VARYING ENVIRONMENTAL AND PSYCHOLOGICAL STATES IN HUMAN LIFE

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ABSTRACT

In usual life, we experience so many and various unsteady states. The surroundings themselves may vary and they relatively change by moving. Human cannot necessarily respond in real time. Moreover, previous states affect present physiological and psychological states. In this lecture, three aspects concerning the relations between humans and surroundings are discussed.

Firstly, positive/negative thermal pleasure, especially the former, pleasantness and its applications are explained. In the past, I illustrated negative thermal pleasure that is not an uncomfortable state, positive thermal pleasure that is comfortably warm/cool, pleasantness, and discomfort on a two-dimensional plane. It was pointed out that there were three points regarding thermal pleasantness: 1) It occurred when discomfort disappeared; 2) It did not continue for a long time; and 3) It might accompany sudden shock. Applications such as a “cool room” in hot seasons, natural ventilation, a “cat-like lifestyle” and so on are introduced.

Secondly, cognition of places is discussed. After a big earthquake people seek sanctuary in large open areas, which are recognized as the safest place if there are no artificial and natural dangers. The characteristics of such places are good states of spaciousness in upper 2πsr and stableness in lower 2πsr. We can move freely on the stable ground. On the other hand, we often meet discrete changes of space with movement and a cognition gap occurs, which will also arouse a fresh impression and pleasantness. On this basis, various situations, atriums and aquariums and so on are explained.

Thirdly, the variation of inhabitants’ awareness of their surroundings identified by social surveys is described. Data was collected for more than 20 years. The chain structure of dissatisfaction by the Guttman scale in four residential areas in Tokyo is introduced, and an analysis of each of three surveys at intervals of several years in two residential areas in each of Nagoya and Tokyo by Hayashi Quantification Method Type III is explained.

Keywords: Thermal comfort, Pleasantness, Cognition of spaces, Inhabitants’ awareness

1. INTRODUCTION

For architectural space design, first it is very important to know the static optimal conditions as the basis of design. In usual life, however, we experience so many and various unsteady states. The surroundings themselves may vary and they relatively change when we move. Humans cannot necessarily respond in real time. Moreover, previous states affect present physiological and psychological states. The human psychological state differs depending on the previous condition, even for the same present state. By determining these dynamic states exactly, we can develop a new design method. Most of the existing studies on comfort concern almost the steady state after exposure for sufficient time to adapt.

Chapter 2 examines the thermal environment, and introduces a two-dimensional thermal sensation model (Kuno et al., 1987; Kuno, 1995). Its applications and thermal pleasantness are explained. Chapter 3 discusses the cognition of places, and shows examples where a sudden change arouses pleasantness. Chapter 4 describes stable and transient tendencies in inhabitants' awareness of their surroundings identified by social surveys over many years. The human mind is a multi-dimensional world and has fuzzy aspects.

2. THERMAL ENVIRONMENT

2.1 Two-dimensional thermal sensation model

Figures 1–5 are conceptual diagrams. Figure 1 is the basic one in which the A-P plane represents the ambient and physiological conditions. Figure 2 shows three types of movement of Point S, which simultaneously indicates the ambient and physiological states. Figures 3(a) and 3(b) are linguistic planes, L planes, corresponding to Japanese and American English, respectively. In British English, the term 'hot' is rarely used to express usual climatic circumstances except in scorching situations like very hot air and strong sunlight. Figure 4 shows the psychological architecture sandwiched between the A-P and L planes. Figure 5 shows positive/negative thermal pleasure (McIntyre, 1980) and discomfort.

This model was constructed by the human psychological process, taking into consideration the following three points: 1) The human mind is not always one-dimensional; 2) Differences of terms are very important, because the human mind thinks of various things in words and language; and 3) The human mind is not binary but somewhat fuzzy. These considerations are natural in social psychology. Either PMV or SET* is based on only one optimal physiological state under ambient conditions, but my model has a neutral zone, which is more reasonable in view of control theory. The flexible sandwich structure in Figure 4 can explain various phenomena like seasonal acclimation, intra-individual differences, non-thermal effects such as the hue-heat effect, and so on. Because a companion paper (Nakahara et al., 1987) was on the hue-heat effect which needed to be explained in the review process, I immediately added this three-dimensional psychological structure. From this model, it was pointed out that there are three points regarding thermal pleasantness: 1) It occurs when discomfort disappears; 2) It does not continue for a long time; and 3) It might accompany sudden shock.

