EFFECT OF PEDESTRIAN OBSERVATION MODE ON PERCEPTUAL CONTINUITY OF THE STREETSCAPE

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Introduction

Over recent years, municipal governments and developers in Japan have compiled a range of design guidelines regulating the physical features of buildings so as to maintain and/or create an aesthetically desirable streetscape. Of these guidelines, the "preservation type" aims to preserve existing historical and cultural landscapes, while the "development type" aims to ensure that a newly built streetscape will be attractive and harmonious. The second type was the topic of our previous study (Ohno, Soeda and Nakajima[1]); here, we focus on the first.

Design guidelines typically attempt to control the streetscape by specifying such physical architectural features as façade color and height to fall within a certain acceptable range. These variables and ranges, however, are all too often decided arbitrarily without basis in scientific and empirical research. Moreover, assessments of streetscapes usually only consider the building façade (elevation) as viewed from a single stationary point on the street (e.g., Sanoff[2]). Yet this is hardly the only mode in which we view our surroundings in actual daily life, and it follows that the extent to which different physical features influence our appreciation of a streetscape will depend on how we come to look at it. In examining how pedestrians judge a streetscape, it is therefore necessary to identify the most influential variables separately for each given observation mode.

The present study compares how physical features of buildings and their layout affect pedestrians' evaluation of the perceptual continuity of a streetscape in different observation modes.

[1] Ohno, Ryuzo, Soeda, Masashi, and Nakajima, Kohhei. The Effectiveness of design guideline regulations for improving streetscape, *Proceedings of 6th Conference of the European Architectural Endoscopy Association*, Bratislava. 2003, pp. 21-27.
[2] Sanoff, Henry. *Design Games*: Playing for keeps with personal and environmental design decisions, William Kaufmann, Inc. 1979.

Method

Experimental settings

The experiment employed a set of virtual streetscapes each composed of a different imaginary building inserted into the same basic row of 15 buildings taken from an existing street.

A visual simulation system tested the effects of the building features of 1) height, 2) width, 3) fenestration, and 4) recess from the street on subjects' impressions of perceptual continuity. We excluded color and building material as variables because they have already been treated extensively in previous research and also because their effects do not seem as likely to be influenced by variations in observation mode.

Two observation modes were studied (Fig. 1): looking 1) while moving perpendicularly toward the building façade (*orthogonal view*) and 2) while moving parallel with it (*parallel view*).

Experimental stimuli: virtual streetscapes

1. Basic street

We photographed building façades along several streets in the Tokyo-Yokohama area, selecting three sites with widely varying physical characteristics for use in the experiment (Fig. 2). Three-dimensional computer line drawings of the streets were generated from the photographs while also removing the colors and material textures. This resulted in three basic streetscapes consisting of 15 buildings each: Ginza (G street), Motomachi (M street), and O-okayama (O street).

2. Inserted building

Streetscapes are always gradually changing through the construction of new buildings. The more unified the original streetscape is perceived to be, the more likely it is to be affected by a new building (Oku, Kamino, Funahashi, Koura and Kita[3]). To test the effect of a new addition to the basic streetscape, we created an imaginary building based on the already-existing structures: the frequency distributions of three variables (height, width, recess from the street) were calculated for the 15 buildings in each row, and the corresponding values for the building to be inserted in that row were systematically fixed to be 2σ apart from the mean (Tab. 1).

Table 1. Physical characteristics of the inserted building

Street	Building height (m)			Building width (m)			Recess from the street (m)		
	-2σ	Mean	+2σ	-2σ	Mean	+2σ	-2σ	Mean	+2σ
G street	36.3	47.8	59.4	6.6*	19.6	43.5	-2.1	3	8.1
M street	7.3	12.3	17.3	2.8	9.1	15.4	-0.2	0.63	1.5
O street	4.3	8.5	12.6	2.4*	5.5	15.2	-1.4	0.27	0.9

** Narrowest width of the existing buildings, since the -2σ value was minus.*

[3] Oku, Toshinobu, Kamino, Keijin, Funahashi Kunio, Koura Hisako and Kita, Michihiro. The effect of one building transformation on the estimation of continuity of townscape-The stereogram simulation experiment. City planning review. Special issue, Papers on city planning 30. 1995, pp. 295-300.

