SMILE AND BEHAVIOR – NEW EVALUATION METHOD FOR PEDESTRIAN ENVIRONMENT

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Abstract: In this study, the authors explore the possibility for the new evaluation methods of pedestrian environments. Pedestrian's behaviors and expressions are focused as indexes to the quality of walk spaces; such visible information is superior to data from questionnaire surveys in randomness because that can be gotten without target's knowing. The visually observable information, biological reaction, and questionnaire survey data of pedestrians were collected in case study areas in Japan. In the view point of pedestrians' behaviors, it was found that people's behaviors were diversified in a street whose walking environment had been improved. In terms of pedestrians' expression, it was found that the level of pedestrians' smile was higher in the improved pedestrian environment. The results suggest that pedestrians' behaviors and expressions may become new evaluation indicators for pedestrian environments.

Keywords: Pedestrian Environment, Evaluation method, Smile and Behavior

1. INTRODUCTION

In these years, pedestrian friendly streets, such as pedestrian malls, has been planned in more and more cities. However, reallocating road space for pedestrians are often objected by vehicle drivers and roadside merchants. Drivers may claim their inconvenience of accessing the area and merchants may afraid that their sales become weak because of decrease in customers driving to their shops. To push such projects, planners have to consult those objections and give accounts of propriety of pedestrian friendly improvements. However, it has not been established yet that an adequate evaluation method to measure pedestrians' consciousness or level of happiness to explain the advantages of well developed pedestrian environment.

So far, the most popular method to evaluate pedestrians' preference is the questionnaire survey to pedestrians (ex. Hine, 1996). However, the method has some problems; for example, we cannot take a sample randomly because it depends on individual voluntarism whether he/she responds to a questionnaire survey. Furthermore, questionnaire surveys itself may affect the mind of pedestrians. That is to say, to ask pedestrians, who may relax with walking or enjoy sightseeing, to answer a questionnaire survey can bother them and the annoyance may influence their opinions and feeling.

In recent years, the usage of biological reactions such as sweating and heart rate has been studied to get to know subjects' feeling to evaluate environments (ex. Lee, 2011; Hussein, 2012). The method gives us the sequential data of pedestrians' feelings. However,

the method has a weakness; the sample size we can get is too small. To solve above mentioned problems, a new evaluation method, which does not make pedestrians be aware that they attend to an evaluation process, should be developed.

In this study, the authors focused on pedestrian's visually observable behaviors and expressions, which are gotten without target's knowing, as information to evaluate pedestrian environments. Ideally, those observable information can be gotten from all the pedestrians in a targeted area, independently of their cooperation. If it reflects pedestrians' feelings influenced by the quality of walking space, it may be an impartial evaluation indicator. The goal of this study is to develop new evaluation method for pedestrian environments considering pedestrians' behavior and expressions. In the following part, the visually observable information of pedestrians is tested whether it is reasonable as a pedestrian environment indicator, integrated with other data that may represent pedestrians' mind: biological reactions and thoughts gotten from questionnaire.

2. LITERATURE REVIEW

Regarding the relationship between the quality of outdoor space and people's behavior, Gehl (1987) observed each individual's behavior in public space carefully and he found that wider variety of behaviors were observed in a better public space. In this study, Gehl analyze the relationship between public spaces and human behaviors but do not establish evaluation methods. To make the visible behaviors or expressions evaluation indexes, it should be bridged to subjects' emotions.

It can be traced back to Charles Darwin that the history of the studies on the relationship between emotions and expressions. Darwin (1872) claims that the same states of mind lead uniform expressions throughout the world, based on the result of a questionnaire to people who observe natives. Ekman and Friesen (1975) conducted an experiment that the subjects of different nations were asked to read emotions of people in photographs and he found that subjects can judge accurate emotions independently of their culture. Russel (1994) reviewed researches to validate that emotions are universally recognized from facial expressions and his comparison of 8 studies shows that the recognition score of "happy" expression is relatively high cross-culturally. On a practical level, researches of the relationship between emotions and expressions are conducted much in the field of medicine and infant (ex. Jaeger et. al., 1986; Phillips et. al., 1990; Kawakami et. al., 2009). Along with facial expressions, body languages have been studied in relation to subjects' emotions. Mehrabian (1971) has concluded that non-verbal communication transfers more information than verbal communication with an experimental result that body languages occupies 55%, tone of voice occupies 38%, and word itself occupies 7%.

In these years, biological reaction or Autonomic Nervous System (ANS) responses have been utilized in order to understand subjects' psychological conditions. Collet et. al. (1997) have tested relationships between subjects' basic emotions such as happiness and six ANS parameters: skin conductance, skin potential, skin resistance, skin blood flow, skin temperature and instantaneous respiratory frequency. They have found that specific ANS patterns is associated with each basic emotion. Kreibig (2010) reviewed 134 publications that report experimental investigations of emotional effects on ANS response. Kop et. al. (2011) have found that positive and negative mood influence differently on heart rate variability(HRV). Sequeira et. al. (2009) reviewed research about electrodermal activity (EDA), and have concluded that EDA could be a powerful tool for exploring emotional processing. Some researchers have applied ANS responses to evaluate the psychological state

of the road users or people in public spaces. Sumida (2002) have used heart rate to measure drivers' stress depending on vehicle types and vehicle speeds. Kuroko et. al. (2002) proved that a plant-dominant setting decrease noise stress comparing a concrete-dominant setting using subjects' heart rate and subjective evaluation. Ikeda (2010) have examined the effect of sidewalk developments on the physical load of hand-rim wheelchair with R-R interval, which is measured using an electrocardiograph. Hussein et. al. (2012) have observed the stress of elderly people crossing intersections using EDA. The development of small size measurement hardware make it possible to get pedestrians' sequential data.