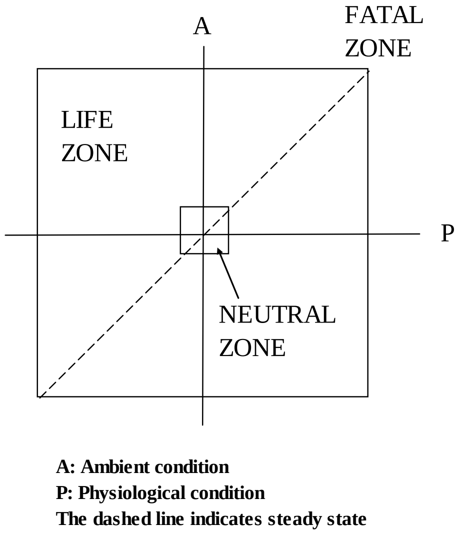


Figure 1. Basic figure of two-dimensional model

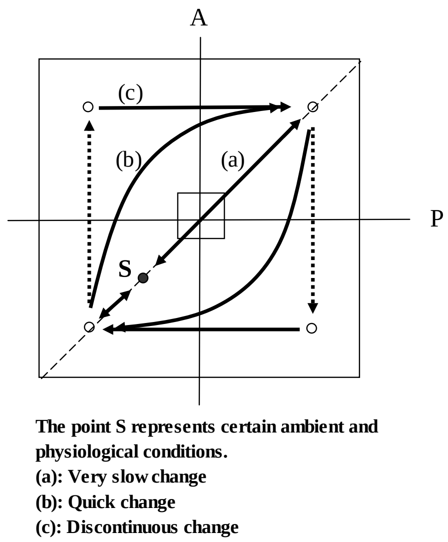


Figure 2. Loci of Point S

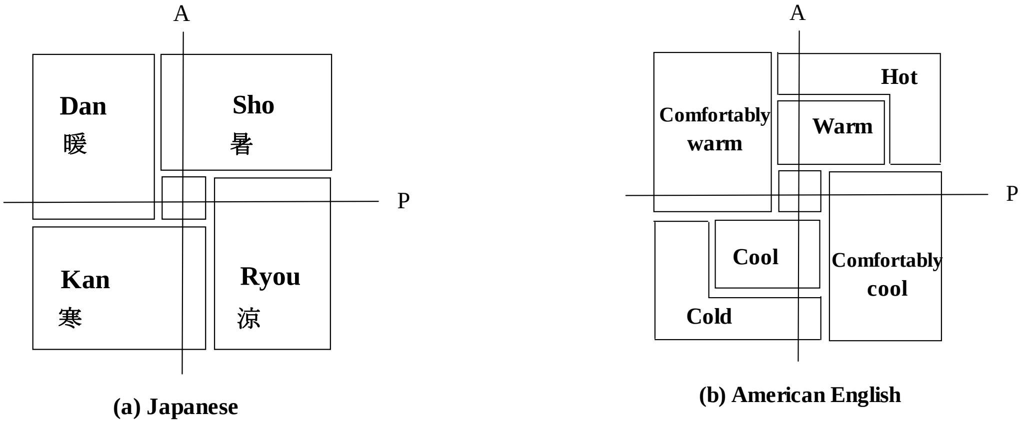


Figure 3. Standard L planes

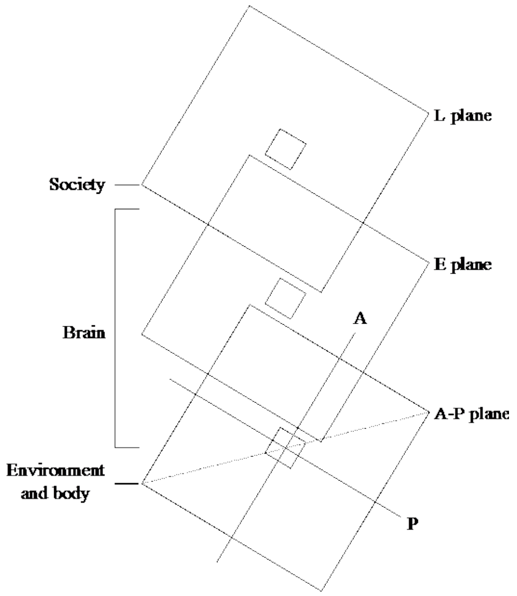


Figure 4. Psychological architecture

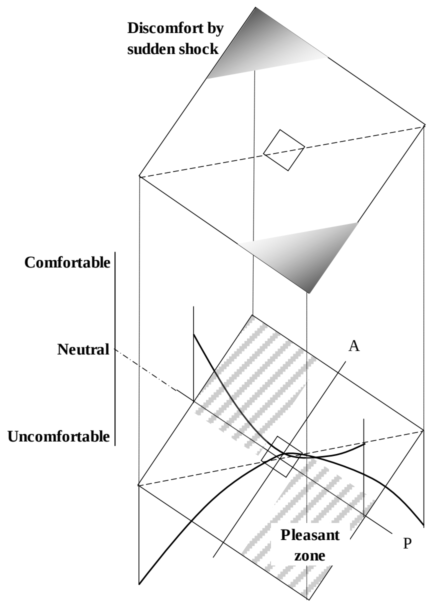


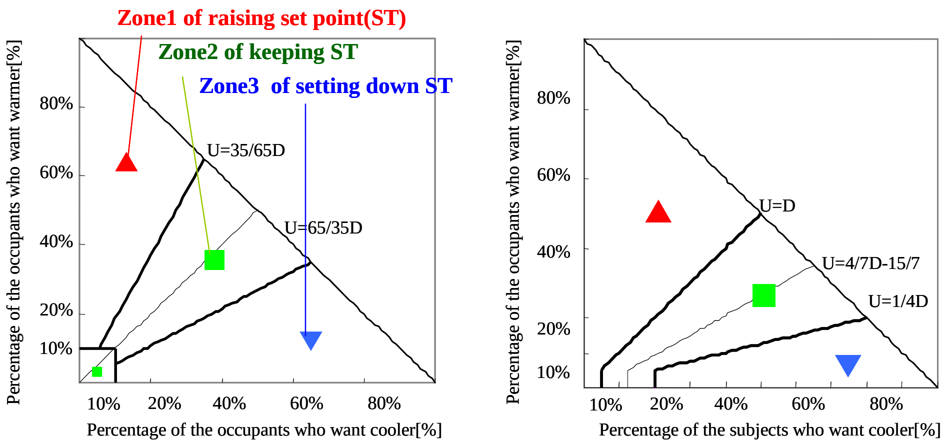
Figure 5. Thermal comfort: Neutral Zone and pleasant zone

There was a very famous experiment on pleasantness by Chatonnet and Cabanac (1965). The subject's body temperature was controlled by water in a bath tub and the subject put his hand in a washbowl containing temperature-controlled water. Judging from papers sent to me by Cabanac, himself, firstly he presented a two-dimensional table in 1981 (Cabanac, 1981), which was one chapter of a book. I did not know this latter fact when I presented the two-dimensional model in 1987. The difference was that the stimulus was neutral. His result was "indifferent." In the case of whole-body thermal feeling, however, we feel comfortably warm/cool and pleasant upon moving from a cold/hot environment to a neutral one. It seemed to take more than 10 years for Cabanac to reach a two-dimensional idea. When I was a postdoctoral fellow of JSPS, I could not indicate my thermal feeling as one of the subjects in an experimental chamber at the University of Tokyo according to the Japanese conventional thermal sensation scale using the terms "hot," "warm," "cool," and "cold." This marked the start of my studies on thermal comfort, and it then took me nearly two and a half years to reach a similar idea. This was in 1984, when I was 30 years old.

