Interpersonal Distance

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Abstract

This research has several goals. Firstly, it aims to investigate the preference for different interpersonal distances between team members and to translate the findings to the design of work environments. Secondly, this research aims to investigate whether a change in the viewing condition can influence the participants' experience and judgement of interpersonal distance. This was done through the use of pairwise comparison. The effect of two independent variables on the preference of personal distance were considered, namely the different distances between two team members varying from 74 cm to 300 cm and the viewing conditions from which the situation assessed, namely the POV perspective and bird-eye view. Generally, findings suggest that participants did have clear preferences for particular interpersonal distances Also, it was possible to assess a range of distances which the majority of participants preferred. Lastly, the viewing condition seems to have an influence on participants' judgement of interpersonal distance. The overall pattern of preferences remained even though it is more distinctly indicated in the bird eye-viewing condition. The findings are discussed in the context of past research on proxemics and increasing possibilities due to the use of virtual reality as a research tool.

General Introduction

Interpersonal distance and proxemics are relevant research topics with regard to design of workspaces. There might be different needs regarding interpersonal distance, depending on the working context, which should be considered for the design of workplaces to ensure employees satisfaction and productivity. Interdependence in teams such as those working in aircraft crews, research teams or railway control centers, might require a specialized design of their work space in terms of interpersonal distance. However, virtualization of prototypes allows design teams to test participants' acceptance and preferences for design options and to assess an optimal design solution. However, there is a lack of research about proxemics in these special working situations. This research aims to contribute to the exploration of proxemics specifically in teamwork situations and with regard to virtual prototyping.

Proxemics and Teamwork

Proxemics is highly relevant to this study because it investigates the proxemic behaviour in a work-related context, especially with regard to the design of work environments. The American Psychological Association (2018) offers the following definition of proxemics: “It is the study of interpersonal spatial behavior. Proxemics is concerned with territoriality, interpersonal distance, spatial arrangements, crowding, and other aspects of the physical environment that affect behavior”. As this study focuses on the use of interpersonal distance in context of teamwork specifically, it is crucial to reflect on the research connecting both aspects. The following paragraph aims to do so.

Generally, research by Hall (as cited in Nova, 2004) shows that interpersonal distance is more than the mere distance between individuals. Hall (as cited in Nova, 2004) focused on the use of space during social encounters and shaped the term of personal space. Personal space can be defined as the invisible boundaries that immediately surround an individual. The physical distance one wishes to maintain towards others depends on the relationship with the

counterpart, the situational circumstances and whether an interaction is expected (Little, 1965; Sundstrom & Altman 1976). Therefore, it can be said that physical and social distance between two interaction partners tend to match one another (Cristani et al., 2011). In accordance with this, four personal zones have been formulated (Hall, 1957, as cited in Cristani et al., 2011; Hans & Hans, 2015; Nova, 2004).

- *Intimate distance* refers to the distance up to 0.5m surrounding an individual. Within this zone people mostly interact with close friends, family and intimate partners. Violations of these personal boundaries can produce negative responses within an individual such as anxiety.
- *Personal distance* refers to a distance between 0.5 and 1.25 meters around an individual. Within this distance interaction and communication with friends occurs and represents a feeling of closeness towards them
- *Social distance* refers to a distance between 1.25 and 3.5 meters around an individual. Within this personal zone one mainly interacts, with whom we consider to have a formal, impersonal relationship such as colleages. An individual does not necessarily feel the need to interact with others in the outer part of this zone. However, as other people come closer, individuals often feel the need to acknowledge their presence.
- *Public distance* refers to a distance greater than 3.5 meters around an individual. Interactions within this zone refer to formal and not intimate encounters with a group or crowd such as when giving a speech.

Therefore, it would be interesting to investigate where within these zones interdependent teamwork usually takes place. Teamwork is characterized by its interdependent nature and the combination of individual and collective efforts required for successful performance (Paguio &

Jackling, 2016). Outcome interdependence seems to create higher responsibility for one's own, other's and combined efforts and therefore has a motivating effect (Van der Vegt, Emans, & Van de Vliert,1998). Thus, the extent of interdependence in teamwork calls for a certain level of interpersonal interaction like monitoring behaviour (Marks & Panzer, 2004), communication (Barrick, Bradley, Kristof-Brown & Colbert, 2007; Gundlach, Zivnuska, & Stoner, 2006), and effective helping behaviour (Bachrach, Powell, Collins, & Richey, 2006; Torrente, Salanova, Llorens, & Schaufeli, 2012).

Monitoring behaviour can be described as the observation of the working activities and performance of fellows (Dickinson & McIntyre, 1997 as cited in Marks & Panzer, 2004). According to Marks and Panzer (2004), monitoring behaviour improves team performance through the ease of coordination, the exchange of feedback, engagement in supporting behaviour and the detection of errors. This seems to be relevant in particular for teams working in an interdependent setup, because each member would be able to adapt working activities and timing (Dourish & Bellotti, 1992; Marks & Panzer, 2004). Monitoring behaviour requires some sense of physical proximity between team members to access the others' working status. Monitoring behaviour seems to be most applicable in collocated working arrangements (Dourish & Bellotti, 1992). This offers team members a context for their own efforts. Therefore, proximity in collocated office designs supports task and group awareness (Dourish & Bellotti, 1992).

Moreover, proximity between team members supports collaboration through face-to-face communication and supporting behaviour like immediate feedback or helping with a task when the workload becomes heavy (Herbsleb, Mockus, Tinholt, & Grinter, 2000; Olson, Teasley, Covi, & Olson, 2002). The willingness to ask for help and to provide assistance strongly depend on existing norms (Cleavenger, Gardner, & Mhatre, 2007). These norms define whether it is acceptable to ask for and receive help within a certain group of individuals. However, it appears as if these supporting norms are more distinct within interdependent teams. Due to the interconnectedness of the work performance, individuals appear to be more willing to express a

request for help and to provide assistance to others. According to Parrino (2015), the combination of proximity and a collaborative relationship, which usually would exist between interdependent team members, can facilitate knowledge exchange. Again, this can be beneficial for teamwork, since it eases coordination, cooperation, arriving at agreements and greater contributions to group work (Olson et al., 2002). The possibility for formal and informal face-to-face communication due to proximity also has valuable effects on group identity and team culture (Kiesler & Cumming, 2002). Therefore, it is worth mentioning that proximity is thought to be beneficial for teamwork since it facilitates collaboration and work relationships.

