Seat preference in public squares and distribution of the surrounding people: An examination of the validity of using visual simulation

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1. Introduction

Public squares are shared by people who use them for various purposes. When people choose seats in a square, they unconsciously evaluate not only the physical characteristics of the space but also the distribution of others already present (Hall, 1966; Sommer, 1969; Whyte, 1988). Knowing the hidden rules of this behaviour will be important in designing squares that remain comfortable even in crowded situations.

Most past studies of seat choice preference have reported on statistical tendencies derived from observations of subject behavior in actually existing sites (i.e., Abe, 1997; Imai, 1999; Kawamoto, 2003). However, they provide no clear theoretical model for explaining the basic mechanisms regulating such behaviour. The present study conducts a series of experiments in both real and virtual settings in order to extract quantitative relationships between subjects' seat preferences and the presence of nearby strangers and to clarify what factors influence their seat choices.

2. Method

Two sets of experiments were conducted. The first experiment used two existing public squares (see Figure 1). At each site, 19 subjects (8 male and 11 female university students) were asked to walk about and to evaluate each of several pre-designated positions supposing they wished to sit there to 1) have a brief rest, 2) eat food, and 3) read a book. Subjects were also asked to rate the seats supposing there were no other people at the site. The second experiment was conducted in a virtual reality simulation laboratory at the Tokyo Institute of Technology. Subjects were asked to conduct the same tasks as they did before, this time employing virtual reality simulations of the two squares used in the first experiment.

The validity of using visual simulation was evaluated by comparing the ratings made by each subject in the real versus virtual square. Using the data thus validated, a hypothetical formula was proposed and tested for explaining subjects' evaluations of seat positions as a function of such factors as the distance and angle between the seat and another person already present.

2.1 Experiment 1: actual setting

Experiment 1 was conducted in the two public squares shown in figure 1. Subjects were shown site maps indicating the seat positions to be evaluated. They were asked to rate each position by writing a score ranging from 20 (most preferable) to 0 (least preferable) on the map according to how suitable they felt the spot to be for 1) having a brief rest, 2) eating food, and 3) reading a book. Subjects were also asked to perform the same evaluations supposing that there were no other people there.