2.2 Determining the set temperature by occupants' voting

As occupants of modern offices have computers connected via the Internet or an intranet, it would be possible to arrive at a consensus by computer. Modes already conceptualized and developed include

those that prioritize comfort, energy saving, and women (Murakami et al., 2007). Figures 6(a) and 6(b) indicate the comfort and energy-saving modes of cooling, respectively. In the comfort mode, each request for change has equal weight, and a "no change zone" is provided to avoid hunting in the center. If the number of occupants expressing the same vote is less than 10% of the total, they are ignored as a minority opinion. In the energy-saving mode, boundary lines are set below those of the comfort mode, and it is easy to raise the set air temperature. In the female priority mode, women's votes are weighted more highly than men's. Decisions on change are made according to the comfort or energy-saving mode. The set temperature became 26°C in the case of the comfort mode, and 28°C in the case of the energy-saving mode. No particular complaints were made during each experiment, but occupants' impressions after all the experiments were not so favorable toward the energy-saving mode. Moreover, the higher the outside air temperature was, the more dissatisfied the occupants felt (Murakami, 2008).
A similar method has also been conceived for heating during cold seasons. Because of the heat generated by human bodies, lighting, and office equipment, however, this system is more effective for cooling than for heating.



(a) Comfort mode (b) Energy saving mode

Figure 6. Logic used to determine set temperature

2.3 A "cool room"

When the room temperature is set at a lower level, which means higher in summer, occupants who have just returned from outside the building will not return to the neutral state in a short time and will continue to experience thermal strain. This causes more complaints, and sometimes harsh complaints. A device to enable those occupants to return swiftly to the neutral state may be required, such as a special room that is slightly excessively air-conditioned (Kuno, 2007). People enter this room first to eliminate their thermal strain, and then begin to work in their own office space. People decide for themselves how long they remain in this room. Even if the air-conditioning of their office space is set at a lower level, there will not be many complaints. The same also basically applies to visitors. Reception rooms and suchlike should be controlled in the same way. If visitors remain in them for too long, however, the room temperature will need to be readjusted. As such special rooms are small compared with the whole office, their influence on energy saving is not great. We confirmed the effect of a 'cool room' experimentally (Matsubara et al., 2012; Iwata et al., 2012; Iwata et al., 2013).
The gaps between the five areas, the neutral zone, the two pleasant zones, and the two discomfort zones, are expressed in the two-dimensional thermal sensation model. The part outside of the upper-right corner of the neutral zone is considered to be fuzzy. When approaching from the discomfort zone, an uncomfortable feeling remains, and from the neutral zone, a comfortable feeling

remains.

2.4 Natural ventilation

In the past, we confirmed the effect of fluctuating wind (Xu et al., 1996; Xu et al., 1999a, 1999b). Fluctuating air movement was better than constant air movement at the same mean air velocity under 30°C in chamber experiments. It was also found that the mean comfort vote did not become uncomfortable with natural ventilation of more than 0.6 m/s at an air temperature of 32°C in an experiment in a full-size model house (Ko et al., 2008; Ko et al., 2009). Later, we conducted the same experiments in different model houses (Saito and Kuno, 2012; Ota et al., 2013), thinking that the result was a psychological effect of natural wind. Measuring skin temperatures, however, we found that measured mean skin temperatures were lower than those calculated by the two-node model (Saito et al., 2014). Our team will present the result of a CFD analysis in this conference (Matsui et al., 3016).

2.5 A "cat-like life style"

We also reported on the effects of sunshine in winter in Japanese housing in the above-mentioned papers. By effectively using natural ventilation in warm seasons and sunshine in cool or cold seasons, we might be able to live comfortably without using much energy. Not so strong air-conditioning and personal conditioning devices like a fan, radiator panel and so on also might be effective.

It is said that cats look for and stay at the most comfortable place for them in their owner's house except for eating and so forth. Although most Japanese houses are not large, they are large for cats. Cats do not do physical work. For humans, most actions have some aim; even relaxing is a task. Usually rooms are designed along architectural theory. Each room has its own purpose. Even if an inhabitant changes the way of using a room, however, there is almost no problem. If there is a comfortable place without any air-conditioning and artificial lighting, it is one choice. Today, not only comfort but also ease of performing a particular life action is required. Each inhabitant may think of economic and/or global issues. If there is always such a place available, it is possible to move and live like a cat. If there are multiple such places, life will be more pleasant.

We conducted some experiments using full-size model houses (Ko et al., 2010; Fujita et al., 2016), and showed that the evaluation of each life action changed with the season.

3. COGNITION OF PLACES

In the early 1990s, super high-rise buildings exceeding 1,000 m in height, ultra-deep underground architecture, and various atriums were discussed in Japan. What are the differences from usual architectural spaces?

