 important Kansei words related to the survey and conduct a survey of customers. Put the obtained data through a statistical analysis (multivariable analysis) to understand the factors that make up the Kansei. Use the results of the statistical analyses from a few different product Kansei surveys to develop a new product.
   c. Cerebrophysiological method. Nagamachi earlier described that Kansei is the emotion generated from the prefrontal cortex. In order to know what is happening inside the cerebrum, we need the cerebrophysiological method. Methods that are commonly used are fMRI, NIRS, EEG, etc.
   d. Artificial intelligence. In Kansei engineering, the data acquired from the Kansei analysis is used as an artificial intelligence rule base and inference engine. When we set the design that we are looking for as the objective function, and enter the appropriate Kansei words, an ideal design will be generated. There are a wide variety of artificial intelligence methods.
   e. Design from marketing. There is also a method where the required data for a new product are extracted by analyzing the data acquired from surveys, before commercializing the product. The use of *text mining*, and recently *big data*, are popular.
2. As a method of job improvement:
   a. Industrial engineering improvement. In an effort to maintain production efficiency and quality, we seek to improve the work flow or consider the work distribution between robots and humans.

Such systems include modules where parts are preassembled into units, as an effort to reduce assembling time. Among them, the Toyota Production System is an excellent example.

b. Ergonomics improvement. This refers to improvements that make work easier by considering physical limitations, reducing action energy, or sufficiently incorporating human strengths and weaknesses.

c. Kansei ergonomics improvement. This method motivates workers, thus bringing pleasure and a sense of purpose in work, and as a result, production efficiency will improve. The cell system is one such example.

d. Service innovation. This is a method that not only tries to introduce the concepts and techniques of an engineering system in the service industry, but also focuses on customer Kansei and develops advanced services that maximize understanding of customer Kansei and customer satisfaction.



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# 3

# *Kansei Service Innovation*

## 3.1 Organization Innovation in a Tenmaya Hiroshima Shop

Simply explained, service innovation is a "scientific idea" that aims to improve the productivity of the service industry by integrating an engineering idea. Other countries started with this concept long before, such as Germany and the United States. In Japan, the Ministry of Economy, Trade and Industry announced a policy in 2007.[1]

Professor Nagamachi has been fully involved in this area since 1969, when he started as a student, and achieved some great results from the stakeholders and employees. One day in that year, the general secretary of the trade union of the Tenmaya Hiroshima department store in Okayama requested him for consultation in the office of Hiroshima University. In this department store, managerial employees were also involved as labor union members, and they seemed to be worried about their employees' work motivation.

The main point of the consultation was to improve the employees' work motivation, including the elevator and escalator girl's enthusiasm, which was waning. Professor Nagamachi often visited the Tenmaya Hiroshima shop and felt that the girl's smile was mechanical, not sincerely coming from her heart, and that customers sensed this as well.

Professor Nagamachi spent a number of hours discussing behaviors and supporting the workers and supervisors. As mentioned in Chapter 2, the rules in working life include feeling work responsibility, self-development/self-growth, and a desire to produce a result that is highly valued by the company. Professor Nagamachi feels that the worker should not assume that the buyer is an expert on the product and has special knowledge, and that this store is the only store that sells the product that the buyer wants.

Professor Nagamachi wanted to give each member of the department store a chance to feel important. Therefore, it was recommended that the store execute serious training on product knowledge for all employees and supervisors and give them some responsibility for product purchasing, thinking that they would seriously sell the product they selected. The supervisor

was happy and thought that it was a brilliant idea and returned to the office to discuss this with the branch manager and general manager.

The workers' union started a discussion internally, and thought that it was an interesting idea and agreed to try it; therefore, they entered the discussion with the management (officer) team. The objective of the discussion was actually a proposal to let all of the employees (excluding new employees who joined the company less than 1 year prior) conduct research on each product for its current attractiveness, raw material characteristics, sewing characteristics, cost structure, and saleable product characteristics, including the selection method, retail price and cost (profit margin), etc. Upon completing the study, the employees would be given a budget to travel all over Japan to offer the outstanding products at all counters.

The response from the company was that the Hiroshima shop had its own dedicated buyers for dedicated products, and to make the employees confident and specialized in product knowledge, they would need a couple of months of training. Because this would not result in any profit, the company rejected the proposal.

The union was confident of this idea and strongly hoped it could be executed. They were not giving up even though they received negative comments; Professor Nagamachi and Suwa, a fourth-year student (currently president of Kumahira Manufacturing), were sent to the Tenmatsu shop to experience the operations in the department store and conduct an awareness survey of the employees who would be involved in this project. There would be a risk if all the shops suddenly made changes; therefore, initially, just for discussion purposes, they appointed the chief secretary, who visited the university, to be responsible for the sixth floor's daily life goods (sweaters and underwear).

The guidance team consisted of the manager, assistant manager, and each product's veteran leader. After 3 months of intensive training and receiving a proposal from each employee that had a budget for purchasing goods, they visited each location (store in Ginza Tokyo, general store at Kyoto, and Hiroshima's famous wholesale). This new method was called the self-order system. This is a system where the ordering is done by the employees.

An explanation was given by the members returning from purchasing to the members at the counter, and each of them understood the overall message and conducted collaborative work by adding attractive words to the showcase content, product arrangement, and the detail and good point of purchase advertising (POPA). The next day, they transformed the selected products for the new showcases selected. The workers' faces shined at the opening of the shop at 10:00 a.m. Most of the customers enjoyed being welcomed by the worker with a loud voice, which they had never experienced before, and also, some of the customers who had come before noticed that now the worker was explaining the added value of the product with a confident voice. The sales are also improving gradually. The largest improvement is the members' motivation and job satisfaction.[2]

As a comparative study, the second floor, which had a similar product with a high price was considered. The responsible management had not been introduced to the program, but was given the same questionnaire (51 items) on the same day for comparison. The employees' motivation was very high for the sixth floor employees, and the management communication level was also frequent for the sixth floor. The target value (job reward) against display ability, approval, and sense of accomplishment greatly contributed, and the result was consistent with the Herzberg motivator factor. Sales also increased more than the year before.

The demand from other departments to introduce the suppliers' liability system, which started on the sixth floor, gradually increased, except for the dry goods and jewelry areas. It also spread to other departments, but after 3–5 years, the management closed it down and finally discontinued it, except for the necktie section.



## 3.2 Shop Master System at Seibu Department Store

Professor Nagamachi describes a story that caught his attention in a book published by Diamond Publisher, where Seibu Department Store was supposed to perform a transformation.[2] His idea was that inside a small shop in this department store, a young leader was to be in charge for all management: employment of subordinates, training, purchasing of goods, and profit management. Then the group would become highly motivated as an autonomous team. Additionally, if some of the profit were divided among the team members, their satisfaction would be greatly increased. Professor Nagamachi named this idea the "Shop Master System." This idea is better, theoretically, than the supplier's accountability system at the Tenmaya Hiroshima shop.

In the beginning, a number of stores that launched the shop master system suddenly increased to 80%, and this system suddenly widened to all the stores in the department store, excluding the cinema and specialized store. The Seibu Department Store was the head and each department store formed a series that spread to all the inside shops within the Seibu Department Store, as well as all the children department store subsidiaries under Seibu. The Takashima series also expanded to other series, and then the Tenmaya department store also introduced it. When Professor Nagamachi visited the Tenmaya Hiroshima shop again for shopping, the managers were much happier and said to him, "We are truly sorry now." rendering him speechless. A good system brings good effect. Sales are also growing, and job satisfaction and the morale of employees have improved significantly. This kind of example is called "human engineering world job design" (organization design).

## 3.3 Kagaya Service Innovation

Professor Nagamachi believes everybody will think of Wakura Hot Spring (Kagaya) when we talk about the best Japanese service hotel in Japan. In December 2010, when the Taiwan Kagaya Beito Hot Spring opened, it received delegates from Taiwan. Very skilled and possessing great hospitality, Kagaya became a world-class hotel. Kagaya was founded in 1906 by Oda Yoshiro in Noto Peninsular (Figure 3.1).

It is well known that the Showa emperor, empress, and family were customers of Kagaya. Kagaya at that time consisted of 246 rooms (capacity: 1460 people) and was supported by 650 employees; as a business, it was continuously prosperous and believed it should construct a new facility in a separate building to meet its popularity.

At this time, CEO Mr. Oda thought that the best service was to provide room service to each customer. However, as the service women aged, carrying food trays became heavy work for them. He asked for a consultation by the office Foundation for Older Persons Employment Development (Tokyo).

Professor Nagamachi has found that excellent service to make customers happy is for the elders like Nakai-san (skillful service lady), who had a good technique, but not for young employees. Oda, the president, concluded that the hotel could not lower the hospitality level, but for the old Nakai-san, it could not improve the work anymore.

The issue to resolve concerned balancing the actions of the workers carrying the cuisine and the excellent hospitality required. Dealing with the Kataoka manager, the managers discussed details of workers' issues, visited the site several times, and finally achieved a great solution.




**FIGURE 3.1**
Hotel Kagaya hospitality. (From home page.)

**FIGURE 3.2**
Kaga Shop food automated transport system.



The solution was to construct an automated transportation system with robot food carriers to serve each customer room. When the food was ready and still hot, the robot transported it to the customer room, where it was delivered at the specified time. The Nakai-san then served the food with the appropriate hospitality.

Although the transportation was done by a robot, the hospitality skill was by Nakai-san, and the service was further improved by sharing both skills. In other words, the problem was solved by introducing innovation into the service industry (Figure 3.2).[3]

## References

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# 5

# *Activating Kansei in Product Development*

## 5.1 Activating Kansei When Creating a Product

Because Professor Nagamachi was as an assistant professor prior to his work in quality control, he was strongly influenced by two professors from University of Hiroshima involved in the Deming Prize jury. His specialization was in total quality control (TQC). The quality control outline is getting the customer request, starting with the customer need, setting the guideline, and educating product management to maintain quality by changing unbalanced activity according to customer needs, in other words implementing Kansei engineering.

Beginning in the 1970s, the term *emotional engineering* was already in use, but most of Professor Nagamachi's foreign colleagues at international conferences used *emotion* in the context of bringing strong emotions like grief and pleasure. So, Nagamachi was advised to use the more suitable Japanese term: *Kansei*. Then in 1986, Professor Nagamachi received information from friends at the University of Michigan that Kenichi Yamamoto, president of Mazda, gave a special lecture titled "Kansei Engineering" at the University of Michigan; thus, the term *Kansei engineering* came into use, and now is known the world over.

*Kansei* is a word the Japanese would normally use to express sentiments such as "I wish there were something like this," "I want to do this," "beautiful," "delicious," and so forth, which are synonymous with emotion. When a customer makes complaints such as "Why do I have to do this?" or "I wonder if this is sold at the supermarket," it is time to develop a product to fill that need.

When you want to do something or feel inconvenienced, you feel an emotion; for example, when you feel something such as "delicious," you will directly react with emotion. This kind of emotion or sense is grasped in advance. What you can express is taste, shape, design, etc., and if you design a product in an appropriate way based on customer emotion, you should be able sell it. Product development is the most active use of Kansei.

To start creating saleable products through Kansei, it is important to accurately capture the emotions of the customer. As discussed in Chapter 1, there are various forms of emotion that can be expressed. Based on that,

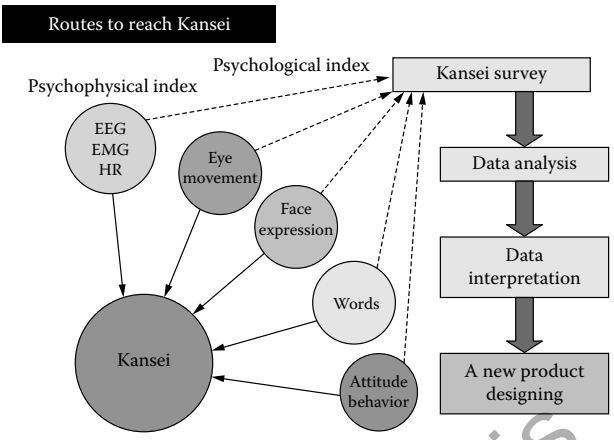



**FIGURE 5.1**
Route to reach Kansei (method).

the most accurate way to capture emotion easily is to use the selection method. Refer to Figure 5.1.

The center for Kansei appears in the brain's physiological content in various formats, such as brain waves, functional magnetic resonance imaging (fMRI), Nuclear Information and Resource Service (NIRS), electromyography from the body, galvanic skin response (GSR), etc. When you have an interest, open your eyes and focus on the target.

Your expression will change when you eat delicious food, and you will say, "Delicious!" Kansei 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 method, where the goal is the design. To do this, we need to collect Kansei data and analyze these data using physiological, engineering, and statistical analyses to produce useful information.

These kinds of analyses reflect only the current state information. We use this information to develop new products to satisfy customer needs expressed through the Kansei data. We continue to gather and analyze Kansei data over time to determine our progress and realize future product development. This is the ability of Kansei engineering.