3. RESEARCH SCHEME

This part explains how this study explore the adequacy of pedestrians' visually observable characteristics as the evaluation indicators of the pedestrian environment quality. Regarding the quality of pedestrian environment, we focused on existence of car traffic. It is considered that pedestrians may think the quality of pedestrianized roads are different from roads where cars passed continually. We chose a case study road that is occasionally pedestrianized. On the case study road, pedestrians' behaviors and expressions were observed on the road at normal time, where car traffic exists, and at pedestrianized time, where the road was closed to traffic. Along with the observation, we collected data representing pedestrian consciousness by existing ways: questionnaire survey and stress survey using a biological reaction: EDA. The result of the pedestrians' behavior and expression survey is compared with the result of the questionnaire survey and the stress survey to test the possibility for evaluating pedestrian environment with such visible information. Figure 1 shows the concept of the study.

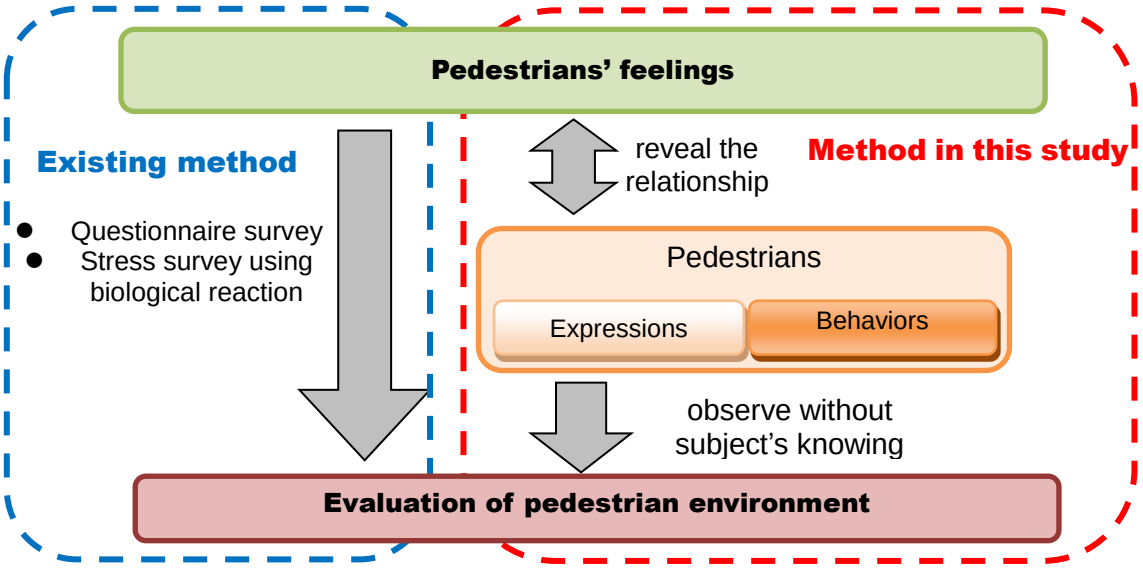

Figure 1. Research scheme of this study

In this study, we supposed that a road with no vehicles would be highly evaluated as a walk space by pedestrians than that with cars. First, we tested the hypothesis by a questionnaire survey and a stress survey on the pedestrians in the subject road. Secondly, moving pictures of pedestrians were took on the subject road when it was pedestrianized and when cars drove on it. Using the video, we analyzed deference of pedestrians' behavior and

expressions depending on pedestrian environment. As mentioned above, questionnaire surveys and stress surveys have its limitation. In this study, considering the limitations, we applied them to verify the relationship between pedestrians' observable characteristics and their feeling.

4. METHODOLOGY

4.1 Subject Road

In this study, we focused on Ichibangai street in Kawagoe city in Japan. The street is historical shopping street located along a major arterial road running north-south in the Kawagoe area. The two-lane road is around 9 to 11 meter width, and pedestrians and cars move at same grade level on the road. Ichibangai street is lined with traditional buildings called "Kura", which offer a glimpse into old Japanese towns. The landscape attracts a lot of tourists to the area. In this context, Ichibangai Street is full with pedestrians and cars, both of which include tourists and local residents.

According to a survey conducted by Kawagoe City in 2009, traffic volume per 12 hours on a weekday was 23,342 vehicles, and that on a holiday was 20,302 vehicles4). Table 1 shows a result of a pedestrian and traffic count that was conducted by the authors on a holiday in 2009. In one hour during the peak hours, 1,931 pedestrians and 721 vehicles passed through Ichibanga Street.