Generally, human spaces are designed in a similar style. There is a stable floor to resist gravity and sufficient space, otherwise we cannot move freely. The spaciousness of the upper part and stableness of the lower part are needed in order to be free. These factors can be evaluated by the angle factor, which is the surface area projected onto a unit sphere. The unit is steradian (sr), and a hemisphere is 2πsr. Humans notice their standing position relative to beyond the walls, floor, and ceiling (Figure 7). Situations are divided as shown in Table 1 by phases and distance from humans.

An earthquake takes away spaciousness and stableness from humans instantaneously and thus triggers serious fear. After a big earthquake people seek sanctuary in large open areas, which are recognized as the safest place if there are no artificial and natural dangers or inconveniences like war, crime, rain, snow, storm, flood, volcanic eruption, and so on. The characteristics of such places are good states of spaciousness in upper 2πsr and stableness in lower 2πsr. We can move freely on the stable ground.

On the other hand, when we move, we often encounter discrete changes of space and so a cognition gap occurs, which may arouse a fresh impression and pleasantness. Examples include opening a door and turning a corner, beyond which another world spreads out. Conversely, the end of a corridor of the first floor may lead to the second floor. The first floor is easier for us to escape from than the second floor. Let us consider two examples. Photo 1 is the plaza in front of the statue of Mr. Saigo in Ueno, Tokyo. This side is on a hill, but the other side is the roof floor of a building (Photo 2). Photo 3 is a platform of the Yamanote Line. Walking along the platform, it looks uniform, but part of it is actually a bridge (Photo 4). After a big earthquake, who would want to be in such places?

Figure 8 shows some situations in and around an atrium. In offices, usually the ceiling is not so high. When we move from the office to the atrium, we feel spaciousness and pleasantness. Photos 5 and 6 are atriums of the Shinjuku NS Building and the Seavans Building, respectively. These atriums have bridges, which create a sense of surprise because their existence is unexpected. Upon seeing a bridge, we want to cross it because we feel not only danger but also pleasantness. Because the bridge of the NS Building is very heavily built, however, it does not feel so pleasant to be near it. On the other hand, the bridge of Seavans is slender and delicate. If it were dangerous, no one would use it. If it does not look dangerous, it does not arouse pleasantness. It looks dangerous but is safe, which creates pleasantness.

Aquariums have similar aspects as atriums. The visual objects are aquatic creatures. There are various types of aquariums that show shallow, intermediate, and deep layers in turn, make visitors feel like they are at the bottom of the sea, and so on. Some use tubes instead of bridges. All of them give visitors a pleasant strong impression.

I presented these contents (in Japanese) in the past (Kuno, 1994) and also some experiments on urban spaces and inner spaces of model houses (Yamaguchi and Kuno, 2012; Yamaguchi et al., 2013; Nakane et al., 2013; Nakane and Kuno, 2014; Oyabu et al., 2014; Oyabu and Kuno, 2015). In this conference, I will also describe an experiment (Tamashiro et al., 2016).

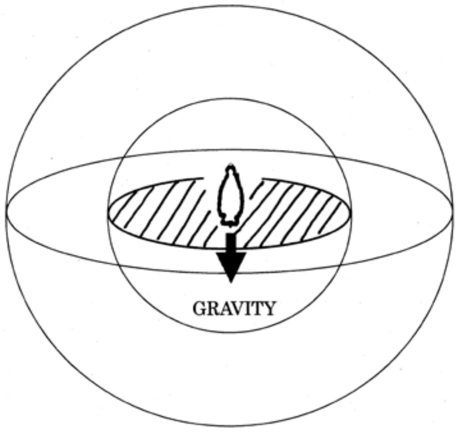


Figure 7. Upper 2πsr and lower 2πsr

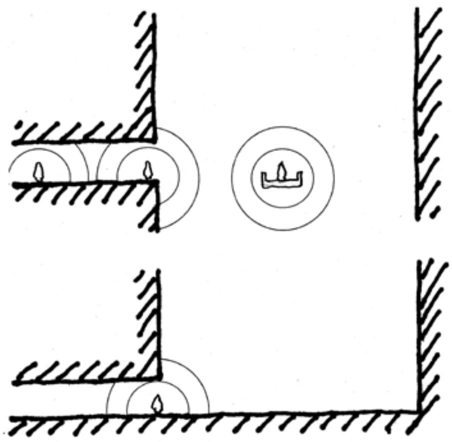


Figure 8. Various situations in an atrium

Table 1. From underground to the sky

	small	air	sky		
lower 2πsr	**stableness**	liquid	on the sea	in the sea	
	large	solid	on the ground	bottom of the sea	underground
			air	liquid	solid
			large	**spaciousness**	small
				upper 2πsr	