## 5.2 Recommend Customers Touch with Hands

There are two points to consider when performing product development and utilizing customer emotion. First, customers feel attracted when they see a new product and then they touch it and check whether it impacts

their feelings or not. When they don't feel an impact when they touch it, this means that the opportunity to get in touch with the customer is not developed and there is no chance of the product being purchased. We cannot call this a new product. Attractive elements of product appearance include shape and color that attract the eye to the appearance and hold an attractiveness characteristic. You will get a feeling such as "Oh, there is something unusual. I wonder what it is." Certainly, this characteristic of attractiveness is the result of Kansei analysis and must be taken into account in design.

Second, when you feel the attraction, then you also feel the impulse to buy and try the product, and unexpectedly your face is shining. This opportunity can be repeated, and is good if you can realize it. Feeling attraction in the face is called *primary first moment of truth* (*FMOT*). It is called *secondary FMOT* when the attraction comes after the purchase. It is a great success if you can design new products that have this characteristic (Figure 5.2).

According to the Kansei research so far, the first element to create attraction (attractiveness) is the structure of color, which represents about 70–80% of attraction. The second element is the shape, and furthermore the roundness design part is greatly affected. You can get the weight of a factor by using Kansei analysis and need to consider when to proceed with the analysis.

Google recently emphasized the importance of the zero moment of truth (ZMOT). The zero moment is actually before we see the real thing in person, where the customer somehow received the information, via TV, Facebook, Twitter, etc., and already had the intention to purchase or not. This kind of



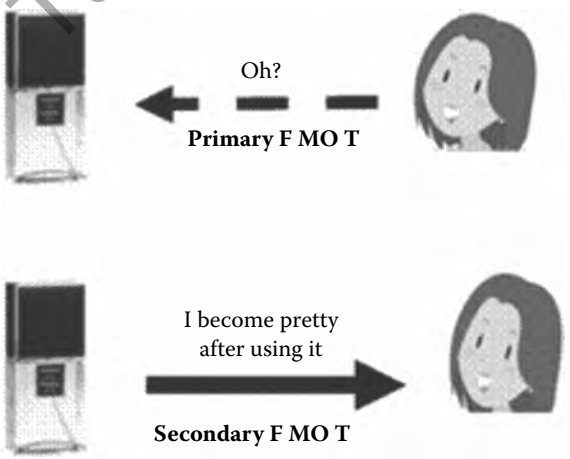



**FIGURE 5.2**
The changes from attraction to purchase to repeater.

media information creates the attractiveness and the effective opportunity. We need to use Kansei analysis from media information for advertising. Professor Nagamachi introduced some new Kansei products that were developed under his responsibility.

## 5.3 Human Living System

The human living system is the first to apply Kansei engineering. It was broadcasted live at 7:00 a.m. in Tokyo NHK Studio 103 in 1974. At that time, Professor Nagamachi and a female student discussed and explained the use of Kansei engineering in the interior of a live studio. There were many callers from the NHK staff and external callers from the audience or viewers that wanted to make use of Kansei engineering. The company was NishiNihon Interior Co., Ltd. in Fukuoka.

Two years earlier, Iwashige Ritsuko, a master student of architecture, applied Kansei engineering in her research thesis in the study of interior design. She produced a human laboratory in a 1/10 ratio model with walls, floor, curtains, etc., that could change color in several ways and let students evaluate the Kansei. When analyzed through factor analysis, the results reflect the emotions of the specific person to a particular interior decoration rule. The name of her new product was the *human living system*.[1,2]

The customer visits the company when he or she wants to purchase a room in a new building or apartment. The salesperson can easily explain Kansei engineering by showing a pamphlet of the human living system. And then the salesperson presents the video created by the Hakuhodo. They describe each person's feeling of staying in the room using their own words.

For example, "comfortable," "luxurious," "Western style," "I will be in a relaxed mood," "It makes me want to listen to music," "It makes me want to talk to my friends," etc. All these are Kansei word expressions. An actual example is shown in Figure 5.3. This is one of the examples that comes from the same Kansei words. When a Kansei word is identified, the product code combination of the walls, floor, and ceiling of the room and curtains is identified. Each product has different colors, as reflected in Figure 5.4, which has a set of five combinations based on the same emotion, and customers will select their favorite color from them. For example, a customer said, "When I enter the room, it makes me want to study." Corresponding to that, the salesperson will select a suitable atmosphere for studying. A customer who is a child can find a suitable atmosphere from one set.

In a short time, the profit was about 2 billion yen, as all the newspapers such as "Nihon Keizai," "Nihon Kogyou," "Asahi," and "Yomiuri," ran reports of the system. This company was also fortunate in that it had worked on the interior decoration of Mitsui Home Co., Ltd. This mechanism was used for

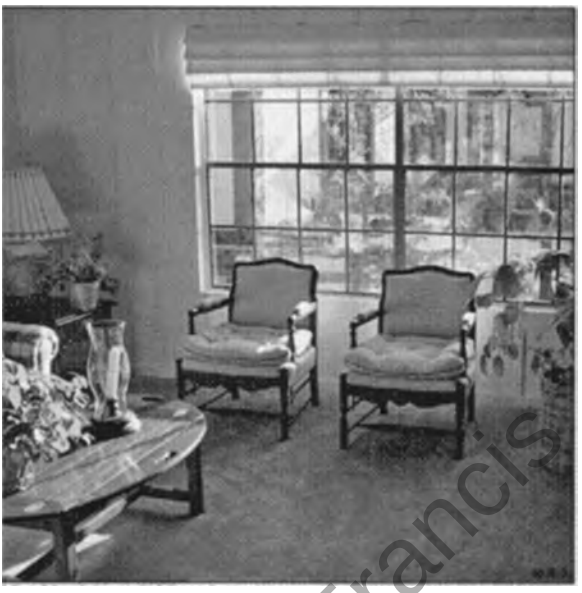


**FIGURE 5.3**
Luxurious example of Kansei.

**FIGURE 5.4**
Selection of showroom walls, floor, ceiling, curtains, etc.

about 200 types of material, all of which were purchased from Sangetsu (Ltd.), but from Sangetsu's perspective, it could only sell 200 types without orders from other companies.

Without giving his name, Professor Nagamachi visited Nagoya Sangetsu to learn the real circumstances in Sangetsu, and, as compensation, he gave

advice on the method of showroom sample display and went home without being recognized. Of course now, Sangetsu is back to being a key player and the top company in their industry.

## 5.4 New Refrigerator Development at Sharp

In 1978, Professor Nagamachi received a request from the design executive in charge at Sharp asking for guidance on Kansei engineering for its 150 designers. The designers were all gathered at the Sharp headquarters, and although the explanation was conducted twice, they complained it was difficult to understand. So Sharp decided to apply Kansei engineering to a new type of refrigerator and hired Nagamachi to develop a new type with two doors.

To do the new thing based on industrial engineering, Nagamachi decided to observe and monitor how a housewife uses a two-door refrigerator each day. He organized a team consisting of six female designers and monitored these homes with a camcorder.

Since two-door refrigerators were common in those days, the camcorder was installed in front of the refrigerator and continued shooting for 2 hours while a meal was cooked. When the scheduled investigation finished, the members were asked whether they found any clues during the observation, but they could not come to a conclusion, so Professor Nagamachi decided to look at the video recording again.

Some people were asked to record the number of openings and closings for the upper and lower doors, as well as the main item that was taken out. These data are important to help us think further. Even with six people monitoring the recording, they could not come up with an idea of what the new refrigerator should be.

In those days, it was normal for the upper door of the refrigerator to be used for food freezing and ice making, while the lower door was used for the dish to be prepared that day. When Professor Nagamachi looked at the video, he found that the lower door opening and closing represented 80% of both door opening and closing. Most instances were for vegetables, tofu, eggs, and others materials intended for use in cooking immediately. In brief, the result of this investigation concluded that the homemaker was always bending down to open the lower door to take out vegetables, etc.

Here, Professor Nagamachi recapped the discussion in Chapter 2 on the problem of working posture. In order to open the lower door of the refrigerator to take out vegetables, for example, the person needed to bend his or her knees and hips,[5] using four to five times the energy used in a standing position. Homemakers were always in a difficult posture but did not complaint about it, so the engineer and designer, who were

assigned to study the emotional aspect, needed to take care of the bending and stretching posture even though it was not complained about by the customers.

As a collaborative work, the new product development group and designer group changed the lower door position to the upper door position, and the upper door position to the lower door position, and the difficult posture was avoided as shown in Figure 5.5. This has become the new design. By the way, to make customers even happier, an investigation on what they stock in the refrigerator was done and a mechanism invented to allow customers to control the temperature corresponding to the storage of each food.

The upper compartment of the refrigerator is the storage compartment for tofu, eggs, beer, etc., with 2–5°C. The lower compartment is divided into two storage parts; the freezer compartment contains upper and lower storage, so that the temperature can be adjusted to coordinate with the different frozen foods. This temperature control device is the new design. In the video, a person removed frozen meat, put it on a table, and then went out, allowing it to retain its taste. Defrosting temperatures were estimated and a chilled area was invented and placed between the freezer and the refrigerator compartments. With the range of 0–2°C, it maintains the taste of meat and fish.

With these improvements, homemakers no longer needed to bend frequently at their waist. Kansei justified the development of the new refrigerator.

Starting in 1979, Sharp manufactured the new type of refrigerator for a while, but soon after Hitachi, Toshiba, Matsushita, and others started manufacturing it too. Of course, at that time Sharp was the top maker of the refrigerator. Thereafter, this model received a high reputation in Japan for a long time. Recently, we discovered that Samsung from Korea sells exactly



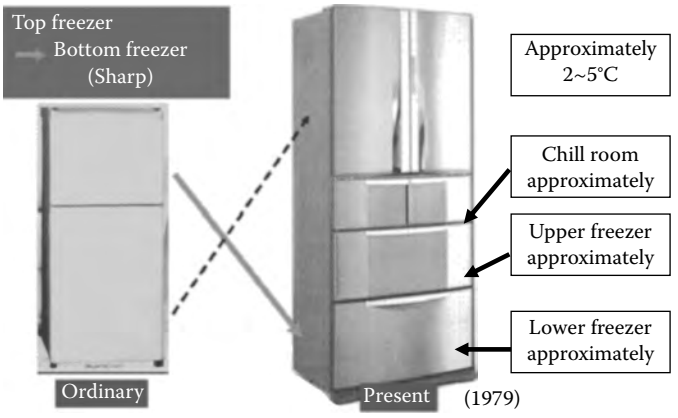



**FIGURE 5.5**
From two doors to a new type of refrigerator.

the same type of refrigerator, the concept of which had been duplicated from this. It is popular in South America and Southeast Asia as well.

There is great interest for other parties to see the activities of Kansei development and implement it. This group developed what Professor Nagamachi did during the refrigerator development activities related to the video shooting (camcorder).

The market share of Sharp at the time was about 3%, and management was thinking of stopping the production. The group asked permission from management to analyze how to use the development process for the refrigerator as well as the video shooting device that was used to shoot at the site.

A perfect opportunity to purchase the video shooting device is when a child is born. A young father is able to video his new baby's face, and as the baby grows, he can videorecord the baby crawling on the floor, which was previously impossible to do. The focus of the development was based on this need, and then a lens was invented that can be rotated 350°, so that the user does not have to assume an impossible position.

In the topmost part of Figure 5.6 is the traditional heavy camcorder. The second image is the innovative recording equipment with an image storage system and a liquid crystal, which is the LCD ViewCam, and slowly it became smaller and eventually evolved into a digital camera. Currently, every smart phone is built with a camera installed. The evolution until now is shown in Figure 5.6.



## 5.5 Wacoal Good-Up Bra

Wacoal sold a bra (Good-Up Bra) that, at that time, became popular not only among teenagers, but also among young women. It brought a new era to bra design for other companies to follow.

Wacoal manufactures underwear for females. It not only sells in Japan, but is also known internationally, and its development ability is very highly regarded. Professor Nagamachi received a request from Nakano Hiroshi, the production quality development executive, to work together on introducing Kansei engineering in an attempt to develop a new bra product.

When Professor Nagamachi finished his lecture overview of Kansei engineering to the employees, including the designer, he received excellent development and research capabilities from the members of the Human Science Research Center and proceeded to the operation.

First, Professor Nagamachi started to understand the emotion of using the bra from the female user's perspective. In surveys of 2000 women regarding emotions and feelings, questions such as "What do you want to achieve when you wear a bra?" were included. Eighty percent of the females answered that they are wearing a bra in order to be "beautiful"



**FIGURE 5.6**
From the traditional type of camera to digital cameras and LCD ViewCams.

and "elegant." In other words, "I want to be beautiful and elegant" is the need of the female, and if he achieved development of a bra based on this need, the female customer would be satisfied and would buy the product.

As part of the second phase of the Kansei engineering research, Professor Nagamachi conducted the most popular research and analysis. He collected all types of bras from various makers and of various sizes for young females to try on; each was evaluated by these two Kansei words: *beautiful* and *elegant*. He created a score list to evaluate the collected bras using a scale of 10 points, a product is beautiful = X points, a product is elegant = Y points, etc.

