Designing for experiences in blended reality environments for people with dementia

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Abstract. Blended Reality environments have the potential to provide scalable solutions that are affordable, adaptable and easily deployable to support people with dementia. Use of these technologies is associated with experience of presence which is an experience with technologically mediated perceptions that generates a feeling of being there and the illusion of non-mediation. Our study examines what constitutes an experience of presence for people with dementia when they interact with MRTs.

An observational study with ten participants (MoCA = 18 to 23, Age= 63 to 88 years) played a game of Tangram on Osmo. Six of these participants also played Young Conker on HoloLens. The experiences of the participants in the digital space, the physical space, and their attention crossover between the two spaces were coded in Noldus Observer XT 14.1.

The study found four main themes that have an impact on the experience of presence in PwD – correspondences, effortless access to physical and digital content, awareness of reality and emergence. Correspondences between physical and digital spaces require PwD to have constant information about the state and nature of physical and digital content. The transitions between physical and digital should be seamless. PwD demonstrated positive experiences with Osmo, an augmented Virtuality technology while their experience with HoloLens, augmented reality technology was negative. The factors impacting experience of presence were prominent in Osmo while they were mostly absent in HoloLens throughout the game play. The outcomes of this study have resulted in a set of recommendations and guidelines for designers to design correspondences for experience of presence. We are currently working on developing prototypes using these guidelines for evaluations with PwD.

Keywords: Blended reality, Mixed reality, Presence, People with dementia, Assistive technology.

1 Introduction

People with dementia (PwD) struggle to participate in Activities of Daily Living (ADL) such as cooking and laundry as they have difficulty in sequencing tasks in an activity. Blended environments such as Mixed reality technologies (MRTs) could present opportunities for older adults with dementia to carry out ADL independently with little or no help from care givers. Intelligent prompting systems have been developed and evaluated with people with dementia (Mihailidis, Boger, Craig, & Hoey, 2008; Pigot, Mayers, & Giroux, 2003). Orpwood, Adlam, Evans, Chadd, & Self (2008) created a smart apartment equipped with passive sensors and light controls, bed occupancy monitor, tap and cooker monitors and voice prompting devices. Although these developments have been promising, they lack scalability in terms of adapting to different places and activities in the house. Blended environments could offer affordable, adaptable solutions that can be easily adopted and deployed.

Use of MRTs as intelligent devices have been explored with Microsoft Kinect (Chang, Chou, Wang, & Chen, 2013), augmented reality (AR) HoloLens (Aruanno & Garzotto, 2019) and projection based systems (Ro, Park, & Han, 2019). Kinect-based prompting system improved task completion in two participants, one with early onset dementia and one with an acquired brain injury. AR HoloLens was used to develop a game-based memory assessment tool for early Alzheimers diagnosis. Garzotto, Torelli, Vona, & Aruanno (2019) developed three holographic activities using HoloLens in cooperation with neurologists to stimulate memory functions affected by Alzheimers disease, with the goal of delaying the cognitive decline. A projection based MRT with 360 degrees of space was evaluated with PwD for applications such as therapy, entertainment, spatial art and mental care aids. Although the technologies were successful in meeting the functional needs of people with dementia, there is a need to understand experience and engagement of people with dementia with blended environments and mixed reality technologies. This study thus has investigated engagement and experiences of PwD with MRTs through the concept of presence in blended environments proposed by (Benyon, Mival, & Ayan, 2014; Hoshi & Waterworth, 2009). The study explores two types of MRTs – Augmented reality and Augmented virtuality to understand the experience of presence in these technologies and how can designers develop these technologies for people with dementia to engage with the content and medium presented by MRTs.

2 Background

A blended environment such as MRTs consists of a physical and digital space which have been brought together to create opportunities for new experiences. Each of these spaces are defined by elements to interact with, people and the relationship between them. Examples of physical elements are objects and artefacts that build these spaces, while examples of digital elements are buttons, images, animations, information architecture, etc. According to Benyon, Mival, & Ayan (2014), volatility of the space to change is also a characteristic of these spaces. Mixed reality is a combination of physical and digital spaces and it comes in different forms depending on how the physical and digital worlds are integrated (Desai, Blackler, & Popovic, 2016). It spans physical-digital reality spectrum (Fig. 1) proposed by Milgram & Kishino (1994), from physical spaces augmented by digital elements (augmented reality) to digital spaces augmented by physical spaces (augmented virtuality).