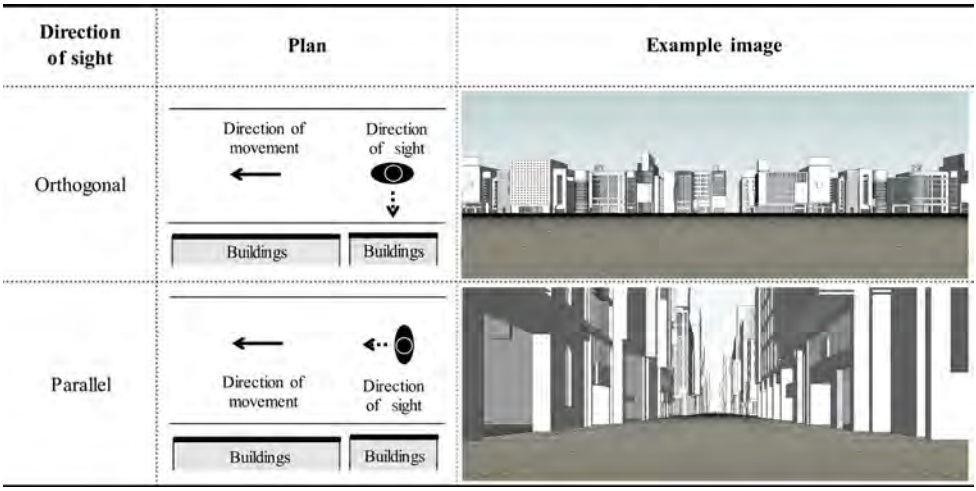

Fig. 1. Experimental observation modes
Source: Ryuzo Ohno, Yang Yu.

