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Constructing Social Spaces in Virtual Environments: A Study of Navigation and Interaction

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ABSTRACT

Virtual environments introduce a new type of space that people inhabit. Two virtual worlds, Active Worlds and Onlive Traveler were observed to investigate how social norms involved with personal and group space, privacy, crowding and territoriality affect people during interaction and navigation. The results parallel many findings on social norms in physical environments. People were disturbed when their personal and group spaces were violated and when spaces were crowded. Privacy was also indicated through positioning and other signals. The results suggest that virtual environments are perceived by people as a social space.

Keywords

Navigation, personal space, virtual environments, social behaviour, avatars

SOCIAL NORMS IN PHYSICAL AND VIRTUAL SPACE

Collaborative virtual environments are gaining visibility as new arenas for interaction, and consequently, as new areas for scientific investigation. How people move through virtual environments, approach others, position themselves in relation to others, and establish their own boundaries, is affected by how such a space is perceived. Understanding how individuals make use of their space during social interaction creates a deeper understanding of the environmental role in behaviour. The regulation of behaviours that occur in relation to the environment, i.e. personal space, privacy, territoriality, and crowding, are necessary to maintain a preferred level of interaction and communication within one's social world. Altman [2] describes this regulatory process as interpersonal control.

In this paper we are interested in examining the relationship of an individual to the space that they inhabit in a virtual world. Behaviour in this space is affected by numerous factors: the presence of others, one's ideas about the space, desire for privacy, and the functionality available in the system to navigate and position oneself in this space.

Personal Space

In order to understand social behaviour in a virtual space, we can draw upon research that has investigated how people behave toward each other in physical space. During interaction and communication, one perceives the immediate space around one's body as personal. The study of people's personal space is called proxemics [20, 21], and focuses on the societal use of personal space, comfortable interpersonal distances, and self-protection from violations. Personal space may be defined as an area with invisible boundaries surrounding an individual's body which functions as a comfort zone during interpersonal communication [11, 25, 34, 42].

Personal space, a portable territory according to Sommer [38], may disappear in certain environments such as a crowded subway car or elevator. It is not spherical in nature as it is believed to be disproportionally distributed in front of a person rather than in other directions [18]. Various analogies have been used to describe personal space, such as a bubble [27], an aura [42], or an electrical field [25].

Personal space is a social norm; negative and emotional reactions occur with violations. Generally individuals choose to navigate around rather than violate others' personal spaces, whether they are interacting in groups, dyads, or as individuals. Cheyne and Efran [8] found that people are more likely to avoid two confederates engaged in conversation than when the confederates were inanimate objects. Emotional reactions have also been observed with individuals whose personal space has been violated, ranging from disbelief to actually leaving the environment [16]. There is significant support for the belief that stress occurs when one's personal space has been violated, both in crowd situations [43] or when alone [21]. Studies have also found that people are uncomfortable when violating personal space

between two conversing people [13, 14] or the interpersonal space in a group [3, 9].

Group Space

A group consists of two or more people usually face-to-face, who over a time period, influence each other during social interaction and interpersonal communication [18, 26]. Groups, similar to individuals, also surround themselves with an invisible area that functions as a boundary during group interaction [18]. Edney and Grundmann [12] labels this area as group space. Invasions of group space have been reported with large physical distances separating group members [9] or when the group is mistaken for a crowd [29]. The number of group members determines group physical size as group space is perceived to increase as group membership increases [27].

Group membership was originally documented by Sumner [41] who coined the terms 'in-group' and 'out-group' which refers to social groups that an individual belongs to and doesn't belong to, respectively. The degree of identification with in-group membership depends on the level of group cohesiveness (i.e. the strength of the intragroup relationship linking group members to each other and to the group as a whole [18]). Groups are not isolated units; group membership and group cohesiveness are influenced by the environment [18].

Privacy

Similarities may exist between personal space and private space during intimate communication. Definitions used to describe privacy include: selective control by individuals or groups of one's personal information; one's degree of interpersonal communication; and one's level of social interaction [2, 42]. An imbalance results when one's perceived level of social interaction differs from one's optimal level. Altman [2] refers to these nonoptimal privacy states as crowding (higher levels of interaction than optimal) and social isolation (lower levels of interaction than optimal). He suggests that desired levels of privacy are established with perceptual or behavioural adjustments; for example, using verbal communication (I want to be alone) when a nonverbal signal is ineffective (i.e. sitting alone in a room with a closed door).