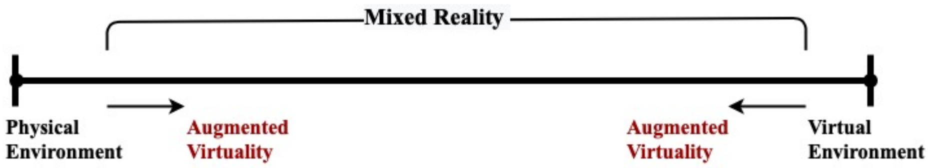


Fig. 1. Mixed Reality on a physical-digital continuum, (from Milgram & Kishino (1994))

An example of augmented reality (AR) technology is HoloLens from Microsoft with overlapped physical and digital spaces. Digital holograms are overlaid in the physical world. An example of augmented virtuality (AV) is Kinect Xbox from Microsoft where digital elements are manipulated by elements in the physical world. The middle section of the continuum represents various combination of physical and digital objects and spaces, ranging from spaces with sensors and QR codes, to augmented reality overlays in physical space, seen through a smartphone.

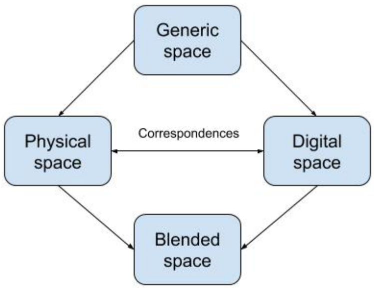


Fig. 2. Conceptual blending of physical and digital spaces *(Benyon et al., 2014)*

Blended theory provides a theoretical framework for research into mixed reality technologies for people with dementia, specifically with the focus on their experiences with physical and digital worlds and the transition between them. The concept of a presence articulated through blended spaces gives us a way of designing for people with dementia. Fauconnier & Turner (2008) discussed blending as a process of generating new insights by blending four mental spaces into new ideas. Two input spaces that have something in common to a generic space are blended into a new space that has partial structures from the two input spaces but has its own emergent structure. Our past experience and knowledge influenced by our cultural and cognitive models allow the new mental space to be experienced in a different way. The new experiences and logic could then result in new insights and ideas. Benyon et al. (2014) applied conceptual blending to conceptualise a blend of physical and digital spaces (Fig. 2). Spaces are associated with properties of oncology, topology, volatility and agents, which define the generic space. Designing blended spaces involves developing physical and digital spaces such that people can observe and interact with them and can also experience the transition between them. In other words, correspondences between physical and digital spaces should be developed for an experience of presence. This study thus discusses the experience of PwD with MRTs using blending theory.

Blended spaces present challenges to people in terms of engagement with each of the spaces and making a smooth and natural transition between the two spaces. These spaces should be designed for people's interactions, such that they are able to understand the concepts and the design elements. Rather than focusing on technological innovations in blended reality, the design focus should be on innovations in interaction modalities and experiences with them. Research such as Astell, Smith, & Joddrell (2019) have shown that PwD engage with digital interfaces on tablets and smartphones. Recent works by Aruanno, Garzotto, Torelli, & Vona, (2018), Desai et al. (2020), Garzotto, Torelli, Vona, & Aruanno (2019b) have explored the use of mixed reality technologies with PwD for cognitive assessment and rehabilitation. Desai et al. (2020) studied interactions of PwD with off the shelf technologies. They found that PwD could complete continuous perception action loops of interactions with appropriate audio and visual prompts presented by the MRT.

This study investigates experience of presence in PwD by understanding their experience in physical and digital spaces and how they navigate the transitions between them. The success with which physical and digital entities are observed and detected by people with dementia, referred to as presence in blended spaces (Benyon, 2012; Floridi, 2005), affects experience and engagement of people with MRTs. This will help us design engaging experiences with blended spaces for PwD. This is essential for designing assistive support systems for PwD.