Next, Professor Nagamachi examined the collected bras one by one. The material structure, size, and shape of the cup, fiber-expandable characteristic, diameter of the under wire, color, and design, etc., were recorded on the list by examining all the features in detail. Then he established the Kansei physical characteristics of *beautiful* and *elegant* using a combination of the Kansei score by the tester and the evaluation of physical characteristics of the product, and performed a multivariate analysis. He used the physical characteristics to produce the new bra.

Next, the completed new bra was modeled accordingly as designed from the data interpretation. Using the Moire scale developed by a professor from the Department of Engineering at Shizuoka University, Professor Nagamachi obtained, by imaging, the unevenness of the body when a female was clothed in the new bra (Figure 5.7). This imaging provides a better understanding of the irregularity of the body because it is a contour plot. On the left is the traditional bra, and on the right is the Moire measurement diagram for wearing the new bra.

The design principles for the new product were that the left and right breasts needed to fit inside the left and right body lines, and both breasts needed to be aligned parallel, facing somewhat upward. To understand this, see Figure 5.8, where the left side is from a traditional bra in which the breast appears with impropriety and the left and right breasts face each other in the opposite direction (undesireable).

With this, the new product, using the Kansei experiment and analysis, was validated to create a product that fulfilled the female's needs.

With the Wacoal bra, both breasts are in a raised forward shape; this new product was named Good-Up Bra. It was very popular, with young females purchasing three or four bras, and brought the sales to 750 million yen. This happened in 1992. Of course, other companies also followed, but they could not catch up due to the different design concepts.

Wacoal created a second edition of the Good-Up Bra, and created sexier products such as the Hip-Up Panty, which was continuously a hit in the market.



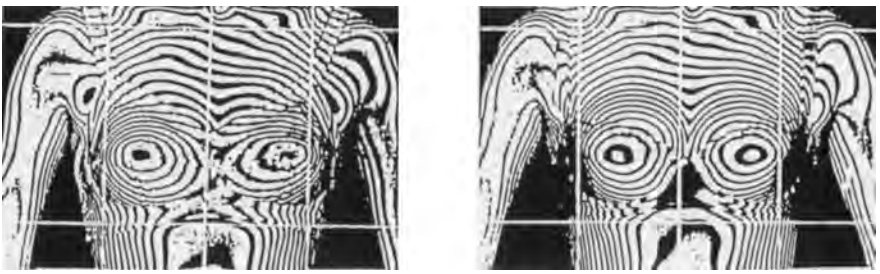


**FIGURE 5.7**
Comparison of the traditional bra (left) and the new Good-Up Bra (right).

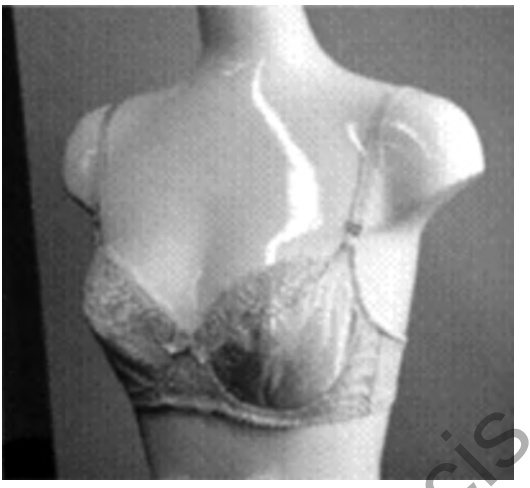


**FIGURE 5.8**
Good-Up Bra.



## 5.6 Hit Product in Komatsu

The Aoki managing director from the giant construction company Komatsu came all the way to Hiroshima and requested that Kansei engineering be applied at Komatsu. Immediately, Professor Nagamachi visited the construction machinery training center in Hakone (near Tokyo), examined the current products at Komatsu, and experienced them, such as driving a large dump truck, to understand the basic concept.

This is not the first experience of Professor Nagamachi in this area, as he also had experience as an ergonomics researcher at the University of Michigan Transportation Research Institute from 1967. At the University of Michigan, there is a 4000-m runway, where Professor Nagamachi conducted research on large vehicles such as aircraft and tankers, and where he also drove the latter vehicle and found that the size of the tire was higher than his height, with eight tires on one side. When he drove a big truck with a 12-gear shift, and changed to the top gear, he arrived at the end of the run, and almost caused an accident.

We were developing a shovel car or excavator using the Kansei product. When we investigated the situation, we found a shortage of drivers and asked their feelings toward the design. Being friendly with them and conducting a survey contributed to the sale.

First, surprisingly, when the actual situation survey was conducted, upon entering the excavator, the drivers take off their shoes and change to slippers. In other words, the driver seat is more like a home for them, which they keep beautiful and clean, and in some cases, it is ideal to work surrounded by music.

From this kind of actual situation survey we started to select the Kansei study words, and again, the needs of the driver became Kansei. The Nakata Engineering Department chief engineer and Iwata design manager participated and have continued to expand the development in this group ever since.

When talking about the driver's Kansei, from the city people point of view, it is not insignificant work but important work, and we want the design to reflect that sense of friendship/relationship. Also, it is hoped that the new design is felt to be smart and have a high-quality appearance. Talking about the construction from the old days, there was an image of mining the land, or classically, the strong form of an angular body of the car in soil color. Professor Nagamachi started with how to break this image.

By the way, Professor Nagamachi was challenged by how to design the angulated body of a car for a sense of relationship and a high-quality form. He also finished the roundness research on how to transform angular things to round. For example, in Figure 5.9, looking at the upper and lower three-dimensional parts, which do you think has an easier feeling?

From the research result, the roundness is about 1 over 12 of the 3D angular part and feels great (sophisticated, friendly), and it comes to a hemisphere shape; when the end of the roundness is increased more and more, one finds a feeling of getting bored.

This principle has also been utilized in cosmetic products of Shiseido, giving the corner of the box a sense of quality and refinement and becoming a little round in design. A box-shaped enclosure of the driver seat in an



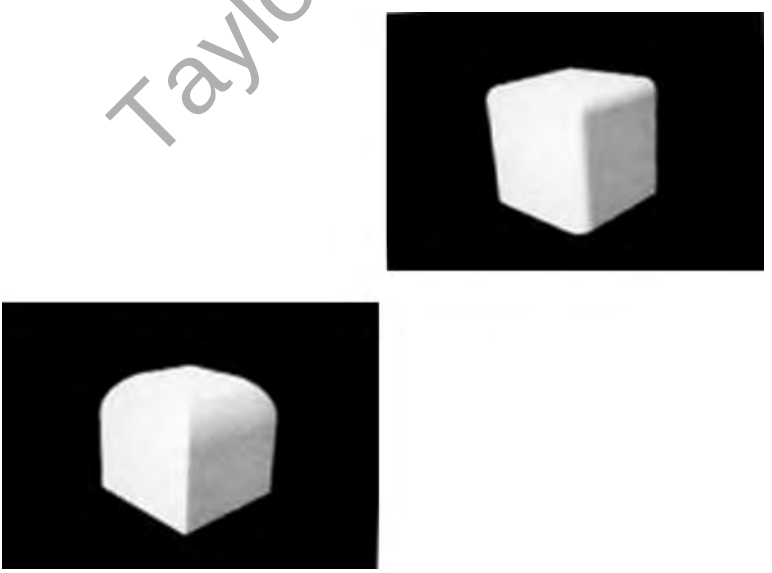


**FIGURE 5.9**
3D Earle Kansei.

excavator is designed in a small format and colored with purple as an idea to express high class and a sense of quality color.

This kind of Kansei and design-related data were provided to the excavator development group, and Avanse Series 1 (Avanse PC45) is shown in Figure 5.10. It received very high marks as an innovative design in the world of construction at that time and received inquiries from a number of vendors.

Because of this, Komatsu was given the Good Design Award in 1992. Then this curved design was applied to a large excavator (PC200t), shown in Figure 5.11. Komatsu also was given the Good Design Award in 1993 again. In addition to the reputation of this large vehicle, aiming to improve the operating rate of the vehicle, the vehicle is equipped with a GPS that can check its movement, but this was an unexpected result.

Only recently, with the construction boom in China, has it been in great demand because some people steal construction assets. Since all Komatsu construction equipment is equipped with a GPS, a stolen vehicle will be found immediately. Komatsu became the first company in the world to install GPS on its construction equipment, giving it a high reputation all over the world. A proposal to mount the GPS is a measure that meets the needs of customers, and the DNA of Kansei engineering has already been implemented by Komatsu.



**FIGURE 5.10**
Komatsu hydraulic excavators. Avanse series PC45.

**FIGURE 5.11**
Komatsu excavators. Avanse series PC200.6. Good Design Award in 1993.



## 5.7 Handrail Development Based on Customers' View

According to the United Nations, when the population ratio of those 65 years old or older exceeds 7%, it is called an aging society; when it exceeds 14%, it is called an aged society; and when it exceeds 21%, it is called a super-aged society. In 1970, the aging population in Japan was 7.1%. In August 2013, the Ministry of Internal Affairs and Communications announced that the population ratio of those 65 years old or older is 24.4%, so we are now in the super-aged society.

In places where senior citizens live, in order to keep a safe and comfortable living environment, barrier-free activity is being implemented. The biggest implementation is handrail installation. At Onomichi City University, associates of an Ishihara assistant professor conducted a survey of those 60 years of age and older in Onomichi City, asking: "Do you use handrails?" Those 65 years old and older who utilize a handrail are shown in Table 5.1. For those 75 years old and above, the usage of a handrail increased. So the handrail is important to them.

**TABLE 5.1**

Handrail Usage Ratio for Senior Citizens above 60 Years Old

| Item | Age of 60–64 | Age of 65–69 | Age of 70–74 | Age of 75–79 | Age Above 80 | Total |
|---|---|---|---|---|---|---|
| Not used | 93.9 | 81.9 | 78.9 | 56.4 | 40.5 | 72.7 |
| Used | 5.7 | 16.8 | 20.3 | 40.6 | 42.4 | 23.2 |
| Requiring long-term care | 0 | 0.3 | 0.4 | 1.2 | 5.7 | 1.5 |
| No response | 0 | 1.0 | 0.4 | 1.8 | 11.4 | 2.7 |

*Note:* All values in %.

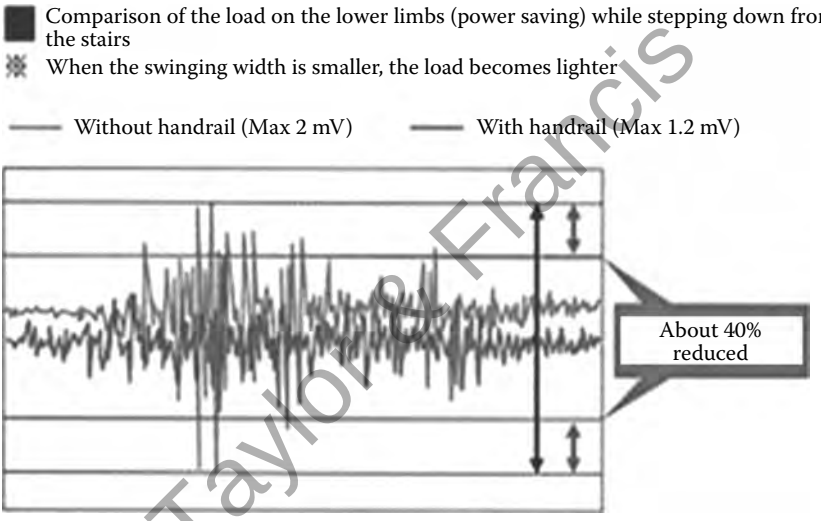





**FIGURE 5.12**

Forty percent say that it is easier to get down when holding the handrail, rather than not holding it. (Experiment by Hiroshima Prefecture Health and Medical University, Shiokawa Laboratory.)

An experiment was conducted to understand the effectiveness of the handrail presence. Seventy-year-old senior citizens were requested to go down the stairs using two methods: with and without holding the handrail. As shown in Figure 5.12, a 40% electromyogram (EMG) level of the feet can be reduced by holding the handrail. When holding the handrail while walking down the stairs, it is safer, makes walking more comfortable, and requires less energy. The effectiveness of handrail usage is great.

Per the recommendation of the old Ministry of Construction, a 40-mm diameter of the handrail is desirable. But according to the joint study between Matsushita Electric Works (now Panasonic Electric Works) and Professor Nagamachi, it was found that older women were unable to grip

the thick handrail. A few handrail samples were prepared with diameters from 30-mm up to 40-mm, with 2.5-mm gaps, with a total of six types of proper thickness handrail to be held by 86-year-old senior citizens. The investigation results are shown in Figure 5.13. Looking at this, it would be good if the diameter were approximately 35-mm. In other words, the palm size for older women is relatively smaller and reduction of the handrail diameter is necessary. However, for men with a weight of more than 65 kg, the 35-mm diameter handrail is dangerous and can more easily malfunction when held, causing them to fall down. As a countermeasure, Matsushita Electric Works has succeeded in increasing handrail strength by combining three pieces of plywood for the 35-mm diameter.