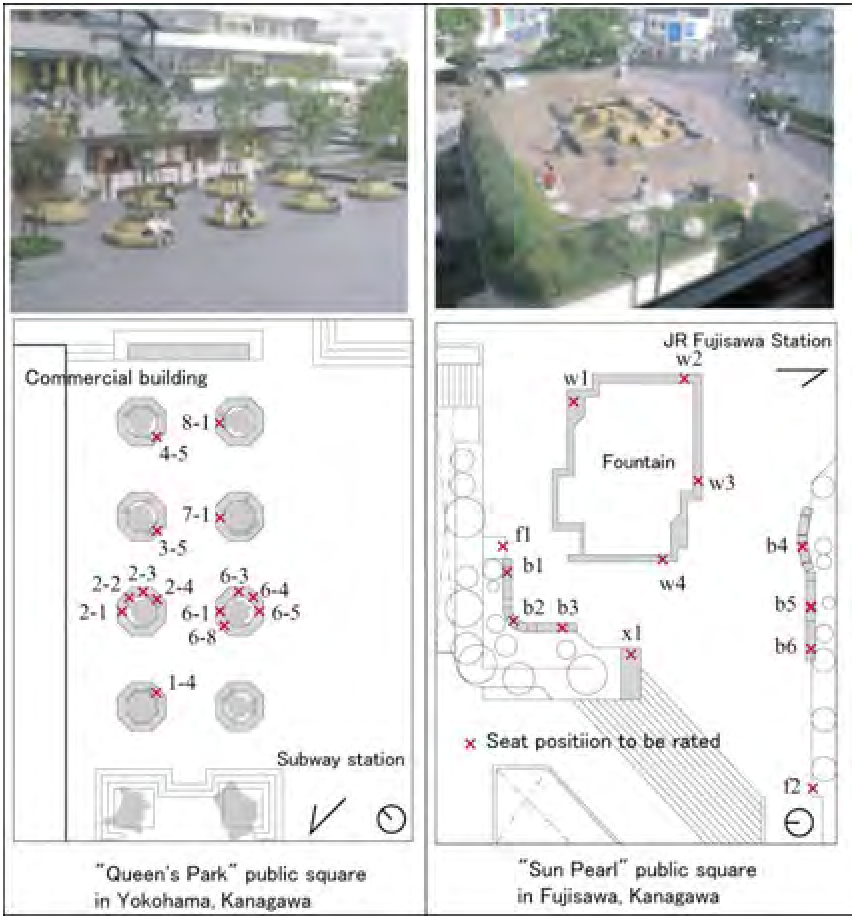

Figure 1 The experimental sites

2.2. Experiment 2: virtual setting

It is difficult to control the distribution of people in an actual public square. Virtual simulations of the two experimental sites were therefore developed as a way of systematically investigating how the presence of other people influences seat choices. Images created on 3D computer graphics software were displayed using the “D-vision” system developed by the Sato Makoto Laboratory at the Tokyo Institute of Technology (see figure 2a). The D-vision gives a wide field of vision covering 180 degrees both horizontally and vertically. In the first session, designed to test the validity of using virtual simulation, each subject evaluated the seat positions under two situations: first, in an empty square, and second, with computer generated figures (see figure 2b) placed in the same positions as when the subject was at the real site. In the second session, human figures were systematically placed within the virtual square to test for the effect of such geometrical values as the distance and angle between the seat position and a person already present nearby.

(a) A simulated scene projected

(b) A computer generated human figure

Figure 2: *Virtual reality simulation*

3. Validity of using visual simulation

Table 1 shows the correlation coefficients between the real and virtual space data obtained from each subject. Figure 3 depicts some of the relationships between scores given in real versus virtual settings. Most subjects, for example subject B (see figure 3a), responded similarly in both situations (i.e., had a high correlation coefficient). Their virtual space data were therefore considered valid for further investigation. Subject A had a relatively high correlation coefficient, but with larger variance. As shown in figure 3(b), this subject gave consistently higher scores in virtual space than in real space. Since our analysis was to be based on the relative change of score, however, data for subjects of this type were also accepted for further investigation. Some of subject Q's results are far removed from the 45 degree line, as shown in figure 3(c). This may have either been caused by some irreproducible difference between the real and virtual setting, for example a dirty seat, or by a mistake on the response paper. Since the overall correlation was still quite high, data obtained from subjects of this type was still judged to be valid. Only a low correlation coefficient was obtained for subject F's evaluation of places for eating food. As shown in figure 3(d), however, this result is probably due to the narrow range of scores given by the subject. Since the scores obtained from the subject in relation to purposes other than eating had high correlation coefficients, as shown in Figure 3(e), we assumed this subject's data to be valid.
Subjects E, G, P, and S showed low correlation coefficients and large variance (see table 1 and figure 3f). The evaluations made by these subjects in the virtual reality simulation did not well correspond with those made in real settings, for which their data were omitted from later analysis.

subject	RESTING R	(av)	READING R	(av)	EATING R	(av)
A	0.82	(4.46)	0.86	(3.85)	0.89	(4.19)
B	0.73	(2.04)	0.84	(1.89)	0.86	(1.15)
C	0.81	(2.21)	0.77	(2.50)	0.73	(2.31)
D	0.87	(2.46)	0.75	(3.33)	0.79	(2.27)
E	0.37	(5.43)	0.36	(4.20)	0.62	(3.73)
F	0.77	(2.56)	0.79	(1.96)	0.48	(1.85)
G	0.72	(3.31)	0.55	(4.67)	0.56	(3.75)
H	0.68	(4.33)	0.72	(3.67)	0.80	(2.92)
I	0.86	(2.35)	0.79	(2.65)	0.55	(3.42)
J	0.76	(2.44)	0.78	(2.46)	0.76	(2.44)
K	0.52	(2.38)	0.82	(1.88)	0.94	(1.21)
L	0.82	(3.33)	0.87	(2.80)	0.81	(2.88)
M	0.68	(2.75)	0.79	(2.06)	0.72	(1.60)
N	0.50	(4.09)	0.81	(2.89)	0.77	(2.76)
O	0.90	(2.17)	0.80	(2.48)	0.76	(2.67)
P	0.38	(3.47)	0.28	(3.52)	0.70	(2.74)
Q	0.89	(1.86)	0.85	(1.84)	0.86	(2.16)
R	0.82	(2.49)	0.71	(2.96)	0.34	(4.92)
S	0.57	(4.35)	0.87	(2.50)	0.48	(4.62)
Ave.	0.71	(3.08)	0.74	(2.85)	0.71	(2.82)

R: correlation coefficient

av: average variance

Table 1: *Correlation coefficients and average variance between real and virtual space data*