Territoriality

Unlike personal space, which only involves an invisible area surrounding an individual, territoriality reflects the personalization of, or marking of an area or object, in order to communicate individual or group ownership [2]. Personalised environments exist in the physical world for regulation of societal behaviour, (i.e. special areas for eating, sleeping and socialising within societies). Territorial encroachment may result in social conflict as behavioural reactions are triggered in order to repel effectively an undesired boundary crossing [2, 28, 36].

Altman [2] classifies territories as primary, secondary and public. Primary territories (i.e. one's bedroom) are central areas in one's daily life that are permanently controlled and exclusively used. Secondary territories (i.e. a neighbourhood bar) are less central and access is less rigidly controlled. Public territories (i.e. community park) are freely accessible for everyone to use on a temporal basis provided one's behaviour adheres to social norms. A community park is a metaphor for a virtual world because of the open physical environment, opportunity for conversation and unrestricted access for community members.

Crowding

Adding individuals to a physical environment may affect how current individuals perceive their amount of space. Crowding is a psychological perception characterised by feelings of personal space violations as one's current level of social interaction is higher than preferred [2]. Stokols [39, 40] refers to this as social crowding. Knapp [25] cites contributing factors to one's perception of being crowded: type of environment (i.e. elevator vs. community park); personality and prior experience with crowds; number of participants (i.e. one, few, community); and social relationship (i.e. friend vs. stranger). Coping behaviour is a natural reaction to reducing stress by either changing one's perception of the situation or leaving the environment [2]. Research on crowding has reported stress reactions and anxiety-coping behaviour in densely populated natural environments including college dormitories [3, 39] and downtown city centres [6].

Guidelines outlining appropriate behaviour, or societal norms, serve to govern what one does within common spaces through interaction and communication. Norms emerge through social contact as people learn acceptable and unacceptable patterns of behaviour [27]. A park is an example of a public space used by members of a community. Common spaces such as benches, walkways, and plazas provide opportunities for social interaction. However, the opportunity to interact with others, independent of physical location, is enabled with 3D virtual environments. The designs of such collaborative virtual environments are developed with the goal of creating spaces to facilitate interaction. Metaphors used in these designs are based on what a public park might offer: common spaces, common rooms and public market squares [e.g. 1, 32].

RESEARCH GOAL

In the same way that personal space and group space, as social norms, are affected during interaction in the physical world, we may also ask how personal and group space are affected as people interact and navigate within a virtual world. Navigation consists of movement through a space; how one relates to the space they inhabit and others who share it through movement and positioning, is the main concern of this paper. We refer to this idea as social positioning.

What makes this study especially interesting for us is that in the virtual world, functionality exists which enable people to both mirror their actions in the physical world, such as the ability to communicate, and to do completely new actions, such as flying.

This paper is part of a larger research study in which we have investigated the attributes and conventions that correspond between the physical and virtual worlds. In this paper, we

report on the aspect of social positioning in a virtual world: we wanted to investigate whether personal space is also used in a virtual world as a means for people to regulate their behaviour by maintaining a comfortable distance for interpersonal communication. However, given the differences between the physical and virtual worlds, if such a personal space exists, we were interested to study how it might be expressed.

METHODOLOGICAL APPROACH AND RESEARCH SETTING

In this study, the effect of social positioning is reported from observing two different on-line environments: Active Worlds [1] (**AW**) and Onlive Traveler [2] (**OT**). Both environments are accessible from the Internet. These environments were chosen primarily since they have been in existence for over one year and offered different functionality for communication and representation, and thus, we expect, for the expression of social conventions. The main differences are that OT has graphical 3D representations and offers text and audio for communication, and AW has graphical 3D representations and offers only text for communication. The basic functionality available for the representations and communication is:

AW: full-bodied avatars can walk and exhibit movements of waving, jumping, and dancing, activated by mouseclicks. Avatars can move in three dimensions by using the arrow keys. Communication between people is text-based by typing on the keyboard. All public messages appear in a scrollable window and also above the avatar's head with the avatar's name for 30 seconds or until the next typed message appears.

