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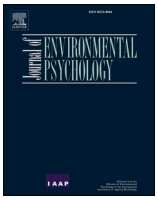

Preferred distance from camera for online interactions and its relation with individual differences in pathogen sensitivity

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ABSTRACT

Humans maintain distance from others in their interpersonal interactions and this has been documented in previous research in real-world scenarios. However, thanks to telecommunication technologies, humans are also interacting online with each other. While individuals are competent in adjusting their interpersonal distance based on their own preferences and others' considerations in a real-world situation, they might not be as competent in their online interactions. The aim of the current study is twofold: a) to investigate individuals' preferred distance from a camera both for themselves and others while in an online interaction, and b) to test whether individual differences in pathogen sensitivity influence their preferred distances in an online interaction. Participants ($N = 159$) were asked to indicate their comfort distance from a camera for themselves and others while interacting in an online scenario. The distance from the camera varied systematically from 50 cm to 200 cm. Results showed that participants preferred to stand 80 cm–120 cm from a camera. As for the avatars that the participants viewed online, men and women preferred female avatars to stand between 80 cm and 130 cm from a camera, and male avatars to stand between 80 cm and 150 cm from a camera. And although the chances of contracting a disease online is zero, we found that germ aversion and concern about contracting COVID-19 were associated with the preferred distances from the camera. We attribute this result to a false positive error in social cognition.

1. Introduction

Individuals prefer to maintain an optimal interacting distance between themselves and others, and this space is invaded when another individual violates the interpersonal distance and approaches too closely when the subject does not desire or expect it (Bell, Green, Fisher, & Baum, 2001; Felipe & Sommer, 1966; Hall, 1966; Hayduk, 1983; Lloyd, 2009; Sommer, 2002, pp. 647–660; Sundstrom, E., & Altman, 1976). Accordingly, individuals seek an optimal distance for their interpersonal interactions, and this distance increases in uncomfortable and threatening situations (Coello & Cartaud, 2021; Felipe & Sommer, 1966; Hall, 1966; Iachini et al., 2016; Kennedy et al., 2009).

There have been recent studies on interpersonal distance associated with the COVID-19 pandemic. Heightened perceived risk of COVID-19 was associated with larger interpersonal distance preference in an online study, while wearing face mask decreased the distance (Iachini et al., 2021). In another online study, Cartaud et al. (2020) used virtual avatars to test the effect of facial masks on preferred interpersonal distance. Wearing facial masks reduced interpersonal distance compared to unmasked faces, irrespective of facial expression (Cartaud et al., 2020). Similarly, Lisi, Scattolin, et al. (2021) showed not only that individuals increase their distance from avatars without facial masks, their preferred interpersonal distance increased further for the positive COVID-19 avatars. A similar effect has been found in a more ecologically valid virtual reality experiment, in which participants passed a virtual agent, with and without a mask, in a supermarket aisle (Kroczek et al., 2022). The negative association of unmasked faces and interpersonal distance has also been reported in other populations such as East Asians (Lee & Chen, 2021).

In the aftermath of COVID-19 pandemic, individuals were advised to use online platforms for interactions, ratcheting up the number of both professional as well as casual and friendly online meetings and social interactions. While individuals are able to adjust their interpersonal distances in an in-person interaction (e.g., Cartaud et al., 2018, 2021; Coello & Cartaud, 2021; Hammes, 1964; Iachini et al., 2016; Pazhoohi et al., 2019; Rapuano et al., 2021; Ruggiero et al., 2017; Smith, 1953; Yee & Bailenson, 2007), the question of what the appropriate distance is for online dyadic interactions remains unknown. In other words,

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individuals have preferential comfort distances in their in-person interparental interactions, as well as in virtual interactions (Buck et al., 2020; Olivier, Ondrej, Pettré, Kulpa, & Cretual, 2010, July; Ruggiero et al., 2017, 2021). Accordingly it is predicted that such preferences in online interactions exist and influence both the distance that an individual situate themselves from the camera (what we call an idiocentric perspective), as well as the distance that they prefer the other avatar to take from their camera (what we call an allocentric perspective).