In addition, the handrails should be mounted close to the wall regardless of rules from the Ministry of Construction. As indicated in Figure 5.14, safe attachment and an easy-to-grip ergonomic location should be in place when considering narrow Japanese-style stairs.

It is also a challenge to mount the handrail height in a house. It is difficult to get one height that functions for both taller and shorter people. It was decided to measure the optimum handrail height by collecting information from 86 senior citizens. A cane-like stick with a spring at the end of the cane with a scale of 1-cm increments was used, and each of the elderly decided the most comfortable height of the handrail. Because the cane is light and spring-loaded, it will determine the optimum height by the elderly person holding it lightly. The result is shown in Table 5.2. A regression equation has been used for these data. Based on the regression equation, each Y can be decided, and the optimum height of the handrail is obtained.



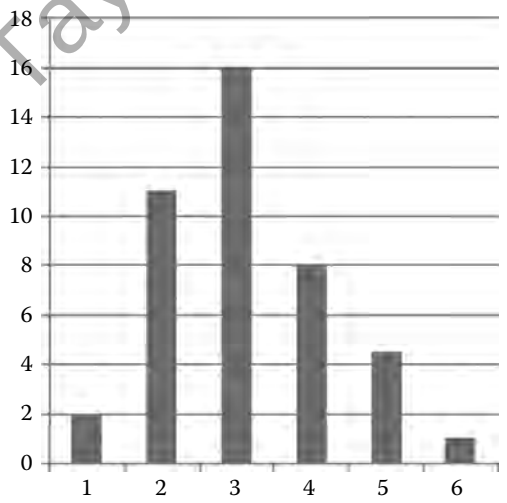



**FIGURE 5.13**
Sample of acceptable handrail thickness (average 35.4 mm).

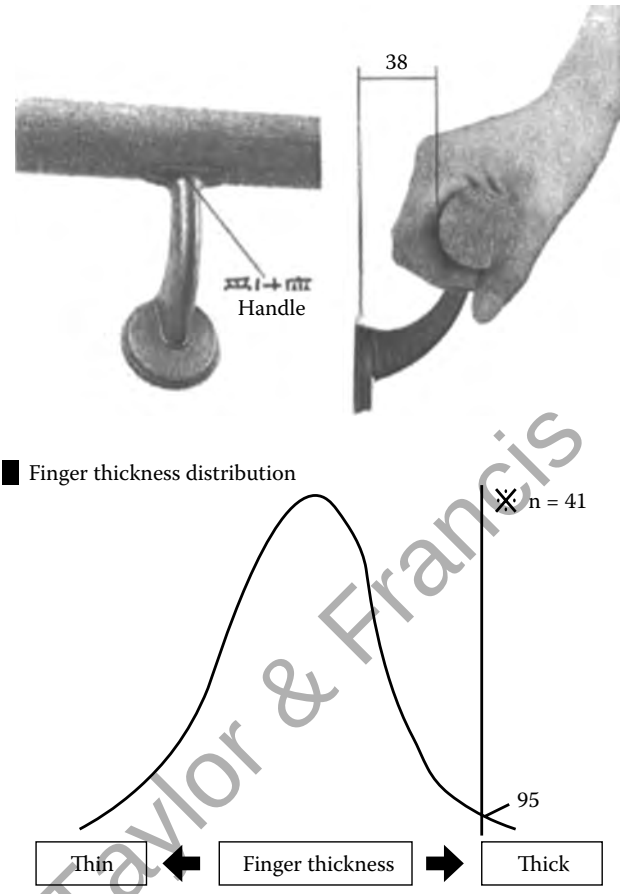





**FIGURE 5.14**
Handrail-mounted method using a human engineering device.

When looking at this regression model, the handrail is not decided based on the person's height alone; the height of the elbows is moderately considered. Then, it is not only a horizontal handrail, but also a vertical handrail. It is needed especially when standing up for a stile (Figure 5.15). An experiment was conducted for mounting the vertical handrail position. Mark 0 indicates the position where the testers were sitting at the upper stile. Then we set the handrail forward every 10-cm from the last position. From a sitting position at the stile, we extended the tester's hand while gripping

**FIGURE 5.15**
Experiment of vertical handrail.



each handrail until he or she was in a standing position. In each scenario, we measured the EMG of the rising action. Details were measured for the supra-spinal muscle of the shoulder, the root flexor muscle of the arm, and the femur biceps muscle of the leg. The result is shown in Figure 5.16.

As indicated in Figure 5.15, to stand up at a vertical handrail from a sitting position, strong physical arm strength is required. In other words, while grabbing the handrail, the body weight needs to be lifted up. However, it is easy to stand up from one's origin to 30-cm handrails and use half of one's energy in the 0-cm position. The reason for this is because the same force toward the hand is being used during holding and raising up the vertical handrail for the 30-cm position (Figure 5.16). Of course, when in the 60-cm position of the vertical handrail, a large force to stand up is needed. It is regrettable that the architect doesn't consider these ergonomic principles. Rather than attaching the same position as he or she does with the vertical stile handrail, it is easy for a senior citizen to use 20–30 cm position toward the front of the handrail.

However, a mounting method that is friendly for senior citizens includes a 40° slant from the stile. When this slanted handrail is used, senior citizens are able to stand up easier due to usage of force at both the hands and feet.

Although the handrail was developed in collaboration with Matsushita Electric Works, Ltd. (now Panasonic Electric Works) and researchers with

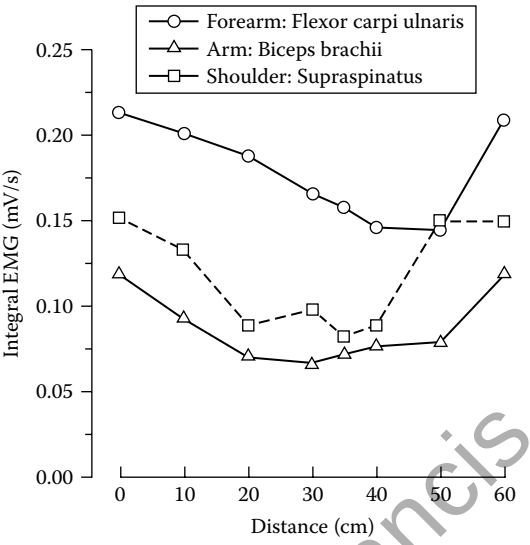



**FIGURE 5.16**
Muscle potential of the rising activities of a vertical handrail. With a handrail 30 cm away from the stile, it is easier to stand up.



joint development by Hiroshima University, with a total of six group members, this product was the top moneymaker for the company.

Matsushita Electric Works incorporated the concept of universal design and Kansei engineering very early and has been pursuing a variety of new development products. The main focus is the Yokoyama Engineering Department councilor. Tile roofs, gutters, walls (siding), outer structures, baths, toilets, kitchens, storage, lighting, floor heating, and others have used the Kansei engineering philosophy in most products. The companies have thought of a variety of new products using the Kansei engineering concept that do not yet exist in the world.

## 5.8 Fun Use of a Toilet Foot Step: A Toilet Design

Introducing a new product developed by Matsushita Electric Works that can be used by common people and senior citizens, Nagamachi received a new toilet design project from the toiletries division. There was consultation between the methodology of Kansei engineering and the Yokoyama councilor. This time, it was related to measuring the human buttocks. It is not permitted to measure by directly touching the student's buttocks. The sensitivity measurement method proposed was to provide seven units of ready-made toilets from various makers. Then let the students test by sitting

on each unit and evaluating the seating condition according to sensibility words. This method was similar to the experience of the Wacoal project, where one part was related to evaluating the sensibility word and the other part measured the physical measurement of the toilet. The analyzed data would be used as basic data for new products. However, the work was not finished yet. The interpretation of the selected data is important to inspire the desired design (Figure 5.17).

The human engineering laboratory of Hiroshima International University set up a sample of seven toilet units that were purchased from a variety of makers. Eighteen male and female students took part as testers. Forty Kansei words were selected for use as the Kansei word related to the comfort of the usage of the toilets. They are as shown in Table 5.2.

Each tester was given the evaluation sheet and sat on the seven units randomly, according to the table in the evaluation sheet, and evaluated the feeling of sitting on each unit. A statistical analysis was done by collecting the evaluations of all voters. First, analysis was conducted of the variance, a Kansei word of what is good in every toilet. Then, by using the same data, the factor analysis was measured and then the Kansei factor of the



**FIGURE 5.17**
Toilet seat scenario experiment.

**TABLE 5.2**

Toilet Evaluation Sheet

| | | | | | | |
|---|---|---|---|---|---|---|
| Name | | | | | Date / / / | |
| Age | Sex | Male, Female, | | | Sample No.( ) | |
| Height | cm, | | Weight | | kg | |
| 1. Easy to sit | ☐ | ☐ | ☐ | ☐ | ☐ | Not easy to sit |
| 2. Large | ☐ | ☐ | ☐ | ☐ | ☐ | Small |
| 3. Wide | ☐ | ☐ | ☐ | ☐ | ☐ | Narrow |
| 4. Easy | ☐ | ☐ | ☐ | ☐ | ☐ | Not easy |
| 5. Balanced | ☐ | ☐ | ☐ | ☐ | ☐ | Not balanced |
| 6. Safe | ☐ | ☐ | ☐ | ☐ | ☐ | Unsafe |
| 7. Not tired | ☐ | ☐ | ☐ | ☐ | ☐ | Tired |
| 8. Soft touch | ☐ | ☐ | ☐ | ☐ | ☐ | Hard |
| 9. Steady | ☐ | ☐ | ☐ | ☐ | ☐ | Not steady |
| 10. Fit | ☐ | ☐ | ☐ | ☐ | ☐ | Not fit |
| 11. Comfort | ☐ | ☐ | ☐ | ☐ | ☐ | Discomfort |
| 12. Easy to urine | ☐ | ☐ | ☐ | ☐ | ☐ | Not easy |
| 13. Easy to stand | ☐ | ☐ | ☐ | ☐ | ☐ | Not easy |
| 14. Want to use | ☐ | ☐ | ☐ | ☐ | ☐ | Don't want |



word interpreted. On the other hand, the physical measurements of the seven toilet units was measured and a list created. The measurement of the physical measurements in this case is 24 types; part of them are shown in Figure 5.18.

After that, as the final statistical analysis, the most important Kansei words selected by the designer (Kansei factor) and the words that have the strongest relation to physical measurements were identified through statistical analysis. The results of the data, together with the designer, were translated into the design form. In terms of Professor Nagamachi's experience with new product development so far, most of products are being led and decided by the new design. Based on the design blueprint, the technical person from Matsushita Electric Works will place them in the Kansei Human Engineering Laboratory. The final mock-up was completed based on the analysis of seven ordinary toilets that were adopted for factories.

After a new sample is completed, verification needs to be conducted to validate the suitable level of comfort, which is what Kansei really aims for. A survey is conducted as a verification experiment by the addition of changes in the seven units. The first validation test of an ergonomic surface was added on top of the sensitivity evaluation (refer to Figures 5.19 to 5.21).

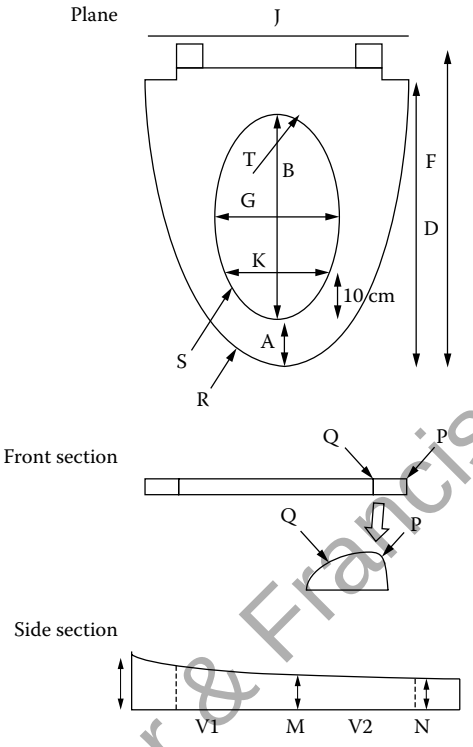



**FIGURE 5.18**
Part of a toilet's physical measurements.



**FIGURE 5.19**
Overall picture of the new toilet.

**FIGURE 5.20**
Result of raising the top cover of the new toilet.

**FIGURE 5.21**
Side view of the new toilet.

First, as shown by a Kansei evaluation test, the result of analysis of variance shows that the new toilet items all scored best in sensibility. The first ergonomic analysis was to validate that the testers should be comfortable to sit. A body pressure measurement device was used to examine body pressure dispersion, which is called force sensitive application (FSA), and checked the pressure of the body on the seat of the toilet.

Put an FSA on top of the seat surface and ask the tester to sit on it. Then, by resting the human body on top of the computer, where the bone in the buttocks hits strongly will appear. In other words, it will illustrate the pressure of the body that receives the most pressure.

