# Tangible Presence in Blended Reality Space

Kei Hoshi and John A. Waterworth

Department of Informatics
Umeå University, Sweden
{keihoshi@informatik.umu.se}

## Abstract

*We discuss issues relating to presence arising from the recent evolution of tangible interaction techniques as an alternative interaction paradigm to the familiar WIMP-based Graphical User Interfaces (GUIs). The intersection of sensory, cognitive and also emotional aspects in such interfaces takes us a significant step further than GUI techniques. We introduce our concept of* Tangible Presence in Blended Reality Space*, and its study as an emerging weaving of HCI and presence research. An experimental study is then described, which examined the influence of three key factors in the way blended realities may be implemented: tangibility, viewpoint and avatar identity. The study examined the effect of manipulations of these factors on rated* **presence** *and* **self-presence***. Our findings emphasize the importance of tangibility for presence, but suggest that* **presence** *and* **self-presence** *are unrelated phenomena. Finally, as critical concerns in future work to design and implement blended reality spaces for a variety of purposes, context sensitivity and usability issues are discussed.*

*Keywords---* **Blended Reality Space, Tangibility, Presence, Rehabilitation, Collaboration**

## 1. Introduction

Mixed reality is an increasingly prevalent approach to interaction that strives to combine the physical and virtual environments. Mixed reality is a growing object of study for the HCI research community, as part of a widespread effort to develop viable and more flexible alternatives to Windows, Icons, Menus, and Pointers (WIMP)-based GUIs (Graphical User Interfaces). However, we still do not have a clear understanding of the scope of this phenomenon, especially its perceptual and psychological aspects. We predict that the intersection of sensory, cognitive and emotional aspects in emerging mixed realities will be significantly important in attempts to go a further step in the development of better combinations between the physical and virtual environment, in what we call **Blended Reality Spaces**.

*Blended Reality Space* is our term for an interactive mixed reality environment where the physical and the virtual are intimately combined (*blended* not merely mixed) in the service of interaction goals and communication environments aimed, for example, at health support and rehabilitation (see, e.g. [1]).

The present study examined three key factors in the way blended realities may be implemented for such purposes:

(i)     the extent to which tangible tools play a role in interaction;

(ii)    whether a first person or a third person perspective is provided from the user's point of view; and

(iii)   if a third-person perspective (of a self-representing avatar) is used, how closely the representation matches the appearance of the user.

The experimental study combined manipulations these variables and examined their effect on both perceived presence [2] and self-presence [3].

Tangibility in the HCI literature is described as being built upon sophisticated skills situating digital information, to varying extents, in physical space. But the approach is subject to our current limited abilities to represent changes in material or physical properties of objects and spaces [4]. We often find a lack of tangibility in our everyday lives with digital artifacts. At the same time, our everyday lives are increasingly pervaded with digital information from environmentally built-in media devices such as high definition displays, automated systems and sensor-based environments. Further, information surrounding us is often displayed in the periphery as well as to the focus of our attention. It is vitally important that the emerging trend towards tangibility is provided using the most appropriate combinations of the physical and virtual. We believe this to be especially true for people with special needs in their everyday lives, and this is main motivation for our work in this area. Optimal combinations of tangibility and evoked presence carry the potential to make full use of, while not overburdening, the flexible but limited capacities of selective attention; this will be a key issue for the design of future interaction approaches.

Aspects of the experiment presented below have been briefly reported before [4]. In the present paper, we further discuss the importance of a strategic combination of tools, perspectives and avatars in the successful development of Blended Reality Spaces for those with mental or physical disabilities such as, for example, for an elderly person to

securely improve and maintain their well-being and independence in their own home.

## 2. Issues in current HCI research

Since the ubiquitous GUI was introduced and became the standard paradigm in HCI, it has contributed enormously to the development of society, especially the way we work. Recently, we have witnessed the emergence of a wider variety of HCI technologies, such as implemented within sensor-based environments, including handheld smart phones with more intuitive onscreen interfaces, and these are now pervasively penetrating society. However, we still cannot effectively utilize our skills for manipulating physical objects to any great extent, skills which are predicted to improve the nature of interaction, especially for people with mental and/or physical special needs. Research work on tangible interaction has been focusing on aspects such as manipulation of building blocks or shaping models out of virtual/physical clay [5]. However, the perceptual and psychological aspects of the effectiveness of those interaction styles have yet to be fully studied and explicated to any great extent. The issues of the post GUI/WIMP paradigm and the importance of the intersection of sensory, cognitive and emotional aspects are discussed in the following section.

### 2.1. Beyond the GUI/WIMP paradigm

The evolution of interaction techniques has largely also been the history of improving the usability and appeal of the WIMP-based GUI. These work well in many situations most obviously and importantly for some kinds of office work. But the work and the style of interaction have co-evolved and reinforced each other: we do the work we do because of the tools we have, and we have the tools we have because of the work we do.

