

# Research on a Furniture Layout Assessment Method from the Perspective of Preserving Personal Space

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## Abstract

The aim of this research is to propose an assessment method on furniture layout from the perspective of preserving personal space. To this aim, we made an experiment first to gain the measurement of change in personal space when some partition is installed within it. Then, using this data, we proposed several indicators to assess furniture layout, and through assessment and analysis of furniture layout examples, we verified that the proposed method is available enough.

*Keywords: personal space, partition installed within personal space, furniture layout*

## 1. THE PURPOSE OF THIS RESEARCH

Personal space (P.S.) is the area surrounding an individual which they do not want others to invade. Walls and furniture construct architectural space that determines to a certain extent individual stands and his or her surrounding environment. And the issues concerning the preservation and invasion of P.S. have a significant impact on the psychology of multiple individuals sharing the same space.

This research first aims to gain the basic data through experiments how P.S. is affected when the height of partitions such as various partition walls or back of chairs, installed within P.S. is changed. Using this data, the research proposes several indicators to assess furniture layout, and through assessment and analysis of furniture layout examples, intends to propose finally a quantitative method for assessment of appropriate furniture layouts in various spaces from the perspective of preserving P.S.

## 2. EXPERIMENT ON THE IMPACT OF PARTITION ON P.S.

### 2.1. Purpose of Experiment

Although many researchers have measured P.S.(e.g. reference 3.), this experiment re-measures P.S. by studying and organizing past methods and standards. Additionally, by changing the height of partition

installed within P.S., it quantitatively examines the resulting change in the shape of P.S. in both cases of standing and seated position.

## 2.2. Outline of Experiment

### (1) Method of Experiment

The experiment was conducted in a space that was large enough so that objects other than the partition used in the experiment had no effect on the P.S. measurement. As Figure 1 shows, the individual who served as part of the experimental setup stood still or sat on a chair in the center of the room. The chair was of the smallest possible size, so that no part of it protruded from the position of the seated individual.

The partitions were 100mm in thickness and 800mm in width. Their height was 800mm, 1100mm, 1400mm, and 1700mm in the cases when the experimental-setup individual was standing, and 400mm, 700mm, 1000mm, and 1300mm when the individual was sitting on a chair. The partitions, which were made of foamed polystyrene, were set behind and to the side of the individual. For the seated experiments, the subjects who invaded the P.S. of the individual used a chair with wheels for practical purposes. Additionally, a 1mm-thick paper was used in the experiment that measured the effect of the thickness of the partitions.

### (2) Subjects

Twelve male students of the Department of Architecture at the Tokyo University of Science

### (3) Measured Items

The following measurements regarding P.S. were taken:

1. P.S. for both standing and seated positions
2. Partition installed in the back / to the side: four patterns each, 16 patterns in total
3. Effect of multiple partitions: eight patterns
4. Effect of the thickness of a partition: four patterns

### (4) Method of Measuring

The subjects were asked to walk (in the standing experiment) or to move sitting on a chair (in the seated experiment) one by one towards the experimental-device individual and to stop when reaching a position where they did not want to get any closer to the individual. The subjects were instructed in advance that the build, facial expression, clothing, and other personal characteristics of the experimental-device individual should not be considered in determining when to stop moving toward him. With the experiment using partition, P.S. was measured in four directions: forward, backward, left, and right. But when symmetry was observed, we omitted one of the measurements (Figure 1).

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## 2.3. Result and Discussion

### (1) Difference in P.S. in Seated and Standing Positions

As Figure 2 shows, P.S. in the seated position was larger than P.S. in the standing position, especially to the front. However, when P.S. in the seated position was measured from the tip of the toe, instead of from the center of the body, it had approximately the same shape as P.S. in the standing position. In other words, P.S. in the seated position was affected by the length of the part of the legs that protruded from the body.

### (2) Change in P.S. due to Partition

After conducting experiments both in seated and standing positions using four different partition heights, it