Photo 1. Plaza in Ueno: Angle 1

Photo 2. Plaza in Ueno: Angle 2

Photo 3. Platform: Angle 1

Photo 4. Platform: Angle 2

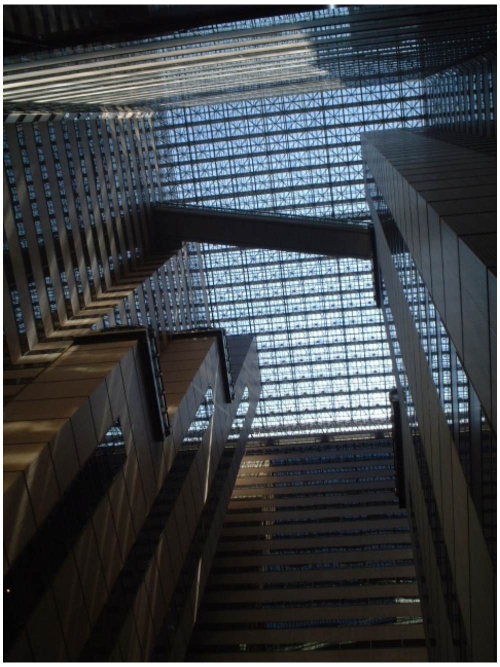


Photo 5. Atrium of NS Building

Photo 6. Atrium of Seavans Building

4. INHABITANTS' AWARENESS OF THEIR SURROUNDINGS

How do inhabitants evaluate their residential and urban environments? Let us introduce two analyses. Data was collected from 1978, for all residences within one square kilometer in various areas. Housewives were enrolled as subjects by using systematic sampling, which is a kind of random sampling from a basic register of residents. A social survey was conducted by questionnaire. Questionnaires were sent to each subject by post and were collected by investigators. The number of samples was about 400 persons in each area, and the collection rate was about 80%. The data collection continued until 2005, covering 48 areas in total, including plural surveys of the same areas. However, this method has become impossible in the last decade in Japan, because local governments started to refuse to allow sampling from the register to protect personal information and prevent crimes.

The first example is the analysis of four residential areas of the survey in Tokyo in 1978 and 1979. The extended method of MSA was used (Kuno, 1985; Kuno et al., 1986). The basic concept is the Guttman scale, which has a stepped structure. MSA extracts plural Guttman scales from the data. The extended method permits overlapping and the creation of tree-structures. A chain structure of dissatisfaction was analyzed. In the ideal state, if a lower rank item is 'yes,' all higher rank items must be 'yes,' and if a higher rank item is 'no,' all lower items must be 'no.' The coefficient of reproducibility was set at 80%. This analysis was a part of my doctoral thesis (Kuno, 1980).