Many researchers have discussed ways to modify or even escape from this self-fulfilling trend and have, for example, experimented with sensor-based techniques for interacting with virtual entities via the manipulation of physical object in space. Most of the broad range of new interfaces developed by HCI researchers and designers are seen as alternatives to the current GUI paradigm and try, in one way or another, to diverge from the WIMP-based approach [6]. We can find numerous emerging post-GUI/WIMP interaction styles, and they emerge as a huge growing trend in the HCI literature, because of their clear advantages of bringing more real, more tangible and more usable interaction. Typical examples are: augmented reality, tangible interaction, ubiquitous and pervasive computing, context-aware computing, handheld, or mobile interaction and so on [6][7]. Many of these new interaction styles clearly exhibit the combination of the physical and the virtual. But do these interaction styles have many benefits for those who use them? We find challenging and interesting applications for educational, medical and industrial usages, but many are

not at all suitable in many other situations, and especially not for people with special needs. In terms of the perceptual and psychological aspects of use, the effect of these post-WIMP interaction styles have yet to be fully studied and explicated.

Another post-WIMP trend is that digital media are becoming more pervasive in our everyday life. Everywhere in our built environment devices such as video screens, electronic access systems, and sensor based smart environments are rapidly increasing. But there is still a huge gap between media and ourselves as bodies in physical reality space.

Technology creates the virtual world, but also exists in the physical world - with which the virtual often competes for our attention. From an idealistic viewpoint, in a true blending of the physical and the virtual, the technology itself should completely disappear from our perception. We have previously suggested that in such a situation, there will be no conscious effort of access to information [8]. It would then be possible to realize an ideal in which our activities are characterized by a natural flow of action, without any intrusion from technology, from the physical-virtual divide. Like a fish in a clear stream, a high-skilled player playing with an immersive, interactive and body-movement oriented computer game shows a clear example of less or no conscious effort of access to information. The user perceives and acts directly, in everyday life unmediated activities.

### 2.2. Perceptual and Psychological aspect: Presence and Tangibility

**Presence**, the experience of "being there" in a mediated environment, has become closely associated with VR and other advanced media. As media becomes increasingly interactive, perceptually realistic, and immersive, the experience of presence becomes more convincing [9]. Presence is also described as the perception of a virtual experience as a physical experience. However, since information and communication technology (ICT) become more pervasive such built-in environment as video screens, electronic access systems and smart sensor techniques, creating mixed realities, the effectiveness of interactive mixed realities has been linked to the sense of **presence** judged by users of the space in recent research [10].

Commercialized games have also been applied to training for people with sensorimotor disorder or with cognitive dementia. In typical examples of both Wii and video-capture games, the players have no direct physical connection with the game environment. Their physical movements are detected by either the "Wiimote" (the Wii remote control) or by a camera. Body movements performed by players are generally in response to game-initiated events. When their free body movements in physical space are tracked and used as inputs to the game, a truly merged physical/media space may be created during play, which we call Blended Reality Space.

**Blended Reality Space** is an interactive mixed reality environment where the physical and the virtual are seamlessly combined and affect each other. As yet, this is an ideal guiding research and design, rather than an actuality.

Currently, we live in the physical world in which computers are distributed, with interaction windows onto the virtual world provided by the display, keyboard, and mouse. It is not a surprising idea to combine "the interface" the virtual and the rest of physical product of an interactive device, since the user sees the product itself as a unified physical/virtual system. But the rest of the physical world, and most of the bodily skills and experiences of the user, lie outside this unified world. Mixed reality is an increasingly prevalent approach to interaction that strives to combine the wider physical world with a virtual environment. Mixed reality is a growing object of study for the HCI research community, as part of a widespread effort to develop viable and more flexible alternatives to Windows, Icons, Menus, and Pointers (WIMP)-based GUIs. Blended reality is a form of mixed reality, but as yet most mixed reality falls well short of the blended reality ideal.

Achieving true blended reality will not be easy, for many reasons - not least the singularity of physical space and the multiplicities of the virtual. There are also several physical constrains that give limit users' interactions, such as those of physical displays, other input-output devices, and social factors. For example, the user typically concentrates foreground tasks through full access to a fixed display. The mouse reflects the two dimensional paradigm with WIMP interface that supports easy spatial navigation in these dimensions, clicking icons, selecting area and dragging data objects. This two-dimensional input-output interface is still limited when applied to, for example face to face collaboration or distributed environments. And while physical activity is easily reflected in the virtual space, the converse is much more difficult. Many researchers have discussed ways to modify or even escape from this self-limiting trend and have, for example, experimented with sensor-based techniques for interacting with virtual entities via the manipulation of physical object in space.