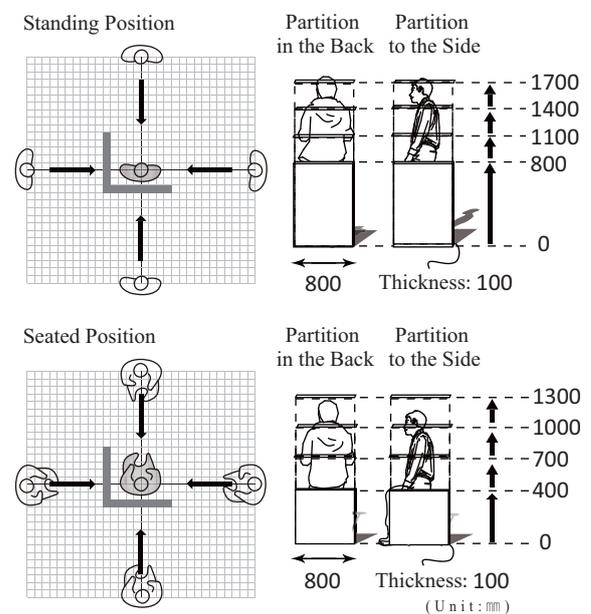


Figure 1. P.S. Measurement Method with Partition

was found that the higher the partition was, the smaller the P.S. became in the direction to the partition (Figure 2). Furthermore, when the partition was as high as the eye level, the subject did not pay any attention to the presence of the experimental-device individual and was able to approach the partition to a distance from which he could touch them. This means that both to the back and to the side, a partition of sufficient height could cancel out P.S.

### (3) Comparison of effects by one on two partitions

Comparing an overlap of P.S. measured separately to the side and to the back, and P.S. measured with partitions installed both to the back and to the side, little difference was observed. It is possible to conclude that a simple overlapping of P.S. shape is possible.

### (4) Effect of Thickness of Partition on P.S.

When two partitions that were identical except for their thicknesses were used, the P.S. in the direction of the partition set expanded in all experimental patterns by almost 100mm with the case of a 100mm-thick partition compared to a 1mm-thick partition. Since there was almost no difference in the shape of P.S. in the directions in which no partitions were installed, the thickness of the partition can be ignored.

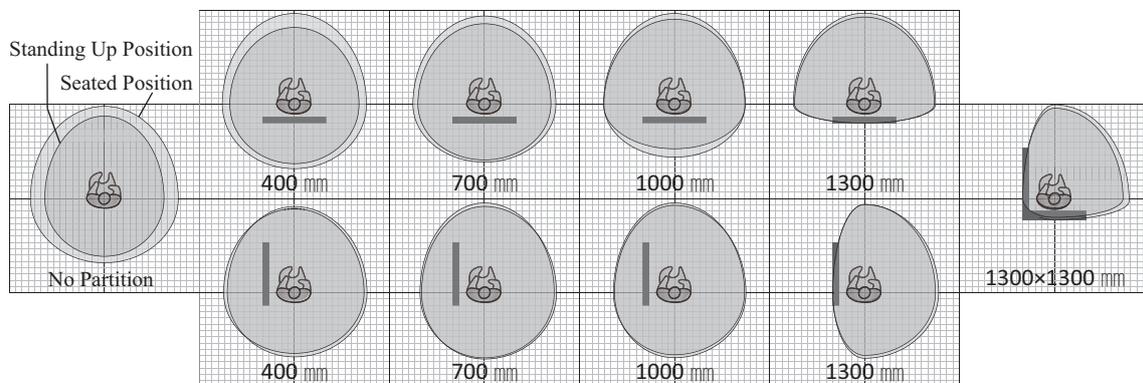


Figure 2. Changes in P.S. Shape by Partition (numerical values are heights of partitions)

## 2.4. Summary

This research demonstrated that a partition installed within P.S. affects the shape of P.S. The higher the partition was, the smaller the P.S. measurement values became in the direction of the partition. This quantitatively confirmed that P.S. external to the partition can be canceled out depending on the partition of sufficient height.

## 3. EXAMINATION OF A FURNITURE LAYOUT ASSESSMENT METHOD FROM THE PERSPECTIVE OF PRESERVING PERSONAL SPACE

### 3.1. Purpose of Study

Using examples of furniture layout patterns in various spaces, P.S. of a furniture user was mapped out and the characteristics of each space were analyzed using assessment indicators set in this examination. Additionally, based on the result of these examinations, the characteristics of furniture layout patterns suggested by each indicator and the effectiveness of the indicators were analyzed to propose an aimed assessment method.

### 3.2. Setting Assessment Indicators

#### (1) Basic Concept of P.S. Preservation

The overlap of multiple P.S. was considered as an “invasion” from the perspective of preserving P.S. Of course an invasion happens with a body of an invader entering into the P.S., but also may happen without such a body. In this experiment, both patterns were considered as an overlap of P.S. and used for analysis.

(2) Definition of Assessment Indicators

Table.1 shows the definitions of floor areas used for assessment indicators of this study. Figure3 shows one of furniture placement example plans to explain the floor areas defined in Table1. Table2 shows the definitions of assessment indicators set based on the floor area measurements as described in Table.1.