In the current study, we aimed to investigate individuals' preferred distance from a camera for themselves and others while in an online interaction. While there are studies for testing the preferred distances for interpersonal interactions in different contexts (e.g., Cartaud et al., 2020; Iachini et al., 2016; Pazhoohi et al., 2019; Ruggiero et al., 2017; Yee & Bailenson, 2007), to the best of our knowledge no research has explored the distance preference in an online interaction. This question acquired momentum during the COVID-19 pandemic as many people were required - and since may have chosen - to change many social interactions from in-person to online. Moreover, here we test whether these preferred distances are associated with individual differences in pathogen disgust vis-a-vis perceived vulnerability to disease and concerns about contracting COVID-19. While in a real-world situation it is shown that those individuals with higher disgust, disease susceptibility perception, and concern about contracting COVID-19 prefer larger distances from others (Hromatko et al., 2021; Welsch et al., 2021; cf. Lisi, Scattolin, et al., 2021), we investigated whether these concerns also influence preferred distances during an online interaction, despite the fact that the chances of contracting diseases when interacting online are zero. In general, while we hypothesize a positive association between distance ratings for themselves from the camera and individual differences in pathogen and diseases variables, we do not expect individual differences in such variables influencing the distance preference for other individuals (i.e., avatars) from the screen. Yet, we explored whether a false positive effect is present (i.e., a negative reaction in the absence of an actual threat). Moreover, as there is no previous research on the preferred distance for an online interaction, the range of preferred distance in this study is exploratory.

2. Methods

2.1. Participants

Participants were recruited during the COVID-19 pandemic (July 2021) from Amazon Mechanical Turk workers located in Canada. An a priori power analysis conducted using WebPower (Zhang & Yuan, 2018) indicated a required sample size of 112 participants to detect a medium-sized correlation ($r = 0.30$, $\beta = 0.90$) between preference from camera and disease/disgust measures. A total of 159 individuals (64 men and 95 women) participated and completed an online survey; 14 individuals (3 men and 11 women) self-identified as non-heterosexual. Men were aged between 20 and 77 years ($M = 47.75$, $SD = 16.55$) and women were aged between 18 and 75 years ($M = 42.47$, $SD = 15.97$). A total of 70 participants (44.0%) reported being married, and 10.1% reported being not married but in a relationship. Additionally, 31.4% reported being single, and 14.5% were either widowed, divorced, or separated. As for their highest educational degree, 23.9% had a high school diploma, 21.4% had a post-secondary diploma, 37.1% had an undergraduate degree, and 17.6% had a postgraduate degree.

2.2. Measures

2.2.1. Perceived vulnerability to disease

We used the 15-item Perceived Vulnerability to Disease self-report instrument (Duncan et al., 2009) to measure individuals' chronic concerns about the transmission of infectious diseases. The answers range from 1 (*strongly disagree*) to 7 (*strongly agree*) on a 7-point Likert scale, with higher values indicating higher perception of vulnerability to diseases. The scale is composed of two subscales of *perceived infectability* that assesses beliefs about one's own susceptibility to infectious diseases, and *germ aversion* that assesses emotional discomfort in contexts that connote high potential for pathogen transmission (Duncan et al., 2009).

2.2.2. Pathogen disgust

To measure individual differences in pathogen disgust, we used 7-item pathogen disgust scale from Three Domains of Disgust Scale (Tybur et al., 2009). The pathogen disgust subscale comprises 7 items measuring attitudes to performing or observing actions on pathogen disgust (e.g., stepping on dog poop). We used a 7-point Likert scale with 0 indicating *not at all disgusting* and 6 indicating *extremely disgusting* (Tybur et al., 2009).

2.2.3. COVID-19

We asked participants to provide their answers about their attitude towards COVID-19 disease on a 7-point Likert scale from very low (1) to very high (7) for the following questions: "How concerned are you in general about the coronavirus outbreak?", and "When you are in public how concerned are you about contracting the coronavirus?".