Haptic feedback helps users feel a degree of tangibility, a convergence between the physical and virtual. But in a true blending of the physical and the virtual there will be no gap between the emergent virtual/physical space of technology and the physical world. Objects will have both physical and virtual presence, experienced by users as their own tangible presence in the blended reality, providing a natural flow of action and direct access to information. In other words, while haptic feedback can contribute, tangibility is more than just haptics.

In current, partially blended gaming spaces, there exists the potential to give players a more immersive and physically challenging gaming situation, which can be expected to also produce a strong psychological feeling of presence within the merged space, since the technology effectively disappears from attention. This in turn may facilitate players'

performance and maintain motivation and interest in the game [2].

The feasibility of using the Wii-system in a rehabilitation setting for adolescence with cerebral palsy has been evaluated in a case study [11]. This example shows potential of blended reality space for people with special needs. This interaction style is formed in harmony between the physical and the virtual, utilizing tangible interaction. Tangible interaction is currently surprisingly underutilized. Although technology is increasingly part of our bodies, not only embedded devices such as pacemakers or electrodes on the brain but also carried devices such as mobile phones, we find very few applications that utilize tangible interaction to bridge the gap between the physical and the virtual.

## 2.3. Examples of lack of tangibility

Mobile phones have become more "intelligent" and pervasively penetrated into our everyday life. They may include small TVs, tiny cameras, "intuitive" interfaces and internet access, yet the technological combinations still fail to take account of the context of their use. For example, in multi-user communication by mobile phone in an emergency situation, the sender and receiver, unaware of the context in which the phone call was made and received, are at risk of misunderstanding each other. Exchanging tangible knowledge to avoid the risk and using peripheral attention capabilities could to deepen mutual understanding of what the emergency situation actually is. A potential approach would be to use sensor technology to monitor the sender's state directly through the availability of the present external situation, visual features of the surroundings and the periphery. Such information could be presented to the receiver in a variety of different forms, and transmitted as embedded information to any form of communication [1].

Designing simple and adequate representations for peripheral media using tangible objects is a key part of developing better combinations of the physical and virtual. We can also find experimental prototypes that try to complement lack of tangibility in the HCI literature. Ambient intelligent spaces, interactive spaces in which users utilize background information with ambient media but without being disrupted in their foreground tasks. Ambient media attempt to achieve a natural flow in the transition of the users' focus of attention between background and foreground [12]. This shows one way to turn architectural or physical spaces into an ambient and information environment [13].

In everyday life, we catch plenty of clues as a means to interpret how things are around us. Our peripheral attention draws on subconscious awareness, for example, of the weather outside our window, if we hear thunder or a sudden rush of wind. If there is no impact stressed, we could continue to execute tasks at the office without intrusive distracting [see also 5, 12]. We could interpret even more complex implicit information from outside the window. For example, a sensitive combination of brightness, a wind

direction and humidity gives us the feeling of the coming rain. The sources of ambient information help our natural flow of action without distracting, if they are suited for the situations. The ambient information can be a part of our situation to make a natural flow of action in our everyday life.

This concept of "ambient information" or "ambient media" has been widely studied in the HCI community. Although most of their starting questions are concerned with the limitation of visual attention and direct manipulation as GUI, ambient media are still abstract, largely indirect manipulation and intangible [5]. We need to experiment with a variety of ambient media such as sound, light, airflow, and water movement for background interfaces for awareness of virtual space at the periphery of human perception.

These examples of lack of tangibility make new issues and questions rise to the surface of our thoughts about tangible interaction. Is it possible to support inference of contextualized situations? How we can conduct a nuanced approach to design blended reality space? How do ambient media help to improve the perception of a virtual experience as a physical experience? How can optimal tangibility be provided in an actual situation and with the most appropriate combination of the physical and virtual?

Motivated by these questions, we describe an experiment combining manipulations of tangibility with person perspective and avatar identity, and examining their effect on both perceived presence and self-presence. This gives hints strong cues support a more nuanced approach to the design of blended reality spaces.

## 3. Tangible Presence in Blended Reality Space

As we already mentioned, *Blended Reality Space* is our term for an interactive blended reality environment where the physical and the virtual are intimately combined and affect each other. Through this physical-virtual combination, the physical objects provide users with clues about the virtual environment and help them develop skills in their environment, such as picking up, positioning, altering, and arranging objects [5]. This definition provides a common understanding of the concept, but it does not identify the factors influencing presence, nor does it describe the exact nature of the experience.

What aspects does blended reality space contribute to the experience of **presence?** Motivated by this question, we describe below our experimental study that examined three key factors in the way blended realities may be implemented: (i) the extent to which tangible tools play a role in interaction; (ii) whether a first person or a third person perspective is provided from the user's point of view; and (iii) if a third-person perspective (of a self-representing avatar) is used, how closely the representation matches the appearance of the user. We focused on the effect of these variables on rated presence [2] and self-presence [3].

