The Effect of Face Mask and Approach Pattern on Interpersonal Distance in COVID-19 Pandemic Using VR Technology

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Abstract. In the COVID-19 pandemic, control measures including wearing masks, ensuring hand hygiene, and maintaining a physical distance of at least 1 m were recommended to prevent the spread of virus. The purpose of this study was to investigate the influence of face mask, approach pattern and participants' gender on interpersonal distance in the pandemic environment. Virtual reality (VR) technology was applied to build the experimental environment. This study recruited 31 participants including 17 males and 14 females, who were asked to interact with virtual confederates with and without a face mask. The interpersonal distance was recorded when participants actively walk towards the virtual confederate or approached passively by the confederate. Three-way ANOVA results showed that face mask and approach pattern had significant effects on interpersonal distance. The distance when facing the confederate with a face mask was significantly closer than without a face mask. Moreover, participants preferred a significantly larger distance in the passive pattern than in the active pattern. The participants' gender showed no significant effect on interpersonal distance and no interaction effects were found. The findings in this study helped to further investigate the nature of interpersonal distance and contributed to a better understanding of the human behaviors in the pandemic environment.

Keywords: COVID-19 pandemic · Interpersonal distance · Virtual reality · Face masks · Approach pattern

1 Introduction

The COVID-19 pandemic is still spreading around the whole world and poses a threat to global health. In order to reduce the risk of virus transmission [1], World Health Organization (WHO) recommended that people have to maintain a certain physical distance and wear face masks in public places, which changed people's lifestyle and social behavior. Interpersonal distance was defined by social psychology as the safety buffer maintained by individuals between themselves and others [2–4]. Interpersonal distance will expand when people feel uncomfortable or dangerous and decrease when

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people feel safe and comfortable. Ruggiero et al. [5] and Cartaud et al. [6] found that interpersonal distance increased when people saw an angry facial expression than a happy one. Another study found that interpersonal distance increased when people heard an aggressive conversation than a neutral one [7]. After the outbreak of the pandemic, whether the interpersonal distance changed in the background of the epidemic needs to be studied, and the impact of wearing masks and active and passive needs to be further studied.

There were four common measurement methods to collect interpersonal distance, including real measurement, virtual reality simulation, video method, and paper and pen test [8, 9]. Yu et al. [10] measured the interpersonal distance in eight directions in the real environment. However, the real environment measurement may increase the face-to-face interaction between people and increase the risk of infection in the epidemic. The questionnaire method was used in the study of Wang et al. [11], which showed that interpersonal distance would be reduced when participants faced confederate who wore face masks, but this method could not enable participants to experience the feelings of true interaction. However, VR technology allows participants to immerse in the virtual environment and interact with the virtual confederate, which can bring the true feelings in the social activities. One of the main advantages of VR simulation is its immersion and interactivity. Besides, VR simulation can fully control the experimental variables. For example, the characteristics and behaviors of virtual confederates such as walking speed, eye gaze, facial expressions, etc. [12], can be controlled by researchers. In addition, communication between participants and researchers can be decreased to reduce the risk of infection in the epidemic.

Therefore, the purpose of this study was to further explore the interpersonal distance in the epidemic and evaluate the effects of wearing masks, approach pattern and gender of participants on the interpersonal distance in the background of the epidemic. The findings of this paper contribute to further study the nature of interpersonal distance and help to better understand the human behaviors in the epidemic.

2 Method

2.1 Participants

Thirty-one college students (14 females) ageing 19 to 27 years old ($M = 21.6$, $SD = 2.17$) were recruited. Each participant had a normal or corrected vision, and no cognitive impairment or any other disease was found according to their self-reporting. Besides, all participants were not familiar with the virtual confederate and were not aware of the purpose of the experiment.

2.2 Experimental Environment

The experiment was carried out in a 6 * 8 * 4 m^3 laboratory with no obstacles. The experimental VR device was Oculus Quest2 which equipped with an LCD display. The VR headset has a single-eye resolution of 1832 * 1920 and supports the refresh rate of 90 Hz, which could realize controller-free gesture tracking. Unity software was used

to simulate the virtual environment scenes and build the confederate model. Wearing VR glasses, participants will see an open square with three buildings on the left and a playground on the right. There was a yellow line on the ground to guide participants towards the front. A virtual confederate with a height of 175 cm who was standing 4 m in front of the participants. The virtual confederate wore a white shirt and black jeans. During the experiment, there were two conditions: one confederate wearing a face mask and the other did not wear a face mask. The virtual environment was shown in Fig. 1.