Even though this research illustrated the possible benefit of proximity for teamwork, it remains unclear what degree of proximity is meant by that, which is important to know in order making decisions on environmental design. This is important since both too large and too close interpersonal distance can lead to discomfort and dissatisfaction within team members (Argyle & Dean, 1965; Sundstrom & Altman 1976; Hall, 1957 as cited in Nova, 2004). The following section will describe the theoretical backgrounds of the negative effect of too close interpersonal distance in general and with regard to teamwork.

The nonverbal expectancy violation model makes an effort to explain the violation of personal space and its consequences. The underlying assumption of this model is that everybody holds expectations towards the nonverbal behaviour of an interaction partner (Burgoon & Hale, 1988; Burgoon & Jones, 1976). These expectations are formed based on standards for specific types of relationships, social situations and associated behaviour. An example are interpersonal distance norms and the associated relationship and interaction. Violations of these expectations will lead to emotional, cognitive and behavioural changes. Too much proximity can be experienced as inappropriate interpersonal distance and a threat to control over interpersonal interaction (Baum & Koman, 1976). This experience can cause stress, discomfort, dissatisfaction and behavioural compensatory strategies like less facial regard, withdrawal and aggression (Baum & Koman, 1976; Sundstrom & Altman, 1976). The

model also distinguishes between positive and negative violations. Positive violations would have positive consequences for the interpersonal interaction and relationship, whereas negative violations will be followed by negative consequences. This can be described as a reward-punishment-model (Burgoon & Jones, 1976). Interaction partners who do not violate the existing expectations will be approached but those who negatively violate them will be avoided in the future. Evans and Howard (1973) suggest that humans use personal space to maintain an acceptable stress level and to keep negative affect under control. This suggests that too much proximity can also have an opposite effect of teamwork. In a work-related context this would cause less concentration, interruption and loss of privacy (Kraut, Fussell, Brennan, & Siegel, 2002). Thus, the effect of proximity seems to strongly depend on its degree.

Generally, it can be concluded that the degree of proximity influences the quality of collaboration, meaning that too little proximity can have a negative effect on task related behaviour whereas too much proximity can result in negative emotions and compensatory behaviours which could be unfavorable for teamwork too. However, to be able to design sophisticated work spaces and to avoid negative effects due to inappropriate proximity, the appropriate degree of proximity needs to be specified.

Virtual reality and spatial design

The design of work spaces often starts with a task analysis of the target group (Droivoldsmo & Louka 2016). This enables designers to define the requirements of their spatial design and represents the bases of further decisions on the design (Droivoldsmo & Louka, 2016). For example, a certain degree of proximity could be a requirement with regard to interdependent teamwork. This would ensure necessary collaboration (Parrino, 2015) However, knowing that some degree of interpersonal proximity is crucial does not lead to concrete design solutions. Using virtual reality for the creation of prototypes of spatial design allows design teams to detect faults at an early stage in the design process and to identify an optimal solution

(Droivoldsmo & Louka, 2016). Furthermore, virtual prototyping enables the design team to integrate the end user into the design process from an early stage on. This can be done by testing the design the designs correspondence to the users needs and the user's acceptance of aspects of the design (Bordegoni, 2011) Regarding the example of interdependent teams, virtual reality can be used to construct prototypes of seating arrangements and to assess an optimal interpersonal distance between team members. This can result in more concrete design implications such as a concrete bandwidth of interpersonal distance that should be considered when designing the workspace for interdependent teams. Therefore, virtual reality is thought to be a promising, effective and time and cost-efficient tool to evaluate design options such as those of work spaces (Dijkstra, van Leeuwen, & Timmermans, 2003).

Comprehensive prototypes are characterized by immersion and presence. Immersion refers to the degree to which a virtual environment is experienced as real, whereas presence describes the feeling of being there (Jerald, 2015). This creates the illusion of actively being in an hypothetical situation rather than being an passive observer (Dijkstra, van Leeuwen, & Timmermans, 2003). Therefore, the viewing condition seems to contribute to that. The shift of perspective enables participants to acquire a perspective that might remain barred to them under natural conditions (Hamilton & Thompson, 2007). The application of more direct viewing conditions holds the potential to create a direct experience, which can alter the perception of participants and the resulting data (Hamilton & Thompson, 2007). Altogether, virtual reality distinguishes itself from more linear animations with predefined movements through the active experience and participants' freedom to interact freely with the virtual spatial design and to experience the consequence of their actions (quelle1). Due to that, judgements within virtual reality are thought to better mirror participants' preference under natural conditions, which improves the reliability and validity when evaluating design preferences (Dijkstra, van Leeuwen, & Timmermans, 2003).

However, using virtual reality as a tool to develop and test aspects of spatial design presumes that participants would behave similarly in virtual environments compared to reality. As this study focuses on proxemic behaviour with regard to VR, it is crucial to consider literature on its connection. Early studies of proxemics in a two-dimensional virtual reality showed that people not only monitor their personal space but also adapt interpersonal distance to the situation (Krikorian, Lee, Chock, and Harms, 2000). More recent studies supported this by showing that the violation of personal space in virtual environments results in a feeling of discomfort, the associated and physiological response and avoiding behaviours (Bailenson, Blascovich, Beall, & Loomis, 2003; Llobera, Spanlang, Ruffini, & Slater, 2010; Wilcox, Allison, Elfassy, & Grelik, 2006).