### 3.1. Our hypotheses and the experiment

Various scholars have debated the definition and value of the concept of presence. Presence is described as the perception of a virtual experience as a physical experience. Self-presence is an extension of the sense of self identity, and is seen as the extent to which a participant feels a virtual representation of self to be accurate [2][3]. Presence in a virtual environment (VE) traditionally depends on shifting attention from the physical environment to the VE, but does not usually require the total displacement of attention from the physical locale [14]. Presence is also not constrained to high technology situations, because - according to some authors at least - we may feel quite high presence when reading books or watching movies [3]. The present study used the Nintendo Wii video game and console, commonly available and widely used technology that can provide a satisfying and involving gaming experience even with relatively inexpensive technology, including computer graphics with quite low resolution. Based on earlier findings, we arrived at the following hypotheses listed in Table 1.

Many researchers have experimented with sensor-based techniques for interacting with virtual entities via the manipulation of physical objects in space. Such interaction concepts are often termed "tangible" and have been frequently discussed in the HCI (Human Computer Interaction) literature. The main idea of such a tangible interface, built on movement and position sensing techniques, is to provide physical forms which serve as both representations of and controls to digital information. The applications make the digital information directly manipulable with our hands, and perceptible through our peripheral senses through their physically embodiment [5][15][16]. The effects of tangibility on presence and self-presence have yet to be fully studied and explicated, but our expectation was that a physical tool would enhance the sense of presence *(Hypothesis 1, 2)*.

Avatars provide a concrete representation of the player's actions and identity [17][18][19]. We expected that there would be both higher presence and self-presence when the avatar resembled the player more accurately. We also expected that using a tool with either kind of avatar would produce higher presence than not using a tool *(Hypothesis 3,4,)*.

A 1st person perspective duplicates the natural view of ones own actions by providing interaction with the blended reality space as if from the players' own physical viewpoint [20]. With a 3rd person perspective, they see their own representation as an avatar whose bodily movements reflect their physical movements in real time [20]. Because of this difference, we expected a stronger feeling of presence to be elicited with a 1st person perspective *(Hypothesis 5)*.

| Factor | Dependent Variable | Hypothesis |
|---|---|---|
| **Tangibility** (Tool/No-tool) | Presence | *Hypothesis 1*: Participants who use a physical tool will feel more presence than participants who use only their body as a tool, with both 1st and 3rd person perspectives. |
| | Self-Presence | *Hypothesis 2*: Participants who use a tool will feel more self-presence than participants who use their body as a tool for both an avatar similar and dissimilar to self. |
| **Identity** (Similar/Dissimilar) | Presence | *Hypothesis 3*: Participants who play with an avatar similar to self will feel more presence than participants who play with an avatar dissimilar to self. |
| | Self-Presence | *Hypothesis 4*: Participants who play with an avatar similar to self will feel more self-presence than participants who play with an avatar dissimilar to self. |
| **Perspective** (1st/3rd perspective) | Presence | *Hypothesis 5*: Participants who have a 1st person perspective on the game will feel more presence than with 3rd person perspective both with a tool and without. |
| | - - - | - - - |

**Table 1 Hypotheses and related factors on Presence and Self-presence**

## 3.3. Method

To test these hypotheses, we created several different versions of blended reality space, based on the Nintendo Wii gaming environment, its wireless movement-sensing Wiimote interaction device, and a 60" plasma display (as shown in Figure 1). For the present study, the simplest avatar-oriented game from various Wii games was chosen: Wii tennis (3rd person view) and Kororinpa (1st person view). Wii tennis requires a swinging motion of the handheld Wiimote to hit the virtual ball, while Kororinpa requires more delicate hand movements of the device to guide a marble through virtual mazes.

For the tangible (with tool) conditions we embedded the Wiimote in a physical tennis racquet or maze board (Figure 1, 2). For the no tool conditions the Wiimote was worn in a glove on the back of the participant's dominant hand (Figure 1,2). In the third person view conditions, the avatar used was either the pre-supplied one (identical for all participants) or was one designed by each participant to resemble himself or herself, known as a Mii. Miis are customizable and allow the participants to capture a likeness or caricature of themselves, or others (Figure 2).

16 participants (20 to 65, average age 37 years) volunteered and took part in the study. All participants experienced all conditions in a within-subjects experimental design. We used this type of design because of its high sensitivity to treatment effects, given the high variance between subjects on this kind of game. It was also felt that playing several different games in one session has more validity than focusing on only one, since a higher level of interest and attention is maintained. The danger of sequence effects influencing the results was avoided by carefully balancing the order in which individual subjects experienced the different conditions.