2.1 Tangible Presence

Engagement with a technology is possible if we feel present in the medium and do not notice the mediating technology (Benyon, 2012). Lombard & Ditton, (1997) defined presence as a feeling of 'illusion of non-mediation'. Witmer & Singer (1998) referred to presence as 'the subjective experience of being in one place or environment even when one is physically situated in another'. Both the definitions, developed in the context of virtual reality environments, suggest that the digital world should remain ubiquitous to us when we interact with it from the physical world. Floridi (2005) rejects this idea of presence and suggests that successful observation and detection of all the entities in the environment, both in physical and digital constitutes experience of presence. Benford, Magerkurth, & Ljungstrand (2005), Benyon (2012), Wagner et al. (2009) and others have further emphasised that blended environments are not just about creating illusions of being in a certain environment. Tangible presence in blended reality spaces involve people moving through experiences with objects in physical and digital worlds, such that the actions on the objects flow naturally and there is direct access to information (Hoshi & Waterworth, 2009). The correspondences and blending between physical and digital spaces should be carefully designed such that the user activities flow seamlessly between the physical digital interface. The mediating technology disappears from the perception. Hoshi (2011) differentiates between mixing and blending of physical and digital spaces. Mixing refers to distribution of objects, media and content between physical and digital spaces. However, blending between the two spaces requires careful design and planning for continuous flow of information between the two spaces. The objects in the physical space for example could offer prompts that direct the user to perceive the feedback from the digital space. Hoshi (2011) refers to this as blending of the spaces and suggests that MRTs for the vulnerable, the elderly and the socially handicapped should be designed through blending rather than mixing.

PwD respond differently to various types of objects and content in the physical and digital spaces due to their impairment (Desai et al., 2020). Thus, their experience of presence with blended reality spaces could also be different. This study will study experience of presence in PwD with blended reality spaces. Thus, the concept of presence could be used to develop design guidelines for engaging user experiences with blended reality for PwD. Although experience of presence has been discussed in literature, mostly from the context of virtual reality environments, there is lack of study that investigates factors that influence presence in blended environments such as MRTs for PwD. The research question for this study thus was: What aspects does blended environments such as MRTs contribute to the experience of presence in PwD?

3 Research Design

This research was an observational study conducted at Memory and Company, a memory health club for seniors with dementia. Game play using MRTs - Osmo and HoloLens was introduced to Memory and Company clients in their daily day programs. Only participants who consent to participate in the study were recorded playing games on MRTs. The study was approved by Ontario shores centre for mental health hospital research ethics board. Informed written consent was obtained from all participants and their care givers.

Ten people in early stages of dementia and low cognitive impairment (MoCA = 18 to 24, Age= 63 to 88 years) participated in the study. The Montreal Cognitive Assessment (MoCA) is a rapid screening tool to detect cognitive dysfunction for early diagnosis of Alzheimers disease. It consists of 30 questions targeting attention, concentration, executive functions, memory, language, visuo-constructional skills, conceptual thinking, calculations, and orientation. Each question is scored as per the MoCA scoring guidelines. The total possible score is 30 points. A score of 26 or above means that there is no cognitive impairment. As the score gets lower, the level of impairment increases.

We used two MRTs – HoloLens from Microsoft and Osmo from Tangible Play in the study. These two technologies represented AR (HoloLens) and AV (Osmo) types of MRT and were easily available for the study off the shelf. Participants played Tangram on Osmo and Young Conker on HoloLens. These games were chosen after exploring several games available on these technologies and in consultation with the staff at Memory and Company. The primary criteria for the selection was that the games should be easily introduced in the day program of the participants and should also be known to be usable in general masses which we assessed through user ratings and reviews. Pilot studies with 2 older adults in their early stages of dementia (MoCA = 18 and 22) were carried out before the actual study to determine the suitability of the technologies and games for the study.

We will describe the technologies using blending theory shown in **Fig. 2** to understand the physical and digital spaces in these technologies and the correspondences between them.

3.1 Osmo and Tangram.

Osmo, AV technology, with distinct physical and digital environments to interact with separately, allows physical play with a digital environment on a tablet. It comes with a reflector, a stand to place the tablet on, and games (**Fig. 3**). The camera on the tablet captures any physical activity performed in front of the tablet. The captured information is fed back into the digital world on the tablet and integrated with added digital elements in an app.