Altogether this shows the potential advantages of design virtualization for design teams of any kind and specifically for spatial designs. It allows to test design aspects and to detect defaults from an early stage. Also with regard to proxemic behaviour virtual prototyping could be a suitable testing tool, since human subjects seem to show similar proxemic behaviour in virtual environments compared to reality. This is essential since this study is focused on interpersonal distance between team members and aims to translate its findings to the design of workspaces.

Current study

This research has two goals. Firstly, it aims to investigate the effects of varying interpersonal distance in the context of teamwork. This is essential because theories of personal space clearly show the possible advantage of sophisticated spatial designs and its influence on the comfort, satisfaction and productivity of employees. Moreover, research also showed the negative consequences due to inappropriate closeness in working environments, especially in the context of interdependent teamwork. Also, it was found that people feel comfortable with different interpersonal distances depending on the relationship and expected interaction with others (Cristani et al., 2011; Sundstrom & Altman, 1976; Little, 1965). Team members of

interdependent teams experience a special kind of relationship. It seems like a more collective rather than an individualistic approach is applied when interdependence is high (Gundlach, Zivnuska, & Stoner, 2006). This collectiveness increases team identification and performance (Gundlach et al., 2006). Thus, it would be interesting to explore which interpersonal distance participants perceive as most comfortable when interacting with a team member, to place them into a theoretical context of Hall's personal zones (Hall, 1957, as cited in Cristani et al., 2011; Hans & Hans, 2015; Nova, 2004) and to arrive at implications for the design of workspaces. Therefore, this research aims to investigate the proxemic behaviour in this specific work setting. Is it possible to describe patterns with regard to participants' reference for different interpersonal distances?

H1: There is a bandwidth of distances that the majority perceives as comfortable.
H2: There are differences within the preference data concerning the compliance of preferences for certain distance conditions across participants.

Secondly, this research aims to investigate whether a change in the viewing condition can influence the participants' experience and judgement of interpersonal distance. VR holds the potential to create a more active experience rather than taking the place of a passive observer (Dijkstra, van Leeuwen, & Timmermans, 2003). Therefore, the viewing condition seems to contribute to that (Hamilton & Thompson, 2007). This study uses static representation of virtual seating arrangements with varying personal distance shown from two perspectives, namely the POV view and the bird-eye view. Firstly, the POV-view, which is the perspective of one of the team members in the working arrangement. Secondly, the bird's eye view, which can be described as the perspective from an angle slightly above the two seats. Under natural conditions, participants who are not part of an interdependent team would only be able to evaluate the working arrangement from a bird eye perspective. Virtual reality enables them to

take the perspective of an actual team member. However, this change in perspective might result in a more direct experience and influence their evaluation of interpersonal distance. Therefore, the following research question is formulated. Does the perspective influence participants' preference in regard to personal distance between two interdependent team members?

H3: There is an effect of the perspective (POV- view versus bird eye view) on the preference regarding interpersonal distance between team members.

A questionnaire survey design was employed to explore preferences for environmental designs within subjects in terms of proximity. The effect of two independent variables namely, interpersonal distance and viewing condition, on subjects' preference for seating arrangements were assessed. Within this study the independent variable of proximity was manipulated in order to investigate its effect on the dependent variable, namely participants' preference for interpersonal distances. Moreover, the effect of the second independent variables, namely the perspective on the dependent variable of perception of interpersonal distance was investigated.

Methods

Participants

Participants were recruited in two ways. Firstly, participants were recruited via the participant pool of the University of Twente. The participants recruited via this participant pool were rewarded with participation points. Secondly, opportunity sampling was used. This means that researchers asked people in their social circle to participate in this study. Also, the study was shared on social media (Facebook and Instagram). The participation in this study was anonymous and voluntary. In this way *a* total of 177 participants were reached. However, incomplete data (*N=107)* was excluded from the data set. This resulted in the data of 70 participants. Participants' age ranged from 18 to 65 (*M*=26.33, SD=10.23). Moreover, within this sample 64.3% were female, 32.9% were male and 2.9% indicated gender other than that. This study was approved by the Ethics Committee of the Faculty BMS at the University of Twente.

Materials

Within the scope of this study a questionnaire was constructed, which contained pairwise comparison questions. Images of virtual working environments were used, either from the POV or bird-eye perspective were used in these questions. Only Images taken from the same perspective were presented together (as in Appendix A). For each viewing condition ten pictures were constructed (as in Figure 1).

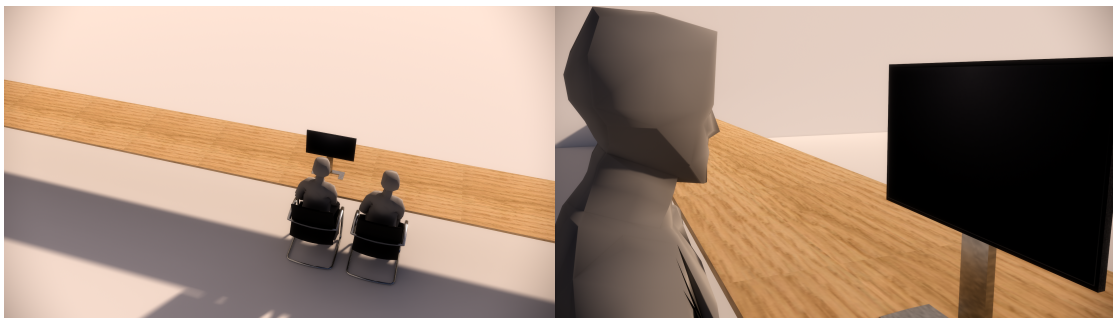

Figure 1

Images of virtual working environments. The left image shows a seating arrangement with 75cm interpersonal distance from the bird's-eye perspective. The right image shows a seating arrangement with 75cm interpersonal distance from the POV perspective.