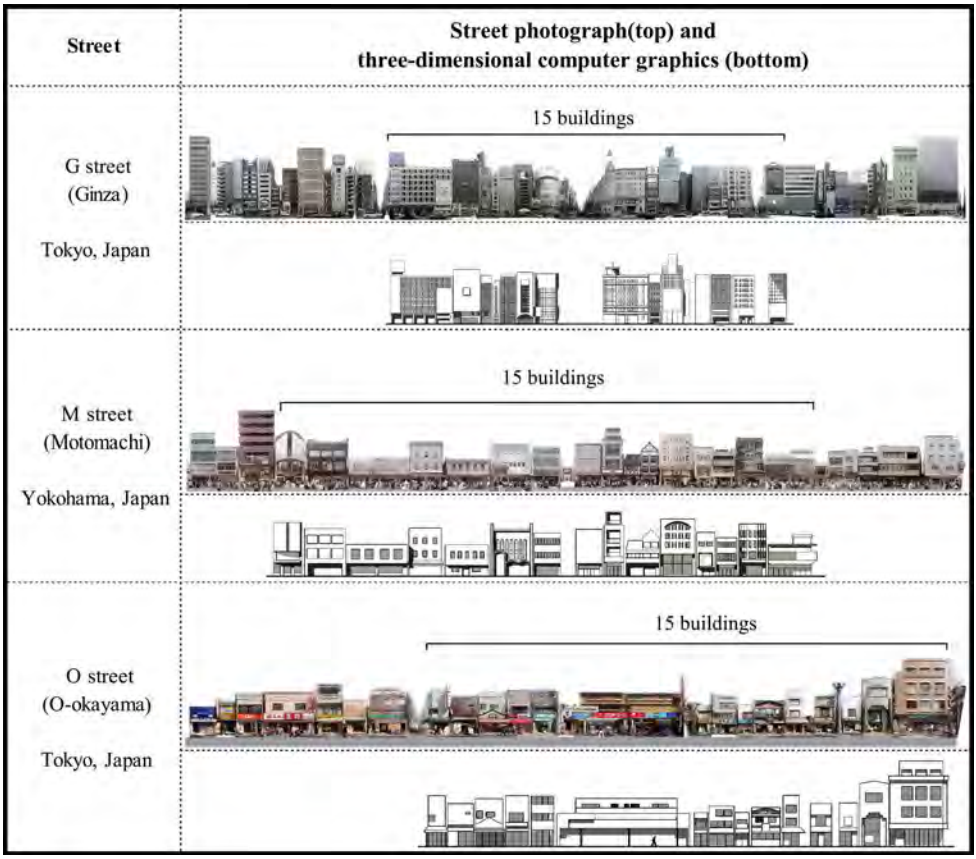

Fig. 2. Street photographs and resulting three-dimensional computer graphics
Source: Ryuzo Ohno, Yang Yu.

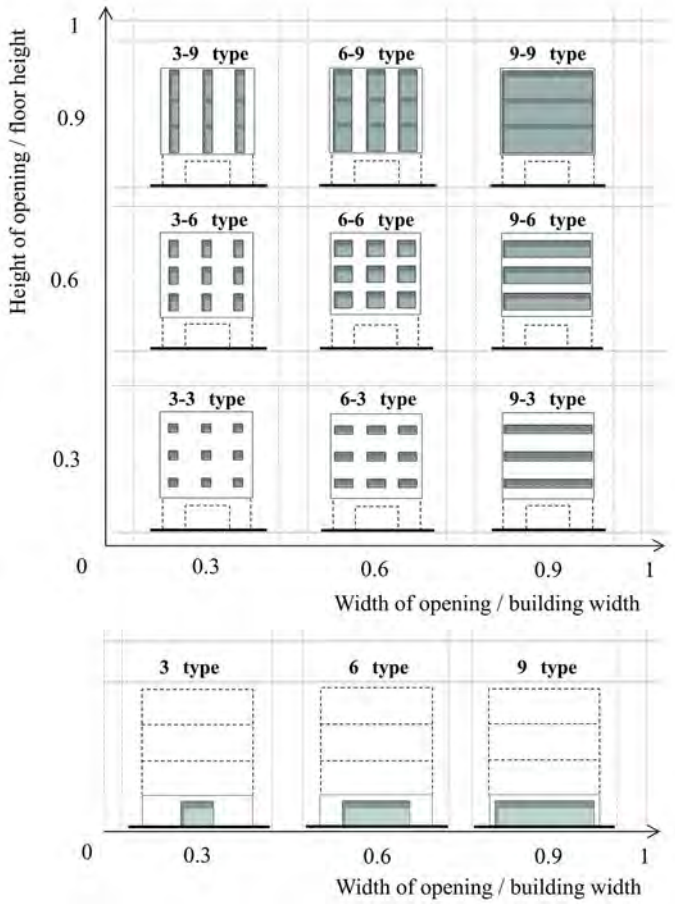

Fig. 3. Fenestration types

Source: Ryuzo Ohno, Yang Yu.

The fenestration of the inserted building was likewise determined through an analysis of the existing architecture; in doing so we considered the openings on the ground floor and those above it separately, given their large differences in design. We began by calculating the ratio of horizontal opening width to building width and of vertical opening height to floor height for all 15 buildings on each street. For the floors above the first, we divided the horizontal and vertical ratios into three categories each to give nine combined fenestration types (Fig. 3, top); each building was then classified into the closest type.