Table 1. Hourly traffic volume on Ichibangai Street

	No. of Pedestrian			No. of Car including bus (bus)		
Direction	nothing	southing	total	nothing	southing	total
Volume	931	1,000	1,931	351 (18)	370 (15)	721 (33)

Observing time: May 10 (Sun), 2009, 14:40 – 15:40

The street is closed to traffic and pedestrianized several times every year. The situation enables us to compare pedestrianized environment and normal environment of the road. Furthermore, there is another shopping street named Crea Mall Street, which is not a pedestrian mall but cars rarely passed on it, on the way to the nearest rail station from Ichibangai street; we can observe a number of same pedestrians both on Ichibangai Street and Crea Mall Street, and compare their behaviors.

4.2 Descriptions of Pedestrian Consciousness Surveys - Existing Methods

4.2.1 Stress survey using skin potential level

In order to evaluate a pedestrian environment, we surveyed pedestrians' consciousness by two existing methods. One is a stress survey using pedestrians' biological reactions, electro dermal activity measured with perspiration. We conducted a stress survey on 23rd November, 2009, when the road was pedestrianized and on 29th November, 2009, when the road was open to cars as usual. To measure pedestrians' stress level, we used skin potential level (SPL), which reflects subject's arousal level. In this survey we used a skin potential meter, TS02-SPL made by TECHNO SCIENCE Co., Ltd, which measures emotional sweating of a subject's hand using the difference in the electrical potentials. The instrument is used for measuring autonomic nervous activities, evaluating psychological experiments, etc. The measurement

interval is 5 seconds. Five subjects walked on the subject street equipped with the skin potential meter with an accompany person. Every subject walked one designated route on a same position of the road and crossed a same pedestrian crossing. During the survey, we took moving pictures of the subjects from behind to know what happened thorough time. Before starting measurement, subjects walked around wearing the measuring equipment in order to get used to it. From this survey, we got subjects' time-series data of SPL. We normalized the data and compared the values got in the car free environment and the normal environment with passing cars.

4.2.2 Questionnaire survey

The second survey with existing method to get pedestrians' consciousness is a questionnaire survey. The questionnaire survey was conducted on November 29th, 2008 on the subject street. The subject is pedestrians who walked on the subject road. Survey staff asked pedestrians to respond to the questionnaire and one who accepted it was invited to a booth along the street. Respondents were asked to answer how they thought about the ordinary subject street and how they would thought about the pedestrianized subject street. On that day the street was normal situation that meant vehicles passed bidirectional, so questions related to the car free environment was asked with an image picture. The survey offered 271 responses.

4.3 Descriptions of Observation of Behaviors and Expressions

4.3.1 Pedestrian environment and pedestrian behaviors

We took two ways to compare pedestrian behaviors related to pedestrian environment. First, we compared people on Ichibangai Street when it was pedestrianized and open to vehicles as usual. In this analysis, the subjects observed in the two situations are different because the subjects were people who came there that days by chance as tourists, visitors, residents, and so on. By the second way, we tried to observe same subjects on the differently situated streets; we compared same people's looks when they were walking on Ichibangai Street where car traffic existed and on Crea Mall Street, a shopping street, where it is not prohibited but motor vehicles rarely passed through. Crea Mall Street is located on the way to rail stations from Ichibangai Street, so some people coming to Ichibangai Street from rail stations on foot were observed on Crea Mall Street. We took moving pictures on the two streets and searched ones who walked on both the streets, and compare the differences of behaviors and expressions.

To compare car-free Ichibangai Street and it with car traffic, video surveys were conducted for 9 days in total. The date and time are shown in Table 2. Along with the survey on Ichibangai Street, we took moving pictures on Crea Mall Street on 29th November, 2009.

Table 2. Schedule of video surveys

traffic condition of Ichibangai Street	date and time	note
car free	27th July, 2008, 12:00 - 18:00 3rd to 5th May, 2009	week end or national holiday
with car traffic	29th November, 2008, 11:00 - 18:00 2nd, 6th , 9th, 10th May, 2009, 5:00 – 21:00	week end or national holiday On 29th November, Crea Mall was also surveyed.

Using the recorded moving pictures, the following observed behaviors were counted: the relative position of pedestrian groups, the way adults dealt with infants, the way individuals took pictures, couples holding hands. The behavior items were supposed to be influenced by car traffic so chosen to the analysis.

4.3.2 Pedestrian environment and pedestrians' expressions

To analyze the relationship between pedestrian expressions and pedestrian environments, we focused on pedestrians' smile. A facial expression sensing system, "Smile Scan" made by OMRON Corporation. The Smile Scan system detects the shape of eyes, mouth, wrinkles and other facial parts of a subject, and computes the subject's level of smile in percent figures (Konishi et. al., 2008,
Figure 2). The system is mainly developed for training of service industry people to make smile. Some studies focusing on smile have used the system. Kuma et. al. (2010) test the function of a hobby robot to make elderly people smile. Shirai et. al. (2011) analyze patient's smile that differs depends on the expression of an intervenient.