This is shown in Figure 5.22. A body pressure variance value of seven units used in the experiment by other toilet makers shows results similar to those of the right side of Figure 5.22. The black line is prolonged to the thigh of the leg from the waist muscle; this is because when sitting, the direction of blood flow is obstructed toward the foot. On the other hand, the left part of the figure shows the seat-sided pressure variance value of the new toilet, and the black short lines come out only from the waist bone muscles to the leg. In other words, the new toilet shows that the sciatic nodule well supports the body and the blood is flowing in the direction of the foot. This achieved an emotion of "sitting feeling good." Everyone who sat on the new toilet would say, "I wanted to read a book while sitting on this."

The second ergonomic validation point is whether the new toilet has become a friendly product for the elderly. In fact, before the product development of the new toilet, Matsushita Electric Works had mounted armrests for senior citizens on the toilet. Their objective is to allow senior citizens to stand up more easily by gripping the armrests. It became a little easier, but there were still complaints.



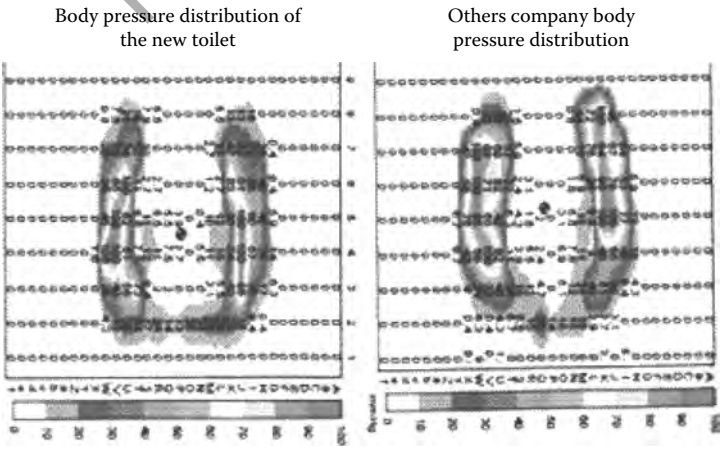



**FIGURE 5.22**
Comparison of body pressure variance.

To further improve the product, the seat was tilted forward in the direction of the bearing surface to feel comfortable. Senior citizens between 70 and 80 years old took part in the experiment. Quadriceps muscles, the gastrocnemius muscle, and the soleus muscle were connected with an electrode that measured the EMG while standing up. The result was incredible. The EMG during stand-up from the new toilet was reduced to about 1/10 compared to the horizontal seating surface of toilets from other companies. Also, one of the senior citizens agreed to say that it is very easy to stand up.

By applying ergonomics and Kansei engineering, a new product, such as the example, can be developed. This new product was named Torres (TRES). The TRES sold very quickly for the manufacturing company and its production became very busy because of the customers' rush orders.



## 5.9 Decide the Brand Name by Kansei

There are a variety of ways to determine the name for newly developed products. It is very difficult to predict which method can lead to the most profitable result. The following research shows that when the brand name is read, it should sound as though it expresses the characteristics and content of the product. For example, a parent is considering what name to give his or her newborn child. In most cases, a name is given based upon wishing the baby an ideal way of life. Kanji character is also considered. When the name is spoken, it's a great success if the name has an ideal impact on way of life of the baby. The same goes for new products. It is important to give customers an image of the product when they hear the name of the product. As an example, the Wacoal Good-Up Bra can give the image of position shape up. Tuning of a new product and branding using Kansei will definitely increase sales.

When breathing, the air goes through the trachea and vibrates the vocal cord. The breath can be sent to the mouth and nose and change to sound. Even when the mouth is narrowed or widened, the voice is changed, as well as when the mouth is opened widely or closed. With loud laugh sounds (ahaha), the mouth opens widely, and with quieter laugh sounds (ihihi), the upper and lower teeth are aligned. When producing voice to match with Kansei, the breathing method is controlled by the mouth palate pattern (refer to Figure 5.23).

The next study shows the relationship between tone and voice. The relationship between the voice and mouth shape can be displayed as shown in phonetics in Table 5.3. Breath goes through the nasal cavity when one says MA-MI-MU-ME-MO or NG, and the voice becomes different when releasing and biting the teeth. Table 5.4 shows the relationship between the voice and palate shape. This is called the *point of articulation*. With breathing through the nose, stopping the breath and then releasing it at once will give

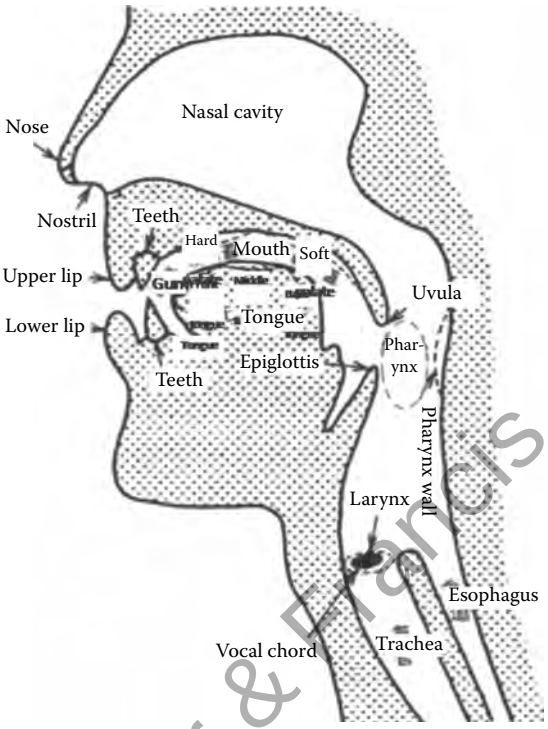



**FIGURE 5.23**
Anatomical drawing of the palate.

**TABLE 5.3**
Phonetic Symbol Table

| | | Bilabial | Alveolar | Palatal Alveolar | Velar | Velar Uvular | Glottal |
|---|---|---|---|---|---|---|---|
| Consonant | Nasal | M | | n | | N | |
| | Occlusive | p, b | t, d | | ç | k, g | |
| | Fricative | | s, z | ʃʒ | c | | h |
| | Approximant | | | | j | ɯ | |
| | Affricate | | ts, dz | tʃ dʒ | | | |
| | Flow voice | | ʃ | | | | |

various sounds, as shown in Table 5.5. Although it is quite complex to put out a shape and breath of the mouth, phonetics was organized as in these tables. Based on the data, the relationship between the type of voice and the shape of the palate is converted using artificial intelligence rules.

Next, there will be very complex analytical work. One of the monthly magazines of Bungei Shunju was selected, and all the words related to Kansei

**TABLE 5.4**

Classification by Articulation Types

| Name | | Speaking Method |
|---|---|---|
| Bilabial | Pa Ha | Open both lips after closure |
| | Ma | While both lips are closed, pass through the breath to the nasal cavity |
| | Fu | With a small gap between both lips, generate breath friction |
| Alveolar | Ta Da | Release after closure in the breath and gum tongue tips |
| | Ra | Pass through to the nasal cavity after closure in the breath and gum tongue tips |
| | Na | Pass through breath in between the gum and tongue gaps and generate breath friction |
| | Sa Za | |
| | Tsu Tzu | |
| Palatal alveolar | Shi Ji | Put the tongue tip in between the gum and hard palate and generate breath friction |
| Palatal | Ki | Release breath after closing both sides of the tongue and hard palate |
| | Hi | Narrow the front tongue surface and hard palate, and generate breath friction |
| | Ya | Narrow the front tongue surface and hard palate to the extent that breath friction is unable to be generated |
| Velar | Ka Ga | Release after closure of soft tongue and inner tongue surface |
| | Wa | Narrow the base of the tongue and soft palate, and generate the breath friction |
| Uvula nasal sound | Ng | Back tongue surface close to the soft tongue at the back of the tongue surface (inner tongue surface), and pass through the nasal cavity |
| Glottal | Ha He Ho | Narrow the glottis without vibration of the vocal cords and generate friction |



words were jotted down from the first page until the end. From hundreds of words, *like* and *dislike* were excluded and only the words suitable to human emotional expression were kept. Then, they were transformed to Kansei evaluation data, and using factor analysis, we picked the words according to some factors and reduced the list to 68 terms.

Each of the 68 words, as mentioned above, is put into a classification table and then a list is created of articulation point and articulation type. This is the basic database for the sound of words. Back to the previous factor analysis, detailed study of each factor and sound evaluation of the words was performed and 20 positive vs. 40 negative words were selected that are appropriate Kansei words. This is the basic measurement scale for evaluating the brand in the future. The list is shown in Table 5.6. Next, to judge the impact to a customer's ear of a person's name or product branding, evaluation with a 40-item Kansei word scale was used with the plus and minus side method.

**TABLE 5.5**

Classification by Articulation Types

| Articulation Types | | |
|---|---|---|
| **Name** | | **Speaking Method** |
| Nasal | Ma Na En | Breathe using a place in the oral cavity or head to close it and flow out using the nasal cavity |
| Occlusive | Pa Ba Ta Da Ka Ga | Breathe using a place in the oral cavity or head to stop a while and one time immediately breathe again |
| Affricate | Tsu, Tzu, Chi Ji | Stop the breathing for a while, and start to open it slowly |
| Fricative | Sa Za Ha | Breathe using a narrow path to open its surroundings |
| Approximant | Ya Wa | Interfere until the breathing almost does not have friction |
| Flow sound | Ra | Narrow the oral cavity until the breathing almost does not have a frictional degree |

**TABLE 5.6**

Influence of Kansei Evaluation Scale (40 Words)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | Soft | —— | Hard | 21 | Elegant | —— | Not elegant |
| 2 | Bright | —— | Dark | 22 | Modern | —— | Not modern |
| 3 | Spread | —— | No spread | 23 | Cute | —— | Not cute |
| 4 | Unique | —— | Not unique | 24 | Simplicity | —— | Not simple |
| 5 | Open-minded | —— | Not open-minded | 25 | Japanese | —— | Foreign |
| 6 | Heavy | —— | Not heavy | 26 | Attractive | —— | Not attractive |
| 7 | Refreshing | —— | Not refreshing | 27 | Romantic | —— | Not romantic |
| 8 | Clear | —— | Ambiguous | 28 | Good feeling | —— | Bad feeling |
| 9 | Simple | —— | Complicate | 29 | Dry | —— | Wet |
| 10 | Gorgeous | —— | Plain | 30 | Adult | —— | Young |
| 11 | Cold | —— | Warm | 31 | Impressive | —— | Not impressive |
| 12 | Personal | —— | Not personal | 32 | Beautiful | —— | Not beautiful |
| 13 | Sense of dance | —— | No sense of dance | 33 | Intellectual | —— | Not intellectual |
| 14 | Good influence | —— | Bad influence | 34 | Healthful | —— | Not healthful |
| 15 | Aerodynamic roundish | —— | Not roundish | 35 | Smooth | —— | Thin and bony |
| 16 | Friendly | —— | Unfriendly | 36 | Monotonous | —— | Not monotonous |
| 17 | Masculine | —— | Feminine | 37 | Fresh | —— | Not fresh |
| 18 | Sense of flow | —— | No sense of flow | 38 | Lively | —— | Quiet |
| 19 | Sharp | —— | Not sharp | 39 | Calm | —— | Restless |
| 20 | Strong | —— | | 40 | Luxury | —— | Not luxury |

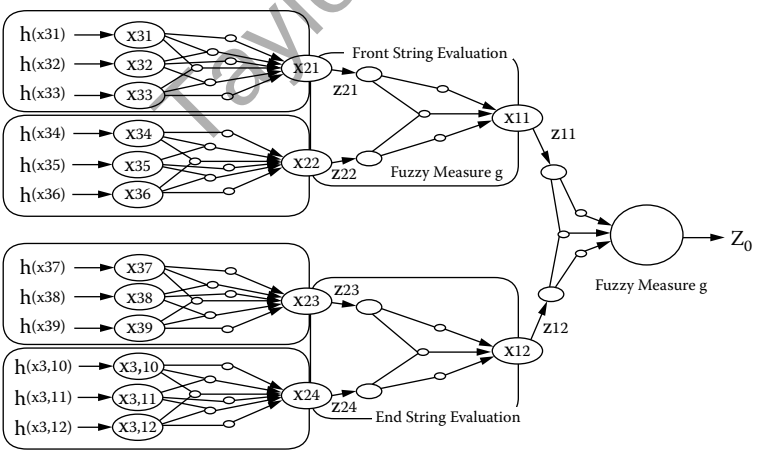
Finally, an artificial intelligence diagnostic system is developed to find the human feeling when hearing any brand name. First, create a system made up of four characters of meaningless words. Then let the tester use Table 5.3 to evaluate the Kansei. Use the result and compose an eight-character word. Build this evaluation to construct artificial intelligence (hierarchical fuzzy measure and integral model). Due to a complex process (omitted here), a three-layer model was developed, as shown in Figure 5.24.[3,4] A Matsubara assistant (currently a Hiroshima City University professor) and Maeda graduate student built the model patiently.[1–3]

Next is the result of the diagnosis hierarchical fuzzy measure and integral model (HFI). First, to indicate how well the model is diagnosed, all readers' understanding of *jigoku* ("hell") was used and the impact of the sound presented. The result is shown in Figure 5.25.