OT: the avatars are heads, and have four different emotions that one can activate by a mouseclick: happy, sad, surprise, and anger. The avatars exhibit what appear to be random blinks. Movement (three dimensions plus rotation in four directions—left, right, forward, and backward) is made by using arrow keys. Communication is audio (outgoing audio is activated by pressing down the control key and speaking into a microphone) or text-based (pulling down a menu, selecting an avatar, and typing into a message which appears on the screen). The text is limited to two lines.

Two different researchers spent approximately 40 hours in total observation time: 21 hours in AW, and 20 hours in OT. Each observer was primarily responsible for recording observations in one particular environment, but each observer also spent time in the other environment to become familiar with it. Although the on-line characters adopted by the researchers were varied somewhat, most of the time the same on-line character was used during the time spent in the environments. The observations were made during September-November, 1997. The observers met periodically and compared observations to make sure that the categories were being coded consistently. On-line recording and logging was not performed due to privacy concerns.

To investigate social positioning, we were interested to what extent the notion of space in the physical environment, and what types of behavioural expectations [22], transfer into a virtual environment. The following behaviours were coded: 1) Is a certain social distance kept? 2) What happens when this distance is violated? 3) How is social positioning used to welcome others into a group? 4) How is social positioning used to exclude people from a group*?* 5) When people move through the environment, do they disturb others' personal spaces?

The following actions are possible within the environments, with the available functionality: (AW): arrow keys move the avatar; combined with the control key, the speed is increased (OT): arrow keys move the avatar; in conjunction with the shift key, the speed is increased; double clicking on another's avatar brings one face-to-face with them at a distinct distance; selecting the "go near" command brings one close to an avatar anywhere in the space, but one is not in front; avatars can move backward and forward to adjust their distance.

RESULTS

Personal Space

We observed in both virtual environments that communicating avatars kept a distinct physical distance between themselves. Invasions of personal space occurred when the Observer **(O)** positioned the avatar face-to-face in extreme close proximity to another avatar. Generally we observed reactions to this violation of personal space, and they mostly expressed discomfort. One example of discomfort occurred when, after limited conversation, O moved directly in front of another avatar eliminating the physical distance. Immediately the other avatar navigated back and maintained a slightly larger distance than had been previously observed during communication between avatars. The response of the avatar's owner expressed by both verbal responses and behavioural reactions confirmed her discomfort:

> *Laracat: This is a nice distance to keep....:)*
>
> *Laracat: ...[I backed up] the same way I'd back up if a "real" person got up too close....someone I don't know very well*

Another example of discomfort occurred after a lengthy conversation; O moved directly in front of another avatar removing the physical distance. Twice, the other avatar moved back two steps and twice O removed the existing physical distance. His verbal response confirmed his discomfort.

> *Moon [avatar name of O]: Is this too close..☺*
>
> *Spike G: [moves back]hahaha*
>
> *Spike G: Moon I can't breathe*
>
> *Spike G: I hardly know you*
>
> *Spike G: Moon...ppl [people] will see you....cut that out*

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[1] Copyright © 1995 - 1998 Circle of Fire, Inc.

[2] Copyright © 1994 - 1997 OnLive! ™ Technologies, Inc.

*Spike G: *blushing**

Spike G: [to everyone] Moon is...um....naked and....well....touching me basically...

In both instances of discomfort, there was no observable response from the other avatars surrounding them. Some other verbal reactions included:

Moonbeam, you are so forward

Don't feel like having sex right now.... hahaha

You're being politically incorrect

I come from the Midwest. In the Midwest, we maintain a social distance of 28 inches

In one case in OT, an avatar did not move away. O (female) asked avatar (male owner) if he minded her being so close. His answer: *"No, I like it"*. Sometimes avatars in OT moved very far away quickly in the distance (using the shift key for a fast getaway) as a response, or they turned the avatar to the side.

Awareness of personal space seemed to exist with people of different cultures. After some discussion, O approached closely an avatar owned by a Japanese woman. The avatar did not move, so O asked the avatar if she felt O was too close. The avatar politely replied, *"Oh, I will move back"*, and promptly did.

In one case, the invasion of personal space in OT became harassment. A female was subjected to offensive language by a male, and the male avatar began to ram itself into the female avatar. The female reported that a friend of hers was close by who promptly got a support person who disconnected this avatar. The female reported to O that this experience was quite emotional for her, "*like a nightmare*".