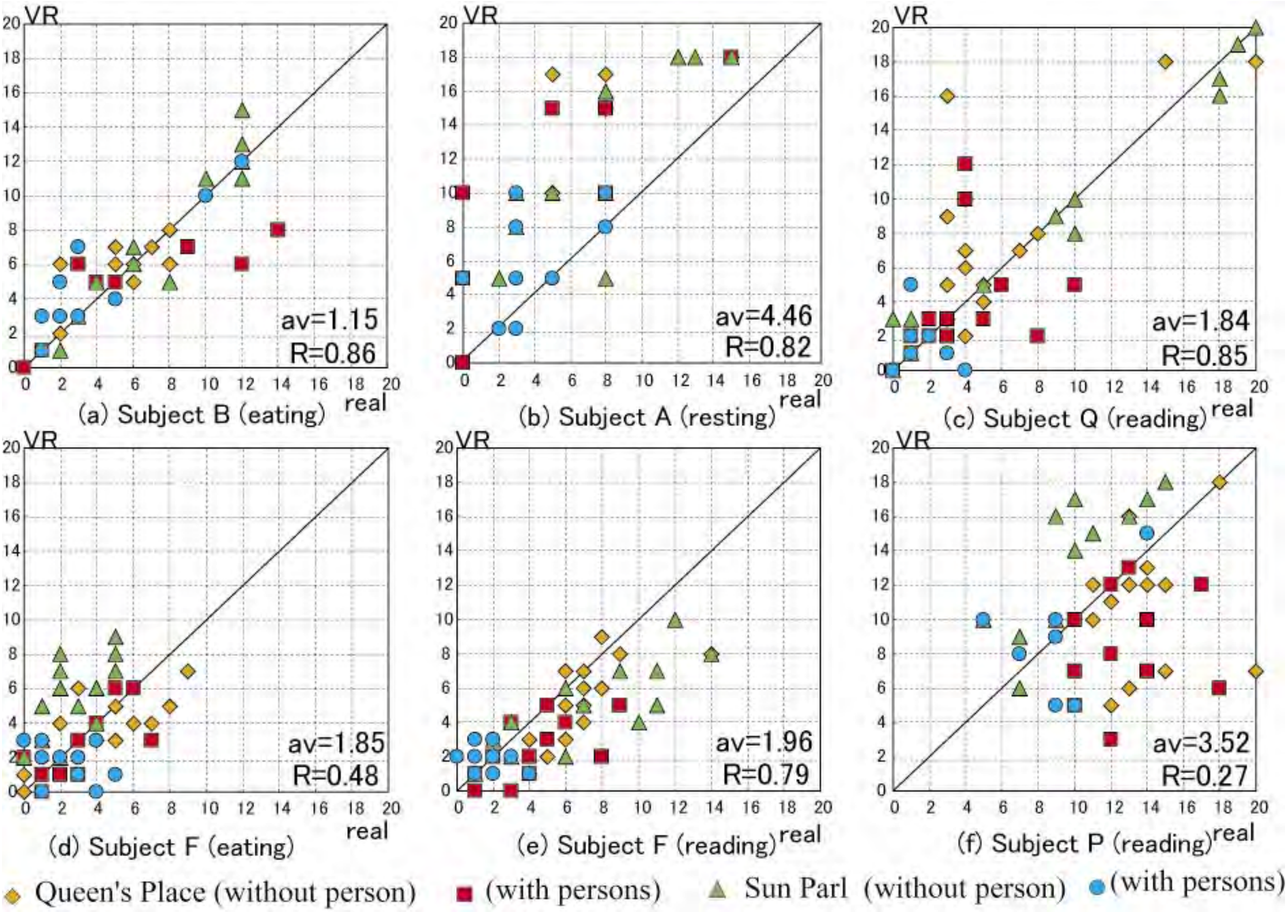

Figure 3: *Relationships between real versus virtual space data*

4. Impact of the presence of a nearby stranger on seat preferences

The intensity of impact (□E) of the presence of a nearby stranger on seat evaluation can be defined as the difference between the score given to a seat position when no one else is present versus when there is one other person. It is expressed by the following equation:

$$\square E=(E0 - E) / (E0 + E / 2)$$

Where E0: The score given to a seat position when no one else is present
E: The score given to a seat position when one other person is present

The influence of such factors as the distance and angle between the seat position and the other person was examined by comparing the values of □E in various situations.

