Virtual Environments and Human-Computer Interaction Anxiety: An Experimental Study

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ABSTRACT

In a world where interaction is a significant part of everyday life, personal space (PS) – an invisible bubble surrounding human body - is important. This is because PS functions as a comfort zone during interaction, a factor in designing physical environments, and invading such space produces anxiety and discomfort. Little is known, however, about how personal space might operate in virtual environments and what features the interface model of these environments should incorporate in order to reduce the anxiety produced by the invasions of such space in these environments. To begin to address this, we have conducted two experiments concerning personal space invasions (PSI) in collaborative virtual environments (CVE). Results suggest that reactions to PSI in CVE tend to differ in various ways from reactions to PSI in the physical world though some participants experienced anxiety when their avatar personal space was invaded. Recommendations to incorporate some features in the interface model of these environments are presented.

Keywords

Collaborative virtual environment, personal space invasion, anxiety level.

1. INTRODUCTION

Personal space (PS) in the physical world is an area with invisible boundaries surrounding individuals which functions as a comfort zone during interpersonal communication [Dos69][Aie87]. It is influenced by many factors such as age [Hay83], culture [Aie87], gender [Gif96], and environmental factors such as room size [Eva96] , room ceiling height [Coh84a], and environment location (i.e. indoors or outdoors) [Coh84b]. Personal space is often referred to as "interpersonal distance" – the distance apart from each other that conversational partners adopt. Personal space invasion occurs when an individual enters another's personal space and thus produces discomfort and anxiety. The concept of personal space invasion anxiety level (PSIAL) refers to the degree of anxiety generated from an invasion of someone's personal space.

The study of personal space is of crucial importance, as evidenced by the fact that designs in the physical world take account of personal space issues.

Wiles [Wil78] for example found a relationship between the personal space allocated and the anticipated time of the event; thus telephone booths are allocated small space because the time people spend in them is little whereas homes for the elderly and prisons are allocated much larger spaces. Further, interpersonal distance can influence the level of understanding between interactants. Latan [Lat95] found that the further individuals are away from the source of communication the less influence it has over them. In medical clinics, people are more forthcoming when there is about 5ft space between themselves and the therapist. Moreover, [som58] found that altering the layout of chairs from being in rows in a clinic to being in circles increases the level of interactions between the patients. Clearly, then, personal space is an important issue in people's

lives in the physical world. As people start to spend more time in the virtual world, it is important to investigate whether personal space exists in these environments and if so, how designers of the virtual worlds should seek to cater for it.

The rest of this paper is organized as follows: section 2 presents the research goals of this work. Section 3 reports on an experiment that was conducted to investigate the influence on personal space of avatar gender. Section 4 reports on an experiment that was conducted to investigate the influence on personal space of the virtual environment layout. Section 5 discusses the obtained results. Section 6 provides a summary of the research re-iterates its conclusions, and makes suggestions for further work.

2. RESEARCH GOALS

There is some evidence to suggest that the concepts of personal space and PSIAL have indeed been transferred to collaborative virtual environments. For example, [Bai01] conducted an experimental study in immersive virtual environments (IVEs) and found that individuals avoided violating others' personal spaces. Sommer [Som02] and Krikorian et al [Kri00] found similar results. Becker and Mark [Bec98] found that people in a desktop collaborative virtual environment that is accessible from the internet get annoyed if another avatar comes too close. Jeffry [Jef98] observed the same virtual environment as Becker and Mark for several weeks and noticed that individuals sometimes maintain a distance between their avatars when they are interacting and tend to show some discomfort feeling when other avatars invade their avatar personal spaces. Despite the above research results, however, much is still unknown concerning PSIA in CVEs, and the research outlined in this paper seeks to address some of these unknowns. For example, what are the reactions of the CVE users to PSI? Do CVE users keep a comfort zone when they are interacting? Does avatar gender affect the PSI reaction in the CVEs? Further, with regards to environment architecture, does the environment's layout affect the PSI reaction in the CVEs as it does in the physical world and if it does, how should CVE designers manage it in order to design highly effective CVEs? In order to answer these questions, "*The Avatar Gender*" and the "*Environment Layout*" experiments have been conducted by the authors in ActiveWorlds[1], an internet based CVE, to investigate respectively the impact of avatar gender and the environment layouts on PSIAL in the CVEs