The reactions to closeness could also be due to blocking an avatar. While the comments indicate otherwise, to test this hypothesis, in OT, O moved close to others but stood to the side, so as not to block the view. The same reactions still occurred. In AW, the text above the avatars overlaps when the avatars are too close, but text also appears in the window below. The comments suggest that it is not the text overlap that people are annoyed about since their comments have more to do with a social distance being violated.

Although sometimes verbal responses indicated that people were not bothered from personal space violations, their behavioural reactions indicated otherwise:

Wicca: doesn't bother me in here, just in real life

The avatar immediately moved back to establish a physical distance.

O: Does this [my position] bother you?

Equip1: Not at all Mango[avatar name of O]

A short time later this avatar moved on to another location.

After speaking to another avatar, for 5 minutes with a comfortable physical distance, O moved face-to-face, removing the physical distance. When asked, the avatar did not admit being affected and this is confirmed by his behaviour as the avatars remained in extreme close proximity for the duration of the conversation.

Drew21: no, not bothered, we have been talking for a few minutes, so I know you are not getting in my face

However, in spite of the avatar not minding the closeness, the avatar's comments did indicate that he was aware that his personal distance was being violated.

Group Space: Positioning and Movement within a Group

We observed that in AW, the relative distance between avatars in face-to-face conversation increased as the size of the group increased, from two avatars up to three or four. When additional members navigated into a group, the other members repositioned themselves, expanding the group's physical space and relative personal space. The physical shape was determined by the size of the group: two avatars formed a line, three formed a triangle, four formed a diamond, and larger groups adopted a circle-shaped form.

Group membership, especially in OT, was generally indicated by the avatars positioned face-to-face. When a new person was accepted into a group, the other avatars always repositioned themselves to make room for the new member.

However, it was also observed that avatars who interacted sometimes moved together using the same motions. This seemed to indicate group membership, such as simultaneously flying up and down in rhythm (i.e. bobbing vertically), walking together, or teleporting together. These interactions would generally be casually initiated, such as:

Weagan: wanna go look around...follow me [on foot]

Tully: Mango[avatar name of O], wanna go flying now?

Tully: Mango: Let's go in America...just follow me [teleport with me]

Dancing together also occurred. In AW, interacting avatars clicked to activate their avatars to dance, or to show happy gestures by jumping up and down. Simultaneous movements of group members sometimes served to create a "social boundary" separating the group from others. In OT, a dance was simulated by the avatars moving back and forth together using the arrow keys. During a dance, another avatar tried to join in the dance but was not acknowledged. Other simultaneous movements including rotating towards avatars in the same direction while speaking to each other. It was noticed that no other avatars approached the group during this conversation.

One particular avatar expressed her happy dance often to extenuate her conversations in an effective manner. Her happy dance was unique consisting of 2 twirls, a jump in each direction and a final twirl at the end.

Mango [avatar name of O]: Where are you from?

Andi: Los Angeles [happy dance]

Mango: cool, what was that dance?

Andi: my happy dance [happy dance]

Mango: use often

Andi: yes, all the time, I like it [happy dance]

Mango: I think you are the first person I've met to use effectively emotion buttons

Andi: I really like them, I wish other people would use them more often!

Privacy

In both environments, while the avatar positioning indicates that people are speaking in a group, other visual information also signalled that the conversation was private. Avatar positioning is sometimes also used to indicate a private conversation, in this sense creating a privacy marker. For example, two avatars turned completely upside down signalled that they were having a private conversation (with their own common perspective). This was confirmed when O (who was right side up) approached them, tried to join in, and was not acknowledged. Joint movement can also indicate privacy. Two avatars in a group that O approached moved below the floor to a semi-hidden location. Another example of a privacy marker was when two avatars were positioned face-to-face in close proximity.

Avatars were also observed physically separated from the main gathering points either vertically or horizontally. For example, two avatars conversing far off in the distance from the main area signalled to observers that a private conversation was occurring. Attempts at communication usually resulted in non-response or the avatars leaving to another location. For example, when O approached two avatars, Lass and Lila, who were face to face engaged in conversation, O's greeting was ignored. O later observed they were engaged in an intense conversation and so did not respond.

O once positioned herself at a far distance from the central part of the environment. Occasionally O received text messages from people who said hello, but no avatar approached.