After each game in the various conditions, the participants filled out a questionnaire regarding their feelings of presence and self-presence. Subjects were asked to rate each question on a scale from poor to excellent, which were translated by the experimenter into a numerical scale from 0 to 5. T-tests were used in order to compare the means of the dependent variable scores. The questionnaire consisted of 28 questions, which in aggregates correspond to six factors thought to be correlated with presence and self-presence: Awareness, Immersion, Involvement, Naturalness, Realness, and self-presence. We partially based this on the presence questionnaire published by Witmer & Singer in 1998 [14].

**Figure 1 Experimental Condition: 1st Person Perspective**
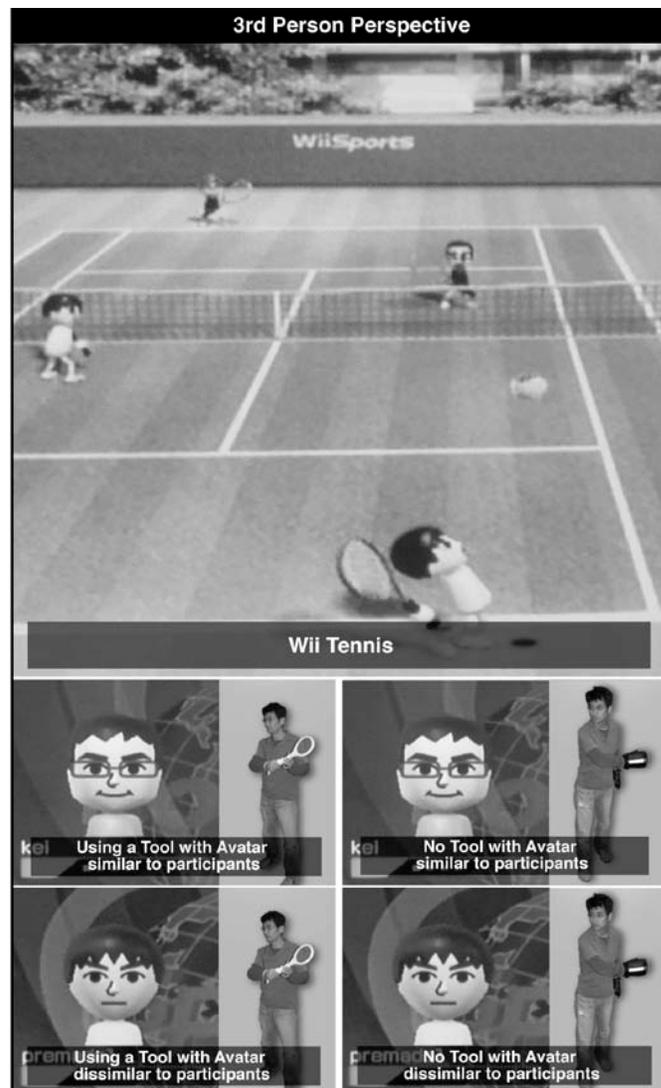


**Figure 2 Experimental Condition: 3rd Person Perspective**

| Factor | Hypothesis | Result | P-value | |
|---|---|---|---|---|
| **Tangibility** (Tool/No-tool) | *Hypothesis 1*: Participants who use a physical tool will feel more presence than participants who use only their body as a tool, with both 1st and 3rd person perspectives. | **Supported** | 1st: | $0.05 > \mathbf{0.001}$ |
| | | | 3rd: | $0.05 > \mathbf{0.002}$ |
| | *Hypothesis 2*: Participants who use a tool will feel more self-presence than participants who use their body as a tool for both an avatar similar and dissimilar to self. | Rejected | Similar: | $0.05 < \mathbf{0.765}$ |
| | | | Dissimilar: | $0.05 < \mathbf{0.563}$ |
| **Identity** (Similar/Dissimilar) | *Hypothesis 3*: Participants who play with an avatar similar to self will feel more presence than participants who play with an avatar dissimilar to self. | Rejected | $0.05 < \mathbf{0.336}$ | |
| | *Hypothesis 4*: Participants who play with an avatar similar to self will feel more self-presence than participants who play with an avatar dissimilar to self. | **Supported** | $0.05 > \mathbf{0.00017}$ | |
| **Perspective** (1st/3rd perspective) | *Hypothesis 5*: Participants who have a 1st person perspective on the game will feel more presence than with 3rd person perspective both with a tool and without. | Rejected | Tool: | $0.05 < \mathbf{0.365}$ |
| | | | No-Tool: | $0.05 < \mathbf{0.432}$ |