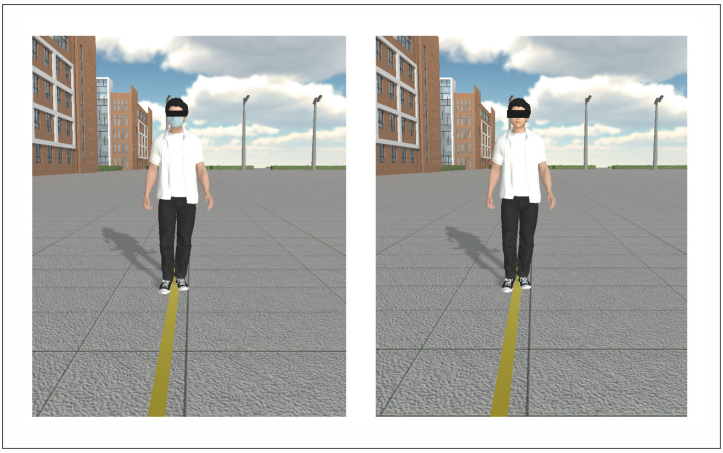

Fig. 1. Virtual reality experimental environment and virtual confederate with or without a face mask.

2.3 Procedure

Before the formal experiment, experimenter helped participants wear the VR device and the physical environment around them was isolated. Accordingly, participants can familiarize themselves with the virtual environment under the guidance of the experimenter including watching and walking freely in the virtual lab for about 2 min. Two trails were provided to participants to be familiar with the experimental procedure before the formal experiment. In active pattern, participants were required to approach the virtual character actively. When participants felt uncomfortable due to the proximity they stopped and pressed the button on handle to affirm the position, then the distance between the middle of virtual confederate and the participant was calculated and saved automatedly. In the passive pattern in which the virtual character walked towards the participant at the speed of 0.5 m/s, when the participants felt uncomfortable, the virtual character can be stopped by pressing the handle similarly. Once the handle was pressed during the experiment, the distance between the participant and the virtual character will be automatically recorded.

The experiment was conducted in two approach patterns and two face mask states. The experiment sequence was random and balanced, and a 2-min break between every two experiments was offered for participants to have a rest. Each trail was repeated

twice, and a total of 8 measurements were required for each participant. During the formal experiment, as shown in Fig. 2, participants conducted the experiment according to oral instructions of experimenter.

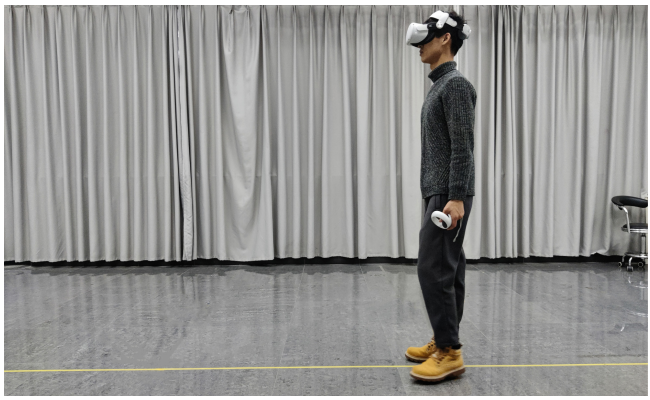

Fig. 2. The experiment procedure: the participant is walking towards the confederate in VR environment

2.4 Statistical Analysis

Each experiment trail was repeated twice, and the average was calculated and used for the analysis of variance (ANOVA). In the study, data were analyzed using SPSS 25.0, and a three-way ANOVA was performed to clarify the relationship between independent variables (mask wearing, approach pattern and participants' gender) and dependent variables (interpersonal distance).