Except for changing interpersonal distance between the two team members, these pictures show the exact same virtual working environment. The closest interpersonal distance displayed in one of the pictures was 75cm. The distance between the two team members constantly increased with 25 cm in the following pictures. The largest interpersonal distance displayed was 300 cm. This resulted in 45 comparisons for each viewing condition and 90 comparison questions in total. Within each question the images were presented contiguously. The right pictures always showed a seating arrangement with closer interpersonal distance compared to the left image. Within the questions, no indications about the actual distance between the two people in the picture were given. This needed to be done for the images compared. The construction of the used images was based on the theory of personal space by Hall (1957, as cited in Nova, 2004; Cristani et al., 2011; Hans, & Hans, 2015). For construction of the images distances above 0.5 m were used, since usually people only allow close and intimate others to enter into their intimate personal zone (Hall, 1957, as cited in Nova, 2004; Cristani et al., 2011; Hans, & Hans, 2015). There was no reason to assume that interdependent team members are perceived as that close and intimate. Also, a standard desk chair is 70cm wide, which reflects the minimum possible interpersonal distance.

Procedure

Subjects were able to access this study either via the participant pool of the University of Twente or a link leading to the study. Before participants were able to start the study, they had to agree with the terms. Participants had to proceed with the questionnaire as illustrated in *Figure 2.* The first part inquired for participants' personal data such as age and gender. Prior to each of the following parts of the questionnaire, a case description was presented (as in

Appendix B). Participants were asked to adapt the perspective of an interdependent team member. In order to avoid distortion within their perspective, participants were asked to answer the following questions independent from social distancing norms due to COVID 19. In the following parts of the questionnaire participants did a pairwise comparison for which images of virtual working environments were used. Participants were able to indicate their preference by clicking on the image showing the preferred seating arrangement. The major difference between part two and three was the perspective from which the virtual working environment was shown. In the second part exclusively, pictures from the POV- perspective were used. In the third part only, pictures with bird eye-view were used. Pairwise comparisons were randomized within each viewing condition. The random order of questions was different for both viewing conditions. The random order of the questions did not change for each participant but the same random order was used for each participant. After answering all questions, participants received the information that they completed the study successfully and could close the window.

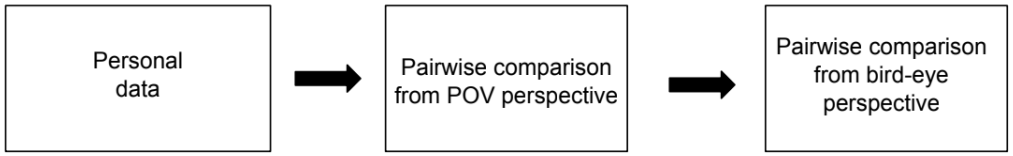

Figure 2
Questionnaire flow.

Data Analysis

In order to answer the first research question and to explore the data in terms of participants' preferences for certain interpersonal distances, the following data analysis was conducted with the program IBM SPSS. During this study a pairwise comparison was applied. One advantage of pairwise comparison was to order several interpersonal distance options in terms of preference. To do so, every condition was compared to the other conditions. Participants had to indicate their preferences, resulting in the raw data. After incomplete

responses were excluded, two preference matrices were constructed for every participant, one for each viewing condition (POV and bird-eye perspective). These preference matrices revealed information about individual preferences in terms of interpersonal distance. In order to make a statement about the complete sample, all matrices of the same viewing condition were aggregated. This resulted in two upper-triangular preference matrices. Based on that, the two upper-triangular preference matrices were complemented. The result was a full matrix. Based on that, scores were calculated, ranks were assigned and descriptive statistics were conducted. This reveals information on the bandwidth of conditions that the majority of participants preferred and disliked.

In a further step, a distance matrix was calculated, which reflects a mental distance rather than the physical distance between the distance conditions (as in Appendix C). The distance matrix illustrates the conformity of participants' preference. The goal of this was to determine how far each of the preference values is distanced from the 35 mark. The mark of 35 represents a clear preference for one of the compared distance conditions, whereas 0 refers to no consistent preference across participants and both of the compared distance conditions were valued equally. Therefore, the distance matrix illustrates the mental difference between participants' preference rather than physical distance between conditions. This was used to perform a cluster analysis. Cluster analysis used to explore an underlying structure in the compliance regarding the strength of participants' judgments. More precisely this analysis was chosen in order to investigate whether the preference data can be represented in meaningful clusters. These clusters could result in a clearer picture on which distance conditions evoke a clear preference across respondents and for which distance conditions were the responses more equally distributed. This is of particular interest since consistent positive or negative reactions towards certain distances might be considered during the design process of work spaces. Generally, there are different kinds of cluster analysis, which are based on different algorithms. In this study hierarchical cluster analysis was conducted which uses either a dividive

or an algometric algorithm. In the divisive algorithm, all distance conditions are grouped together in a single cluster. In a top down process this single cluster is divided into multiple clusters. Compared to that the algometric algorithm uses a bottom up process. In the first place, this algorithm considers each distance condition to be a cluster itself. In the following procedure, it repeatedly combines the two nearest clusters to a larger cluster. Ward's method was used to determine the distance between clusters. To assess the proximity of clusters their clustroid was calculated, which is the smallest sum of squares to other points. The latter procedure is used for a hierarchical cluster analysis in SPSS. In order to answer the second research question, the results of the cluster analysis for both conditions and the ranking of both full preference matrices were compared. The higher the similarity between those results, the less influence of the viewing conditions on the preference of interpersonal distances was expected.

Results

First, the procedure and results of presenting the data as a preference matrix and its scoring and ranking will be described. Secondly the results of the cluster analysis will be shown. These results will provide information on preferences of interpersonal distances and allow for interpretation of underlying groups of interpersonal distances due to a similar degree of like or dislike.

Scoring and ranking of the preference matrix

The preference data was presented in a triangular preference matrix. This preference matrix can be complemented based on the assumption that the respondent's preference would not change regardless of whether 'Distance A' is compared to 'Distance B' or the other way around. The result was a full preference matrix. The preferences of all participants for each interpersonal distance were summed and resulted in a preference score. The preference scores are ranked. The lowest rank refers to the least liked distance condition and the highest rank to the most liked condition. This procedure was applied to the preference matrices of each viewing condition, namely POV and bird-eye perspective (as in Table 1 & Table 2).

