Situational Transformation of Personal Space

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Abstract. This paper describes an experimental study that investigated how interpersonal distance varied depending on situational factors, as well as postures and gender. The results revealed statistically significant simple main effects of the "task", "combination of bodily directions", and "devices". Interpersonal distances were affected by the differences between: (a) "without task > with a task", (b) "front > lateral", (c) "lateral > side-by-side", and (d) "front > backward" under the conditions except for "typing" task. It was considered that interpersonal space was co-constructed through an interactive process by a dyad.

Keywords: Personal space · Spatial behavior · Nonverbal communication

1 Introduction

This paper describes an experimental study of the flexibility and situational transformation of personal space. The study investigated how interpersonal distance varied depending on tasks, devices, combinations of bodily directions, postures and gender. We propose two types of data correction models for measuring interpersonal distances.

Personal space can be defined as "an area individuals actively maintain around themselves into which others cannot intrude without arousing some sort of discomfort" [14, 24]. Dosey and Meisels [7] interpreted it as a body buffer zone which serves as a protection against perceived threats and emphasized the ownership of personal space. Research on human spatial behavior influenced various design issues not limited to the area of architecture [24] and environmental design [10], but extended to service design, proxemics of social robots [19], and human-robot embodied interaction.

1.1 Flexibility of Personal Space

The dimensions of personal space are not fixed but vary according to internal states, culture, and context [25]. Research findings suggested that the influences upon interpersonal distance were caused by various factors including gender [11], age [4], culture [2], personality traits [10], attractiveness [11], psychological disorders [26], attitudes [20], approach angle [28], eye contact [4], co-operation [27], experimental environment including room size [8], lighting conditions [1] and indoor/outdoor [6].

There is a considerable interaction between personal space and interpersonal distance. It affects the distribution of persons [24]. Interpersonal distance may be outside

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the area of personal space if two unfamiliar persons exist in a spacious room. On the contrary, it may be less than the boundaries of personal space when crowded.

1.2 Our Approach

Tasks and Combination of Bodily Directions. We aim to cover more natural settings, especially of tasks, and of combinations of bodily directions. In addition to a typical experimental setting (face-to-face, with no task), we shed light on an ordinary situation doing such a small task as listening-to-music and e-mailing, and also included alternative combinations of bodily directions such as “side-by-side” and “backward” (Fig. 1).

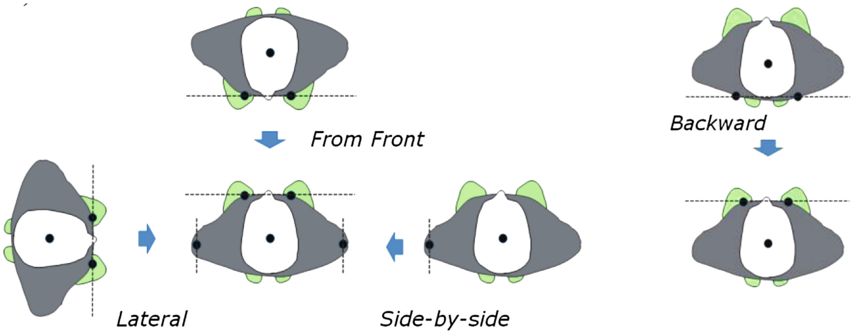


Fig. 1. Personal space and various combination of bodily directions

Validity and Reliability of Measuring Method. Research on personal space has employed diverse methods. Measures of interpersonal distance have typically been used as a dependent variable. Altman [3] distinguishes three classes of methods: simulation, laboratory methods, and field methods. The stop-distance method [7, 16] and unobtrusive observation [9] had been widely used and evaluated as feasible techniques for experimental and naturalistic studies, respectively [14]. In our study, we employed the stop-distance method that yields high test-retest reliability [14, 22]. It controls rate of approach (slow), facial expression (neutral), gestures (arms and hands relaxed at side), conversation (not permitted), and eye contact (absent).

In the use of stop-distance method, the distance is usually measured by the feet positions [14]. It well works when the participants face each other in a sufficient distance. However, a considerable error possibly occurs especially in a close distance or under a sort of situation such as sitting side-by-side. As for the validity, the methodological improvement is a key for investigating the anisotropy and flexibility of personal space.