(3) Setting of P.S. Size used in the Examination

The P.S. size used in this examination was set by reassessing various P.S. measured in past research projects, and adjusting them to the aforementioned experimental result (Figure 4).

Table 1. Definitions of Floor Areas for Assessment Indicators

Subject room area	The floor area of the room that is subject of assessment
Total P.S. area	The total area enclosed within the outermost borderlines of multiple P.S. borders
Subject P.S. area	The total P.S. area excluding the canceled P.S. area, that may be invaded
Canceled P.S. area	The P.S. area that will not be invaded due to furniture placement
Overlapping P.S. area	Overlapping P.S. area in the subject P.S. area

Table 2. Definition of Assessment Indicators

Cp.s.	Cr.s.	Lp.s.	Lr.s.	Or
Canceled P.S. area	Canceled P.S. area	Overlapping P.S. area	Overlapping P.S. area	Subject P.S. area
Total P.S. area	Subject room area	Subject P.S. area	Subject room area	Subject room area

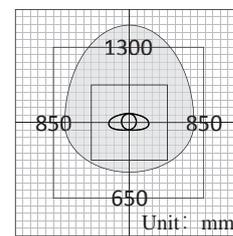


Figure 4. P.S. Size used in This Study

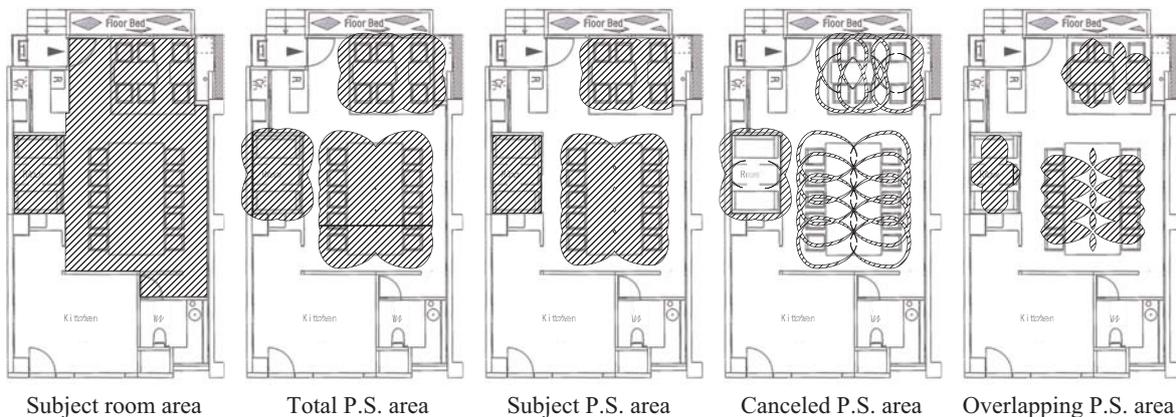


Figure 3. Explanation of Each Floor Area Used in Assessment Indicators

3.3. Assessment and Analysis of Furniture Layout Examples

(1) Outline of the Assessment

The aforementioned indicators were used to assess all 192 examples collected from architectural reference documents.

(2) Analysis by Architectural Purpose

Since architectural purposes affect furniture layout, it is presumed that each purpose will show different indicator values. Using the categories in architectural reference documents as the base, architectural purposes were classified into ten categories and the average values and standard deviation for each category were measured. As a result, restaurants that vary in space design showed average deviation in all values. Theater halls where seats are laid out unidirectionally, presented high Lp.s. and Lr.s. values with a small deviation. Different characteristics were present to some degree for each architectural purpose. Naturally, large standard deviations were observed among all examples (Figure 5).

(3) Analysis Focusing on the Similarities in Assessment Indicator Values

Some examples showed similar indicator values despite their different purpose categories. This fact suggests that even though the purpose or the characteristics of spaces may differ, categorization not based on purposes, as well as categorization of spaces with similar P.S. preservation traits may be possible.

Using the five assessment indicators as variables, a cluster analysis was conducted. The result suggested that there are two clusters concerning Cp.s., Cr.s., and Lp.s. One is a group of restaurants, classrooms and offices, and the other one is a group of trains and theaters. In deeper level of clustering, there are five clusters somewhat corresponded to the categorized purposes. Therefore, the analysis was able to quantitatively demonstrate that furniture layout is affected by architectural purposes (Figure 6).

**3.4. Examination for Improvement of the Assessment Method based on Assessment Results**

(1) Examination by Results of Cluster Analysis and Correlation of Each Indicator

A large deviation was observed in the bimodality that represents the size of impact that each indicator had over the cluster analysis results. Cp.s., Cr.s., and Lp.s. in particular affected clustering. The comparison of correlation coefficient of each indicator reveals that seven groups out of ten had strong correlation of 0.6 or above (Figure 7). This suggests that each of the five indicators does not effectively assess furniture layout.