This computer system doesn't know what *jigoku* is, but most of the emotional words point to the negative, which is on the right side, such as dark, closed, cold and sounding bad, indecent, and ugly—all considered negative images. There is no result here, but *paradise* has been used for evaluation as the opposite word for *hell*. The system surprisingly analyzed like a human sense in its way of thinking.[5]

Next, let's analyze a person's name. The name of a currently young, popular, and famous model, Suzuki Nana, is being selected in Kansei. What should be noted here is that it is not related to the family, but it is the last name and it cannot be applied to the analysis. The given name by the parent is subject for evaluation. So, how about *Nana*?






Z0: Total evaluation value
Zij: Each part evaluation value
Xij: Each part evaluation item
h(xij): Evaluation value for each part evaluation item (data input)

**FIGURE 5.24**
HFI model diagram for word impact evaluation.

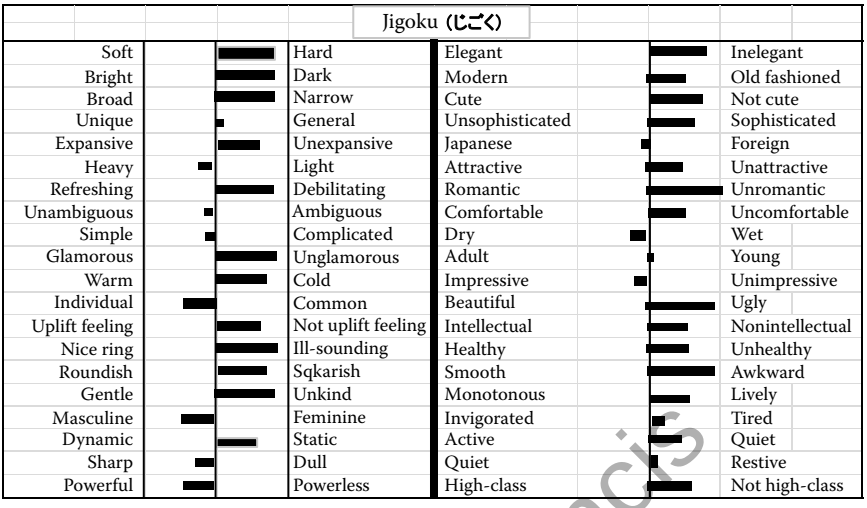



**FIGURE 5.25**
Kansei evaluation of Jigoku.

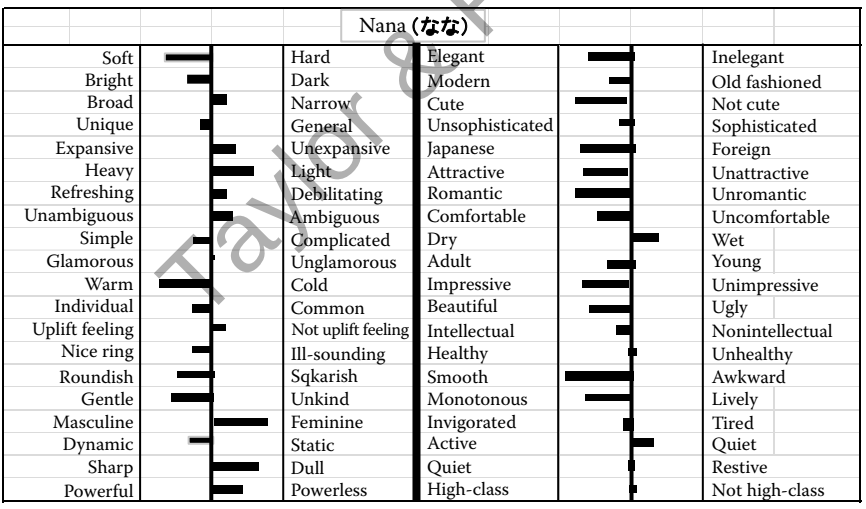



**FIGURE 5.26**
Kansei evaluation of *Nana*.

Analysis results, as shown in Figure 5.26, consist of soft and warm and roundness, gentle like a girl, cute and elegant, and solid compliment. It becomes the Suzuki "Nana's" Kansei evaluation. The number 1 of the top 10 best names for girls by the Meiji Yasuda Life Survey for 2012 is *Yui*. The Kansei evaluation of this name is not as good and came out as a calm Japanese girl, but there is no other remarkable specialty.

Also among the top 10 best names is *Ren*; although this analysis is for a modern individual, the result indicated it is somewhat feminine and not a distinguishing feature. It shows that it may be good to avoid giving a name like this.

In the United States, a very popular girl's name is *Lily*. If we input the name *Lily* into the brand name system, it is able to diagnose the pronounced image, although it is an English name. The result is shown in Figure 5.27. The name *Lily* gives people the sound of bright, lovely, clear, feminine, modern, romantic, young, charming, and smart. People feel it as a good sound.

Let us analyze the brand name that was given to a real product. What is the sound of the small type of the Nissan March? The analysis result is shown in Figure 5.28, and it sounds like a rounded, gentle, warm, feminine, cute, and elegant car. The design of the March is also rounded and feels simple; the design and the brand name match and are popular among the ladies.

A lot of the Kansei artificial intelligence system has been developed, except for a sound diagnostic system of words. There are a handle Kansei system for Nissan Motor, a design system for automotive interiors for Isuzu, a kitchen design system for Matsushita Electric Works (ViVA), a cockpit design system for Komatsu, a color coordination system for Sharp, and others. With a combination of Kansei and artificial intelligence, there are a lot of interesting mechanisms occurring that are not only pleasing to designers but also effective tools in business. The kitchen system of Matsushita Electric Works is very successful, and a lot of visitors from domestic and external customers visit it every day.



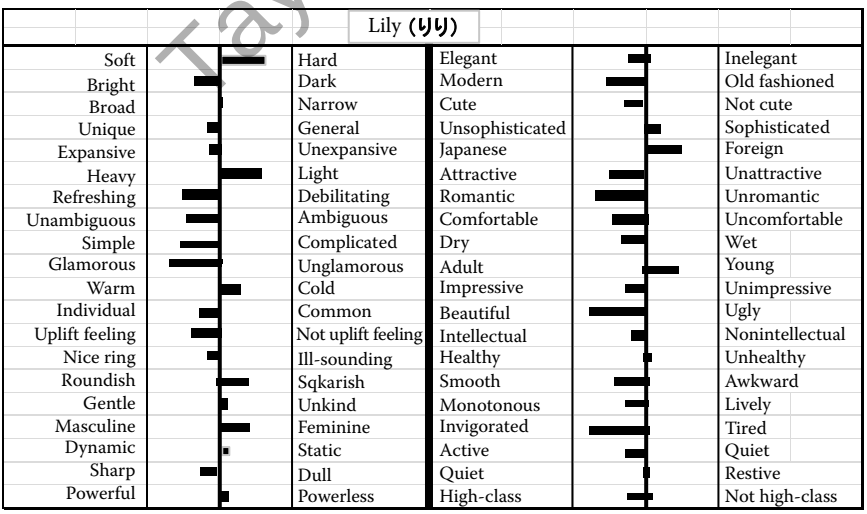



**FIGURE 5.27**
Kansei evaluation of *Lily*.

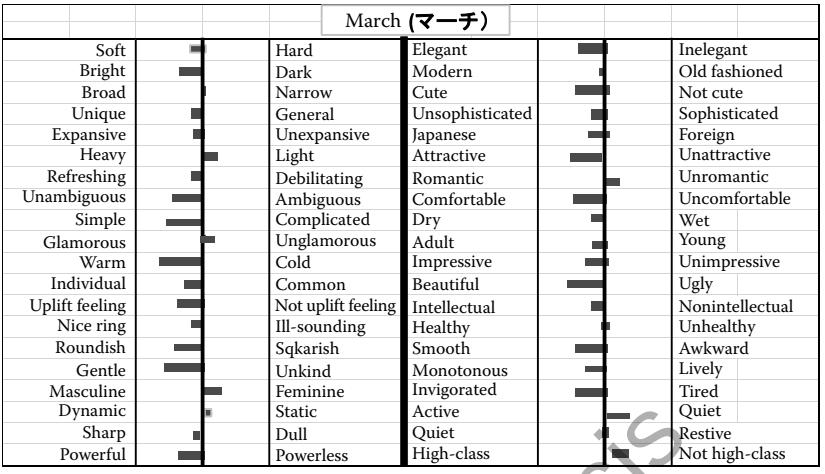



**FIGURE 5.28**
Kansei evaluation of *March*.

## 5.10 Confectionery Package Design at Nestle

In February 2007, Nagamachi made a presentation on Kansei engineering at the PACE Conference Packaging Design International Seminar in Paris. At this event, he met Nestlé packaging and design director Anne Roulin, and Daniel Magnin, head of packaging and design for the Nestlé Confectionery R&D. Both of them were very interested in Kansei engineering and wanted to know more about Kansei engineering and its methodology. There was a good discussion at the venue. Later, Mr. Magnin visited the Hiroshima office and a more in-depth discussion resulted; as a result, a formal contract was signed to introduce Kansei engineering to Nestlé Confectionery Business in March.

For phase 1 of this project, five to six lectures were given to the packaging and design department, marketing department, and their administrators, explaining Kansei engineering in detail. They were new to this topic, and lots of questions were raised; the most challenging questions and discussions were from the marketing group. Marketing research is to conduct surveys in order to know the consumers' buying behavior, which makes is quite different from Kansei at its roots; Kansei is to investigate images that trigger the same emotion shared by the consumers, and then convert these images into design data. Eventually, they understood after several meetings. Then it was time to conduct lectures for the designers: Ben Mortimer (Nestlé Confectionery R&D) and Pascual Wawoe (freelance). They are passionate and insightful persons, and we enjoyed every minute. In conclusion, they decided to upgrade the package design of After Eight®, a chocolate with high evaluation from Nestlé, by using Kansei engineering.

### 5.10.1 Step 1: Gathering Research Candidates

First, we had to determine the more well-known manufacturers and their chocolates in Europe. Keeping those brands in mind, we bought more than 100 types of chocolate from various high-end supermarkets. We sorted them accordingly: items rival to After Eight, eye-catching packages of shape, size, and color (Figure 5.29).

Even after the sorting, we still had too many items; we needed to select only the best brand, shape, size, color, and package design from those groups. We selected 21 items, including several types of After Eight, in this round (Figure 5.30).

**FIGURE 5.29**
Chocolate package samples in the first stage.

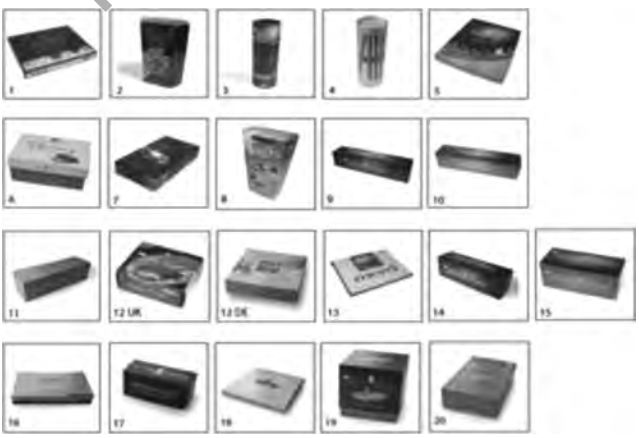


**FIGURE 5.30**
Test samples for packaging design survey.

### 5.10.2 Step 2: Select Kansei Words

In Kansei engineering, we conduct our research by evaluating Kansei words, words often used by the target consumers (adjectives or descriptions or key words). Therefore, selecting the right key words is very important. Two young designers and Nagamachi selected many key words related to package design for evaluation.

We prepared a questionnaire with 23 questions with 7-point scales with the final selection of key words, and they were divided into three stages. The first stage of evaluation was "imagine the chocolate inside the box by observing the package design." The second stage was to evaluate the package design related to the key words. The third stage was the "emotion of opening the package and seeing the chocolate inside or on the package itself."

At this point, the package samples and the questionnaire were ready. Nestlé chocolate sells best in the United Kingdom and Germany; whether separate package designs or one unified design should be used became another issue. It was decided that a decision would be made after conducting research and analysis in both countries. With the help of native speakers, the questionnaire was prepared in both English and German.



### 5.10.3 Step 3: Conduct Evaluation Research

Recruitment was done through both countries' newspapers without identifying Nestlé; together, 200 participants were recruited, and samples were given to them randomly during the evaluation (Figure 5.31).