Re-modeling. Instead of a foot position, we re-considered a starting point of the interpersonal distance by focusing on several landmarks on human body surface including Acromion (summit of the shoulder), Thelion (a bust point), the tip of the nose, Scapula (on back), and Vertex (upper surface of the head) (Fig. 2). In the present study, we developed two different concepts of modeling the interpersonal distances: “surface” model which employs the distance between body surfaces and “center-center” model which employs the distance between the centers of human bodies.

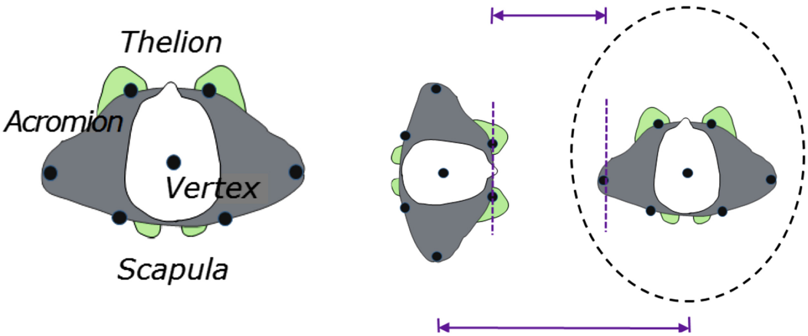


Fig. 2. A plan view of human body and example of the landmarks on body surface

2 Empirical Study

2.1 The Study I

The study I investigated the flexibility of personal space. In particular, the settings were enhanced to include daily tasks and alternative combinations of participants’ bodily directions. The experimental design of the study I is shown in Table 1.

Table 1. Experimental Design of the Study I

Factor		Level	
Between subjects	Gender and gender combination	4	male-male, male-female, female-male, female-female
Within subjects	Posture	2	standing, squatting posture
	Task	4	seeing ahead (no particular task), writing a memo with a smart phone, enjoying music with an ear-phone and a USB player
	Combination of bodily directions	4	from front, backward from front, from a lateral direction(*), side-by-side (facing the same direction from a lateral direction(*))

Note (*): The participant was approached from a lateral of dominant hand.

Participants. Forty four healthy university students including 21 males (ranged in age 19–24 years) and 23 females (ranged in age 18–23 years), who were educated between 13–17 years, participated to the study. Mean stature of male participants was 171.1 cm (SD 5.24) and that of female participants was 157.9 cm (SD 6.96).

Method and Procedure. The data were collected in the time period between November 2014 and January 2015. The participants were recruited individually and were informed that the study dealt with spatial preferences. The data collection was carried out during daytime, in an empty and quiet class room (approx. 6.5 m × 6.3 m with a ceiling height of 3.0 m) of a university located in Tokyo metropolitan area. The brightness was appropriately maintained with an indoor lighting instead of natural light from outside.

According to the stop-distance procedure, an assistant experimenter initially stood three meters from the participant and then approached the participant, in small steps, approximately 0.25 m per step, at a constant slow velocity, approximately one step per two seconds, until the participant began to feel uncomfortable about the closeness. By saying stop, the assistant experimenter's approach halted. In order to minimize a measurement error, the participant was allowed to make fine re-adjustment of their positions. The distance remaining between the participant and experimenter was measured. Each dyad of a participant and an assistant experimenter was not acquaintances.

Data Analysis. There were four factors in the study I. The between-subject factor was "participant's gender and gender combination" (4 levels). The within-subject factors were the "posture" (2), the "task" (3) and the "combination of bodily directions" while approaching (4) (see Table 1). A multiple comparison test was performed. We applied Bonferrroni-Dunn's procedure by using SPSS (ver. 21). It is not necessary to test the null omnibus hypothesis using an ANOVA prior to tD statistic [17, p. 181].

Data Correction by Re-modeling Personal Space. We focused on several landmarks on human body surface: Acromion, Thelion, the tip of the nose, Scapula and Vertex as candidates for a starting point of interpersonal distance (Fig. 2). Data correction on raw data obtained from the stop-distance method was made when needed by using the anthropometric database [18] available from Digital Human Research Center, AIST. Two different models were developed: the *surface* model and the *center-center* model. We applied the surface version in the study I.