The effect of fenestration type was tested only on the G street, which was the single setting out of the three with building façades large enough for the differences in apertures to be clearly noticeable. Here, we created inserted buildings with the upper floors in four extreme fenestration types (3-3, 9-3, 3-9, 9-9). The experimental buildings for the other two streets, by contrast, were all given the fenestration pattern occurring most frequently in each (6-6 for the O-street, 9-6 for the M street).

For the ground floor, the largest opening type (9-3), which appears most frequently in all three streets, was adopted throughout (Fig. 3., bottom).

3. Virtual streetscape

The above procedures yielded eight inserted buildings of varying height, width, and recess for each of the three streets, plus six more (three additional fenestration types in two recess placements) for the G street. One building at a time was randomly placed between the fifth and tenth buildings of the basic 15-structure row, and this row repeated four times to form a single virtual streetscape (Fig. 4). Video images of each streetscape were then prepared in the two different modes of view, resulting in a total of 60 different versions for use in the experiment.

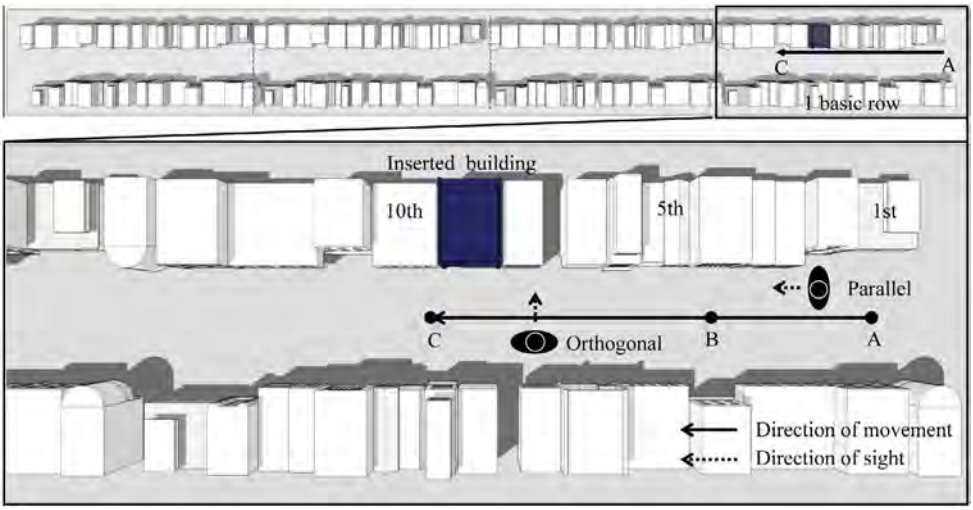

Fig. 4. Overview of virtual streetscape (top) and pedestrian route (bottom)
Source: Ryuzo Ohno, Yang Yu.

Experimental procedure

The virtual streetscapes were shown to each of 20 participants using a video projector on three front screens (each 2.0 m × 1.8 m) together covering a wide visual field (Fig. 5). While watching the video, the participant was asked to indicate with a laser pointer any building that he/she thought disturbed the continuity of streetscape and to also rate the degree of disturbance on a 3-grade scale (somewhat disturbing, disturbing, strongly disturbing). After each presentation, the participant was moreover asked to rate his/her overall impression of streetscape continuity on a 5-grade scale (very low, somewhat low, neutral, somewhat high, very high). Each participant required about 90 minutes for the experiment.

Fig. 5. Experimental setting
Source: Ryuzo Ohno, Yang Yu.

Results and discussion

Perception of overall streetscape continuity by observation mode

As Fig. 6 shows, for the M street the overall impression of perceptual continuity was higher in *parallel view* (vertical axis) than in *orthogonal view* (horizontal axis). No such trend was observed for the G and O streets.