Table1

Complemented preference matrix of the POV viewing condition with preference scores and ranks

Distance	75	100	125	150	175	200	225	250	275	300	Score	Rank
75		11	34	15	20	20	31	27	34	32	224	8
100	59		24	31	36	36	40	41	51	50	368	4
125	36	46		43	42	49	53	56	57	56	438	2
150	55	39	27		44	55	55	61	61	64	461	1
175	50	34	28	26		54	58	61	65	63	376	5
200	50	34	21	15	16		54	64	63	66	381	3
225	39	30	17	15	12	16		65	63	65	257	6
250	43	29	14	9	9	6	5		57	62	234	7
275	36	19	13	9	5	7	7	13		64	173	9
300	38	20	14	6	7	5	5	8	6		109	10

The ranking of distance conditions in a POV view shows that the preference does not constantly increase or decrease with the increase of interpersonal distance. From this

perspective, the most liked interpersonal distance accounts for 150cm, whereas the least liked interpersonal distance is 300cm. One standard deviation above the mean of total scores was used as a cut off score to define the bandwidth of interpersonal distances that were liked the most (M=312,1; SD=118,53). Therefore, the bandwidth of interpersonal distances that participants seemed to prefer was the distance from 125cm to 150cm.

Table 2

Complemented preference matrix of the bird-eye viewing condition with preference scores and ranks.

Distance	75	100	125	150	175	200	225	250	275	300	Scores	Rank
75		18	21	25	27	35	36	40	43	44	289	5
100	52		28	40	43	45	47	49	57	57	418	3
125	49	42		48	52	56	57	54	57	56	471	1
150	45	30	22		59	57	66	62	64	65	470	2
175	43	27	18	11		61	62	63	61	63	409	4
200	35	25	14	13	9		59	60	67	68	282	7
225	34	23	13	4	8	11		59	63	69	284	6
250	30	21	8	8	7	10	11		57	61	213	8
275	27	13	6	6	9	3	7	13		55	139	9
300	26	13	5	5	7	2	1	9	15		83	10

The ranking of distance conditions in a bird-eye view shows that the preference does not constantly increase or decrease with the increase of interpersonal distance. From this perspective, the most liked interpersonal distance accounts for 125cm, whereas the least liked interpersonal distance is 300cm. One standard deviation above the mean of total scores was used as a cut off score to define the bandwidth of interpersonal distances that were liked the most (M=305,1; SD=135,35). Therefore, the bandwidth of interpersonal distance that participants seemed to prefer was the distance from 125cm to 150cm.

Hierarchical cluster analysis

Cluster analysis aims to cluster conditions together based on their similar mental distance. This does not offer insight on the existing number of clusters only but offers information on the affirmation of conditions to clusters. The number of clusters can be assessed by looking at the

scree plot and the belonging of interpersonal distances to a cluster can be described based on a Dendrogram.

With regard to the POV viewing condition, the number of clusters can be assessed by looking at the scree plot. By subtracting the total number of distance conditions (10), presented on the x-axis, with the stage number at which the graph rises rapidly (8), the number of clusters can be computed. In this case the number of clusters is two (as in Figure 3). The Dendrogram shows that the distances of 75cm, 125cm, 225cm, 250cm, 275cm and 300cm are assigned to one cluster (as in Figure 4). The distances of 100cm, 150cm, 175cm and 200cm are assigned to a second cluster.

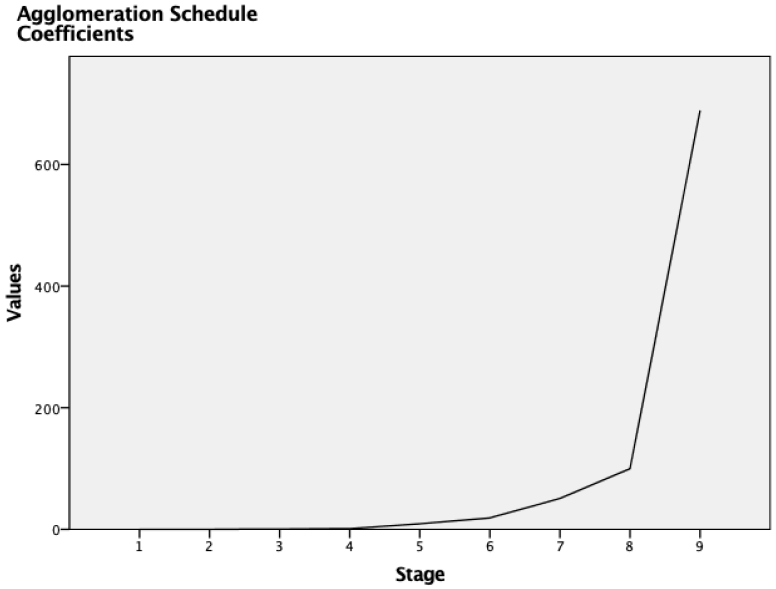

Figure 3

Resulting screeplott from cluster analysis of the data for the POV viewing condition.