**FIGURE 5.31**
A scene of Kansei evaluation.

### 5.10.4 Survey Data Analysis

In the Nestlé chocolate package design analysis the following was done:

1. Analysis of the relationship between Kansei words: This process was to confirm the emotional similarity between the 23 Kansei words used. There might be very high similarity between the Kansei words, even in the UK and Germany.
2. Factor analysis of both countries' data: With the 23 Kansei words, a few special clusters were found, and it was discovered that these clusters (structural factors) were very similar. As a result, we were able to consolidate the two countries' data into one set.
3. Principal component analysis (PCA): This was not a simple PCA. A PCA was used to discover the Kansei words structure (emotion), but then we put a 21-sample axis on top of this structure, so we could see which sample was overlapping with which emotion by searching from the same coordinate axis. This analysis can define the evaluation of each sample; package designers can validate the ideal design factors' location from the consumers' point of view.

   In order to conduct the PCA, we needed to convert the shape, color, size, and package design characteristics of the 21 samples into sample data. We called them the physical traits. They were analyzed on the same coordinate axis.

   From the result, we discovered that some of the applied Nestlé chocolate characteristics were a little bit distant from the attractive position. In other words, we understood that there was room for improving the package design by using Kansei engineering.
4. Partial least squares (PLS) analysis: PLS was used to validate the ideal Kansei words (consumers' emotion) and convert them to physical design factors for implementation, by using least squares methodology, which also draws an applicable conclusion to Kansei engineering.

   Conducting the above-mentioned analysis with sample evaluation data collected from the participants, we created a PLS chart. Within it we could validate the design specs or design elements we must implement in order to achieve an attractive package design. We should be able to create a suggested design that can generate more sales by using this enormous information.

At the Nestlé Product Research Center in York, England, with these enormous design factors, Nagamachi worked with two designers; we each started to draw our new design. Then we put tens of sketches on the wall, observed them from a distance, and finally created a new packaging design. In order achieve this, the three of us had numerous discussions, optimized our design ability, and created an ideal design that could trigger consumers' curiosity.

### 5.10.5 New Package Design Presentation

In mid-November 2007, Nagamachi went to London to present the final result of the Kansei engineering research. We also prepared a mock-up sample to show the audience at the end of the presentation. The reason for having this presentation in London was that all our audiences included designers, marketing staff, and the manager who supervises the design department, so it was convenient to meet there. Ben and Nagamachi spent over an hour explaining the activities conducted and our consolidated analysis result. We were really concerned about the response of the audience. We explained the research in detail, and we sensed a negative response from them, so Ben and Nagamachi looked at each other and then revealed the mock-up sample and said, "This is the result of the research."

The floor became silent for a moment, and then Nagamachi stole a glance at the audience. All of them stood up and gave us a great round of applause. We received a standing ovation.

Mr. Magnin, Ben, and Nagamachi were so glad to know that they all understood. Figure 5.32 shows a picture of the mock-up.

Later on, Ben and his team revised the design and created two more After Eight packaging designs, as shown in Figures 5.33 and 5.34, which we often find in department stores or international airport stores.

A step-up design from our mock-up (Figure 5.32), an individual pack design with a smaller portion of chocolate can now be found in international airports. Nagamachi knew this design was also another step up from the basis of Kansei engineering research.

For Nestlé, based on this successful experience, they recommend using Kansei engineering for new product development. They even developed a Kansei manual for implementation and developed more new products.




**FIGURE 5.32**
After Eight packaging design using Kansei engineering.


**FIGURE 5.33**
New packaging design of After Eight.




**FIGURE 5.34**
The recent new design of After Eight.

The following is the comment from Nestlé:

> Nestlé has been exploring the opportunities that the Kansei engineering approach brings to packaging design, with the support of Professor Nagamachi as well as Design Perspectives from Faraday, and has done pioneering work in applying this technique to package design. Today, Kansei is one of the specific tools in Nestlé's Packaging and Design toolbox for consumer centric development. However, it does not replace the need for experienced industrial designers, graphic designers or packaging engineers whose skills are still needed to turn Kansei-generated data into tangible product packaging.

## 5.11 Curable Bedsores

Japan is a super-aging society. The population ratio of those 65 years or older (the super-aged society) is 24.4%, as announced by the Ministry of Internal Affairs and Communications in August 2013. A major issue due to aging of the bedridden elderly is bedsores. Regardless of age, bedsores (pressure sores) are not limited to the elderly; they are also a big problem for the disabled who use a wheelchair. Due to lying for a long time, bedsores occur and trouble medical personnel.

Pressure sores are the pressure on the skin on the bone under the weight of the body when lying, resulting in a vascular disorder taking place on part of the skin. The failure that occurs, the extended bone, often hits at the sacral area of the buttocks (63%), calcaneus of the heel (7.8%), large trochanter of the hip (6.9%), as well as the occipital region of the head and shoulder blade of the shoulder (Figure 5.35).

As defined by the Japan Society of Bedsores, bedsores are caused by pressure applied to the same side, which causes a blood circulation disorder at the compression site that results in necrotic tissue. Factors related to bedsore occurrence include:

1. Continuous local pressure
2. Friction
3. Shear stress
4. Wetting of the local area
5. Malnutrition



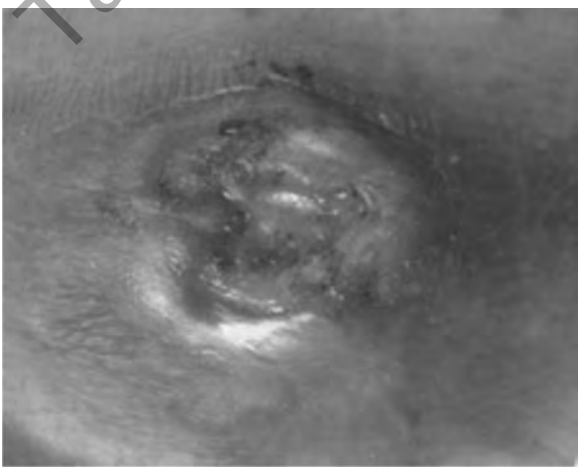


**FIGURE 5.35**
An example of a bedsore.

Factors 1 to 4 are especially the result of the physical action of external handling of the material between the mattress and the body.

Assuming that bedsores are a medical problem, at the same time it can be said that between them and the human being there is a human engineering problem. Here is where we can treat and help prevent bedsores. Ergonomics is studied to produce the desired relationship between an object and human (mind and body). We build a system and develop tools for that. Therefore, bedsore measures are a topic of ergonomics, as well as a medical problem. The Japan Society of Bedsores presents a benchmark index where the average body pressure distribution value on a mattress should be less than or equal to 32 mmHg.

The mattresses that are used in hospitals (except the air mattresses) were purchased separately from 12 types of markets, and then the body pressure of six people was measured using a tool to measure the body pressure distribution value of the FSA. Among them, some had slightly higher than the reference indicators, but in most cases, the values were below the standard. However, we discovered a problem point: the concept of decompression among the medical personnel.

In mechanics, decompression is the case when the body is lying on the mattress and the whole body is treated on the mattress; in other words, some areas of mattress not treat by the whole body on the mattress should function to receive the pressure of the body. This means that you wrap the entire mattress around the body. This is an inconvenience from the viewpoint of sleep science. It will vary from person to person, but in one night, people will turn over 20 to 60 times, and this rolling over is very difficult when the mattress envelops the body; the person would feel tired upon waking up in the morning. In other words, from the engineering perspective, we are required to take the weight of the body horizontally on the entire mattress. This is called *body pressure dispersion*. There were no mattresses to fit to this condition in the survey.

So, Professor Nagamachi went into the study of the material that makes up the mattress. Fortunately, he found it right away. It was a polyester material (Breathair) sold and manufactured by Toyobo Polyester. It is shown in Figure 5.36, where the material is synthesized by complicated entangled pipes made of polyester and has a characteristic of high rebound force. It is most suitable for mattresses where some of the pipe is in a one-by-one vacuum condition and the hollow material in the pipe is buried and has flexible characteristics in fulfilling pipe. The characteristics of Breathair are:

1. Its entangled pipe structure has a strong elasticity.
2. It is highly breathable because of its mesh structure.
3. It is both easy to dry and easy to wash.
4. It is easy to carry for a woman because it is lightweight.

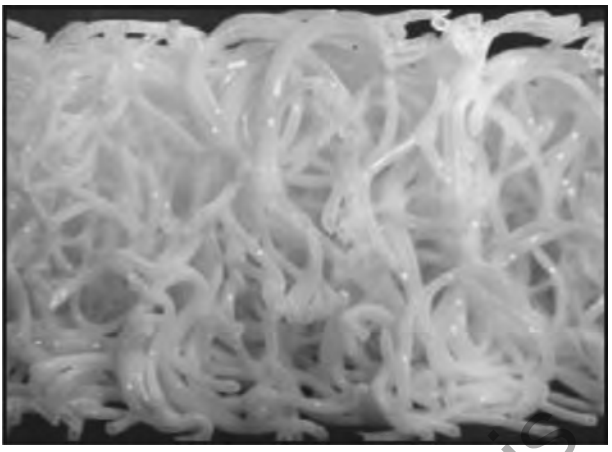


**FIGURE 5.36**
Breathair material.



It has other characteristics as well. For example, we easily can clean the patient in the shower, even if urinary incontinence is present. However, even if the same cannot be said for Breathair, the search for the optimal Breathair structure begins here.

Breathair is the structured production and involves amounts of polyester, differences in density, thickness of the pipe, filled or hollow, Breathair thickness, and other functions that are completely different.

First, in 2006 the researchers obtained Breathair mattresses of different functions and various types, and then began research on the differences in function. In addition, in 2008, Toyobo and Panasonic Electric Works (formerly Matsushita Electric Works), in a three-way collaboration with the Hiroshima International University Human Kansei Engineering Laboratory, started a comparative study on mattresses and polyurethane material of 12 types of commercially available and 70 types of Breathair mattress material (including two-layer, three-layer, etc.).

The research and analysis is measured using the body pressure dispersion value by FSA:

1. Comfortable is good.
2. Sinking is small.
3. Seems to sleep well.
4. Easy to roll over.
5. Comfort.
6. High quality.
7. Elegant.

A survey of Kansei is conducted using a five-step rating scale providing the previous seven types of Kansei words. The testers are men and women (including the elderly) of 40 to 108 kg body weight. This was very tough work.

The FSA measurement was usually used in this study, as mentioned previously, and the mattress needed to be able to support the total body weight; in other words, it is hoped that when lying on the mattress, it is easy to roll over and feels free and supports without sinking. This type of Kansei evaluation was added. In other words, normally the mattress evaluation was done only in a one-dimensional survey of the FSA, but we tried the world's first two-dimensional study of the sensitivity and FSA measurement.

Using 70 types of Breathair material for the tests, the body pressure dispersion value needed to be close to or lower than 32 mmHg. There is a sign of Toyobo, but Professor Nagamachi used P and Q. P is enriched pipe material having a thickness of 3 cm, and Q has a thickness of 5.5 cm. For single units, the researchers had characteristics of "do not sink when used" and "easy to roll over," but when P was put at the upper level and Q at the lower level and added (8.5 cm), the great FSA measurement value and numerical Kansei were developed.

The FSA value will change based on the characteristics of the fabric of the side place to wrap up the mattress and the final products developed from the three types decided upon. These three new product types and the mattresses of 12 types of polyurethane that were determined by the market resulted in the verification by statistical analysis shown in Figure 5.37,

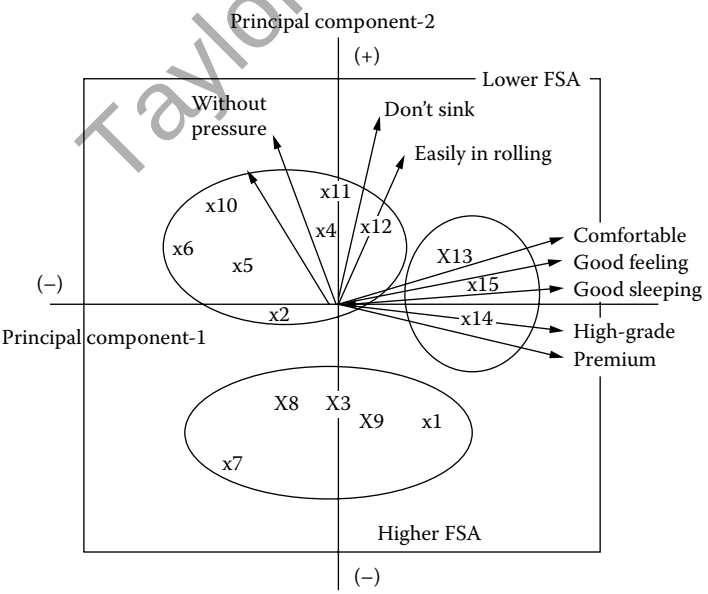



**FIGURE 5.37**
Principal component analysis of 15 different mattresses.

which is the result of the principal component analysis of the 15 different mattresses including three new types that were selected. Interesting results of the analysis were obtained, as shown in the figure, based on the in-depth measurement of the Kansei and FSA measurement data.