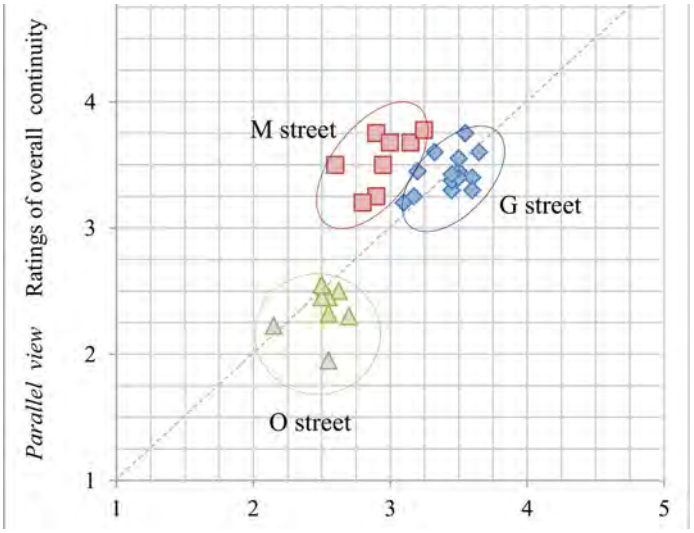

Fig. 6.
Source: Ryuzo Ohno, Yang Yu.

Impact of specific buildings on streetscape continuity

Fig. 7 plots individual buildings according to how viewers rated their disturbance of the streetscape in *orthogonal view* (horizontal axis) and in *parallel view* (vertical axis). Although ratings for the same building were largely similar in both modes, this was not always the case. To further clarify these differences, we chose those buildings whose ratings in the two modes diverged by more than 1.5 and calculated the relative variation $X_s X_s$ for each given physical feature using the following equation:

$$X_s = \frac{|X - X_{avg}|}{\sigma_X}, \qquad X_s \in \{H_s, W_s, S_s, WW_s, WH_s\}$$

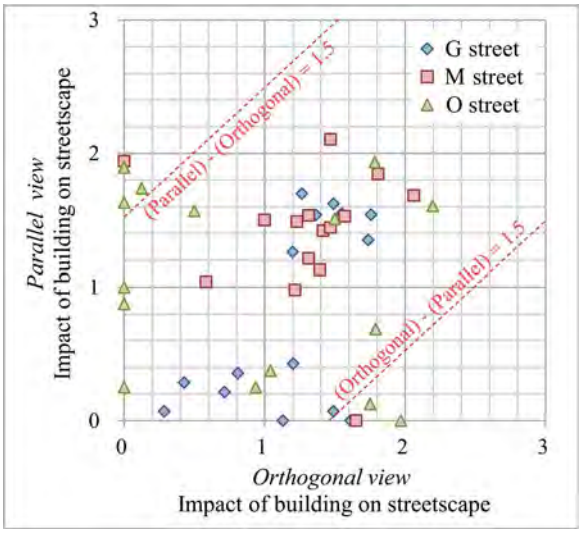

Fig. 7. Ratings of continuity disturbance by building
Source: Ryuzo Ohno, Yang Yu.

The results, shown in Tab. 2, clearly indicate that the relative variation of recess from (or projection into) the street is much higher for those buildings rated as more disturbing in *parallel view* than in *orthogonal view*, while the relative variation of building height is higher for buildings considered to have greater impact in *orthogonal view* than in *parallel view*. Notably, the two variables regarding fenestration varied significantly in both categories.

To identify the cause of these differences, we compared the images subjects saw of the relevant buildings in the two modes. Variations in the height of buildings are more easily perceived in *orthogonal view* than in *parallel view*, where the difference is hard to notice even close-up (Fig. 8).

Table 2. Relative variation for each given physical feature

Observation mode	Physical feature				
	H_s (Building height)	W_s (Building width)	S_s (Recess from the street)	WW_s (Opening width/building width)	WH_S (Opening height/floor height)
(Parallel)* >> *(orthogonal)	0.26	0.39	**0.92**	**1.13**	**1.03**
(Orthogonal)* >> *(parallel)	**1.18**	0.52	0.57	**0.81**	**0.85**

Source: Ryuzo Ohno, Yang Yu.