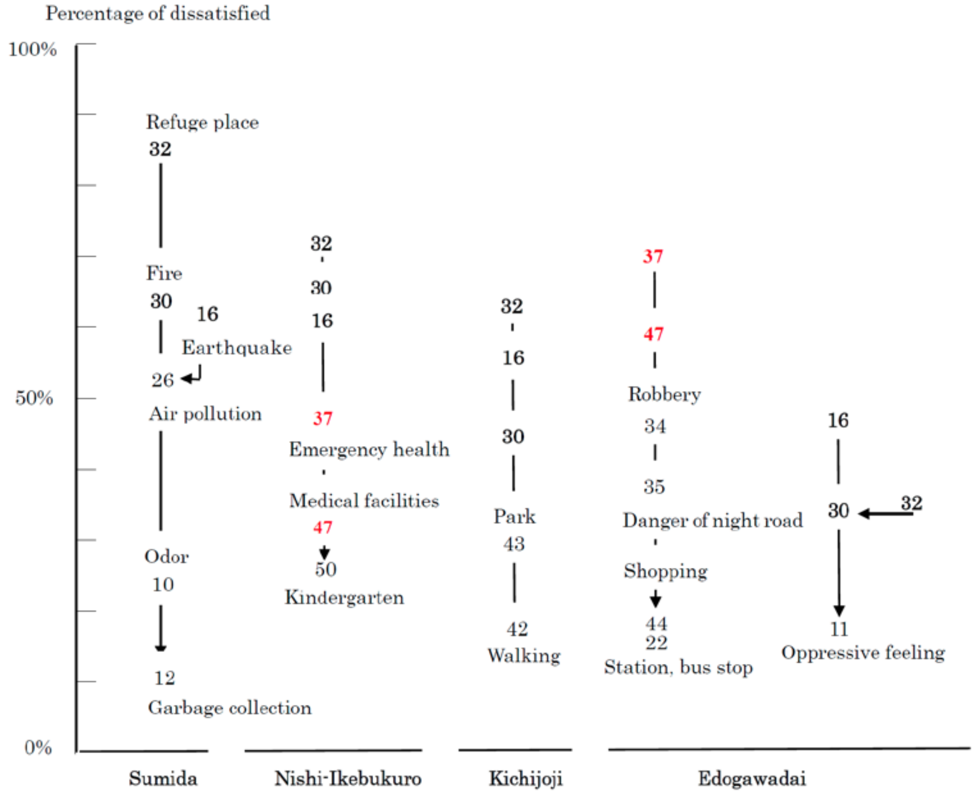


Figure 9. Chain structure of dissatisfaction (1978, 79)

Figure 9 shows the result; only the important Guttman scales are written. The numbers in the figure are the item numbers of 50 environmental items. Their vertical positions indicate the percentage dissatisfaction. The Sumida area is a downtown area and included some cottage industries at that time. The Nishi-Ikebukuro area is near a station on the Yamanote Line, which is a loop line, and is very convenient but crowded. The Kichijoji area is up-town. The Edogawadai area is a suburban residential area and is located not in Tokyo city but Chiba prefecture. The greatest dissatisfaction was with disaster-related items in three areas in Tokyo, followed by unclean neighborhood in Sumida, medical care in Nishi-Ikebukuro, and open spaces in Kichijoji. These results can be interpreted as that the inhabitants thought that they could save themselves in Kichijoji, could be helped by others in Nishi-Ikebukuro, and were at risk in Sumida. Because Edogawadai is a suburban area, dissatisfaction with disaster-related items was not so high and people were concerned about medical care in daily life. Sumida was the most serious, followed by Nishi-Ikebukuro, Kichijoji, and Edogawadai in this order. The meanings of each item differed slightly in each area.

Another question was “Do you think you and your family could survive if a big earthquake like the Great Kanto Earthquake occurred?” Those answering ‘no’ accounted for 72.6% in Sumida, 58.1% in Nishi-Ikebukuro, 44.9% in Kichijoji, and 35.4% in Edogawadai. This order corresponds to one of the chain structures. Although this analysis is static in terms of time, the differing tendencies are dynamic.

The next example is secular changes. The data of three surveys in the Nishi-Ikebukuro and Kichijoji areas in 1979, 1992, and 1997 and three surveys in the Meito and Mizuho areas in Nagoya in 1991, 1997, 2003 were analyzed. The Meito area is a relatively new residential area, and the Mizuho area dates back to olden times. Hayashi Quantification Method Type III was used for the analysis. This method gives scores to both items and individuals so as to maximize the correlation coefficient between them. General items and individuals gather near the center, and specific items and individuals spread to both sides. Because plural solutions are calculated, two solutions are usually displayed on a two-dimensional plane. The correlation coefficients indicate the stress or fitness of that analysis. The higher the correlation is, the lower the stress and the higher the fitness are. At that time, total floor area, site area and investigation year were added as items to the environmental items common to the three investigation years in each city (Hatanaka et al., 2010). The number of environmental items was 34 in Nagoya and 43 in Tokyo. Inhabitants living in a detached house were analyzed.