2.3. Stimuli and procedure

A total of 2 Caucasian male[1] and 2 Caucasian female avatars were implemented using Unity (version 2020.2.1f1). Each avatar was positioned forward facing in front of the camera with 0 degree of eye angle (eye level), in a way that the eyes were gazing straight forward to the camera. The distance varied from 50 cm to 200 cm away from the camera, incrementing in 10 cm resulting in 16 stimulus distances for each avatar (see Fig. 1 for examples). The resolution of stimuli was 800 $\times$ 450.

In the beginning of the study, participants completed a series of questionnaires (i.e., demographic, pathogen disgust, perceived vulnerability to disease scale and COVID-19 questions). Overall, participants were presented with three blocks. In the first block, male and female participants were presented with an avatar that matched their own self-identified sex (the male and female stimuli presented in Fig. 1 were used for this idiocentric block). In this block the same avatar was presented 16 times, each time at a different, randomly selected, distance ranging from 50 to 200 cm. Participants were asked to rate their preferred distance, observing each of the images, while imagining the avatar as themselves from the camera ("I prefer to be at this distance from the camera when interacting online") on a 5-point numeric scale ranging from *do not prefer* (1) to *prefer a great deal* (5).

The idiocentric block above was always presented first. Participants were then presented with one block of two male avatars, and one block of two female avatars (block order counterbalanced across participants). In each block participants were asked to indicate their preferred distance regarding the avatar's distance from the camera on a 5-point numeric scale: "I prefer others to be at this distance from the camera when interacting online". Each of these allocentric blocks contained 32 stimulus presentations, whereby each of the two avatars was randomly selected to appear at one of 16 different distances ranging from 50 to 200 cm.

3. Results

A linear mixed model was conducted with perspective (idiocentric vs. allocentric) and distance on preferred distance as fixed factors, and

[1] For more clarity, throughout this paper sex of the stimuli are indicated using 'male' and 'female', while participants' sex is indicated by 'men' and 'women'.

Fig. 1. Examples of the female (upper row) and male (lower row) stimuli with 50, 100 and 200 cm away from camera, from left to right.

participant as a random factor; the results did not show any significant effect of perspective, $F(1, 6784) = 1.45$, $p = .228$, or distance × perspective interaction, $F(15, 6784) = 0.65$, $p = .883$; The main effect for distance was significant $F(15, 6784) = 0.65$, $p < .001$, therefore a) for avoiding losing statistical power, and b) for including stimuli sex for allocentric perspective in the analysis, each perspective was analyzed separately. For idiocentric analysis, participant's sex was identical to stimuli sex (each individual observed the stimuli of their own sex for this condition), therefore only participant's sex was included in the analysis.

3.1. Preferred distance for themselves

A 16 (Distance) × 2 (Participant Sex) repeated measures analysis of variance (ANOVA) was performed on participants' distance rating for themselves from the screen as a within-subjects variable, and their sex as a between-subjects variable. All post hoc comparisons reported here, and throughout the results, were done using Bonferroni correction, and this is also reflected in the p-values. Results showed a significant main effect for the distance, $F(15, 2190) = 14.97$, $p < .001$, partial $\eta^2 = 0.09$. Post-hoc analysis showed that participants preferred distances of 80–120 cm were significantly higher than the other distances (all $ps < .044$), while distances of 50, 60, 150–200 cm were the least preferred distances (Fig. 2). The main effect of Participant Sex and Distance × Participant Sex interaction were not significant (Sex: $F(1, 146) = 0.90$, $p = .757$, partial $\eta2 = 0.01$; Distance × Participant Sex: $F(15, 2190) = 1.23$, $p = .235$, partial $\eta2 = 0.01$).

3.2. Preferred distance from others

A 16 (Distance) × 2 (Stimuli Sex) × 2 (Participant Sex) mixed ANOVA was performed on the distance rating with Distance and Stimuli Sex as within-subject variables, and Participant Sex as a between-subject variable. For the preferred distance from others, only those who identified as heterosexual were included in the analysis, as previous research has shown that preference for interpersonal distance is variant as a function of sexual orientation (Lisi, Fusaro, et al., 2021; Uzzell & Horne, 2006).