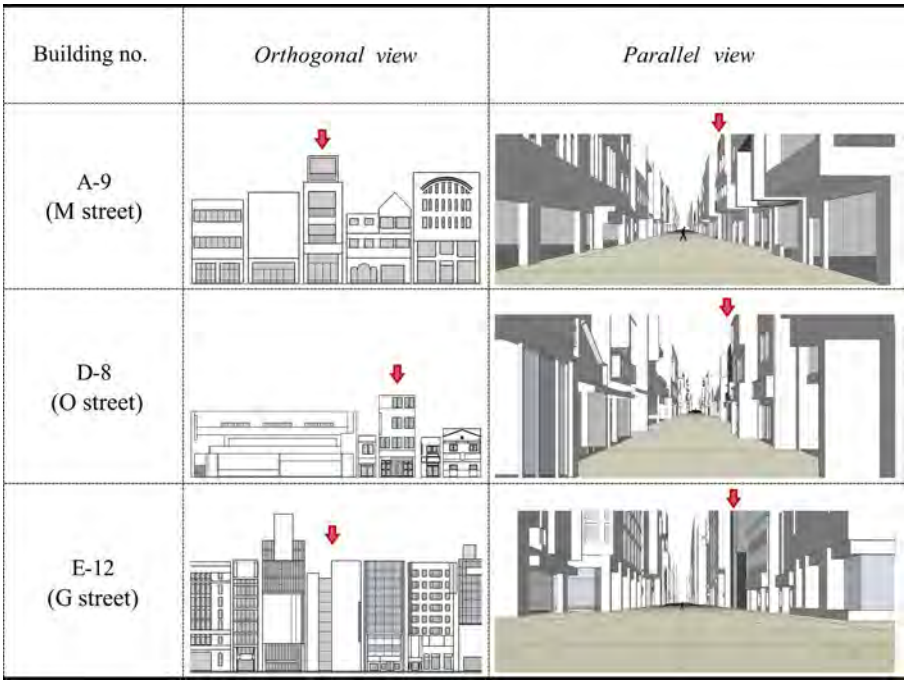

Fig. 8. Examples where disturbance ratings were higher in orthogonal view

Source: Ryuzo Ohno, Yang Yu.

Thus, for buildings of markedly different height, the disturbance rating tended to be higher in *orthogonal view*. On the other hand, the impact of a building tended to be thought higher in *parallel view* when it had a negative recess from (i.e., projected into) the street, something not very easy to see in *orthogonal view* (Fig. 9).