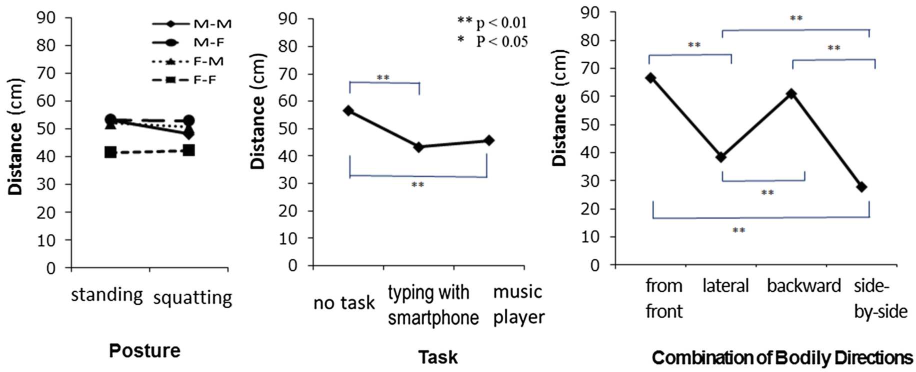
Result. Forty four participants were distributed into four groups of different gender combinations: male (participant)-male (assistant experimenter) (13), male-female (8), female-male (9) and female-female (14). Means and standard deviations of all the interpersonal distances obtained under the condition of standing posture are given in Table 2. The observed data (before correction) ranged between 0 cm (F-F, squatting, music player, lateral) and 183.5 cm (M-M, standing, no particular task, backward); M = 54.2 cm, SD = 27.77. According to Hall's classification [13], they widely ranged from the intimate distance (0−18 in.), to the close phase of social distance (4−7 ft.).

Gender. The factor of "gender" had four levels. The result showed a trend similar to a well-known pattern "male pairs > female pairs" [10], however, there was no statistically significant simple main effect of the gender (Fig. 3-a).

Posture. The factor of "posture" had two levels (standing vs. squatting). There was no statistically significant simple main effect of the "posture" (Fig. 3-a). The interaction of the "posture" and the "combination of bodily directions" was statistically significant ($p < 0.01$). In particular, there were statistically significant differences between

Table 2. Means and standard deviations of interpersonal distances (surface model)

Factors			Task								
			No particular task			Typing w/smart phone			Music player		
Posture	Gender combination (participant-experimenter)	Combination of bodily directions while approaching	n	Mean (cm)	SD	n	Mean (cm)	D	n	Mean (cm)	SD
Standing	M - M	From front	13	89.11	44.02	13	63.85	34.26	13	72.51	37.96
		Lateral	13	42.20	30.68	13	32.84	30.29	13	34.31	25.42
		Backward	13	81.67	44.84	13	58.82	19.80	13	67.17	34.20
		Side-by-side	13	36.95	29.83	13	30.44	25.56	13	28.85	21.68
	M - F	From front	8	78.91	23.49	8	61.38	21.55	8	60.47	22.22
		Lateral	8	62.76	24.55	8	41.79	18.77	8	40.46	18.71
		Backward	8	73.41	28.05	8	58.49	15.43	8	60.32	22.21
		Side-by-side	8	44.67	15.47	8	26.82	15.18	8	30.33	19.80
	F - M	From front	9	78.57	24.12	9	55.17	26.31	9	71.33	18.87
		Lateral	9	52.61	22.49	9	36.88	17.16	9	46.02	17.56
		Backward	9	60.50	17.53	9	60.88	20.50	9	52.70	23.87
		Side-by-side	9	47.08	24.57	9	27.19	19.23	9	35.08	23.83
	F – F	From front	14	71.59	39.98	14	51.71	23.78	14	51.44	28.32
		Lateral	14	47.72	30.45	14	32.23	19.61	14	31.49	28.35
		Backward	14	48.64	35.89	14	47.19	25.80	14	41.57	24.10
		Side-by-side	14	29.29	21.26	14	23.00	19.44	14	22.95	24.98