[1] www.Activeworlds.com

3. THE AVATAR GENDER EXPERIMENT

In this experiment participants, of both genders, had their avatars' personal space "invaded" by another avatar of (either the same or the opposite gender), and reported their anxiety levels through the use of a post experiment questionnaire. The experiment was conducted to investigate the effect of gender on the PSIAL in the CVEs, as several studies have shown that gender has an impact on the personal space in the physical world [Bur98]. Such studies have suggested that (a) females interact at closer distances than male only groups [Aie71], (b) mixed-gender groups interact at closer distances than male only groups [Bax70], (c) females allow closer approaches from others than males allow [Pat87] and (d) female and mixed-gender interactants use touch more than male only interactants [Eli75]. Similarly, Hewitt and Henly [Hew87] identified an order for the four gender combinations of personal space invasion in the physical world: men allow women to invade their personal space to the highest degree, followed by women allowing other women to invade their personal space, then men allowing men to invade personal space, and finally women allowed men to invade their space the least.

The avatar gender experiment involved 40 participants, each of whom had their avatar's personal space "invaded" by the avatar of a further participant - a "confederate" - who was acting under instructions from the researchers. The invasions took place in an already built virtual environment using ActiveWorlds; see Figure 1 for a room in this environment.

Figure 1: A room in the virtual environment where invasion occurred

The results of the experiment suggested that the combination of the gender of the invading avatar and the avatar being invaded did have an influence on the personal space invasion anxiety level. The

descriptive statistics of anxiety with the means and 95% confidence intervals of each gender invasion group are shown in table 1 where, for example, 'M-m' indicates a male avatar invading another male avatar's space, and 'M-w' indicates a male avatar invading a female avatar's space. In this table, the anxiety means of all the groups are either negative or near the value 0 - an indication that the participants in general did not register anxiety when invaded, and indeed tended to be positive about it.

	N	Mean	Std. Dev	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
M-m	10	2.10	8.36	2.64	-3.88	8.08	-11	17
W-w	10	-.90	7.81	2.47	-6.49	4.69	-14	13
W-m	10	-6.50	10.80	3.42	-14.23	1.23	-25	8
M-w	10	-10.50	5.36	1.69	-14.33	-6.67	-21	-4

Table 1: Descriptive Statistics of Anxiety and Gender Combination

Figure 2 presents the graph for the anxiety level split by gender combination. It shows that the anxiety level of the pair man-man is the highest followed by woman-woman, then woman-man, and finally man-woman. Interestingly, this rank order of gender combinations in terms of anxiety felt differed markedly from that found in the physical world.

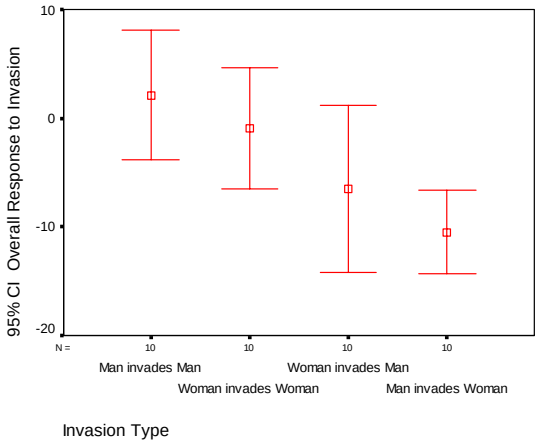

Figure 2: Anxiety means and 95% confidence intervals for gender combinations.

The findings from this experiment suggested that avatar gender combination had an influence on the personal space in the CVEs, the ranking of avatar gender combination groups had a striking difference from those observed for personal space invasion in physical environments, and the participants in general did not register high anxiety as might be expected from personal space invasion in physical environments.

4. THE ENVIRONMENT LAYOUT EXPERIMENT

This experiment was conducted to investigate whether the environmental factors that influence personal space in the physical world remain valid in the CVEs. Within the physical world, personal space is influenced by environmental factors such as room size, room ceiling height, and environment location (i.e. indoor or outdoor). Research studies show that the interpersonal distance is increased in small rooms compared with large rooms [Eva96], low ceiling rooms compared with high ceiling rooms [Coh84a], and indoor environments compared with outdoor environments [Coh82b].

In order to investigate how such environmental factors might affect PSI in a virtual world, 8 participants were "invaded" in differently already designed rooms (and also "outdoors") within a CVE and subsequently interviewed about their experiences, see Figure 3 for the virtual rooms.