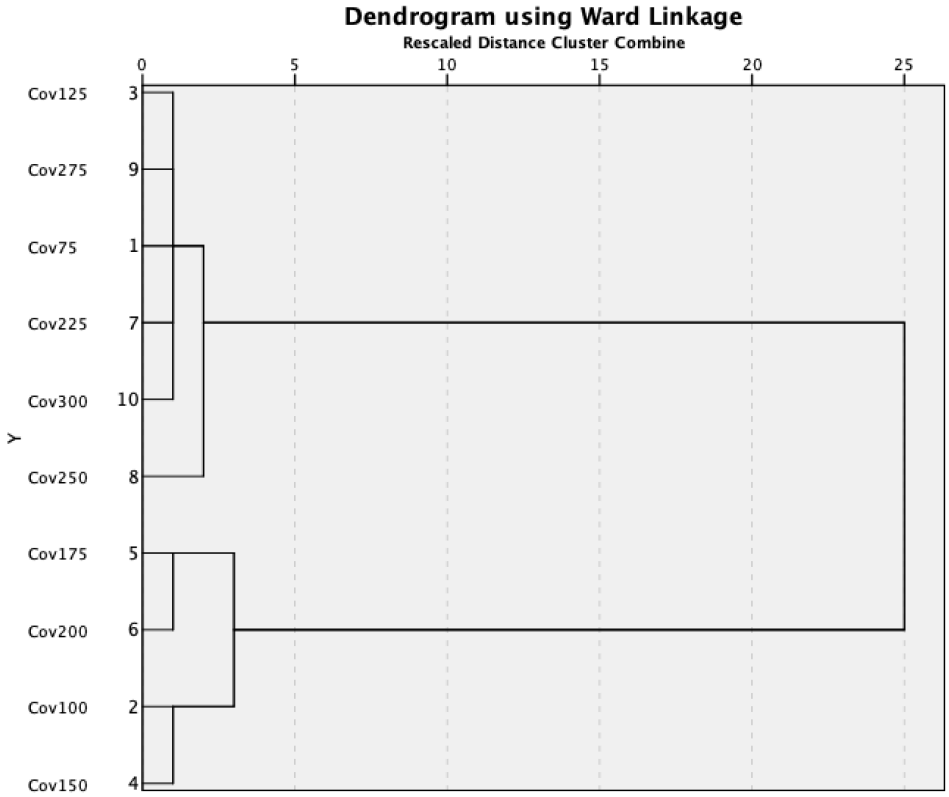

Figure 4

Resulting Dendrogram from cluster analysis of the data for the POV viewing condition.

With regard to the bird-eye viewing condition, with the same procedure as before for the POV viewing condition. In the case of the bird-eye viewing condition, the number of clusters is three (as in Figure 5). The Dendrogram shows that the distances of 175cm, 150cm, 250cm, 275cm and 300cm are assigned to the first cluster (as in Figure 6). The distances of 100cm and 125 cm are assigned to a second cluster and 75cm, 200cm and 225cm to a third cluster.

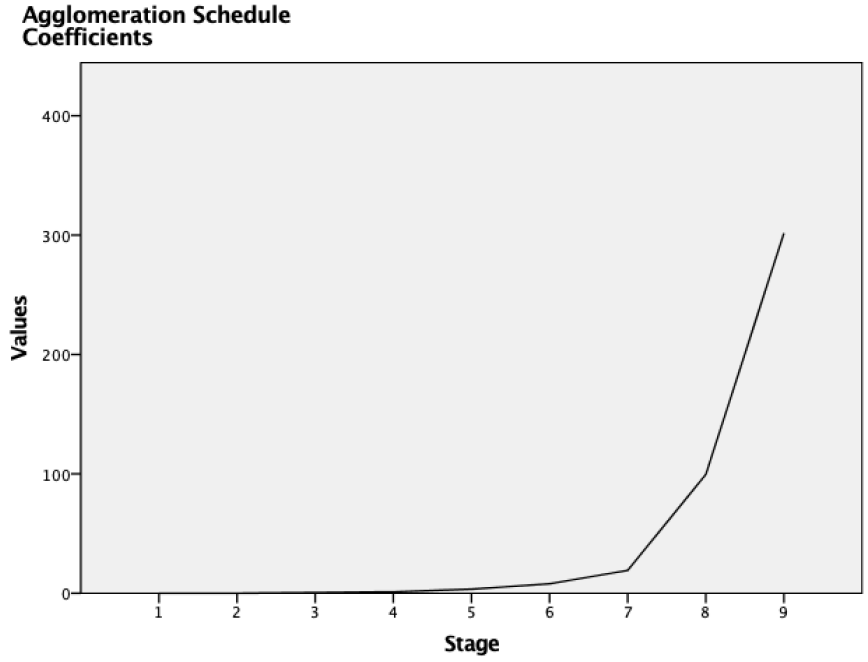

Figure 5

Resulting screeplott from cluster analysis of the data for the bird-eye viewing condition

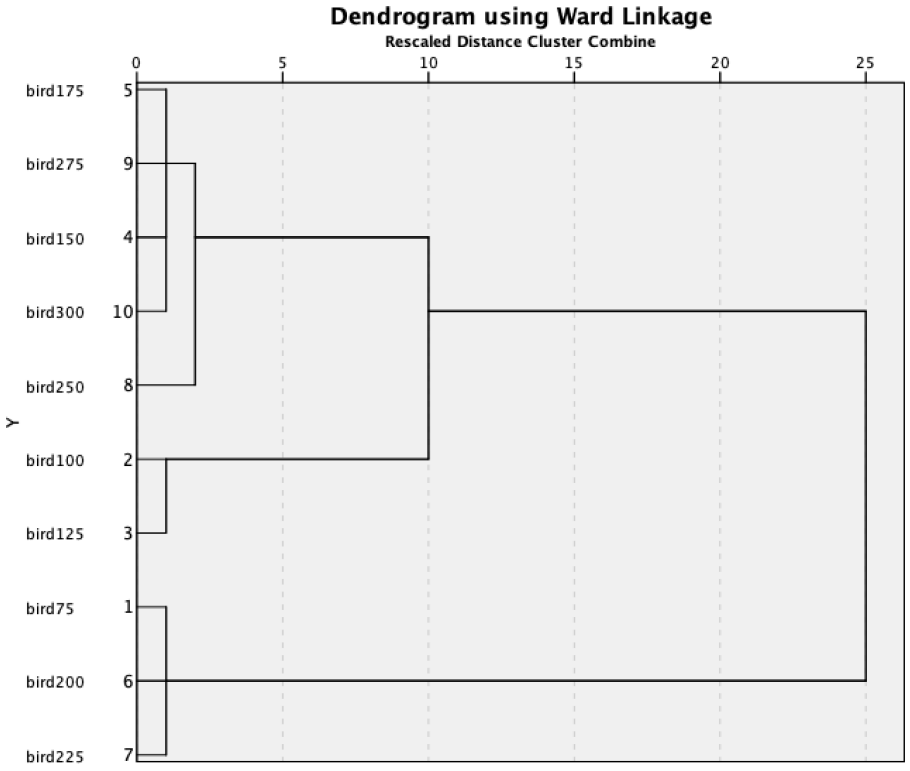

Figure 6

Resulting Dendrogram from cluster analysis of the data for the bird-eye viewing condition.