3 Results

As shown in Table 1, results of ANOVA showed that face mask had a significant effect on interpersonal distance ($F = 7.924$, $p = 0.006$, $\eta_p^2 = 0.062$). In Fig. 3, the interpersonal distance of participants when facing the virtual confederate with face mask ($M = 123.60$ cm, $SD = 39.03$ cm) was significantly smaller than that of facing the virtual confederate without face mask ($M = 142.51$ cm, $SD = 36.12$ cm). The approach pattern had a significant influence on interpersonal distance ($F = 10.947$, $p = 0.001$, $\eta_p^2 = 0.084$). When participants approached the virtual confederate actively ($M = 121.21$ cm, $SD = 29.78$ cm), the interpersonal distance was significantly smaller than that when participants were approached by the virtual confederate passively ($M = 143.87$ cm, $SD = 42.94$ cm). In contrast, gender had no significant effect on interpersonal distance ($F = 0.255$, $p = 0.615$, $\eta_p^2 = 0.002$), and no significant interaction effects were found.

Table 1. Three-way ANOVA results of face mask, approach pattern and gender

Terms	F	df	p-value	η_p^2
Face mask	8.273	1	0.005	0.068
Approach pattern	10.928	1	0.001	0.088
Gender	0.255	1	0.615	0.002
Face mask* Approach pattern	0.000	1	1.000	0.000
Face mask* Gender	1.728	1	0.191	0.015
Approach pattern* Gender	0.004	1	0.950	0.000
Face mask* Approach pattern* Gender	0.199	1	0.657	0.002

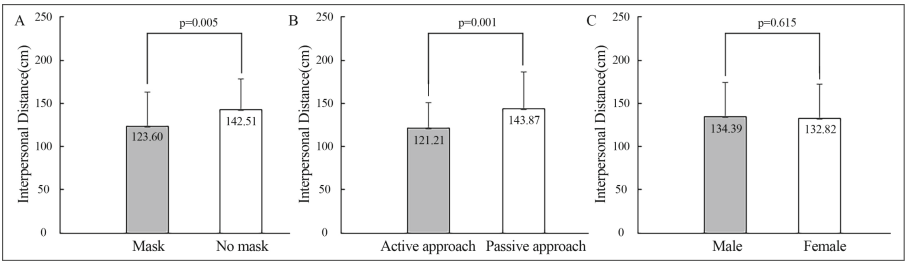

Fig. 3. The interpersonal distance under each main effect including face mask (A), approach pattern (B) and gender (C).

4 Discussion

The results showed that face mask and approach pattern had a significant effect on the interpersonal distance. Participants showed a larger interpersonal distance when they faced a confederate without a face mask than with a face mask, which was consistent with the research results of Wang et al. [11] and Lee et al. [13]. They compared the interpersonal distance of participants facing confederate with and without masks by using online survey. The reason of this phenomenon might be that people felt more dangerous and uncomfortable when they faced a confederate not wearing a face mask. Lisi et al. [14] found a reduction in the interpersonal distance when participants faced mask wearers who tested negative for COVID-19. Importantly, even when COVID-19 test results were unknown or positive, the interpersonal distance from a member wearing a face mask remained shorter. It could be seen that in the context of the epidemic, to some extent, wearing face mask enhanced a sense of security and shortens the social distance between people.

Participants preferred a greater distance when they were approached passively than the case when they actively approached the confederate. This finding was consistent with that of Iachini et al. [15, 16]. When participants were unable to move, they kept a greater

distance, which reflected that controlling the virtual confederate in the passive approach could increase the sense of security. These results further supported the finding that the conditions of motion proximity play a key role in spatial regulation [5]. In the passive approach, a sense of invasion and uncomfortable feeling was generated, leading to a larger interpersonal distance. Different from the results of Lee et al. [13] who adopted the online survey method, which had no real sense of experience. Participants had no chance to feel the sense of pressure when the virtual confederates approached. While using VR technology measurement, participants were immersed in the real experience of passive pressure. Similarly, the results of Lee et al. [12] showed that the comfort distance and reachability distance measured in the VR environment were basically consistent with those measured in the real environment, which indicated that VR technology can simulate the real environment.

The gender of the participants had no significant effect on the interpersonal distance of the virtual confederates. Yu et al. [10] explored interpersonal distance in eight directions, and the gender of participants showed no significant difference, which was in accordance with the results of this study. Therefore, gender differences in the perception of interpersonal distance were not significant, both male and female participants showed a similar interpersonal distance to virtual confederate.