(2) Setting Assessment Indicators Focusing on the Level of Invasion

Indicators that considered all cases of overlapping P.S. to be identical were not examined the level of invasion sufficiently. As Figure 8 shows, a new assessment indicator Rv (Real Violation) was set to label overlapping P.S. without an invasion by a human body as Invasion 1 and overlapping P.S. with an invasion by a human body as Invasion 2 (Table 3).

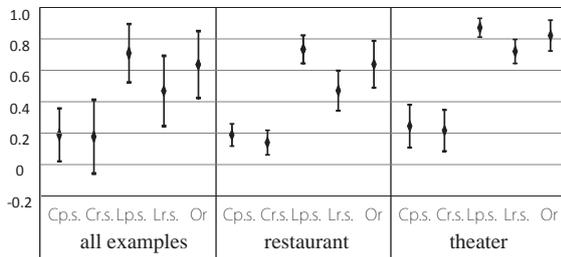


Figure 5. Average Values and Standard Deviation of Each Indicator by Purpose Category

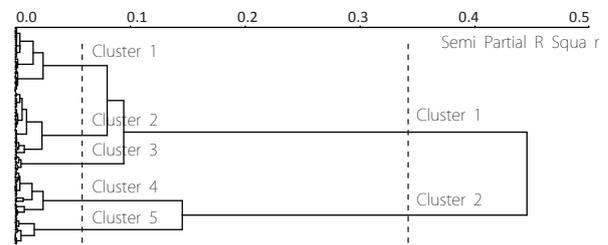


Figure 6. Cluster Tree Diagram (All Examples)

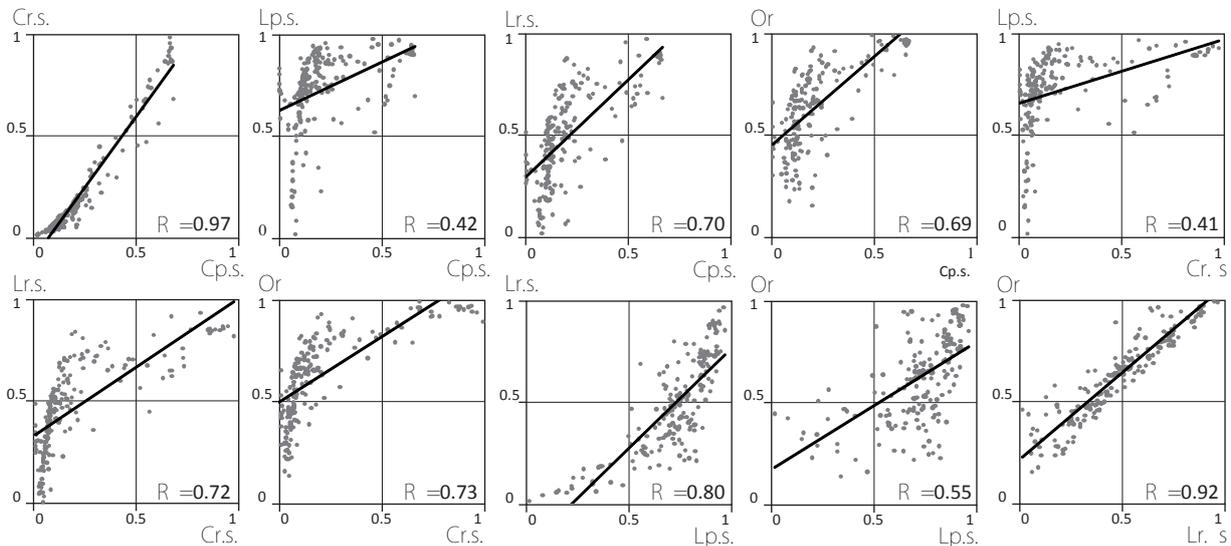


Figure 7. Correlations of Each Indicator Value in 192 Assessed Examples

### (3) Improvement Based on the Examination Results

In addition to Cr.s. and Lp.s., which were proven to be effective based on the correlation of each indicator and the bimodality of the cluster analysis, the Rv that takes the level of invasion into consideration served as a new assessment indicator.

## 3.5. Examination of the Effectiveness of Improved Assessment Indicators

### (1) Method of Examination

Cr.s., Lp.s., and Rv were the three indicators used to reassess furniture layout in subject areas. Subject areas were 33 restaurants with various furniture layouts that served the same purpose.