Discussion

This study aimed to investigate the preferences in regard to interpersonal distances and in context of interdependent teamwork. This was done through the implementation of a pairwise comparison. It took into consideration several distance conditions as well as viewing conditions.

With regard to the first research question, which was covered with patterns within the participants' preference for distances, several things should be mentioned. The scoring and ranking procedure of preferences assess a bandwidth that the majority of participants perceived to be most pleasing. This was the case for both viewing conditions. This supports the first hypothesis. The bandwidth implied interpersonal distances from 125cm to 150cm. In the light of existing research, it could be argued that this bandwidth of interpersonal distance refers to the inner part of the social zone. This appears reasonable when considering the kind of relationship people use to have in these zones. According to Hall (1957, as cited in Cristani et al., 2011; Hans & Hans, 2015; Nova, 2004) people use the social zone to have formal interactions with those they do not have a strong personal connection with. It can be interpreted that interdependent team members might experience a special working relationship, which is still formal and less close as the one people used to have with friends. As the personal distance tends to match the social relationship (Cristani et al., 2011) interdependent team members might use to have an impersonal relationship with each other, even though they are dependent on each other, identify them self to be part of the same team and hold a certain team culture (Kiesler & Cumming, 2002). However, existing theories not only offer a possible explanation for distance preferences but also for the dislike of distances. Both, too large and too close interpersonal distance can be experienced as uncomfortable in the context of teamwork. This might offer an explanation for participants' strong dislike of the largest distance (300cm). It might also explain the strong aversion towards the closest distance (75cm) in the POV condition. The direct experience of this distance condition might be experienced as a violation of personal pace

(Burgoon & Jones, 1976) or people expected to feel interrupted in their individual working processes (Kraut, Fussell, Brennan, & Siegel, 2002).

In general, this finding about the most preferred bandwidth of distances is in accordance with the theory of personal zones and the type of relationship people are expected to hold with interaction partners in these zones. Halls' Theory of personal zones ascribed the interaction of colleagues to the social zone. This research shows that interdependent team members seem not to be an exception of this. However, the aversion towards the largest interpersonal distance condition of 300cm shows that the preference of interpersonal distance is narrowed to the inner part of the social zone. Distance beyond the inner part seemed to be perceived as uncomfortable and dissatisfactory. This should be considered when designing workspaces for interdependent teams.

Moreover, the cluster analysis resulted in the identification of clusters in the preference data. For both viewing conditions the preference data can be clustered into multiple groups. However, it remains unclear why certain distance conditions were assigned to the same cluster. It was expected that distance conditions that evoke a similar degree of compliance across participants' preferences would be clustered together. This cannot be interfered with by the results of the cluster analysis. Therefore, no statement can be made about the second hypothesis, which implies that there are differences within the preference data concerning the compliance across participants' preferences for certain distance conditions. Furthermore, no statement about the third hypothesis can be made based on the results of the cluster analysis. The third hypothesis was concerned with the effect of the perspective (POV- view versus bird-eye view) on the preference regarding interpersonal distance between team members. Nevertheless, a statement about the effect of viewing conditions on the preference data could be made based on the scoring and ranking procedure of the preference matrix. There seem to be a difference even though a similar general pattern remains with the preference for interpersonal distances between 125cm and 150cm. It seems like the overall pattern is more

distinctly indicated, in the preference data of the bird-eye perspective. The high total scores are higher and the low total scores are lower in the bird-eye viewing condition when compared to the totals scores of the POV viewing condition. This might indicate that the direct experience created through the use of a direct perspective does change the experience of interpersonal distance in a way that leads to significant different results. This would disagree with the notion that a direct perspective and experience would result in different data and results (Hamilton & Thompson, 2007). People might be able to judge interpersonal distance without being actively social. However, formulate this as a generally valid statement, further research is required.

In conclusion this study was able to describe a range of interpersonal distances in the context of collocated working arrangements that was preferred by the majority of participants. Furthermore, it illustrated that people do have opinions on interpersonal distances, even though the differences are in a small range of distance and the distances are slightly different. This should be taken into consideration when designing work spaces for independent teams. Moreover, within this study a direct viewing condition did not create a direct experience that resulted in different patterns in the preference data.

Implication for further research

This study did not find differences in preferences for different viewing conditions possible using virtual reality. Due to that future research should further explore the effect of new possibilities with virtual reality such as the effect of direct experiences on proxemic behaviour and their perception of distances in different contexts. Knowing these effects is especially important when research aims to translate its findings from virtual reality to natural circumstances. Besides that, research should assess whether and how individuals' experiences with the pandemic circumstances due to COVID19 influences their perception of distances and proxemic behaviour on a long run.