5 Conclusion

To summery, the effects of face mask, approach pattern and participants' gender on interpersonal distance in the COVID 19 pandemic were explored in this study. VR technology was used to simulate the experimental scenes and build the virtual confederate. Participants preferred larger interpersonal distance when they faced a virtual confederate with no face mask than with a face mask due to the feelings of insecurity and invasion. People were not allowed to move their body in the passive pattern, leading to a larger interpersonal distance than in the active case. However, participants' gender showed no significant effects, and no significant interaction term was found. The current study further investigates the interpersonal distance and individuals' social behaviors in the pandemic context, which contribute to the deeper understanding of the motor nature of this psychological cognitive distance. Based on the constriction of experiment conditions, there are still some shortcomings in this study. The participants recruited were all college students with a relatively young age. In the future studies, the age group of participants will be expanded, and the impact of other anti-epidemic measures on interpersonal distance can be further discussed.

Compliance with Ethical Standards. The study was approved by the Logistics Department for Civilian Ethics Committee of South China University of Technology.

All subjects who participated in the experiment were provided with and signed an informed consent form.

All relevant ethical safeguards have been met with regard to subject protection.

References

1. Leung, N.H.L., et al.: Respiratory virus shedding in exhaled breath and efficacy of face masks. Nat Med. **26**(5), 676–680 (2020)
2. Hall, E.T., Hall, E.T.: The Hidden Dimension, vol. 609. Anchor (1966)
3. Sommer, R.: Personal space. The behavioral basis of design (1969)
4. Hayduk, L.A.: Personal space: where we now stand. Psychol. Bull. **94**(2), 293 (1983)
5. Ruggiero, G., Frassinetti, F., Coello, Y., Rapuano, M., di Cola, A.S., Iachini, T.: The effect of facial expressions on peripersonal and interpersonal spaces. Psychol. Res. **81**(6), 1232–1240 (2016). https://doi.org/10.1007/s00426-016-0806-x
6. Cartaud, A., Ott, L., Iachini, T., Honoré, J., Coello, Y.: The influence of facial expression at perceptual threshold on electrodermal activity and social comfort distance. Psychophysiology **57**(9), e13600 (2020)
7. Vagnoni, E., Lewis, J., Tajadura-Jiménez, A., Cardini, F.: Listening to a conversation with aggressive content expands the interpersonal space. PLoS ONE **13**(3), e0192753 (2018)
8. Gessaroli, E., Santelli, E., di Pellegrino, G., Frassinetti, F.: Personal space regulation in childhood autism spectrum disorders. PLoS ONE **8**(9), e74959 (2013)
9. Bailenson, J.N., Blascovich, J., Beall, A.C., Loomis, J.M.: Interpersonal distance in immersive virtual environments. Pers. Soc. Psychol. Bull. **29**(7), 819–833 (2003)
10. Yu, X., Lee, Y.-C.: Investigating the comfort distance of Chinese in eight directions. In: Long, S., Dhillon, B.S. (eds.) MMESE 2019. LNEE, vol. 576, pp. 461–468. Springer, Singapore (2020). https://doi.org/10.1007/978-981-13-8779-1_53
11. Wang, M., Lee, Y.-C.: Investigating the effects of face mask and gender on interpersonal distance judgments. In: Long, S., Dhillon, B.S. (eds.) MMESE 2021. LNEE, vol. 800, pp. 40–45. Springer, Singapore (2022). https://doi.org/10.1007/978-981-16-5963-8_4
12. Lee, Y.-C., Yu, X., Xiong, W.: A comparative evaluation of the four measurement methods for comfort and reachability distance perceptions. Behav. Res. Methods 1–12 (2021)
13. Lee, Y.-C., Chen, Y.-L.: Influence of wearing surgical mask on interpersonal space perception between mainland Chinese and Taiwanese people. Front. Psychol. **12**, 692404 (2021)
14. Lisi, M.P., Scattolin, M., Fusaro, M., Aglioti, S.M.: A Bayesian approach to reveal the key role of mask wearing in modulating interpersonal distance during the COVID-19 outbreak (2020)
15. Iachini, T., Coello, Y., Frassinetti, F., Ruggiero, G.: Body space in social interactions: a comparison of reaching and comfort distance in immersive virtual reality. PLoS ONE **9**(11), e111511 (2014)
16. Iachini, T., Coello, Y., Frassinetti, F., Senese, V.P., Galante, F., Ruggiero, G.: Peripersonal and interpersonal space in virtual and real environments: effects of gender and age. J. Environ. Psychol. **45**, 154–164 (2016)