In OT, private rooms can be established, and passwords can be used to insure privacy. O once entered a private room where two people were conversing. O remained below the two avatars. One avatar looked down at O but did not acknowledge O.

Social Navigation: Moving through the Landscape

In AW, which uses the metaphor of a landscape, "magic features" [10] such as teleporting were used to ease navigational movement. People usually selected the navigational method which required the least overhead to travel to a particular point. For large distances when the end-point destination was known by co-ordinates, teleporting occurred and for medium distances, flight. For short distances, walking occurred around common areas of congregation such as 'ground zero' (the landing point when teleporting in) to navigate between groups. Billboards are available, that when clicked on, will transport one to another location such as another world or to an avatar's house.

In OT, although awareness information existed in the form of a list, which showed who was present and where in the environment (on a map), it was often observed that people roamed through the environment with their avatars. Rotating the avatar around was often used to see who was in the environment. Scanning by rotation was often used when an avatar first approached a group. Since peripheral vision is limited, it was used as a way to make sure that one's avatar was not blocking another. If an avatar would notice that they were in the centre of the group, they would pull back.

Although physically possible to pass through avatars, it was seen as rude and impolite and this behaviour was not observed very frequently. The comments of some people support this:

SweetN: I try to avoid walking through if I can...rude if you walk through

Wicca: walk through [avatars] only if I have to

Gary: I try to walk around

Crowding

In AW, a large number of avatars concentrated in the immediate vicinity of one's avatar led to a number of noticeable difficulties. The ability to effectively navigate without violating the personal space of others decreases significantly as the density of avatars increases. Since conversation in AW appears as text over the head of the avatar, when avatars were spaced too closely, the text would then become difficult to read since it overlapped. Monitoring one's own conversations, understanding the thread of other conversations, or maintaining conversations with more than one person could become quite difficult. One user commented that she did not like crowding:

Jen13: Mango, im going to go away from here, I am walking south

Mango: can I follow, Jen

Jen13: yes, okay MANGO

Jen13: I never stay there [teleport location into Alpha Worlds called ground zero], too crowded.

Crowding in OT was not observed to be a problem. Groups generally maintained a generous space between them. One reason could be due to the spatial audio. If one is too close to another group, their conversation will interfere.

Territoriality

In AW, the virtual world can be seen as a public place where inhabitants can navigate, create personal structures such as homes and use these homes for social gatherings. As a public space, one feels a part of the world as a regular participant because the environment and individuals present increases in familiarity with each visit. Building a home provides an opportunity to showcase one's craftsmanship, and create a feeling of ownership as the home is a territorial marker for a virtual habitat.

Jazzman: Have you built anything

Cremecheese: Yes Jazzman, I have a house here

Jazzman: Care to show me

Cremecheese: Click on me, add me to your contact list [member feature allows one to join a member of one's contact list in their world]

Jazzman: got ya

Cremecheese: Okay, I'll teleport there and you can follow

Zelanquin: I have a place in AW, gleb[another avatar], want to take a look

Zelanquin: the coords are 6S 1839W I think

Zelanquin: you're welcome to come too mango [avatar name of O]

Building a home leads to an interesting dilemma as to whether it is proper virtual etiquette to visit someone's home when it is unoccupied or whether a home is off-limits unless given an invitation. The example show a frequent home builder seems undeterred by uninvited visitors.

Mango [avatar name of O]: CaRyan...have you built a house here

CaRyan: several

Mango: Does it bother you if people wander through your house without an invitation?

CaRyan: No

Mango: Do you feel that your house is a public place here like the physical world?

CaRyan: well yes and no

Mango: why?

CaRyan: Well Mango.....a little secret...This isn't real

CaRyan: And most people know that people wander anyeway[anyway] so the [they] don't put up private stuff

CaRyan: Basicaly [Basically] a house in here is a display of talents and personality

DISCUSSION

Our results indicate that although there are similarities between the virtual world and the physical world there are also differences that influence and frame the behaviour, social positioning, and navigation of individuals within. To better understand what these results mean, one must first clarify perceptions of space. More clearly, how do people's perception of physical space influence their perception of virtual space?