### (2) Correlation between Furniture Layout and Assessment Indicators

The characteristics of furniture layout as indicated by the new assessment indicator Rv were analyzed. Comparing the furniture layout with the highest Rv and the furniture layout with the lowest Rv (Figure 9) reveals that the former example was a small space only with a bar counter and chairs in close proximity, and the latter example was a regular restaurant with chairs around a table with space in between. In other examples, many layouts showed similar characteristics.

### (3) Examination Using Cluster Analysis

Figure.10 and 11 shows the results of cluster analysis of 33 examples using three indicators. Cluster 1 included many spacious restaurants with enough distance between chairs and walls. Cluster 2 included bars and private dining rooms in which P.S. is affected by the walls. Cluster 3 included establishments with mixed layouts, which caused a variation in the assessment values among different cases.

### (4) Examination of Assessment Indicators based on Correlation Coefficient

The correlation coefficient derived by combining the assessment indicators was extremely low in all combinations (Figure 12). This is because each assessment indicator represents different characteristics of furniture layouts. From this it can be concluded that the indicators are effective.

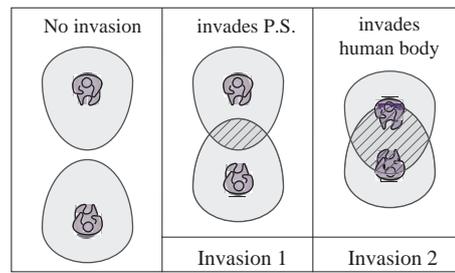


Figure 8. Categories of P.S. Invasion Degree

Table 3. Definition of New Assessment Indicators

Definition of Invasion 2 area	Rv
The overlapping P.S. area in the event that a human body invades P.S.	Invasion 2 area Overlapping P.S. area

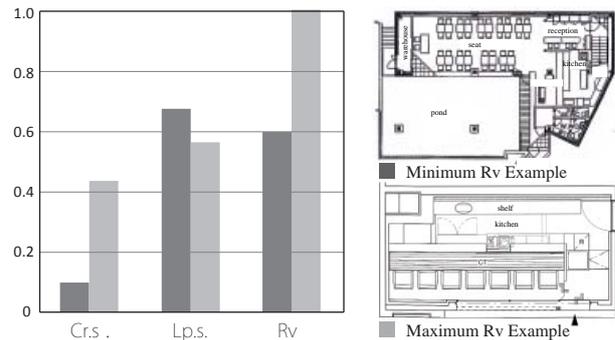


Figure 9. Examples of Furniture Layouts with a Large Variance in Rv



Figure 10. Cluster Tree Diagram (Restaurant)

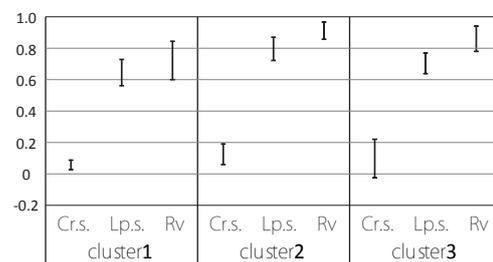


Figure 11. Confidence Intervals of Assessment Indicator Values for Each Cluster

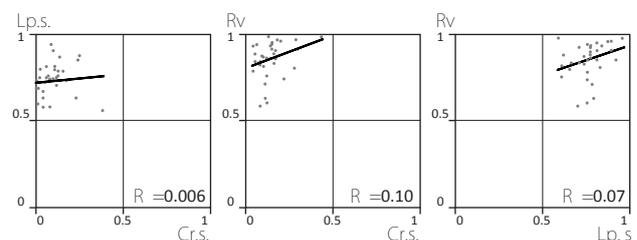


Figure 12. Correlation of the Three Assessment Indicator Values

#### (5) Characteristics Represented by Assessment Indicators

Because Cr.s. tends to be high when a chair is placed close to a wall and low when there is some distance between them, the seat placement, not the seating style, is the influential factor. Lp.s. tends to be high when seats are in line with equal distance from each other. Rv is high when seats are very close together as in a bar or a private dining room, and it can be deduced that the seating style rather than the seat placement is the influential factor. Therefore, Cr.s. and Lp.s. can be used to classify examples with similar architectural purposes to some extent. Rv. represents the characteristics of specific furniture layout.

## 4. SUMMARY

This research proposed a method to quantitatively assess furniture layout from the perspective of P.S. preservation and verified its practicality. Since acronyms may cause confusion, the following terms are preferable to be used when applying this method in the future: “P.S. Preservation Rate” for Cr.s., “P.S. Overlapping Rate” for Lp.s., and “P.S. Invasion Rate” for Rv.

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