The main effect for Distance was significant, $F(15, 2145) = 24.43$, $p < .001$, partial $\eta^2 = 0.14$. The main effects of Stimuli Sex and Participant Sex were not significant (Stimuli Sex: $F(1, 143) = 1.89$, $p = .171$, partial $\eta^2 = 0.01$; Participant Sex: $F(1, 143) = 0.03$, $p = .860$, partial $\eta^2 = 0.01$). However, results returned a significant Distance × Stimuli Sex interaction, $F(15, 2145) = 3.04$, $p < .001$, partial $\eta^2 = 0.02$. Results for female stimuli showed that distances of 80–130 cm were preferred significantly more than the other distances (all $ps < .037$; see Fig. 3a) while distances of 50, 60, and 180–200 cm were the least preferred distances. Results for male stimuli showed a significant preference for distances from 80 to 150 cm, and distances of 50–70 cm, 170–200 cm were rated as the least preferred ones (all $ps < .025$; see Fig. 3b). The other interactions were not significant (all $ps > .067$).

3.3. Correlation analysis

For each participant, an average value of distance preference using the ratings from each condition (idiocentric and allocentric) were calculated.

3.3.1. Preferred distance for themselves

Correlation analysis between self distance preference from the camera and perceived vulnerability to disease, pathogen disgust, as well

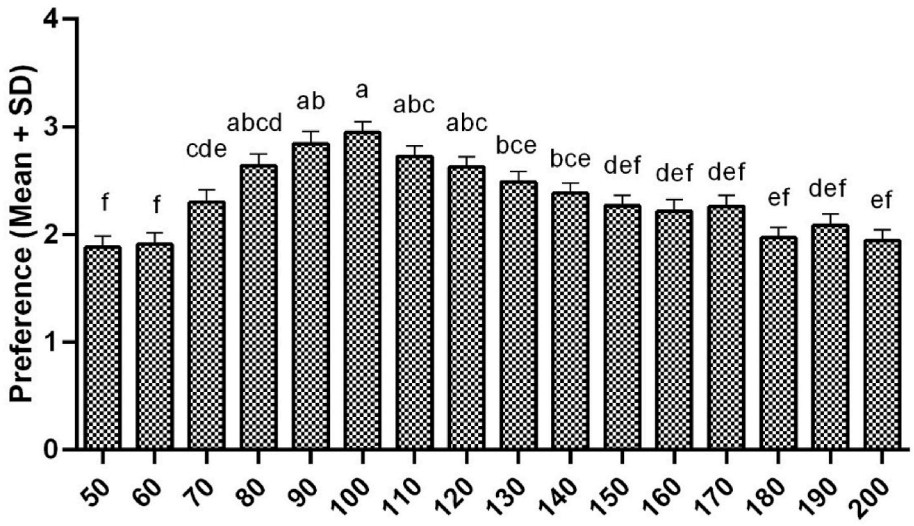

Fig. 2. Preferred distance from camera for an online interaction for both male and female participants. Means not sharing the same letters are significantly different ($p < .01$). Distances from 80 to 120 cm are indicated by the letter 'a', meaning they are not significantly different from each other; distances 80, 90, 110–140 cm, share letter 'b' meaning they are not significantly different from each other, yet 130 and 140 are different from 100 cm, as they do not share a similar letter. Distances 70, 80, 110–140 cm, share the letter 'c' indicating they are not different from each other. Distances 70, 150–170 and 190 cm share the letter 'd' and are significantly different from distances 50, 60, 180 and 200 cm that do not share the letter 'd'. Distances 50 and 60 are not different from distances 150–200 cm as they share the letter 'f', however distances 150–200 cm share the letter 'e' which indicates no difference between those distances and 70, 130 and 140 cm.