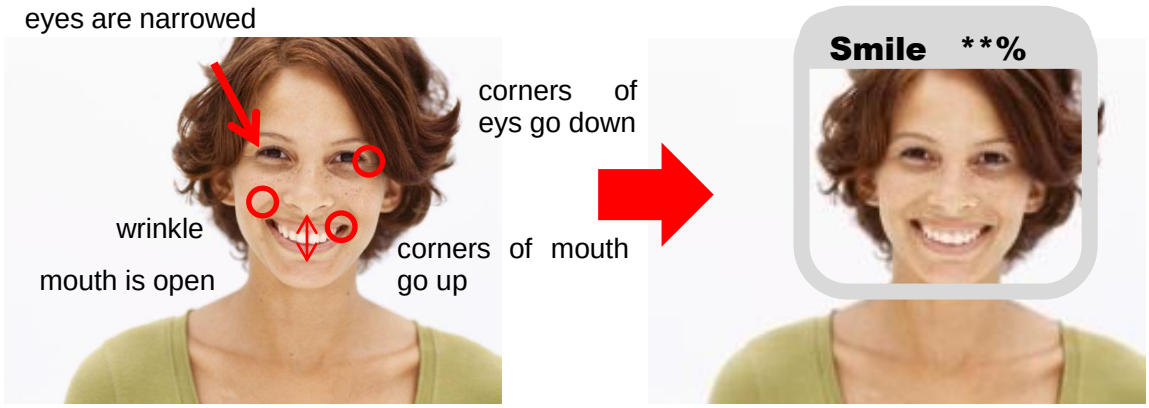

Figure 2. Examples of features analyzed by Smile Scan system
(the figure made using information provided on OMRON website)

We used recorded moving pictures of pedestrians for the analysis. On 15th (Sun) and 29th (Sun) November, 2009, a video survey was conducted. Ichibangai Street was pedestrianized on 15th November. As mentioned above, the Smile Scan system is aimed for smile training, it means that the subject are supposed to be full-faced and not move during the sensor is working. In order to help the system work well, we played the recorded moving pictures slowly and zoomed pedestrians faces on a monitor. The moving pictures on the monitor were analyzed by the Smile Scan system (Figure 3). We analyzed moving pictures recorded from 15:00 and computerized 100 samples for each day. We processed each subject for 10 seconds by the system, and recorded the average and maximum smile level.

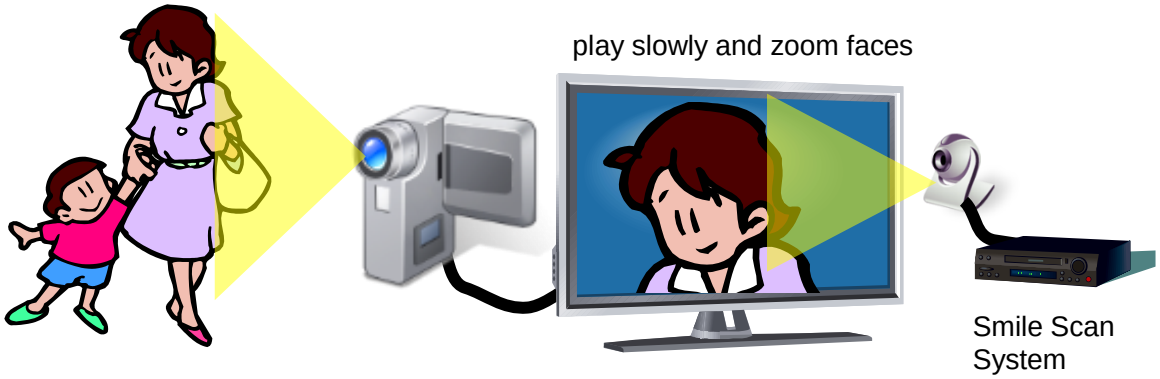

Figure 3. how to analyze pedestrian's expression by Smile Scan system

5. RESULT

5.1 Result of Stress Survey

In this part, result of the stress survey is shown. Figure 4 displays average normalized SPL values of each subject. Regarding the 4 subjects of all 5 subjects, the SPL value at pedestrianized situation is lower than at situation with car traffic. It suggests that the arousal level or stress level of people on the road with car traffic is higher than ones on the road closed to vehicles.

Figure 4. Subjects' normalized SPL

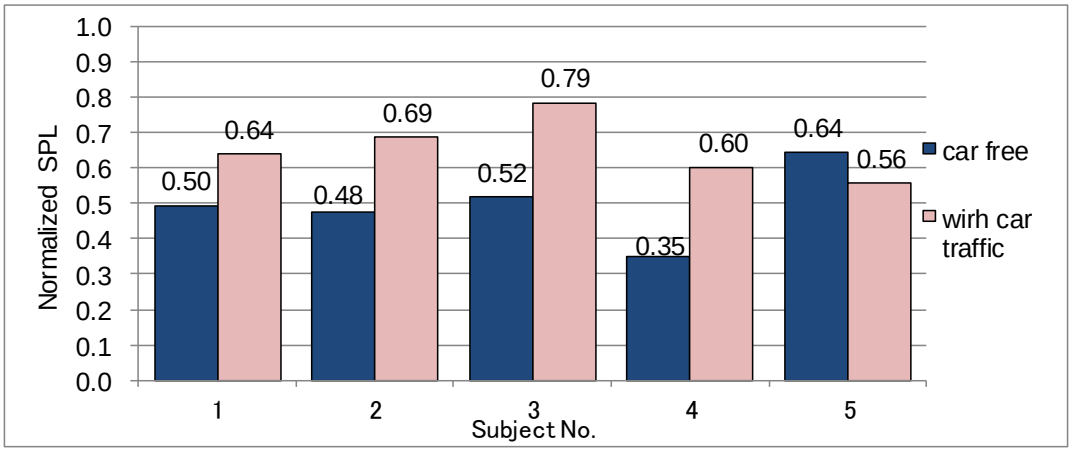

Figure 5 shows time-series data of one subject measured when the subject walked on the Ichibangai Street opened to car traffic. The circles in the graph point out the time a truck passed the subject. When trucks passed the subject, the value of SPL is higher than the average SPL value. The result of the stress survey suggests that vehicles put stress pedestrians.