**Table 2 Results: Effect of tool, perspective and avatar on Presence and Self-presence**

## 4. Results and Discussion

As we predicted, there was significantly higher **presence** when using a tool versus no tool for both 1st and 3rd person perspectives ($p < 0.005$, paired T-test). But there was no significant effect on **presence** of playing from a 1st person versus a 3rd person perspective for either tool or no tool. There was also no effect on **presence** of playing with an avatar similar versus dissimilar to self. Figure 3 shows that using a tool strongly affects rated presence for both 1st and 3rd person perspectives.
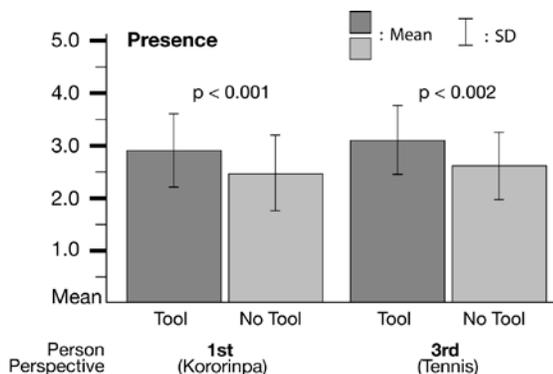


**Figure 3 Using tool: Significantly higher presence for both 1st and 3rd person perspectives.**

There was however a highly significant increase in **self-presence** when playing with an avatar similar to self versus dissimilar to self ($p < 0.001$, paired T-test), but no effect of playing with a tool versus no tool. Figure 4 shows that avatar similarity strongly effects on self-presence.
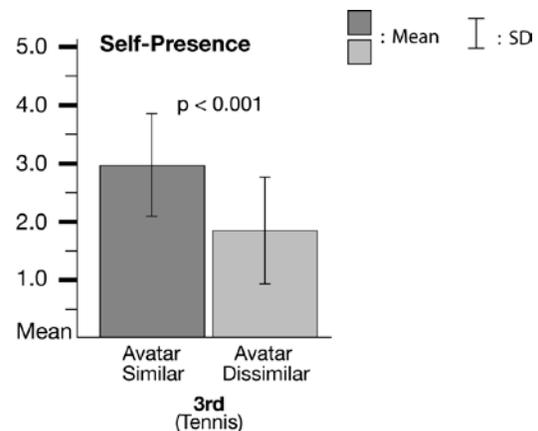


**Figure 4 Avatar similarity: Highly significant difference in rated self-presence**

Our findings seem to confirm the importance of incorporating tangible tools in blended reality spaces aimed at eliciting a high sense of presence, but suggest that tangibility has no effect on self-presence. Although a 1st person perspective is of course more natural than a 3rd person perspective on one's own actions, it did not increase presence, which is an interesting and important finding for the future of blended reality spaces (see also [20,21,22,23]).

However, a weakness of the current experiment is that we used different games to instantiate the different points-of-view: first and third. There could be alternative explanations for both significant and non-significant findings here, relating to the characteristics of the particular games used rather than viewpoint. More valid and generalizable results will be produced from future research using one game that provides the possibility for varying viewpoints. We therefore see our results as merely suggestive of the notion that a first person view may not always be necessary for high presence. This suggestion is consistent with recent findings [22, 23] from more thoroughgoing experimentation on "out-of-body"

experiences (essentially, third person viewpoint experiences of self).

Similarlity of the virtual representation of self strongly affected rated self-presence, but did not affect presence (see [3, 24]). Ratan et al. [3] also found that participants who used a Mii dissimilar to themselves reported significantly less self-presence than participants who used a Mii similar to themselves, but feelings of presence were unaffected by character assignment. Our results therefore confirm those of Ratan et al. [3]. Bailenson et al. [24] found an effect such that subjects indicated more willingness to commit acts in front of an agent similar to themselves than in front of an unfamiliar agent.

In our experiment, subjects created their own avatar (Mii), in their own likeness, or were given a standard default avatar. Designing ones own avatar can be expected to strongly affect the sense of attachment between a subject and their avatar. This could have been avoided by having the experimenter design the user-similar avatar based on photographs. This would have been a better test of the importance of perceived similarity. The current experiment could be seen as looking at the effect of ownership, confounded with similarity. These may have quite different effects, and it would be valuable in future experimentation to independently vary similarity and ownership to tease out any different effects. For example, it would be interesting to investigate whether or not one would feel less self presence with a self-designed, but deliberately dissimilar avatar than with an objectively accurate rendering provided by the experimenter?

Concerning the role of tangibility, it should be remebered that using a racket is the natural way of playing tennis on a physical tennis court. In the game situation, the physical racket, as physical object, seems to work to bridge the gap between the physical world and virtual world, and increases the feeling of presence. It could be argued that if a game environment does not require such a physical tool, the effects of tangibility on presence may be lacking. While this was not tested in the current experiment, we would emphasis that tangibility is not the same as tool-ness. Even in a game where there is no obvious tool - say, a running game - if the game achieved a convincing blending of the physical and the virtual, we would expect a high level of presence to be elicited. For example, in the situation where the game player feels uphill resistance, wind movement, and so on, physical forces. Tangibility is not limited to using tools, and we see no reason to expect that its effect on presence will be so limited either.