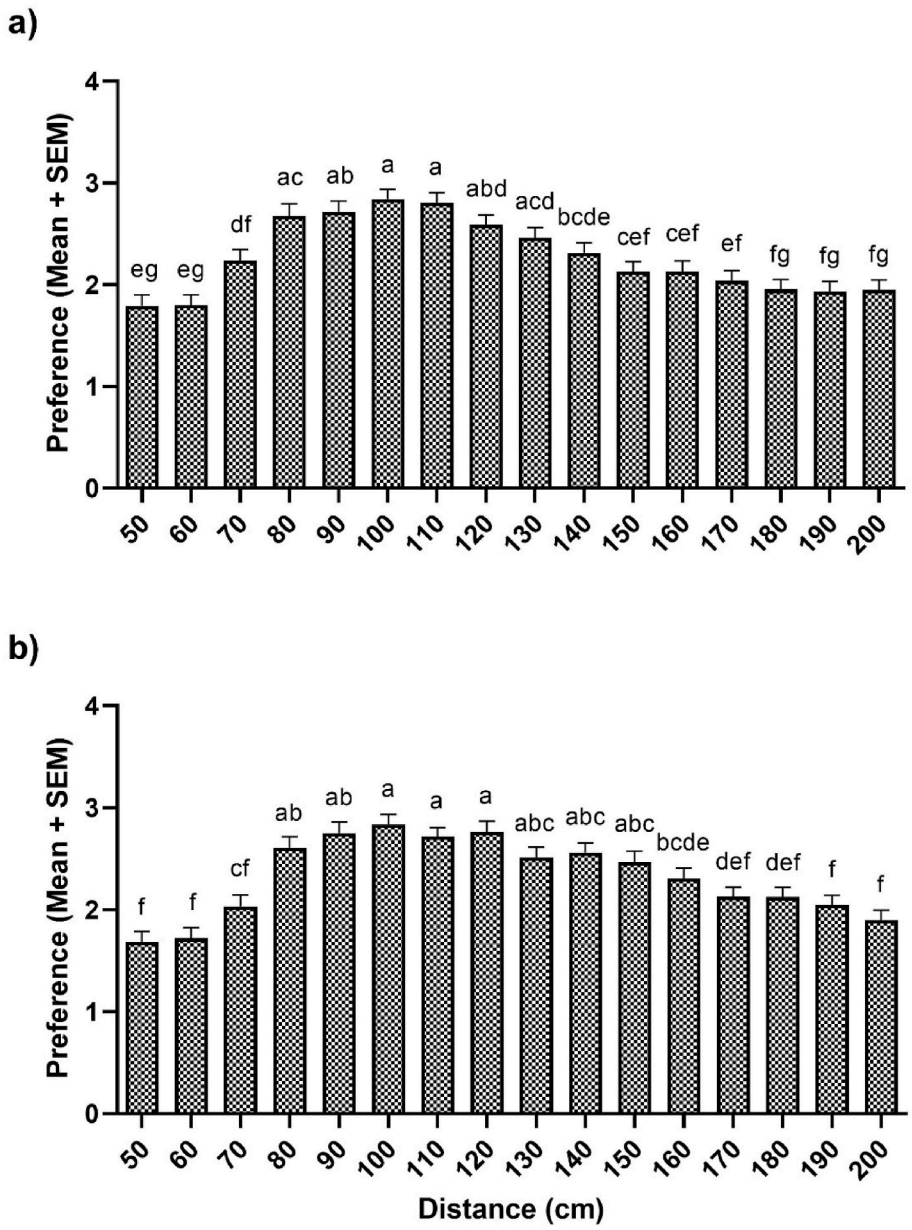

Fig. 3. Preferred distance from a) female and b) male stimuli for an online interaction. Means not sharing the same letters are significantly different ($p < .01$). For female stimuli (upper graph), distances from 80 to 130 cm are indicated by the letter 'a', meaning they are not significantly different from each other; distances 90, 120–140 cm, share the letter 'b' meaning they are not significantly different from each other. Distances 80, 130–160 cm, share the letter 'c' indicating they are not different from each other. Distances 70, 120–140 cm also share the letter 'd' and are not different. Distance 70 cm shares the letter 'f' with distances 150–200 cm indicating a lack of difference. Distances 50 and 60 cm share the letter 'e' or 'g' with distances 140–200 cm, meaning they are not different. Distance 140 does not share the letter 'f' or 'g', indicating a difference with distances 180–200 cm. For the male stimuli (lower graph), distance 80–150 cm share the letter 'a', meaning they are not significantly different from each other; distances 80, 90, 130–160 cm, share the letter 'b' meaning they are not significantly different from each other, yet 160 cm is different from 100 to 120 cm, as they do not share a similar letter. Distances 130–160 cm share the letter 'c' with 70 cm, meaning no difference, and 160–180 cm share the letter 'd' indicating a lack of difference. Distances 50–70 cm and 170–200 cm share the letter 'f' and are not different from each other.

