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Designing Non-Contact Interior Space for Space Users' Sense of Safety

Ju Yeong Kwon and Da Young Ju

Department of AI Design & Design Science, Kookmin University, 77 Jeongneung-ro, Seongbuk-gu, Seoul 02707, Republic of Korea

ABSTRACT

During the pandemic that lasted for over three years, the physical aspect of spatial distancing caused a change in lifestyle and was accompanied by psychological distress. The psychological distress caused by physical disconnection exists alongside a tendency to maintain a certain distance from others due to the anxiety felt when sharing space with others. This inclination to maintain an appropriate distance from others may continue in the post-pandemic era. The purpose of this study is to understand the perception of space users regarding design elements for non-contact interior spaces and to propose appropriate interpersonal distances based on different spatial characteristics. To achieve this, surveys were conducted to grasp the perception of non-contact space design elements. Additionally, experiments were carried out in a variable experimental environment. As a result, the importance of design elements for non-contact spaces, including natural ventilation, air filtering and circulation systems, windows/doors, and space density. In the absence of windows, regardless of the ceiling height, there was a trend of decreasing public distance as the space area increased. When the ceiling height was 2.4 m and windows were present, there was a trend of decreasing public distance as the space area expanded. Given the lack of clearly defined space design from a psychological perspective, this study has provided the necessity and direction for user-centered space design.

Keywords: Non-contact, Interior space, Sense of safety, Proxemics, Interpersonal distance

INTRODUCTION

Physical activity and mobility are fundamentally important factors for quality of life (Rantanen et al., 2021; Saraiva et al., 2021; World Health Organization, 2018). However, during the prolonged period of the pandemic lasting over three years, there has been psychological distress due to physical distancing (Dawson and Golijani-Moghaddam, 2020; Lara et al., 2021; Reshetnikov et al., 2021; Saraiva et al., 2021). Simultaneously, individuals have experienced psychological anxiety when sharing space with others, leading them to maintain a certain distance (Chu et al., 2020; Iachini et al., 2021; Welsch et al., 2021). This tendency to maintain an appropriate distance from others may persist even in a post-pandemic situation (Welsch et al., 2021). Recently, the World Health Organization (WHO) announced the lifting of the Public Health Emergency of International Concern (PHEIC) declaration

for Covid-19. However, it is predicted that new infectious diseases will continue to emerge in the future. In this study, the term "non-contact space" does not solely refer to physical distancing but encompasses spaces where a sense of safety is ensured.

Space users perceive the environment and respond psychologically and behaviorally. Therefore, there is a need for research on creating non-contact spaces that provide a sense of safety through physical environmental design. Studies on interpersonal distance based on Proxemics and the theory of personal space, which have been actively researched even before the pandemic, have also been conducted during the pandemic era. However, there is a necessity to consider both the pandemic period and the post-pandemic period, making it challenging to find studies on spatial design that consider a sense of safety regarding interpersonal distance.

The purpose of this study is to understand the perception of space users regarding non-contact space design elements in interior spaces and to propose appropriate interpersonal distances for each spatial characteristic. To achieve this, surveys were conducted in November 2021 and September to October 2022 to grasp the perception of non-contact space design elements. Additionally, experiments were carried out in a variable experimental environment during September to October 2022, a period when social distancing measures were being eased, to identify spatial characteristics that elicit a sense of safety. Given the lack of clearly defined space design from a psychological perspective, this study has provided the necessity and direction for user-centered space design. At a time when new definitions of space are required, this study is significant in verifying through laboratory experiments the interpersonal distance and spatial characteristics that secure a sense of safety.

METHODS

In this study, the sense of safety refers to a state in which individuals perceive and recognize that their psychological personal space is secured and they are safe from the risk of infectious diseases. To propose design approaches for non-contact spaces that ensure users' sense of safety, the following detailed research methods and procedures were employed. Firstly, a survey was conducted in November 2021, during the period of social distancing measures, targeting 72 individuals aged 20–30 years. The survey aimed to investigate their perceptions of non-contact space design elements. Secondly, in September and October 2022, a variable experimental environment was set up, involving 30 participants aged 20–30 years, to identify the interpersonal distance that evokes a sense of safety for each spatial characteristic. During this experiment, the non-contact space design elements, which were previously surveyed in November 2021, were also investigated. The general characteristics of the survey and experimental participants are presented in Table 1 below.