Limitations

This study has several limitations which raise an objection to the generalizability of assessed tendencies. Firstly, a major implication is the appropriateness of the research method and its construction. Due to COVID19 this study could be done by using an experimental design. However, it is questionable whether the constructed questionnaire can be used as an adequate alternative for data collection. One reason is the lack of behavioural realism. Since the questionnaire uses static pictures, there is no behavioural realism given. Behavioural realism refers to a behavioural interaction with one's environment that is as close to that under natural condition. Nevertheless, behavioural realism is considered to be an important feature of the creation of an illusion of interaction between a participant and an avatar or agent (Blascovich et al., 2002). Furthermore, behavioural realism is thought to affect the participants' proximity behaviour (Blascovich et al., 2002). This influence of behavioural realism on participants' proximity behaviour illustrates the effect a lack of behavioural realism can have on the data. Another limitation with regard to the data collection method can be the risk of acquiescence bias. The acquiescence bias is a response bias, that describes the participants' tendencies to respond to a question without considering the content. This often appears when questions are worded and constructed in an identical or similar way. There might be a risk of this bias as this study used a questionnaire with 90 identical worded questions and identical sequence of pictures with one question (the closer distance option on the left picture compared to a more distant condition within the right picture). Together, the lack of behavioural realism and chance of acquiescence bias can be seen as a threat to the validity of the data collection method. This might also offer an explanation for the high number of incomplete responses. Lastly, there is doubt on the capability of participants who are living under extreme conditions due to COVID 19 and the compelling safeguards to judge interpersonal distances independently of the current circumstances.

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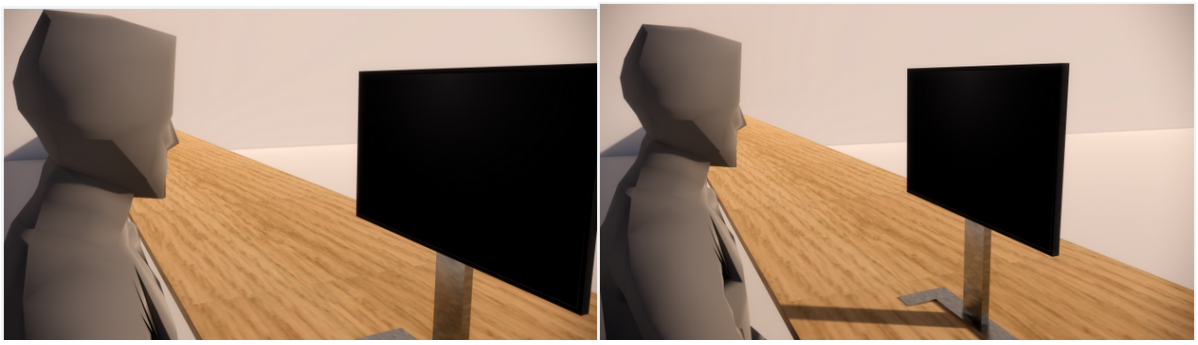
Appendix A

The questionnaire

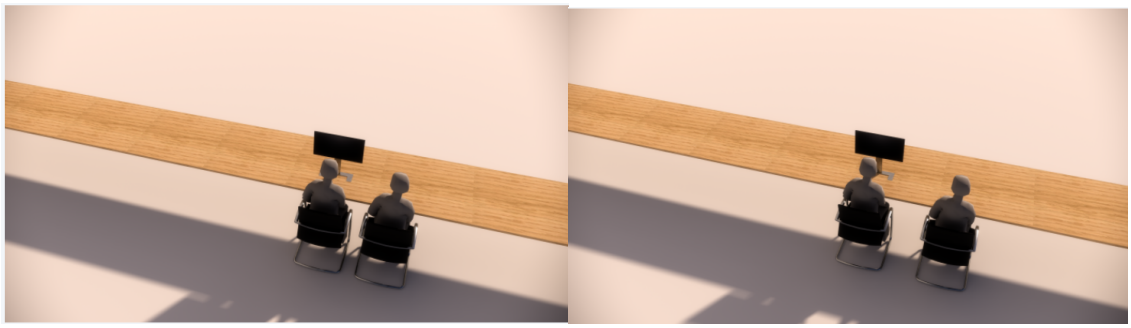
Question 1:
A: These pictures show you and your team member's workplace. Both pictures were taken from your perspective. With this case in mind, please compare the two environmental setups and indicate which one you perceive as more comfortable in the light of interdependent teamwork.

Which environmental setup for teamwork do you like better? Click on the picture you prefer.



Question 90:
These pictures show you and your team member's workplace. Both pictures were taken from the bird's eye perspective. With this case in mind, please compare the two environmental setups and indicate which one you perceive as more comfortable in the light of interdependent teamwork.

Which environmental setup for teamwork do you like better? Click on the picture you prefer.



Appendix B

Introduction to the study

This study is about personal distance. More precisely, it aims to assess the subjective feeling of comfort with the distance between you and another person in a teamwork situation. However, this perception of comfort might be changed due to the CoronaVirus, which is not part of this study. Therefore, imagine the following case:

Think back to the times before we had to take care of interpersonal distance due to the Corona-Virus. Therefore, you do not need to do social distancing, meaning to keep a distance of 1,5 m between you and others. Being closer to others would not be a risk to your health in this particular study.

Based on that, imagine you are part of a two-person team. You know your team partner well and you work together every day. Your work is interdependent, which requires that you and your partner check upon each other's work, support each other and make decisions together. Therefore, you should be able to watch your partner's desktop and to communicate with each other.

Keep this in mind when you answer the following questions.

Appendix C

Distance Matrix

Figure A1

Distance Matrix for the POV perspective condition

Distance	75	100	125	150	175	200	225	250	275	300
75	0	24	1	20	15	15	4	8	1	3
100		0	11	4	1	1	5	6	16	15
125			0	8	7	14	18	21	22	21
150				0	19	23	20	26	26	29
175					0	19	23	26	30	28
200						0	19	29	28	31
225							0	30	28	30
250								0	22	27
275									0	29
300										0

Figure A2

Distance Matrix for the bird-eye perspective condition

Distance	75	100	125	150	175	200	225	250	275	300
75	0	17	14	10	8	0	1	5	8	9
100		0	7	5	8	10	12	14	22	22
125			0	13	17	21	22	19	22	21
150				0	24	22	31	27	29	30
175					0	26	27	28	26	28
200						0	24	25	32	33
225							0	24	28	34
250								0	22	26
275									0	20
300										0