Physical space consists of seven flat shapes, called tans, which are put together to form shapes (**Fig. 4**). The objective of the game is to form a specific shape using all seven pieces, without overlapping each other. A shape is presented to the player on the tablet screen through the Tangram app. The player is expected to arrange the seven flat shapes in physical space to match the shape on the tablet. When the correct flat shape is placed in the right place in the physical space, the corresponding flat shape in the app on the screen is filled with the corresponding colour. This is an indication that the placement of the shape in the physical space is correct.

Digital space consists of a Tangram app on a tablet or smartphone, which presents puzzles and prompts to the player to solve the puzzle. Depending on the level of the game chosen (Easy, Medium and Hard), the puzzles are presented with promots that range from colour and shape information to only shape information (see **Fig. 4**). Prompts such as blinking shapes, animations of next steps and audio prompts are presented to the player through the app.

Correspondences between the two spaces is implemented through image capture of manipulations of tans in the physical space through a camera in the digital space. This means that every manipulation in the physical space is tracked and reflected in the app in the digital space, which in turn informs generation of prompts for the player.

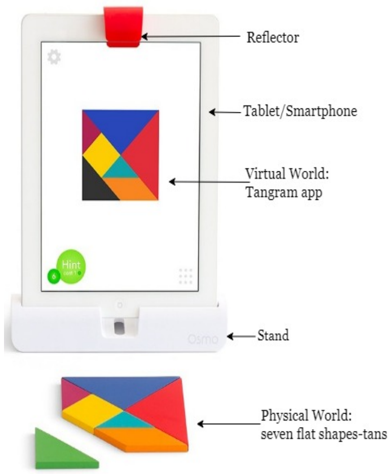


Fig. 3. Osmo Setup and Tangram

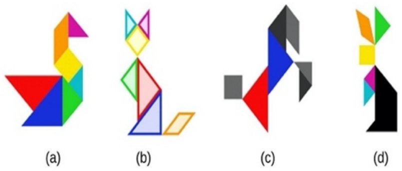


Fig. 4. Tangram pieces arranged in shapes. (a) Seven tans arranged in the shape of a swan. (b) Easy level shape presented in the app (digital world) consists of shape and colour information. (c) Medium level shape presented in the app (digital world) consists of shape and colour tone information. (d) Hard level shape presented in the app (digital world) consists of partial shape information

3.2 Hololens and Young Conker

HoloLens, AR technology with overlapped physical and digital spaces is a holographic computer in the form of a headset (**Fig. 5**). HoloLens uses the physical world to overlay holograms for the user (who wears the headset) to interact with them, see and hear them within their environment.

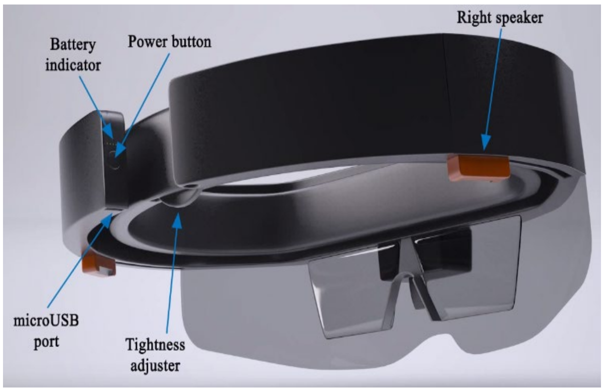


Fig. 5. HoloLens - AR technology

<u>Digital space</u> consists of a game app 'Young Conker' that can be installed in HoloLens from Windows app store. The app transforms existing real-world setting such as a living room into a platform to go on a mystery adventure. The game starts with a scan of the physical space to detect walls and other objects. The game consists of different

levels referred in the game as missions. Each mission involves looking for generated holograms in the space. A holographic squirrel character, Conker interacts with the user through speech. The player is required to guide Conker through their gaze movements to the holograms in each mission. The game prompts the player through visual texts, graphics, animations and Conker's voice to accomplish a set mission in the game.

Physical space is the place or the environment where the game is being played. The player performs embodied actions such as walking around in the room, looking for prompts in the digital space and performing gestures required to complete the mission requirements in the game.