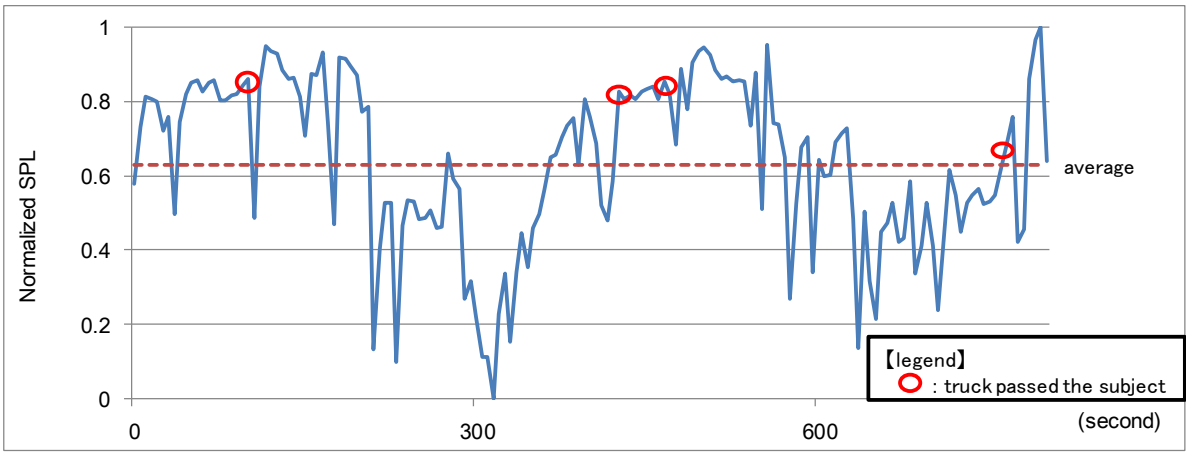

Figure 5. Sequential SPL data of subject No. 1

5.2 Result of Questionnaire Survey

This part explains the result of questionnaire survey to pedestrians who walked Ichibangai Street with car traffic. Figure 6 shows the answer to the question "how do you think about traffic environment of Ichibangai Street" for three situation; with car as usual, car-free, and one way traffic situations. Regarding usual situation with car traffic, only 4.4% of the respondents said "good". On the other hand, 46.1% of the respondents thought car-free environment was "good".

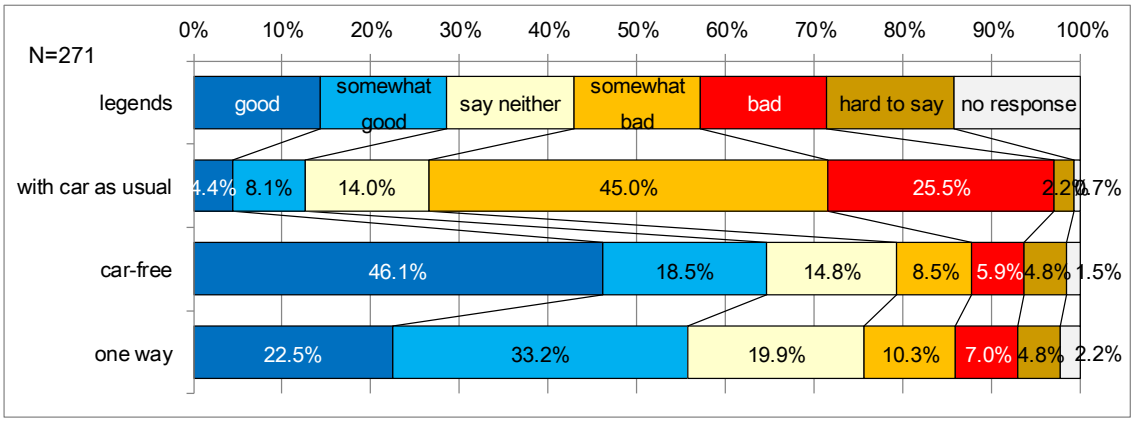

Figure 6. Answer about each traffic environment

Figure 7 shows the answer about question "how do you think the walkability for pedestrians in a group" for same three situations. Only 1.5% of the respondents said "easy" for the usual situation and around a half of the respondents said "easy" for the car-free situation. The result of the questionnaire survey suggest that pedestrianized streets is preferred to streets with car traffic by pedestrians.

In the section 5.1 and 5.2, we compared pedestrians' consciousness about a car-free situation and a situation with car traffic with existing method; stress survey and questionnaire survey. In conclusion, it was found that pedestrianized street was less stressful for pedestrians and preferred by pedestrians. Those results support the hypothesis that pedestrianized streets is highly evaluated by pedestrians than streets with car traffic.