# 5. Implications for Future Perspective

Although not conclusive, as discussed above, presence and self-presence appear, on the basis of our overall results, to be quite unrelated phenomena. The latter may be more important for social presence than individual presence, which suggests a tension in providing for both - but also gives hints for a nuanced approach to design.

The results will also contribute to the design and implementation of strategic combinations of tools, perspectives and avatars for various application scenarios. These findings will, for example, be incorporated into design principles for our planned work to develop free movement based interactions for motor rehabilitation [25] as well as blended reality spaces for collaboration between hospitals, care organizations and the home [1].

In the present study, we have focused on what we believe to be crucial issues, issues that will have implications for the future development of blended reality spaces.

## 5.1. Context Sensitivity

Communication and collaboration through conventional computer and telecommunication systems diminish the qualities of interaction that produce a sense of directness and richness, because of their limited capacity to convey a reality with contexts shared between users. Context is an important, yet poorly understood and poorly utilized source of information in interactive computing [1][26].

Future interaction techniques supporting blended reality space will often need to have a mechanism to select aspects of context to use carefully, structure context in interactive systems, and determine what context-aware behaviors to implement in response to the user's mental or emotional state. Contextual factors will affect and reflect a person's state, and one of the simplest ways of tracking context is through tracking the person's state directly [27]. However, without also tracking physical context this is open to misinterpretation and could in itself be potentially hazardous [28].

In medical applications, for example, such blended reality spaces will be helpful to support the sharing of indications of a patient's true state. Mediating devices will need to be sensitive both to the situational context of their use, and the state of their users. Presence levels will be adjusted dynamically during the management of streams of incoming and outgoing information [29].

## 5.2. Developing new usability methods for Blended Reality Space

Because the concept and study of blended reality space is an emerging area, combining both HCI and presence research, we need to incorporate new dimensions and a coherent group of methods. We also need to carefully explore new ways of observation, description, analysis, modeling and design. Through the present study, we have identified several salient issues for future research.

First, we have realized that a new framework for understanding and manipulating the contextual influences

that affect interactive systems and the users needs to be developed.

Second, measuring degree of presence and examining the computer-generated environments simply as virtual realities is inherently limited. The need to investigate the factors influencing presence in new blended reality spaces will become ever more critical.

Finally, exploring new methods of usability assessment to identify the factors that are responsible for the experience of presence in blended reality space such as ambient environment will be crucially important. An adequate new method will help in designing better implementations and installations for real (actual) environments.

## 6. Acknowledgements

## References

[1] Hoshi, K. & Waterworth, J. A. (2008). Effective collaboration for healthcare by bridging the reality gap across media-physical spaces. Proceedings of PETRA: 1st International Conference on Pervasive Technologies Related to Assistive Environments, Athens, July 2008.

[2] Lombard, M. & Ditton, T. At the heart of it all: The concept of presence. Journal of Computer Mediated Communication (1997)

[3] Ratan, R., Cruz, M.S., Vorderer, P. Multitasking, Presence & Self-Presence on the Wii. Proceedings of Presence 2007, Barcelona, Spain, October 16-18, 2007.

[4] Hoshi, K., Pesola, U-M., Waterworth, E. L., and Waterworth J. A. (2009). Tools, Perspective and Avatars in Blended Reality Space. the Annual Rewiew Of Cybertherapy and Cybermedicine 2009, edited by Brenda K. Wiederhold and Giuseppe Riva. IOS Press in Amsterdam (http://www.iospress.nl), Health Technology and Informatics (SHTI) series.

[5] Ishi, H. Tangible Bits: Beyond Pixels. Proceedings of the 2nd International Conference on Tangible and Embedded Interaction(TEI'08), Feb18-20, Bonn, Germany.

[6] Jacob, J.K. R., Girouard, A., Hirshfield, M. L., Horn, S. M., Shaer, O., Solovey, T. Erin., Zigelbaum, J. Reality-Based interaction: A Framework for Post-WIMP Interface. CHI 2008, April 5-10, 2008, Florence, Italy.

[7] Jacob, J.K. R., Girouard, A., Hirshfield, M. L., Horn, S. M., Shaer, O., Solovey, T. Erin., Zigelbaum, J. Reality-Based interaction: Unifying the New Generation of Interaction Styles. Conference on Human Factors in Computing Systems, CHI 2007 extended abstracts on Human Factors in computing systems, San Jose, CA, USA

[8] Waterworth, J. A. and Waterworth E. L. (2009). Mediated Presence in the Future. Chapter in book published by Routledge, *Mediated presence in the future,* In Cheryl Campanella Bracken & Paul Skalski (eds) , Immersed in Media: Telepresence in Everyday Life.