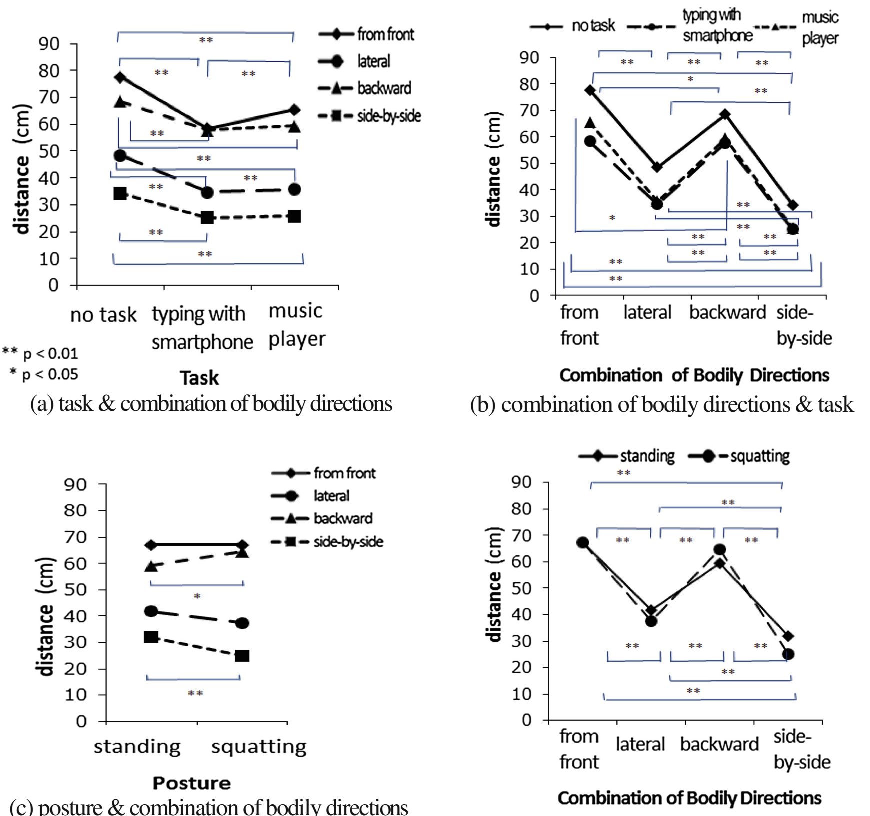


(a) posture & gender (b) task (c) combination of bodily directions

Fig. 3. Mean of interpersonal distance

"standing" > "squatting" only under the condition of "side-by-side" ($p < 0.01$), and between "standing" < "squatting" only under the condition of "backward" ($p < 0.05$) (Fig. 4-c, d).

Task. The factor of "task" had three levels (no particular task vs. typing with a smart phone vs. enjoying a music player). There was a statistically significant simple main



(a) task & combination of bodily directions (b) combination of bodily directions & task

(c) posture & combination of bodily directions (d) combination of bodily directions & posture

Fig. 4. Mean of interpersonal distance (continued)

effect of the "task" ($p < 0.01$). In particular, there were statistically significant differences between "no particular task" > "typing with a smart phone" ($p < 0.01$) and between "no particular task" > "enjoying a music player" ($p < 0.01$) (Fig. 3-b).

The interaction of the "task" and the "combination of bodily directions" was statistically significant ($p < 0.05$). Only under the condition of "from front", there was a statistically significant difference between "enjoying a music player" > "typing with a smart phone" ($p < 0.01$) (Fig. 4-a, b).

Combination of Bodily Directions. The factor of "combination of bodily directions" had four levels (from front vs. backward vs. lateral vs. side-by-side). There was a statistically significant simple main effect of the "combination of bodily directions" ($p < 0.01$). In particular, there were statistically significant differences between "from front" > "lateral" > "side-by-side" ($p < 0.01$), and between "backward" > "lateral" > "side-by-side" ($p < 0.01$) (Fig. 3-c); but the difference between "from front" and "backward" was not statistically significant.

However, the interaction of the "combination of bodily directions" and the "task" was statistically significant ($p < 0.05$). There were statistically significant differences between "from front" > "backward" under all the "task" conditions except for "typing with a smart phone" (Fig. 4-a, b).

2.2 The Study II

In the study II, we aimed to investigate the dynamic characteristics of *interaction distance* between interacting individuals [25]. There were four factors. The within-subject factors were "posture" (2: standing vs. chair-sitting), "combination of bodily directions" (2: face-to-face vs. side-by-side), "task" (5: no particular task vs. holding a device (prior to search) vs. search on a map vs. holding a device (prior to puzzle) vs. puzzle), and "devices" (3: smartphone vs. notebook-PC vs. blackboard).