Figure 3: The environment for the "Environment Layout" experiment

Results from this experiment suggested that the reaction to PSI of some participants (3/8) was strong anxiety. Indeed, one participant stopped the experiment and left the environment because of close proximity. Other participants (2/8) reported mild anxiety and the rest of the participants (3/8) reported no anxiety. All of them expressed a preference to keep a distance between their avatars during conversation.

The following are some excerpts from some of the online interviews where "Exp" stands for experimenter and "Part" stands for participant.

Exp: what was your feeling when I was close to you?

Part 5: well .it feels like in real life. U were a bit to close to me. we do not stand that close in AW [ActiveWorlds] and chat normally. We stand in this kind of distance like now as i real life

(Participant No 7 ran away in the middle of the experiment, even though the conversation had not finished)

Exp: why you run away?

Part 7: because you were standing too close.

Part 7: standing so close makes me uncomfortable

Exp: what was your feeling when I was close to you?

Part 8: People never stand close like that

Importantly, though, the data suggests that the virtual environment's layout has no effect on the personal space invasion anxiety level, contrary to what would be expected from equivalent research in the physical world in which personal space is influenced by environmental factors such as room size, room ceiling height, indoor or outdoor. The proportion of people expressing anxiety does appear higher in this experiment than the previous experiment. A possible explanation is the difference between the two virtual environments for the experiments. The virtual house of the "Avatar Gender" experiment appeared furnished and the virtual house for this experiment appears completely unfurnished. This is an environmental difference that may influence the perceptions of the users and hence the level of anxiety they felt. Another explanation for the difference of anxiety reported between this and the previous experiment is that the participants of this experiment are anonymous to the experimenter (i.e. the experimenter has not met them in the physical world). This context of anonymity might make the participants behave differently as they are less concerned about the judgement of the experimenter (Fenigstein, Scheier and Buss, 1975). Another possible explanation is that the participants of this experiment were authentic AW users, not students artificially introduced to AW as in the previous experiment.

5. DISCUSSION

Caution is needed when considering the above results, for at least the following two reasons. First, participants in the experiments were not able to express their feeling at the time of the invasion, rather they reported it after the experiment, and as such they may have forgotten the exact nature of the feeling when it occurred. Second, ActiveWorlds users can communicate only through text messages – voice messages are not supported. This might also affect the results as the participant might be busy with typing at the keyboard when the confederate's avatar was invading his/her avatar personal space and thus may not notice such an invasion. The switching of attention between the screen and the keyboard may also reduce the participants' degree of immersion in the environment.

Nevertheless, our results may suggest implications for the design of future collaborative virtual systems interface model. In the physical world people are generally well-rehearsed at avoiding invasions of the space of others, and at taking evasive action if their own space is invaded, for example by turning their orientation away from people who approach too close from the front, or moving physically away. Further, as suggested in section 1 above, many aspects of design in the physical world take account of personal space issues.

If collaborative virtual environments are to be successfully used, it may be necessary to reflect these two approaches to personal space management – reliance on the individual and supportive environmental design – in the virtual environments interface model. Our results suggest that this will not be easy, partly because PSI in a virtual world may not straightforwardly parallel PSI in the physical world, and partly because there appear to be large variations in individual responses to invasions of personal space. Our results also suggest that means of fine grained and easy avatar movement should incorporated in the virtual environment model, so that (a) they can easily, e.g. via one mouse click, move their avatar away to adopt a new comfortable interpersonal distance and (b) they do not inadvertently invade the personal space of other users (as sometimes happened in the avatar gender experiment).

6. CONCLUSION AND FURTHER WORK

The outcomes of two experiments about personal space invasion in CVE have been discussed in this paper. The results of the avatar gender experiment suggested that the participants in general did not register anxiety as in the physical environments. The results of the environment layout experiment suggested that some participants reported high anxiety while the rest either reported low or no anxiety, but there was no evidence of any effect of the environment's layout on levels of anxiety felt.

Further work involves related studies in other virtual worlds, in an attempt to provide a generality test of the present results. In particular, the interaction model of the CVE used for the two experiments does not provide facilities such voice messaging and facial expressions. Thus, further work in this regards is to investigate the personal space invasion reaction of the users in a CVE that does provide such facilities in its interaction model. Another aspect of our further work is to investigate

whether CVE user experience influences personal space in the CVEs.

The results obtained in this research may to some extent be peculiar to ActiveWorlds, rather than CVEs in general. Therefore, a further research investigating other CVEs would generalise these results. However, the current results remain relevant to any CVE which adopts similar interface policies to ActiveWorlds.

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