Table 1. General characteristics of survey participants and experimental participants.

Age	Gender	November 2021	September to October 2022
		Number (Percentage)	Number (Percentage)
20–29	Male	18 (25.0)	10 (33.3)
	Female	24 (33.3)	10 (33.3)
30–39	Male	22 (30.6)	7 (23.3)
	Female	8 (11.1)	3 (10.0)
Total		72 (100.0)	30 (100.0)

PERCEPTION OF NON-CONTACT SPACE DESIGN ELEMENTS

The importance of 25 non-contact space design elements was examined during two periods: November 2021 when social distancing measures were in effect, and September-October 2022 when social distancing measures were relaxed, and everyday life was mostly restored. In November 2021, the assessment encompassed both private and public interior spaces to determine their significance. However, in September-October 2022, private spaces were excluded, and the focus was solely on public spaces to assess their importance. Furthermore, in 2022, the importance of these elements was analyzed based on the duration of time people spent in these spaces. It was found that spaces where individuals spent more than 3 hours had a higher importance compared to spaces where the duration of stay was less than 3 hours. The results are presented in the following Table 2.

The importance of non-contact space design elements was identified in both November 2021 and approximately one year later, in September-October 2022. In both time periods, "natural ventilation," "air filtering and circulation systems," "windows/doors (presence, window area, location, etc.)," and "space density (occupancy capacity)" were shown to be highly significant. In public spaces where individuals spent 3 hours or more, physical elements such as "size (ceiling height, area, etc.)," "windows/doors (presence, window area, location, etc.)" and "outdoor view and environment (exterior scenery)" were more important compared to non-contact technological elements like sterilization and disinfection systems, robots, and non-contact entry technology. During periods of social distancing measures due to infectious diseases, technological factors such as "sterilization and disinfection systems," "AI facial recognition thermal detection/human recognition/mask detection, etc.," and "non-contact entry technology and non-contact elevator calling technology" were relatively more important compared to public spaces during the period of normalcy and recovery.

INTERPERSONAL DISTANCE AND SPATIAL CHARACTERISTICS ASSOCIATED WITH SENSE OF SAFETY

An experiment was conducted using movable partitions to vary the scale of the space, considering physical factors such as space area, ceiling height, and presence of window (see Figure 1). The users of the space were given the option to choose their preferred interpersonal distance, which would make

them feel sense of safety in a post-pandemic situation. The space area was set at 8 m^2 and 18 m^2, the ceiling height at 2.4m and 3.45m, and the window area was manipulated to create environments with and without windows. The Table 3 below shows the achieved interpersonal distance that ensured sense of safety based on the physical factors and interpersonal distances considered.

Table 2. The importance of non-contact space design elements.