as concern about COVID-19 was conducted separately for men and women. As for the preferred distance from the camera, men's and women's germ aversion was positively correlated with their preferred distance (Men: $r(62) = 0.26$, $p = .037$; Women: $r(93) = 0.26$, $p = .010$). Similarly, women's general concern about COVID-19 was positively associated with their preferred distance from the camera ($r(93) = 0.22$, $p = .030$); men's general concern about COVID-19, and both men and women concern about contracting COVID-19 were not correlated with self distance from camera (all $ps > .062$). Other associations, including perceived infectability subscale of perceived vulnerability to disease and pathogen disgust were not significant (all $ps > .230$).

3.3.2. Preferred distance from others

As for the preference for others from the camera, participants' germ aversion was positively associated with preferred distance of female, but not male avatars from the camera (Male stimuli: $r(157) = 0.12$, $p = .119$; Female stimuli: $r(157) = 0.17$, $p = .033$). Moreover, concern about contracting COVID-19 in public was positively associated with the distance from both male and female stimuli (Male stimuli: $r(157) = 0.16$, $p = .035$; Female stimuli: $r(157) = 0.21$, $p = .007$). Other associations, including general concern about COVID-19, perceived infectability subscale of perceived vulnerability to disease and pathogen disgust were not significant (all $ps > .087$).

3.3.3. Summary of correlation analysis

In sum, the results of the correlation analysis suggest that germ aversion and concern about contracting COVID-19, but not pathogen disgust and perceived infectability, were associated with the preferred distance from the camera. In other words, the more the participants reported germ aversion and concern of contracting COVID-19, the more they preferred a larger distance from the camera during an online interaction. This was evident for both idiocentric and allocentric perspectives.

4. Discussion

The current study is first to investigate individuals' preferred distance for an online interaction. Participants were asked to rate their

comfort distance from camera for themselves and others while interacting in an online scenario. The distance in this research varied randomly in increments of 10 cm from 50 cm to 200 cm away from the camera. Individual differences in pathogen disgust, perceived vulnerability to disease and concern about contracting COVID-19, were measured to investigate a possible association with the distance preference.

As for their own preferred distance from camera, both men and women preferred distances from 80 cm to 120 cm, indicating that both men and women have similar distance preferences for social distances in their interactions. Moreover, our results showed that participants, both men and women similarly, preferred distances from 80 cm to 130 cm for female, and from 80 cm to 150 cm for male avatars. In other words, individuals' preferred distance from others is consistently 80–130 cm.

Regarding the individual differences, both men and women with higher germ aversion preferred larger distances of others from the camera, while concern about contracting COVID-19 positively was associated with the preferred distance only in women. This sex difference dovetails with the previous findings that women report higher disgust sensitivity as well as germ aversion compared to men (Curtis et al., 2004; Duncan et al., 2009; Makhanova & Shepherd, 2020; Stefanczyk et al., 2022; Tybur et al., 2009). Moreover, participants' germ aversion positively correlated with the preferred distance of female, but not male avatars from the camera, indicating that those who had higher germ aversion preferred a larger distance for the female stimuli. Additionally, concern about contracting COVID-19 in public was positively associated with the distance from both male and female stimuli, meaning those with higher concern of contracting COVID-19 preferred others to be farther from the screen.