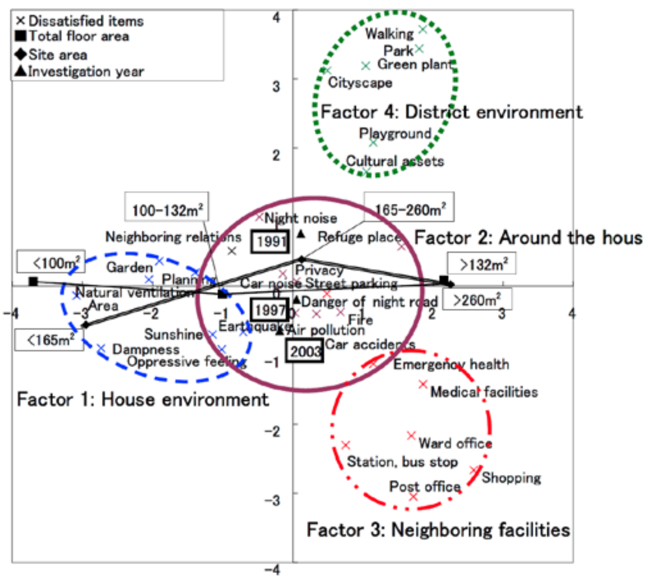


Figure 10. Hayashi Method (Meito)

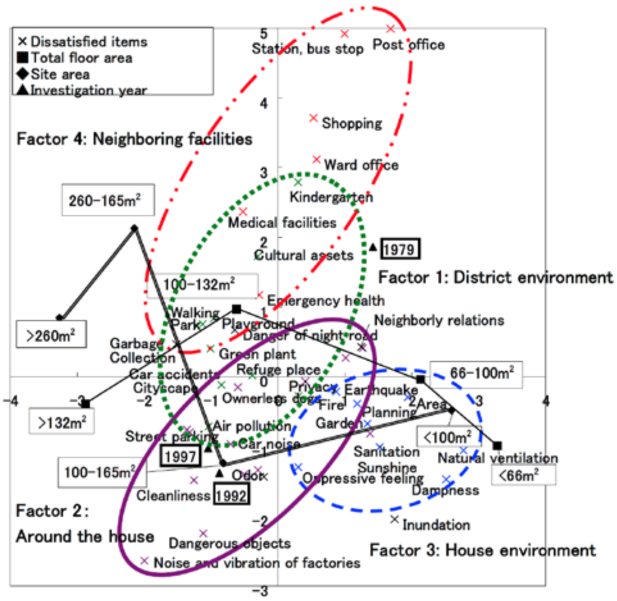


Figure 11. Hayashi Method (Nishi-Ikebukuro)

Figures 10 and 11 show the results of the Meito area and Nishi-Ikebukuro area, respectively. Because there were many items gathered in the center, some items are not shown. Ovals indicate the item groups analyzed by factor analysis. In both figures, the tendencies of the area and investigation year cross at right angles. The other two areas were also the same. The correlation coefficients of the four areas were 0.21–0.29. Because these values are not so high, they indicate that the tendencies are soft relations. However, the correspondence of tendencies in the four areas means that this analysis has sufficient validity.

Inhabitants living in a small house were close to the "house environment" factor in all the areas. The distance between the points of investigation year was similar in Meito, and in Mizuho too. On the other hand, in Nishi-Ikebukuro the point of 1979 was apart from those of 1992 and 1997, and the same was true in Kichijoji. Because the span between 1979 and 1992 is 13 years and almost twice that of the others, this tendency is considered to be appropriate. In Tokyo, the center of dissatisfaction moved from the "neighboring facilities" factor to the "around the house" factor. In Nagoya, it moved from the "district environment" factor side to the "neighboring facilities" factor side. A more detailed analysis is omitted here due to lack of space. Stable and transient tendencies were identified; thus, the unfinished work of my doctoral thesis has been completed.

5. CONCLUSION

Modern society has various problems and there are serious global issues such as unusual weather patterns and major disasters like storms, floods, and so on. There are not only natural disasters but also man-made dangers like serious crime, terrorism, war, and so forth. The way to improve human life should be considered.

Three aspects of the relations between humans and the surroundings were presented: thermal, visual, and social. There are both stable and transient properties. We live in such a situation. There must be ways to use those relations effectively.

Hewitt, who was a lighting engineer, stated in 1963 that lighting had gone through the first stage, useful lighting, and the second stage, comfortable lighting, and was passing into the third stage, pleasant lighting (Hewitt, 1963). In fact, lighting technology and design methods have progressed rapidly and now give humans pleasantness. Even in other fields, such aspects should be considered positively.

6. ACKNOWLEDGEMENTS

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