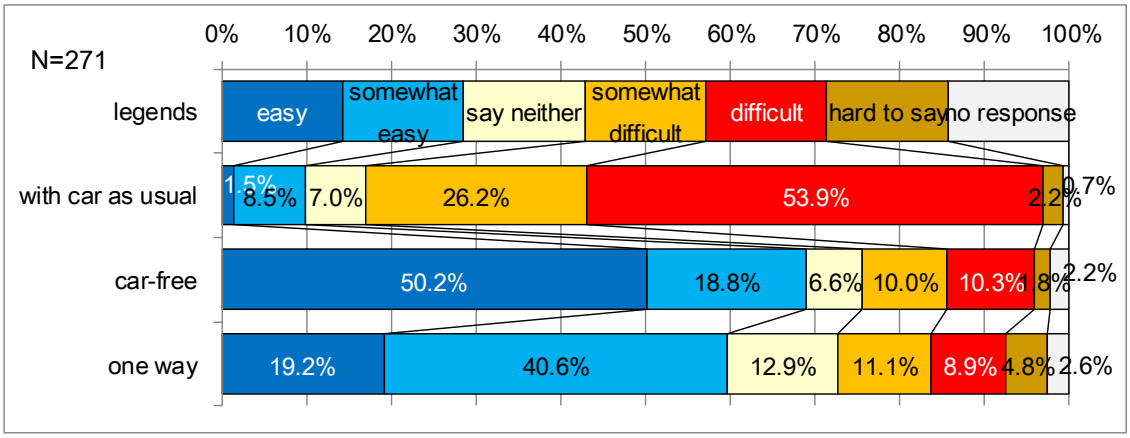

Figure 7. Answer about walkability for pedestrians in a group

5.3 Result of Pedestrian Behavior Survey

5.3.1 Comparison of different situations of Ichibangai Street

This section shows the analysis of pedestrians' behaviors. First, the behaviors of pedestrians on pedestrianized Ichibangai Street and pedestrians on the street as usual are analyzed. Figure 8 shows how pedestrians walking in a group positioned themselves each other. The displayed values show the rates of pedestrian groups in which all the members walked side by side. Regarding groups of two parsons, 87.8% of them walked abreast in car-free environments, while less number, 58.6%, of all the groups walked abreast in car-existing environments. The difference of the rate is significant statistically. Similarly, for groups of three persons and four persons, the rate of groups in which all the members walked in line abreast was significantly larger in car-free environments.

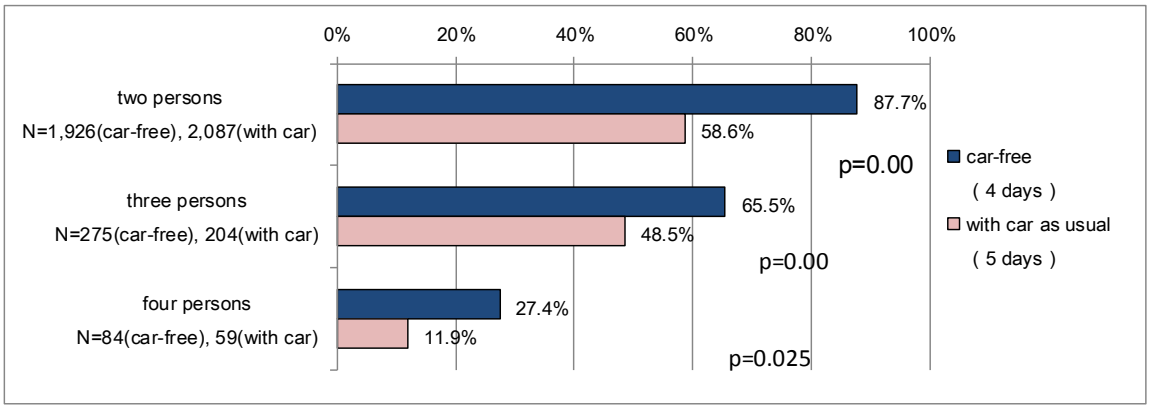

Figure 8. Rate of pedestrians groups walking side by side each other

Figure 9 shows the observed rate of four specific behaviors supposed to be limited by car traffic. Two of them are related to parents with their children. We observed adults with children and whether they held the child's hand or held him/her in arms, and whether the adults with a baby buggy took the child in the buggy. The other two observed items are as follows: whether persons who took a picture stood on street not on sidewalk, and whether couples held each hand. In two of the four items, we found significant difference between car-free environment and car-existing environment. The rate adults who didn't hold their child's hand nor the child in their arms is 55.8% in pedestrianized environment and 30.4% in

usual car-existing environments. Regarding behavior of taking a picture, no one stood on the street when Ichibangai Street was opened to vehicles, while 67.0% of individuals who took pictures stood on the street when Ichibangai Street was pedestrianized. The results suggest that the pedestrianized street encouraged pedestrians to display specific behaviors that are subject to environment.