[9] Ijsselsteijn, W., Riva, G. Being There: The experience of presence in mediated environments. Being There: Concepts, effects and measurement of user present in synthetic environments. G. Riva, F. Davide, W.A Ijsselsteijn(Eds). IOS Press, 2003, Amsterdam.

[10] Bernardet, U., Inderbitzin, M., Väljamäe, A., Mura, A., Verschure, P FMJ. (2008) Validating Presence by Relying on Recollection: Human Experience and Performance in the Mixed Reality System XIM: Proceedings of the 11th International Workshop on Presence. University of Padova, Italy, October 16-18 2008, pp178-182

[11] Deutsch JE, Borbely M, Filler J, Huhn K, Guarrera-Bowlby P. Use of a low-cost, commercially available gaming console (Wii) for rehabilitation of an adolescent with cerebral palsy. Phys Ther. 2008; 88(10):1196-207.

[12] Brewer, J., Williams, A., and Dourish, P., (2007) A Handle on What's Going On: Combining Tangible Interfaces and Ambient Displays for Collaborative Groups, TEI '07: Proceedings of the 1st international conference on Tangible and embedded interactionface and Ambient Display for Collaborative Groups

[13] Ishii, H., Wisneski, C., Brave, S., Dahley, A., Gorbet, M., Ullmer, B., and Yarin, P. ambientROOM: Integrating Ambient Media with Architectural Space (video), *Conference Summary CHI 1998,* ACM Press.

[14] Witmer, B.G. and Singer, M.J. (1998) Measuring Presence in Virtual Environments: A Presence Questionnaire, Presence, Vol. 7, No. 3, June 1998, 225-240

[15] Ishii, H. and Ullmer, B. Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms. *Proc. CHI 1997*, ACM Press (1997), 234-241.

[16] Ullmer, B., and Ishii, H. Emerging frameworks for tangible user interfaces. *IBM Systems Journal 39, 3&4*, (2000), 915-931.

[17] Borberg, M., Piippo, P., Ollila E. Designing Avatars. DIMEA'08, September10-12, 2008, Athens, Greece

[18] Castranova, E. (2003) Theory of the Avatar. CESifo Working Paper No 863. Online publication: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=385103

[19] Becker, B. and Mark, G. (2001) Social Conventions in Computer-mediated Communication: A Comparison of Three Online Shared Virtual Environments. In "The social life of avatars", Schroeder, R. (ed.), Springer, UK.

[20] Waterworth, J. A. and Waterworth E. L. (2008). Presence in the Future. In A Spagnolli and L Gamberini (eds.), Proceedings of the 11th International Workshop on Presence. University of Padova, Italy, October 16-18 2008, pp61-65.

[21] Kallinen, K., Salminen, M., Ravaja, N., Kedzior R., & Sääksjärvi, M. Presence and emotion in computer game players during 1st person vs. 3rd person playing view: evidence from self-report, eye-tracking, and facial muscle activity data. Proceedings of Presence 2007, Barcelona, Spain, Octover 16-18, 2007.

[22] Ehrsson, H.H. The Experimental Induction of Out-of-Body Experiences, *Science* 317(5841), 1048.

[23] Lenggenhager, B., Tadi, T., Metzinger, T., & Blanke, O. (2007). Video Ergo Sum: Manipulating Bodily Self-Consciousness, *Science* 317 (5841), 1096-1099.

[24] Bailenson, J.N., Beall, A.C., Blascovich, J., & Raimmundo, R. Intelligent Agent Who Wears Your Face: Users' Reactions to the Virtual Self. Intelligent Virtual Agent, 86-99, Springer, 2001

[25] Sandlund, M., Hoshi, K., Waterworth, E L, Häger-Ross, C. (2009) A Conceptual framework for design of interactive computer play in rehabilitation of children with sensorimotor disorders, Physical Therapy Reviews

[26] Dey, A., Abowd, G. The Context Too lkit : Aidingt he Devel opment of Context-Aware Applications. CHI '99: Proceedings of the SIGCHI conference on Human factors in computing systems.

[27] Peter, C., Waterworth, J A., Waterworth E W., Voskamp, J (2007). Sensing Mood to Counteract Dementia. International Workshop on Pervasive Technologies for the support of Alzheimer's Disease and Related Disorders, Thessaloniki, Greece, Feb 2007.

[28] Waterworth, J. A. and Waterworth E. L. (2009). Mediated Presence in the Future. Chapter in book published by Routledge , *Mediated presence in the future,* In Cheryl Campanella Bracken & Paul Skalski (eds) , Immersed in Media: Telepresence in Everyday Life.

[29] Waterworth, J, Waterworth, E. Presence as a Dimension of Communication: Context of Use and the Person. Form Communication to Presence: Cognition, Emotion and Culture Towards the Ultimate Communicative Experience. Festschrift in honor of Luigi Anolli. IOS Press, Amsterdam, 2006.