Non-contact space design elements*	November 2021		September to October 2022***	
	Mean**	SD	Mean**	SD
Space layout (Spatial structure)	3.88	0.73	3.80	1.03
Size (Ceiling height, Area, etc.)	3.75	0.85	4.13	0.94
Windows/Doors (Presence, Window area, Location, etc.)	4.22	0.79	4.60	0.62
Furniture (Arrangement)	3.08	1.00	3.76	1.06
Finishes (Functionality, Antimicrobial materials, etc.)	3.44	1.09	3.90	1.27
Outdoor view and environment (Exterior scenery)	3.19	1.16	4.03	1.03
Natural lighting (Daylighting)	3.44	1.05	4.50	0.68
Natural ventilation	4.19	0.71	4.63	0.72
Temperature and humidity	3.81	0.96	4.53	0.82
Buffer spaces (e.g., Linking bathroom to the entrance, Application of disinfection system in the entrance, etc.)	3.82	0.74	-****	-****
Courtyard/Terrace/Balcony/Yard/Nature observation/Rest areas	3.43	0.96	3.93	1.02
Sanitary item storage facilities	3.76	0.85	3.97	1.03
Safety partitions/Partitions/Walls for privacy	3.76	0.88	4.23	0.97
Curtains/Blinds	3.08	1.14	3.60	1.16
Hygiene rules guidance (Information display)	3.61	0.99	3.87	1.07
Natural elements/Plants, etc.	3.01	1.11	3.57	1.10
Air filtering and circulation systems	4.21	0.75	4.70	0.54
Sterilization and disinfection systems (Air showers, Sterilization material distribution system, Clothing management device, etc.)	4.17	0.75	3.83	0.95
Guidance robot, Disinfection robot, Café robot, Delivery robot, Serving robot, Robot-assisted caregiving services, etc.	3.13	1.01	2.73	1.02
Kiosks and other digital devices, Unmanned payment systems, etc.	3.31	0.94	3.27	1.02
Non-contact thermometer	3.53	0.95	3.27	1.08
AI facial recognition thermal detection/human recognition/mask detection, etc.	3.79	0.82	3.27	1.11
Non-contact entry systems, Non-contact elevator calling technology	3.78	0.81	3.37	0.93
Physical distancing and marking/area separation among others	3.58	0.92	3.17	1.32
Space density (Occupancy capacity)	4.08	0.93	4.40	0.89

* The non-contact space design elements proposed by Kwon and Ju (2022) were based on literature analysis and social media big data analysis.

** Likert 5-point scale (1: Not important at all, 3: Neutral, 5: Extremely important)

*** In 2022, the importance of these elements was assessed by differentiating the duration of time spent in spaces. The category of 'public spaces with a stay duration of 3 hours or more' generally exhibited higher importance, and this information was presented.

**** The term 'buffer spaces' primarily applied to private spaces; however, it was excluded in the 2022 survey as the focus was limited to public spaces.

Figure 1: Experimental environment.

Table 3. Interpersonal distance for sense of safety in the post-pandemic era.

Space Area	Ceiling Height	Presence of Window	Interpersonal Distance*	
			Mean	SD
8 m^2	2.4 m		1.853 m	0.321
8 m^2	2.4 m	•	0.950 m	0.330
8 m^2	3.45 m		1.807 m	0.297
8 m^2	3.45 m	•	0.792 m	0.390
18 m^2	2.4 m		1.604 m	0.666
18 m^2	2.4 m	•	1.516 m	0.649
18 m^2	3.45 m		1.600 m	0.717

* Interpersonal distance with stranger

The analysis results for the "public distance," which refers to the interpersonal distance with strangers, in a post-pandemic situation are as follows: When space users were able to choose their preferred interpersonal distance, in an 8 m^2 space area without windows, the public distance exceeded an average of 1.8m regardless of the ceiling height. In an 18 m^2 space area, the public distance was approximately 1.6m regardless of the ceiling height. In cases where there were no windows, the public distance tended to decrease as the size of the space area increased from $8M^3$ to 18 m^2 regardless of the ceiling height. However, when the ceiling height was lower at 2.4m and there were windows, the interpersonal distance increased as the space area became larger. When the space area and ceiling height were the same, having windows resulted in a greater reduction in interpersonal distance compared to situations without windows.

CONCLUSION

This study focused on the sense of safety of space users and examined the perception of non-contact space design elements and interpersonal distance based on space characteristics to create a non-contact space design that considers users' sense of safety. The aspect of environmental creation for air circulation appeared to be particularly important, and other physical factors were also recognized as significant by space users, highlighting the necessity of non-contact space design. The study revealed that the perceived interpersonal distance for feeling sense of safety varies depending on the characteristics of the space. The significance of this research lies in providing design solutions for spaces that enhance psychological safety in both

pandemic and post-pandemic eras, an aspect that has been relatively underexplored in previous studies. Subsequent research should explore spaces of varying scales and physical characteristics to further validate spaces that evoke a sense of safety.

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The corresponding author for this paper is Da Young Ju (email: dyju@kookmin.ac.kr).

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