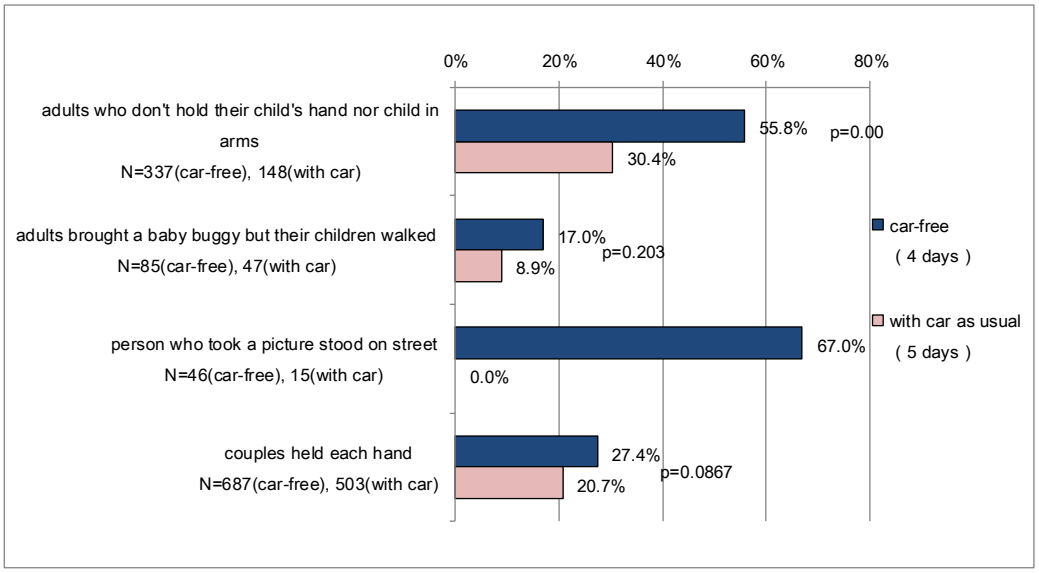

Figure 9. Rate of people who did specific behaviors

5.3.2 Comparison of same subjects in different situations

In this section, same subjects' behaviors in two different situations are analyzed. One is Ichibangai Street where cars pass through and the other is Crea Mall Street where rarely cars drive. We selected two items dealt in the above analysis and for which a large number of subjects were observed: whether two persons walked abreast and whether couples held each hands.

We found 29 pairs walked both the streets on 29th November, 2008. On Ichibangai Street, seven pairs walked side by side, 12 pairs walked diagonally, the other 10 pairs walked in tandem. Figure 10 shows how they walked on Crea Mall Street. All the seven pairs who walked abreast on Ichibangai Street walked on Crea Mall Street Eleven pairs of the 12 who walked diagonally and 9 pairs of the 10 who walked in tandem on Ichibangai Street walked on Crea Mall Street side by side.

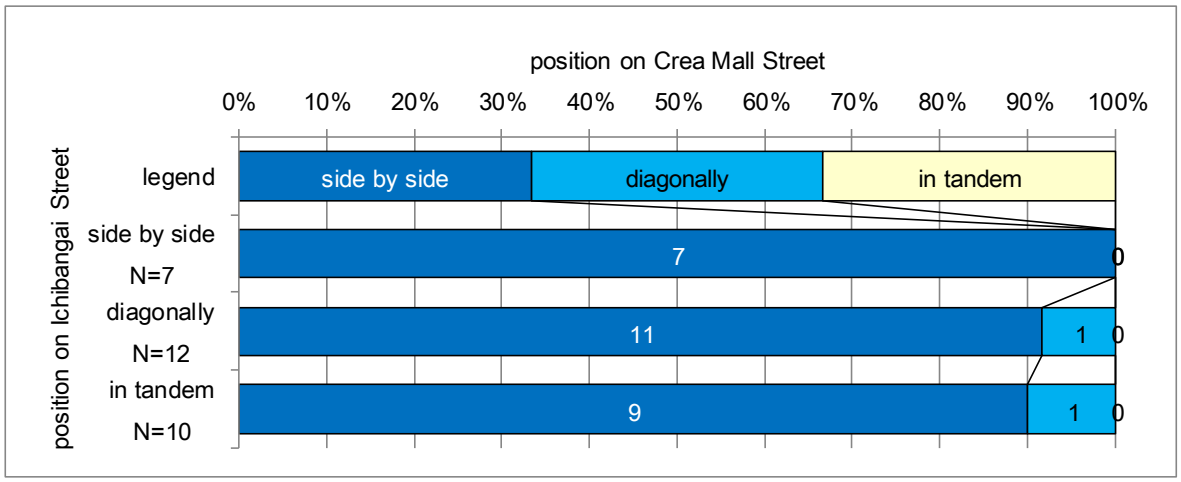

Figure 10. position of two persons on the two streets

Regarding couples, 16 pairs were observed on both Ichibanga Street and Crea Mall Street. Two of the pairs held their hands and the other 14 pairs did not held hands on Ichibangai Street. Figure 11 shows how they behave on Crea Mall Street. The two couples holding hands on Ichibangai Street also held hands on Crea Mall Street. Four couples of the 14 couples who did not held hands on Ichibangai Street held hands on Crea Mall Street contrary to Ichibangai Street.

The analysis shown in this section is luck of sample size, so it cannot be discussed statistically. However, the differences of behaviors gotten by observation of same subjects suggest that the car-free environment allowed pedestrian pairs who wanted to walk abreast to do so and couples to walk holding hands.