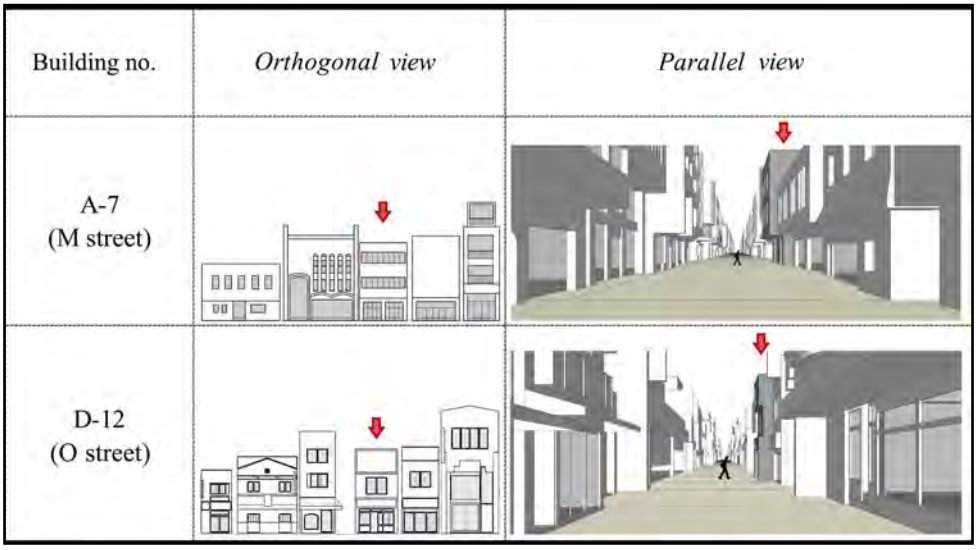

Fig. 9. Examples where disturbance ratings were higher in parallel view
Source: Ryuzo Ohno, Yang Yu.

The effects of the two variables regarding fenestration are harder to explain using static images. As Gibson[4] has suggested, motion is required for humans to perceive the layout of surfaces and objects in space, and so the impact of fenestration, too, will necessarily depend on the optic flow of its patterns as the viewer moves through space.

Influence of difference from adjacent buildings

The degree to which a building is considered to impact the streetscape will likely be affected by its location or context. To examine the influence of adjacent structures on the disturbance rating of a building, we quantitatively defined the difference between a given physical feature of the building and those of both its neighbors using the following equation:

$$X_d = \frac{|X_b - X| + |X_f - X|}{\frac{X_b + X + X_f}{3}} \quad X_d \in \{H_d, W_d, S_d, WW_d, WH_d\}$$

Where X_d: Relative physical difference of the central building
X, X_b, X_f: Values of physical features

[4] Gibson, J. James. *The ecological approach to visual perception*, Houghton Mifflin, Boston, 1979.

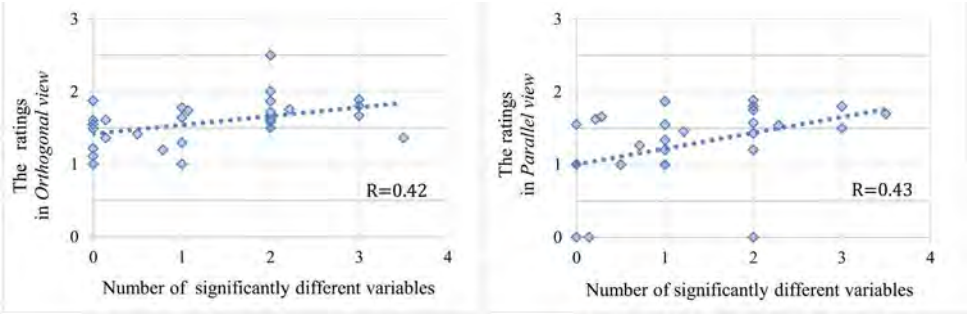

Fig. 10. Correlation between disturbance ratings and level of redundancy of different physical features
Source: Ryuzo Ohno, Yang Yu.

Since an analysis of X_d for individual variables failed to yield clear results, we counted how many variables were significantly apart from the mean value (larger than the standard deviation); in other words, we examined the level of redundancy of different physical features between adjacent buildings. Analysis for the G street revealed disturbance ratings to be correlated with redundancy (number of significantly different variables), as shown on Fig. 10.

Conclusion

The study demonstrates pedestrian perceptions of streetscape continuity to be affected by observation mode. The observation mode influences which specific physical features will prove relevant in ratings of continuity. In *orthogonal view*, differences in building height are more important to perceptual continuity, whereas the degree to which a building projects into the street has greater impact in *parallel view*. Variables regarding fenestration significantly affect moving pedestrians in both views. Ratings of a building's disturbance of streetscape continuity, moreover, can be explained by the redundancy of different physical features from adjacent buildings.

Since the impact of a building's design and layout differs depending on observation mode, it follows that regulation of building elements should not be tied to rigid standards but be conducted more flexibly, according to each individual situation. More reasonable and reliable design guidelines that take the observation mode into account will help to renew traditional neighborhoods while preserving the same original streetscape that people have cherished over the years.