The horizontal axis represents the Kansei evaluation data (principal component 1) axis, and the vertical axis is the average value for the maximum pressure dispersion value of the FSA measurement of main component 2. To make it easy to understand, let's start by discussing two main components. The vertical axis indicates that the body pressure dispersion value of the product that exists in the upper part is low, indicating that the product at the bottom is high. Fifteen types of mattress are numbered along this axis: X4, X5, X6, X10, X11, X12, and so on. They are one group and belong to the class of the lower body pressure dispersion value. We folded into these the desired position as the body pressure dispersion value, and named this cluster 1.

On the other hand, X1, X3, X7, X8, and X9 on the lower side have become lump mattresses of five types; these are the mattresses whose distributed body pressure was undesirable because it was higher than that defined by the Japan Society of Bedsores. It is named cluster 2. With redundancy, Professor Nagamachi began the bed study in 1965, and because it was originally developed for the first time in Japan, the body pressure dispersion measurement instrument in this case became his specialty.

A totally different group of mattresses is distributed on the right of the horizontal axis (principal component 1) in the figure. This is the new product mattress group developed; they are in the desired position for the body pressure dispersion value. This group is different from the other clusters and has been evaluated as "comfortable and easy to roll over and very comfortable." This group is named cluster 3. The characteristics of cluster 3 are intermediate values of moderation, where you can found the desirable characteristics of emotion all together. Clusters 1 and 2 are on the Kansei axis far from the optimal position and represent a product that is not comfortable and difficult to turn over on. Based on this, the new products of P/Q that Professor Nagamachi produced using the Breathair material were verified to be good new products that did not already exist in the world.

The second important validation is the most important. Bedsores indicate that blood flow is inhibited. Permission was asked of an 82-year-old tester with a sacral projection to measure his blood flow using the mattresses that were part of in this experiment. With the help of the Osaka National Institute of Advanced Industrial Science and Technology, the blood flow measurements were realized.

The upper part of Figure 5.38 shows the blood flow data for 30 minutes when the same testers were lying on the commercial mattress, and it shows a situation where the flow value is not substantial. The part on the bottom of the figure shows the new product that has been designed and the testers

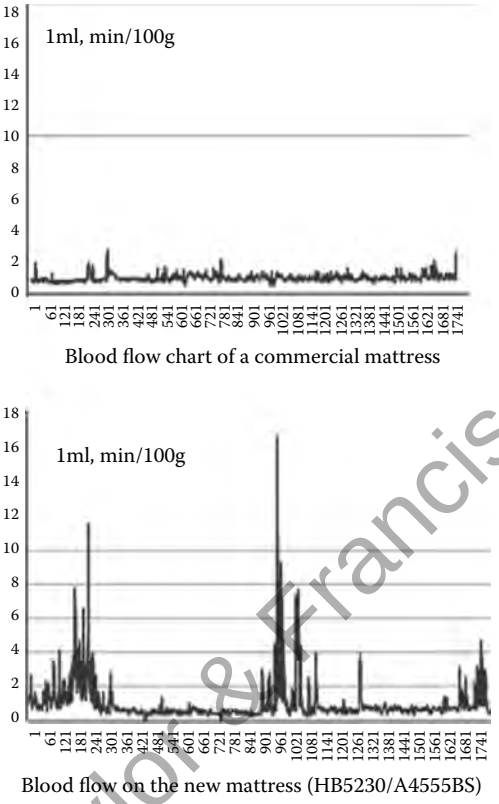



**FIGURE 5.38**
Blood flow situation of new products and commercial products.



lying for 30 minutes on the two-layer Breathair mattress, and it is understood that the blood is flowing when the tester smoothly rolls over.

The new product mattress is a high-elasticity material, and patients can easily roll over and blood flow occurs each time. As described before, although people roll over 20–60 times during sleep overnight, with the high-repulsion mattress, you can roll over several times and oxygen is carried to the skin blood flow easily. As a result, bedsores occur less frequently. The mattress can also comfortably support a change in body position. For the same reason, the product body pressure distribution is received by the entire mattress with high repulsion, making it possible to comfortably sleep.

The third verification is that, with the help of new products for bedsore patients, on-site, on-the-spot investigation is done to see the changes. We donated ten mattresses each to four locations including the national hospital and a public facility. Each facility was led by the plastic surgeon or deputy hospital director; a doctor, bedsore-certified nurses and other nurses, a pharmacist, and a physiotherapist with a team made of, for

example, occupational therapists under the leader and on the condition that the care follow the protocols of the Japan Society of Bedsores—treatment between 6 and 8 months. Meanwhile, each medical leader had a note to capture the progress of bedsores with a camera.

Before this investigation began, approval by the ethics committee was received at each facility, as well as the consent in relation to the personal information of patients. The daily therapy monitoring took the data in accordance with the provisions of the Design-R over the Japan Society of Bedsores (Design-R) and created a graph of the variations. The use of statistical analysis was planned by gathering patient data of all facilities since the progress of each individual is different.

The Design-R is defined by the Japan Society of Bedsores (bedsore course evaluation table) based on the depth (the depth of the bedsore), exudate, size, inflammation, granulation, necrotic tissue, and depth, and these seven indicators are to be recorded. When arranging the first letter of each, it becomes Design-R.

It was found that taking the statistics of all patients is difficult, and data of Design-R from the national hospital bedsore patient population is shown in Figure 5.39. Although at the start of the survey the bedsore patients consisted of 15 people, deaths or change of hospital reduced that number to 7. Upon using the new products, the bedsores of five people, as early as 1 week and by 5 weeks at the latest, were completely cured (short-term cured group). Two patients experienced long-term cures; one of them was cured in 4 months, and the other person was cured but had a recurrence, finally being cured at about 5 months. After this, of all the bedsore patients that were brought in, all of them were cured by August 2013, and the number of bedsore patients



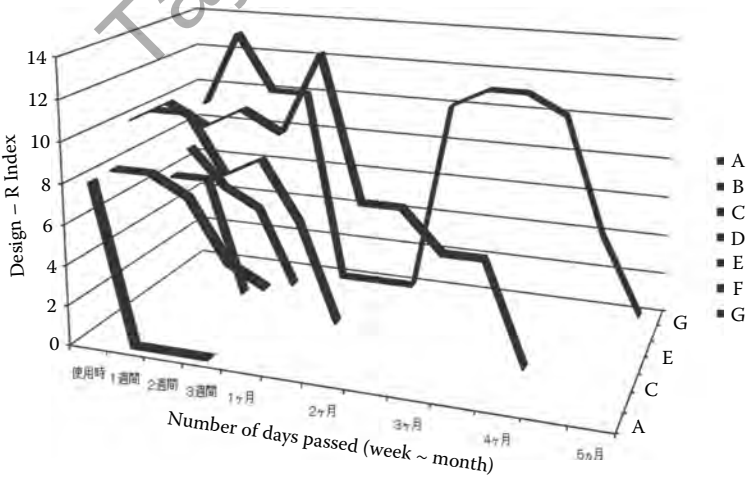



**FIGURE 5.39**
Design-R values of seven patients.

dropped to zero. The same thing happened at four other locations until bedsore patients no longer occurred in hospitals.[6,7]

Bedsores are an extremely painful condition, but they are not impossible to cure. Bedsores can be solved medically, and ergonomics but Kansei engineering points of view are still insufficient. Joint research with the Ministry of Health, Labor and Welfare was requested but grants were rejected, as bedsore treatment was claimed to be difficult. The officer was also required, as medical personnel, to learn this new principle by all means. Indeed, it has developed a reputation very quickly overseas. It should be noted that the mattress is produced only in HappiOgawa and Panasonic Electric Works, as well. Other mattresses are independent of this principle.

## 5.12 Interior Design of Boeing 787

One day in 2003, Professor Nagamachi received a phone call from his American friend living in Michigan, Glenn Mazur. He said, "Boeing would like to use Kansei engineering for aircraft interior design, but do give some guidance." Professor Nagamachi had experience on the interior design of a car or house; this was interesting because it was his first time doing the interior design of an aircraft. The offer was accepted.

Glenn Mazur is a professor at the University of Michigan and also the executive director of the Quality Function Deployment (QFD) for the Secretary General of the International Conference and was a student of a Japanese language course when Professor Nagamachi was a researcher at the University of Michigan. Glenn started learning Kansei engineering in response to Professor Nagamachi's invitation to the QFD International Conference in 2004 on conducting a Kansei engineering workshop, in which Glenn also participated.[8] After a while Professor Nagamachi received a phone call saying, "I will be the instructor. Please guide me." After more time passed, Professor Nagamachi received another phone call from Glenn, with him saying, "I don't know what to do. Please write the method on paper and also send it to me by email." Professor Nagamachi felt annoyed, but Glenn is his friend and junior, so Professor Nagamachi described the method in detail and sent it to him.

Professor Nagamachi did not describe the methodology of researching the interior of a car in this document. The easiest way to do that is to have 10 units of various cars, arranged with the help of a rental car company, and ask 50 testers to note Kansei words (about 30 words) while they are sitting inside the car, and let them answer questions related to the interior of the car. Then all the surveys are collected and statistical analysis performed with Kansei engineering to see what kind of design was seen from a Kansei perspective. But for Boeing and other aircraft manufacturing companies, it is

impossible to arrange to have 10 units of aircraft. So Professor Nagamachi thought of an idea based on the following steps:

1. To explain Kansei engineering in a simple way, start with the words chosen to express the Kansei from frequent flyers who use the aircraft. This is called Kansei words.
2. Provide several sample designs and transform the data to the physical characteristics.
3. Evaluate the sample designs by the frequent flyers using the Kansei words prepared.
4. Determine by statistical analysis the relationship between the physical characteristics and the design Kansei words (multivariant analysis in most cases).
5. Write down a new design with reference to the physical characteristics most relevant to the words of sensibility that we want to achieve.

First, Glenn collected a few dozen customers that often use aircraft and conducted a survey of their emotions (Kansei) when they are on the plane. When the result was collected, Kansei words for investigation were determined. Next, questions were asked of the customers that related to the aircraft's interior: What kind of shape, color, furniture, space, etc.? Then the desirable physical conditions were written up. Based on this reference, Professor Nagamachi told Glenn Mazur to ask several designers to portray the room interior in several ways to complete the Kansei analysis and formal study.

On the Boeing side, a Kansei engineering research team was formed including Glenn, as the designer and human engineer, a next-generation aircraft construction engineer, a psychologist, an industrial designer, an engineer, and a statistical technician. They planned to have a 2-day Kansei engineering workshop led by Glenn, who had received advice from Professor Nagamachi.

By using the brainstorming of Kansei deployment for Mazda and Milbon of Osaka's adoption, with "relax" as the top concept, the expansion of tree-like words emerged. This Kansei term is expanded from the lower terminology. Next, to meet the top concept, image views of the windows and ceiling, lighting, furniture, walls, seats, etc., were created. In the discussion by the team as a whole, six types of room interiors were chosen (Figure 5.40).

Sixty testers were chosen by using a local recruitment agency to interview them. Also, using the advice of the in-house technical person, a three-dimensional screen dome was produced, and as stated previously, six images were captured and evaluated by Kansei words. By statistically analyzing the data, it was decided to appropriate room conditions in Kansei words.[6]

**FIGURE 5.40**
Six types of 7E7 interior design samples.



The final data from Jeanne Guerin, a psychologist in Boeing's Design Department were transferred to the Teague Team as decided by the actual interior design based upon the expertise of Professor Nagamachi and his team members. Starting with the cockpit design, also shown were a reclined seat that did not affect the rear seat, the kitchen design, the color of the ceiling and passageway, the expansion of windows, etc., where a relaxed emotion was utilized everywhere (Figures 5.41 to 5.43).

In addition, the idea of All Nippon Airways dispatch technicians was incorporated in these designs, for example, installation of hot water toilets (however, opening and closing of the bathroom door was a failure). As the room design of Boeing 7E7 (later the 787 Dreamliner) is for Europe, BMW also participated in the design. Windows, for viewing the sky, become large, and when you press the black button at the bottom of the window, the room becomes dark even though there is no curtain. This is due to an energized discoloration gel that has been injected into the window, where you can cut off the light from the outside by pressing the button. The entrance and the inside of the 787 aircraft became the innovative design. An easy-to-maneuver-in cockpit was also an improvement.

**FIGURE 5.41**
Boeing 787 and the large type of windows.

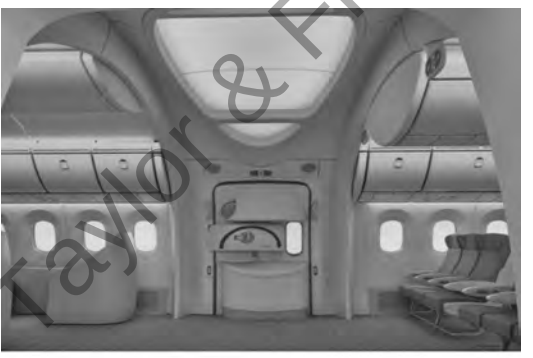


**FIGURE 5.42**
Entrance and inside of 787.

**FIGURE 5.43**
The innovative cockpit design.



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