Figure 4 shows the relationship between the distance from a nearby stranger and the intensity of impact (□E). Subjects exhibited several different types of responses. Figure 4(a) shows that for subject C, the intensity of impact decreased as the distance increased. Most of the subjects (9 out of 15) shared this tendency, although the ratio of reduction was not the same. Figure 4(b) shows a similar pattern, except that in this case the value of □E goes below 0. For subject R, in other words, the presence of a nearby stranger was not necessarily negative; if the person stayed away more than a certain distance, there could even be a positive impact. Several other subjects, for example F and Q, also belong to this type. Distance had no influence on evaluations made by subjects N and I, as shown in figure 4(c). As for subject K, the presence of a stranger had no effect on seat preference except when the person was seated immediately nearby (see figure 4d).

We commonly find that someone sitting right in front of us will make us feel more uncomfortable than someone sitting off to the side. Figure 5 shows the effect that the angle of a nearby stranger with respect to a seat has on subjects' willingness to sit there. Figure 5(b) shows the positions that the stranger image was placed in for the experiment, plotted using four different symbols according to where the figure is located with respect to the seat. These symbols were used in figure 5(a) to show again the relationship

between the distance from an unknown person and the intensity of impact (□E), this time also sorted according to the person's relative location. The results indicate greater impact for when the stranger is in the front zone (indicated by diamond symbol), suggesting that the effect of a nearby stranger is greater when that person is in the front than anywhere else.

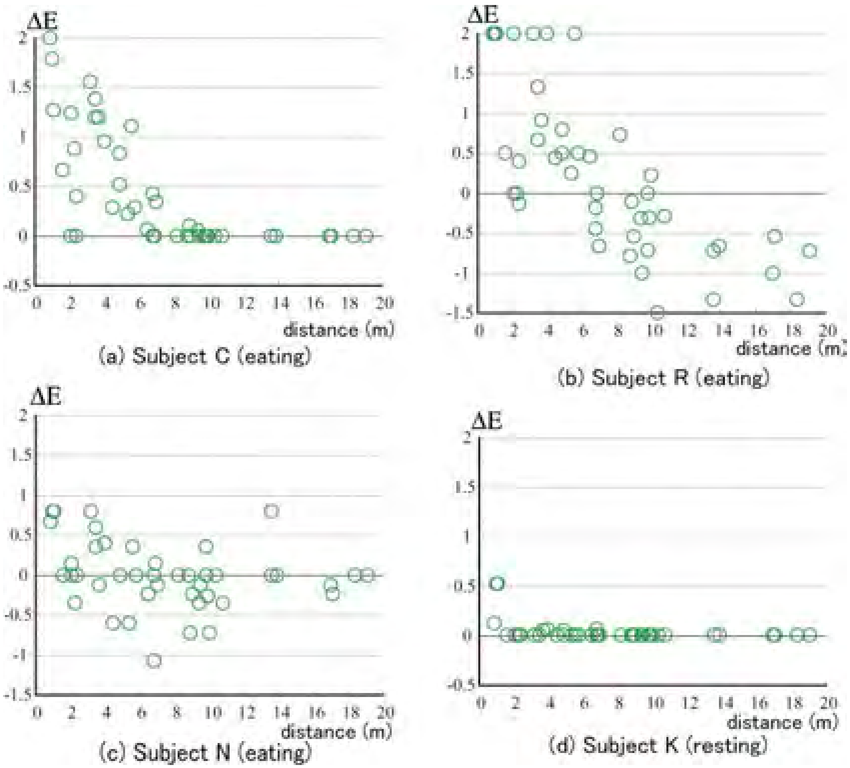

Figure 4 Relationship between distance from a nearby stranger and the intensity of impact

In order to capture this effect induced by the relative direction as well as body orientation of a nearby stranger, a hypothetical formula was postulated as follows:

□E=a1 log(d) + a2□ + b

where a1, a2, b: coefficient

d: the distance between a seat position and a nearby stranger
□: a weight defined by the angle and body orientation of the stranger with respect to the seat position (see figure 6 for a more precise definition)