Participants and Research Settings. Twenty university students including 6 males and 14 females, ranged in age 18-23 years, participated. The stop-distance method was employed to measure interpersonal distances. The data were collected January 2015.

Data Analysis and Initial Results. A multiple comparison test was performed by applying Bonferrroni-Dunn's procedure. Data correction was made by using the center-center version in the study II. There were statistically significant simple main effects of the "task" ($p < 0.01$), the "device" ($p < 0.01$), and the "combination of bodily directions" ($p < 0.01$). The interactions of the "device" and the "task", and the interaction of the "combination of bodily directions" and the "task" were statistically significant.

Initial results revealed interesting findings. For instance, even *before* starting a task, there was a statistically significant difference between "no task" and "holding a device", under the condition of "face-to-face". Furthermore, there was a statistically significant difference between "holding a device" > during the task ("search for a place on a map"), with either devices. The result showed that interaction distance was influenced by the presence of a device and types of co-operation. Further analyses are underway.

3 Discussion

Influence of the Presence of an Eye in Peripheral Vision. The study I revealed not only a well-known anisotropic pattern "from front > lateral" [10] but also an interesting pattern "lateral > side-by-side". After a session of "side-by-side", 16 of 44 participants claimed they didn't notice the presence of an eye. Furthermore, under all the tasks except for "typing while looking-down at a smartphone", there was a significant difference between "from front" > "backward". The result suggested interpersonal distance consciously or unconsciously increased by feeling the presence of eyes even in peripheral vision.

Cognitive Resources and Equilibrium of Interpersonal Distance. The only difference between "without task" (i.e. looking ahead) and "listening-to-music" was the presence of a task "listening-to-music". However, despite this small modification, there was a statistically significant difference between them ($p < 0.01$). There was a considerable relation between the transformation of equilibrium point of comfortable interpersonal distance [2] and a consumption of cognitive resources.

Co-constructing Interpersonal Space by Dyad. Interpersonal distance varies with a complex of multiple causes rather than a single and identifiable cause [13] such as the presence or absence of eye contact. The result also suggested the importance of taking into account various structures of elements another person formed around a body. It is considered that interpersonal space or distance is co-constructed as a result of the cooperative interaction process by two individuals sharing the same environment.

The Third Model. We presented two models of data correction: the "surface" and the "center-center". By taking into account the subjective viewpoints of space perception, we developed the revised versions, "center-to-surface" and "eye-to-surface" models. The modeling of personal space concept was not limited to the issue of measurement. It was closely related to a central theoretical issue on *embodiment* [21].

Reflecting the Complexity of Interaction. Social interactions influence a transformation of personal space [15]. Goffman [12], Birdwhistell [5], and Scheflen [23], for example, pointed out theoretical concern which cut across the areas of nonverbal communication, territoriality, personal space, and phenomenology, and exemplified their interdependence in social interactions. In our study, there were significant interactions of "task" x "device", and also "task" x "combination of bodily directions". It was considered this result reflected not only the flexibility of individual personal space but the complexity of co-operation between persons interacting within an environment.

4 Conclusion

This paper presented an experimental study that investigated how interpersonal distance varied depending on the differences of tasks, devices, combinations of bodily directions, as well as postures and gender.

There were statistically significant simple main effects of the "task" and the "combination of bodily directions". Especially, the study I revealed that interpersonal distance varied depending on the differences between: (a) "without task > with a task" (listening-to-music, typing), (b) {from front, backward} > {lateral, side by side}, (c) "lateral > side by side", and (d) "from front > backward" under all the task conditions except for "typing". On the other hand, however, there was a simple main effect of neither "genders" nor "postures". The results of the study II revealed simple main effects of the "co-operation" and the presence of "devices". The results suggested that: interpersonal distance was influenced by feeling the presence of eyes even in peripheral vision; there was a considerable relation between the transformation of interpersonal distance and a consumption of cognitive resources. By taking into account a significant influence of the structures another person forms around his/her body, it was considered that interpersonal space was co-constructed through an interaction process by a dyad.

In order to grasp dynamic nature of human spatial behavior, it is essential to enhance a methodological framework including re-modeling of personal space concept and the improvement of the validity of a measuring method.

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