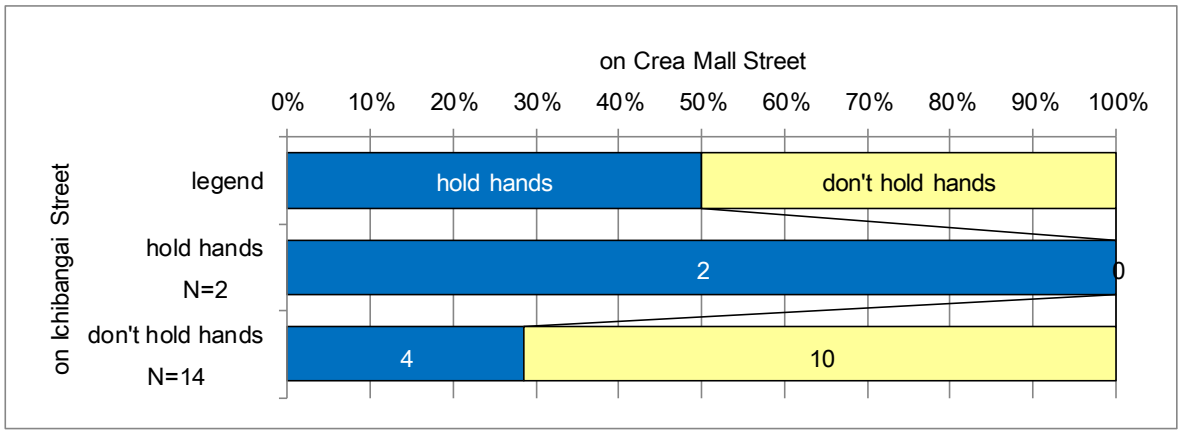

Figure 11. Whether couples held hands on the two streets

5.4 Result of Smile Survey

In this part, the result of analysis for pedestrians' smile is explained. Figure 12 shows example of analysis of each pedestrian. Figure 13 displays the average values of subject pedestrians' average smile level and maximum smile level during 10 seconds of analyzed time. As mentioned above, Smile Scan system used in the analysis computes each subject's smile level in percentage figure, so the analyzed average values also described in percentage. The average "average smile level" of pedestrians who walked on car-free Ichibangai Street is 35.0% and who walked on the car-existing street is 19.8%. The value of car-free situation is significantly

higher than that of the other situation. Similarly, the average of maximum smile level of pedestrians walking pedestrianized Ichibangai Street is significantly higher than that of car-existing Ichibangai Street. The result suggests that the pedestrianized street increase pedestrians' smile level. It means the smile level can be an index for pedestrian environments.

Figure 12. Example result of smile level offered by Smile Scan system

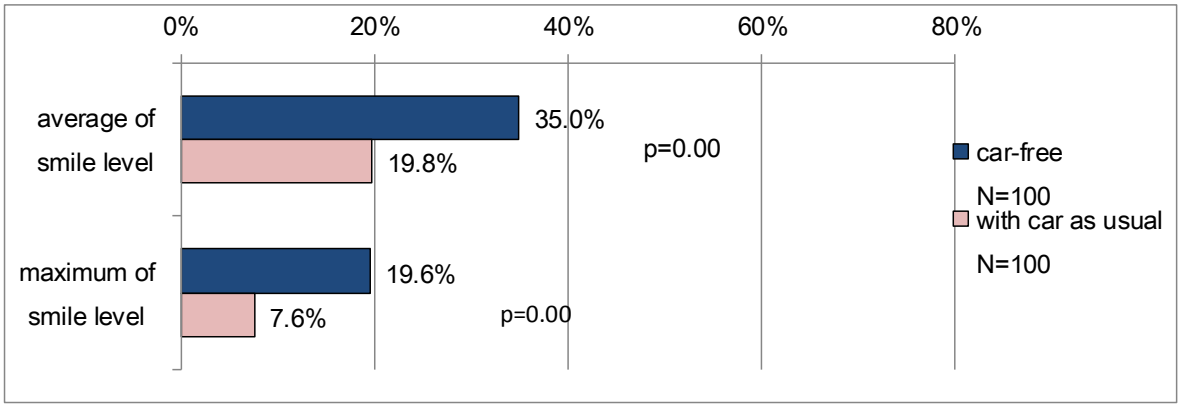

Figure 13. Smile level of pedestrians on Ichibangai Street

6. CONCLUSION

In this study, we aimed to establish new evaluation methods for pedestrian environments. We focus on pedestrian's behaviors and expressions as indexes to the quality of walk spaces; such visible information is superior to data from questionnaire surveys in randomness because that can be gotten without target's knowing. The visually observable information, biological reaction, and questionnaire survey data of pedestrians were collected in case study areas in Japan. Analyzing the biological reactions and questionnaire survey, we judged a pedestrianized situation was highly evaluated and preferred than car-existing situation by pedestrians. Based on the results, we compared visible information observed in above two situations.

In the view point of pedestrians' behaviors, it was found that people's behaviors were diversified in a pedestrianize street. The number of pedestrian groups whose members walk side by side were increased at the car-free environment. The adults who held their children's hand or held their children in arms were decreased in car-free environment. The results suggest that highly evaluated situation, pedestrianized situation, allowed pedestrians to behave more freely. In terms of pedestrians' expression, it was found that the level of pedestrians' smile was higher in pedestrianized environment. The result suggest that pedestrians' smile level increase in a highly evaluated environment. In conclusion, those results suggest that pedestrians' behaviors and expressions may become new evaluation indicators for pedestrian environments.

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