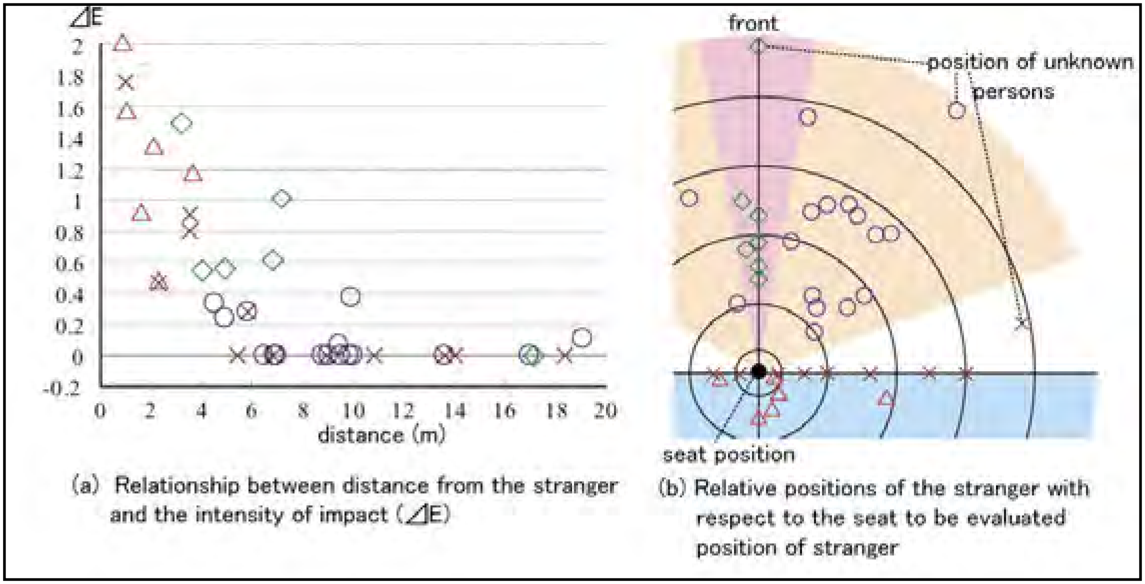

Figure 5: *Effect of the position of a nearby stranger on seat preference*

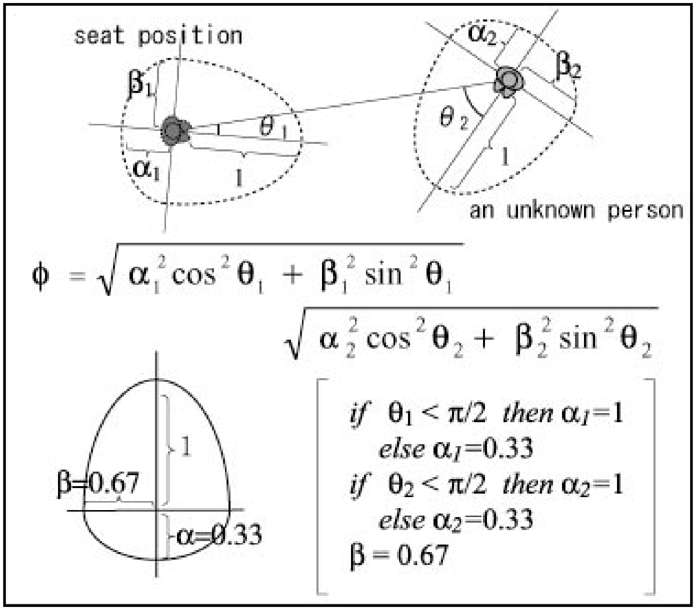

Figure 6: *Definition of the weight □ as determined by the angle of a nearby stranger with respect to a seat position and his/her body orientation*

		a1	a2	b	R	(e)
A	resting	-0.64	0.58	1.16	0.84	(0.23)
	reading	-0.40	0.09	0.84	0.72	(0.19)
	eating	-0.59	0.98	0.63	0.73	(0.22)
B	resting	-0.58	0.91	0.88	0.70	(0.32)
	reading	-0.53	0.68	0.84	0.72	(0.27)
	eating	-0.53	0.70	0.87	0.84	(0.26)
C	resting	-0.65	0.98	0.93	0.80	(0.27)
	reading	-0.65	1.04	0.92	0.84	(0.23)
	eating	-0.34	0.92	0.51	0.83	(0.13)
D	resting	-0.83	1.64	1.09	0.78	(0.37)
	reading	-0.89	1.78	1.05	0.83	(0.32)
	eating	-0.98	2.36	0.82	0.83	(0.29)
F	resting	-0.64	2.05	0.86	0.77	(0.31)
	reading	-0.80	1.35	1.07	0.84	(0.27)
	eating	-0.80	1.61	1.05	0.85	(0.26)
H	resting	-0.66	1.33	1.01	0.66	(0.42)
	reading	-0.81	2.68	0.24	0.77	(0.33)
	eating	-0.75	1.97	0.64	0.70	(0.34)