Perceptions of Space

The perception of physical space is influenced by various factors such as culture [20], language [19], and design of the environment. Architects are well aware of how the environmental design influences individual perception of space. For example, Japanese gardens are structured to continuously alter the visual experience for visitors walking through the garden, creating a dynamic perception of the space [20]. Spaces that are designed to be conducive for interaction are called sociopetal [33]. The best designed spaces for human use create optimal conditions necessary for social interaction, such as those design features common to a cafeteria: open spaces, close proximity with conversational partners, and a pleasant atmosphere intended to attract and bring people together [19].

Societies compartmentalise space into a variety of territorial areas such as work, play and family. We observed similar differences in the compartmentalisation of space, particularly in AW. Individuals congregated in open spaces such as a beach bar in AW or open courtyards serving as 'ground zero' (the landing point when entering a world). Private houses also existed which conveyed a different use of the space.

Navigation through Virtual Space

Both virtual worlds that were studied offer the capability to visually show the presence of others in the same environment. Our results suggest that this visualisation influences who to approach and how one navigates through the space. When navigating through a physical environment, one relies on visual and kinetic feedback to create a physical reality [15]. Similarly, when navigating through a virtual environment such as AW and OT, one receives environmental feedback. One sees where groups and individuals are located, where walls and buildings exist, and one can adjust one's path accordingly.

Movement through the virtual environment, whether flying or walking, is a way for individuals to develop a cognitive map of their environment, as would occur when navigating in a physical environment. The social positioning by avatars high up above other avatars showed that an understanding of physical distance may have been transferred into the virtual world.

In contrast to the physical environment, in the virtual worlds studied, the inability to experience kinetic feedback is compensated by the availability of a bird's eye view of the space. Being able to view the world through a first person or third person viewpoint provides a perspective unique to one's avatar. Seeing oneself during navigation helps minimise personal space and group space violations of other avatars; it provides a better view of what personal and group space boundaries are. We observed that the avatars preferred to navigate around invisible boundaries rather than passing through other avatars. We attribute this behaviour as desiring to avoid rude or impolite actions towards others. This interpretation is confirmed with real world observations by Hall [20]. He found that individuals dislike bumping into or being bumped by others independent of the social relationship with the other person, as it creates a perception that the room is too small. In addition, the most preferred environmental enclosed area is the space that provides the highest degree of freedom of movement possible.

As avatars were unlikely or unwilling to pass through other avatars (from our observations), this shows that personal space norms exist even though design features allow such behaviour. It is interesting that this penetration ability, not

available in the real world, was not viewed as permissible behaviour in the virtual environment. From user comments, it appears that users see this as a violation of personal space. This suggests an extension of the social norm of personal space that is unique within virtual environments.

In the virtual world, one can sense that a landscape is large or that a room is small based on the time it takes to navigate through it. It is not always the case that one can visually assess the size of a virtual space simply by scanning it. Movement through a virtual world is essential for a virtual experience of the world, as in the physical world [15].

The available functionality of the virtual environments affected movement and navigation by providing the user with different navigational options. Usually the quickest and simplest movement was chosen in the virtual environment. For short distances, walking is common in both environments; for medium distances, flying in the virtual world is analogous to using a car in that both are quicker than walking. For large distances, teleporting between locations is somewhat analogous to a plane (or perhaps rocket) in that both provide the fastest opportunity for movement between two locations. The use of teleporting and flying are new transportation methods unavailable in the physical world. What was interesting for us was that we observed that users modified existing social norms and behaviours learned in the physical environment when they used these navigational features, such as flying together to indicate group membership.

Personal Space

Part of our research goal was to examine how personal space is affected as people interact and navigate within a virtual world. In both AW and OT, individuals maintained a comfortable physical distance during interpersonal communication. When the O moved face-to-face closely in front of another avatar, reducing an established physical distance, it elicited reactions suggesting that the virtual actors felt that their personal spaces had been violated. These results parallel physical world research which show that personal space exists [2, 23] and that invasions of personal space trigger emotional reactions such as: verbal responses; discomfort; overt signs of stress [36]; movement back to re-establish physical distance [24]; and sometimes flight as a coping mechanism for emotional discomfort [21].