Testing whether disgust sensitivity is associated with the magnitude of interpersonal space, Park (2015) showed that disgust sensitivity marginally correlated with individuals' interpersonal space. Such behavioral distancing in evident from childhood as preschool age children avoid contact with the sick individuals and spent less time in their proximity (Blacker & LoBue, 2016). Comparing individual differences before and during COVID-19 pandemic, Thiebaut et al. (2021) showed that germ aversion is associated with avoiding social touch and this relationship is stronger when there is pathogenic saliency (i.e., the COVID-19 pandemic). Our results dovetail with these previous findings, however, it should be noted that contrary to the previous studies, the current investigation measured interpersonal distance for an online interaction. Nonetheless, our finding that preferred distances were associated with germ aversion and concern of COVID-19 is counterintuitive, as the chances of contracting diseases during an online interaction is zero. However, at the same time, this finding suggests to a broader evolved cognitive mechanism that indiscriminately regards a virtual interaction as an actual one, suggesting existence of a false positive error – detecting risk when none exists – in social cognition (Haselton et al., 2015; Haselton & Nettle, 2006; Kahneman et al., 1982; Tversky & Kahneman, 1974). Indeed, previous research has shown that individuals higher on germ aversion or vulnerability to disease have more negative attitudes and stereotype about outgroup others such as disabled individuals or immigrants (Faulkner et al., 2004; Park et al., 2003) potentially due to a false positive error. In other words, according to the error management theory, interpersonal perception is susceptible to errors and biases (Haselton et al., 2015; Haselton & Nettle, 2006), and cost of a false positive error (i.e., avoiding contact with a noncontagious person) is lower than the cost of a false negative error (i.e., failing to avoid an individual with a contagious disease) (Haselton et al., 2015; Haselton & Nettle, 2006). Accordingly, we interpret our findings – associations between preferred distance with germ aversion and concern of COVID-19 – as an extension of false positive detection of diseases in a situation where the chances of contracting diseases is actually zero.

Interestingly, our results showed significant associations between distance preference and germ aversion, but not perceived infectability subscale of perceived vulnerability to disease scale. This is in line with the accumulative evidence that a germ aversion construct is more strongly associated with behaviors and emotional discomfort in situations that connote transmission of infectious diseases, while perceived infectability subscale is more strongly associated with vigilance about one's own susceptibility to infectious disease (Duncan et al., 2009; Makhanova et al., 2019; Makhanova & Shepherd, 2020; Young et al., 2011). Moreover, our results showing germ aversion and COVID-19 concern were, but pathogen disgust was not, associated with both the preferred distance for others and self from the camera, suggest a distinction between behavioral immune system (Schaller, 2011) and pathogen disgust (Tybur et al., 2009), supporting those that argue these two systems function distinctively (Murray & Schaller, 2016; Pazhoohi et al., 2021; cf., Lieberman & Patrick, 2014).

Altogether, the results of the current study are line with the findings in the proxemics literature regarding interpersonal distance, whereby distance can be modulated by individual differences and situational factors (Bell et al., 2001; Hayduk, 1983; Iachini et al., 2016; Ruggiero et al., 2017; Winogrond, 1981). One caveat of the current study is the use of avatars which might produce lower ecological validity than actual human faces. Moreover, the stimuli in the current research were not rated a priori for degree of realism or pleasantness for a social interaction. Future research might choose to assess what, if any role these potential shortcomings play in the current investigation. Another possible limitation of this study was the use of relatively young stimuli, while the age range of the participants was broad, which might have influenced perspective taking of the older participants in the idiocentric condition of the study.

In summary, the present study aimed to test individuals' preferred distance from camera for themselves and others in an online interaction context, and showed that the comfort distance begins around 80 cm from camera for themselves and others, both for men and women. Moreover, individual differences in germ aversion and COVID-19 concern are positively associated with this preferred distance.

Author statements

Farid Pazhoohi: Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Writing - Review & Editing, **Alan Kingstone:** Conceptualization, Writing - Review & Editing.

Ethics declarations

All participants consented to taking part in the study. This research was approved by the Behavioural Research Ethics Committee of the University of British Columbia and was conducted in accordance with the Declaration of Helsinki as it pertains to research with human participants.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of competing interest

The authors declare that they have no competing interests.

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