		a1	a2	b	R	(e)
J	resting	-0.66	0.56	1.22	0.86	(0.23)
	reading	-0.70	0.70	1.22	0.88	(0.22)
	eating	-0.59	0.60	1.02	0.83	(0.22)
L	resting	-0.77	1.12	1.56	0.87	(0.24)
	reading	-0.83	1.14	1.61	0.87	(0.27)
	eating	-0.68	1.27	1.57	0.85	(0.25)
M	resting	-0.48	1.22	0.71	0.82	(0.19)
	reading	-0.43	1.27	0.57	0.81	(0.17)
	eating	-0.70	1.39	1.32	0.84	(0.24)
O	resting	-0.53	0.70	0.83	0.71	(0.27)
	reading	-0.56	0.58	0.96	0.79	(0.22)
	eating	-0.83	1.79	0.76	0.83	(0.24)
Q	resting	-1.08	2.95	1.04	0.88	(0.33)
	reading	-1.11	2.48	1.15	0.89	(0.32)
	eating	-0.79	2.64	0.82	0.78	(0.31)
R	resting	-0.99	1.39	1.07	0.82	(0.36)
	reading	-1.01	1.81	0.91	0.74	(0.49)
	eating	-1.20	1.86	1.07	0.87	(0.35)

Table 2: *Values of the coefficients of the regression equation*

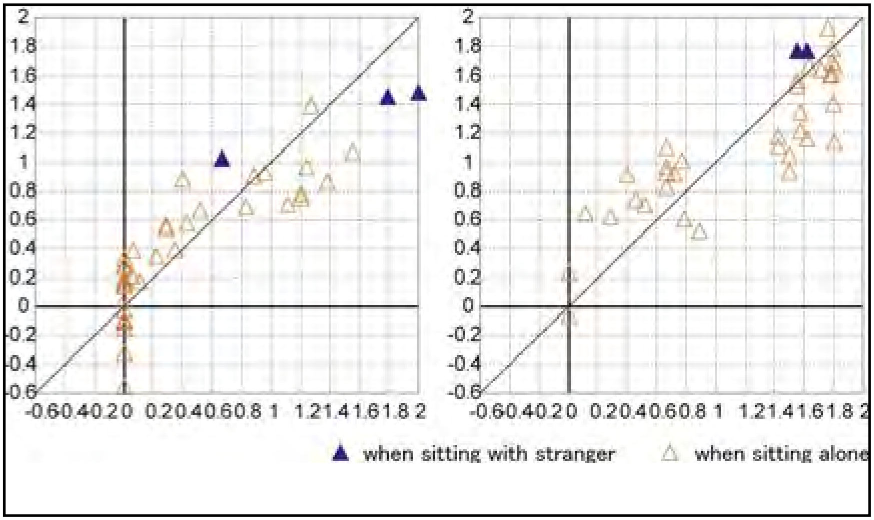

Figure 7: *Relationship between estimated values and experimental results*

Regression analysis was conducted to obtain the values of the coefficients for each of the subjects shown to be influenced by the presence of a nearby stranger (see Table 2). The results showed the influence of each factor to differ considerably across subjects. Differences within each subject (i.e., between the three activities of resting, reading, and eating), however, were not so large.

Figure 7 shows the relationship between the estimated values obtained by the regression equation versus the experimental results. The match between the two led us to conclude the hypothetical formula to be valid, the disparity between the values of the coefficients derived for each subject notwithstanding. This result suggests that while the psychological impact of the presence of a nearby stranger works in similar ways across subjects, there is individual variety in the weight given to each factor.

5. Conclusion

Investigating the spatial component of interpersonal relations through visual simulation was proved valid for most subjects in the study. Using this validated data, we were able to quantify the relationship between seat preference and the distance, angle, and body orientation of a nearby stranger. Interestingly, the existence of another person was not always negative, but could even be positive as long as that person stayed more than a certain distance apart. It was also found that although the psychological impact of the presence of others works in similar ways across subjects, the weight assigned to each factor will differ according to the individual. Although this study deals only with the influence of a single stranger and therefore is still in a rudimentary stage, it will hopefully provide a basis for future studies examining more natural situations where a number of people share a space at the same time.

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