What do these results tell us about how personal space is perceived in a virtual environment? Perhaps the distinction between physical and virtual environments is beginning to blur [35]; with the virtual world become more 'real' in its representation of the physical world and the real world becoming more 'virtual' with the continual emergence of computer virtual environments. As Shapiro [35] suggests, it may be the case that users are developing perceptions of virtual environments that mirror perceptions of real environments, which may explain the discomfort that users feel when personal space is violated. The transference of social norms such as personal space into the virtual world, perhaps may be explained by some users who alter their perception of virtual space into a physical space equivalent. This is suggested by comments such as:

> *[I backed up] the same way I'd back up if a "real" person got up too close...someone I don't know very well*

Group Space

Another research goal was to examine how group space is affected as people interact and navigate within a virtual world. In both worlds, groups naturally formed for communication. In AW, group formation occurred through text streams, and in OT, more than in AW, group formation was manifest by avatars positioning themselves face-to-face. The avatar positions were in a circle for groups of more than two members, and the formation was adjusted in shape and size when members joined or departed. We also observed groups engaged in common movements, such as dancing, walking together, flying, or rotating. When avatars were dancing together in the dance club or rotating together during conversation, as observed in OT, the benefits of this shared experience were two-fold. First, it provided an opportunity for group cohesiveness since members were involved in a common experience. The importance of underlying commonalties is that they foster group cohesiveness, creating a 'we-feeling' identity between group members and which can enhance the significance of one's membership within the group [8]. Second, common group movements provided observers with a signal of privacy that out-group people should not disturb the in-group without an invitation.

The implications for virtual reality is that these results suggest the emergence of group norms and behaviours in the virtual worlds. Group behaviour such as friendship activities have been observed in text-only environments such as MUDs [4] which shows that the natural formation of groups occurs independent of whether people are in physical proximity or not. The robust nature of group formation across electronic and physical environments suggests the development of a collective identity may also be possible in a virtual environment. In the physical world, as a result of sharing space with other individuals, collective identities may be formed resulting in a social group [31]. The development of collective identities in virtual environments may occur in a similar fashion.

Group movements and navigation not only provided a shared experience, but also enables people to develop a common perception of a virtual space. Navigation through the worlds occurred often as group or dyad navigation, and not only as individual navigation. This should not be surprising as AW and OT are shared virtual spaces; it should be natural to expect that people should explore the worlds collectively.

Privacy

We observed signals of privacy, such as two avatars turned upside-down in OT, or close face-to-face positioning in AW. However, this raises the question, why the desire for privacy exists in a virtual environment. As in a physical gathering of people, e.g. a party, one can observe small clusters of dyads

and groups trying to maintain private conversations without distractions, such as through their body language, or by their movement toward a corner of the room. It may be natural in the virtual world as well that some groups are open to new members while others seek privacy. For some individuals, communication with one person or a small group fosters a better building of a social relationship than socialising with a large group of people. Privacy may also occur because people, especially new users, are trying to understand this new virtual experience. By removing oneself from the main activity centre, one can become an observer, without the pressure to interact with others.

Crowding

Crowding affected the quality of social interaction. Sometimes individuals removed themselves from the stressful environment when crowding occurred. For technical reasons, crowds inhibited the social experience in the virtual environments. Many users present sometimes resulted in system slowdowns and reduced the likelihood of receiving messages in a timely fashion. In AW, crowds resulted in text overlap, making messages difficult to read, and in OT, with its spatial audio, standing too close to another group made it difficult to hear the person one was conversing with. Crowded environments were sometimes avoided because the opportunity to disturb individuals or group space by bumping someone during navigation was more likely. The text-overlap in AW could have created the perception that the environment was more cluttered and crowded than it actually was (users needed only to spread themselves out). Therefore, an excessive concentration of avatars was observed to make one's navigation within the crowded environment more difficult and hinder conversation with other avatars.

Territoriality

In AW, the role of building a house is to provide a territorial marker and provide a feeling of ownership for the owner. The number of houses one can build is only limited by one's time and imagination. Individuals were observed inviting friends, acquaintances and even strangers to their house for a virtual 'show-and-tell'. Usually people built in already existing neighbourhoods rather than in uninhabited landscapes. Although it was thought that individuals may perceive their home as a primary territory [2] which may be in conflict with the public, open nature of AW, this was not found. Instead, people welcomed and encouraged strangers to visit them. In this sense, a house is more a display of art and craftsmanship, rather than a private place of residence as in the physical world.

Gender Effects

Although it is difficult to ensure that avatars are not being deceptive with their gender portrayal [see Bruckman [5]], the results suggest that gender does affect interaction as it does in the physical world. For example, in a university library, individuals sitting alone were disturbed by a same-sex intruder when the newcomer sat beside or directly in front of them [17]. Males reported disliking most face-to-face spatial invaders while females reported the greatest disliking for side-by-side invasions. Perhaps reactions are related to the degree to which the individual perceives the invasion as overtly sexual attention-seeking [7].

Whether one attributes another's behaviour as sexual may explain these examples of avatar behaviour in the virtual worlds. In AW, when the male O invaded the personal space of another male avatar, this may have heightened the other avatar's level of discomfort as he perceived the male O's movement as sexual attraction. This would explain his response:

> *Moon is...um....naked and....well....touching me basically...*

In OT, as it is audio it is more difficult to disguise one's gender. When the female O was positioned close to a male user, and asked if she was too close, his response was: *No, I like it*. In this case, the male user was not uncomfortable when a female was close, but in the AW case, the male user expressed discomfort. The harassment of the female avatar by the male avatar in OT shows that users are emotionally affected by disturbing behaviour in a virtual world.

Virtual Movement

Virtual movement can also influence our perception of physical movement. Our understanding of our physical world is based on symbols and concepts that we use to help construct our reality as we move through our world. In the virtual world, our concept of space can be described as non-linear and representational, thus qualitatively different from the physical world [37]. For example, the functionality which enables fast transport (accelerated movement and teleporting) for avatars in both virtual worlds is unavailable for humans in the physical world; this functionality leads to a new concept which is used in interaction. Perhaps a bird's eye view in a virtual environment could lead to a new perspective in one's real world interaction, or a reshaping of one's awareness of physical space.

Prior experience with navigation in a virtual world could possibly transfer and be applied to experiences in other information spaces, such as the World Wide Web. For example, the process of seeking information may be easier to adapt to or comprehend in an unfamiliar information space. Perhaps, the experience people gain in virtual navigation can help web-users overcome the common problem of getting lost while searching for information [37].

Future Recommendations for Designers

In designing spaces for people, designers must focus on creating meaningful tools and environments that communicate and foster interaction in a simple, easy-to-understand, yet powerful manner [30]. This is applicable whether designing a virtual room or a physical room.

Within a virtual environment, designers must focus on creating what Mead and Pacione [30] refer to as a 'representational space'. They believe that designers must understand different attributes of space such as: size (i.e. how large a world should be perceived), the relationship between the space and user (i.e. how the environment

influences the user during navigation), and the quality of space (i.e. what the texture and landscape communicate).

Our results suggest implications for some design features in virtual environments to facilitate interaction and navigation. First, users should be able to easily fine tune avatar positioning in order to quickly adapt to an appropriate comfortable personal space. Users can also be provided with an invisible personal space bubble that can be activated during a spatial invasion, spreading the avatars out. Mechanisms can be provided for indicating privacy in groups by defining, e.g. a "group communication zone" such as avatars changing to light-grey 'group uniforms' when communicating. Mechanisms can help users socially navigate in a non-intrusive manner, such as around other avatars in their path, thus avoiding the invasion of others' personal space. Avatars that are impermeable, and a pre-defined "personal space zone" associated with an avatar, can help people to appropriately position themselves and navigate in virtual environments.

CONCLUSION

Our results suggest that similarities do exist in the physical and virtual reality worlds, through the expression of the norm of social positioning. Whether this is due to one's identification with the avatar, expectations about the space within a virtual environment, design features, or other explanation, cannot be determined without further investigation.

Social norms including personal and group space exists with avatars. This was observed from the physical distance separating interacting avatars, the refusal by avatars to invade another's personal space, obeying personal space during navigation, the positioning of an avatar in the environment to indicate privacy, and in the adverse reactions towards avatars when their personal spaces were violated. These result are in agreement with the assertion by Hall [21] that physical distance has a significant effect on conversation. As observed in this study, when physical distance was reduced, the conversation and behaviour of the other avatar usually changed. Privacy was also indicated through social positioning and other signals. As well, these results suggest that individuals perceive virtual environments as a social space.

Future research needs to explore in greater depth how navigation and social norms expressed in virtual worlds influence behaviour in other virtual environments. In addition, it should be investigated how personal experience within virtual environments influences one's perception of the physical world.

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