Correspondences between the two spaces is made possible through a headset equipped with a range of sensors that tracks gestures of the player in front of the headset and the eye gaze of the player to inform decisions made within the Young Conker app in the digital space.

3.3 Data Collection

Ten participants consented for the study who played Tangram on Osmo. Of these, six also played Young Conker on HoloLens. Four participants did not show up for the play session with HoloLens.

The study was conducted in three sessions on three different days of the day program. Cognitive impairment of the participant was recorded using MoCA assessment tool in the first session followed by game play with Osmo and HoloLens in each of the next two sessions. On the day of the game play with MRT, participants were explained how each technology works and how to play the games on the MRT. Participants were prompted by the researcher when they were unable to proceed with the game play or/and when they asked for help. Each play session lasted for maximum 60 minutes.

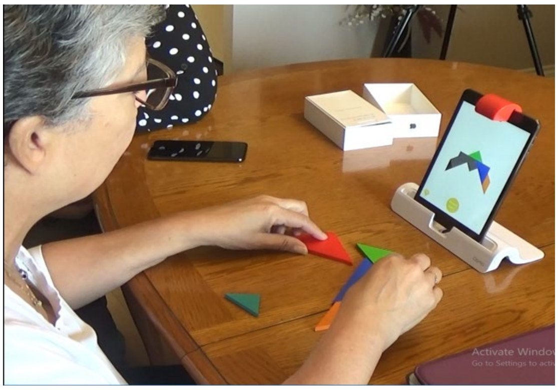
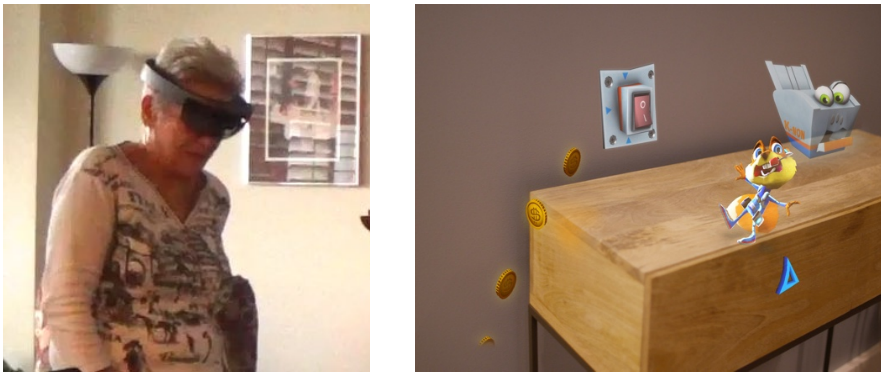


Fig. 6. Participant P1_2000 playing a game of Tangram on Osmo



(a) (b)

Fig. 7. participant P9_2009 playing a game of Young Conker on HoloLens (a) using gaze to move young Conker, the squirrel from one place to another in the game (b) Screen capture of what participant sees through the headset

At the end of each of the game plays, the participants were asked to describe their experience with the technologies, how did they feel about it and if they would like to play again. This was also audio and video recorded for analysis.

3.4 Data analysis

The video data of game play in HoloLens and Osmo was coded in Observer XT from Noldus using thematic analysis techniques of Braun & Clarke (2006), Fereday & Muir-Cochrane (2006) and Tuckett, (2005). Inductive coding process was used where themes and sub-themes that were seen to be impacting experience of presence in the interactions of PwD with the MRTs were coded, see **Fig. 8** (a) and (b).
The heuristics used for coding presence in the data were:

- Awareness of the state and nature of objects in each space for them to make appropriate decisions (Riva et al., 2007)
- Experience the movement across the physical and digital spaces.
- Awareness of self, blended environment and the existence of the digital content
  - Extension of themselves through mediated technology
- Access to the content in physical and digital spaces is effortless
  - Direct interaction with the content in each of the spaces
  - Effortless action and perception
    - For example, input from the user and environment in physical world and feedback/notifications from the digital world
- Changes in the environment due to continuous perception and action results in changes to the subsequent perceptions and actions, referred to as emergence (Desai, Blackler, & Popovic, 2019). This is possible if the user has opportunities to add, change and manipulate the content in physical or digital space or both.

The description of experience of PwD with the two MRTs at the end of the game was coded inductively for type of experience.

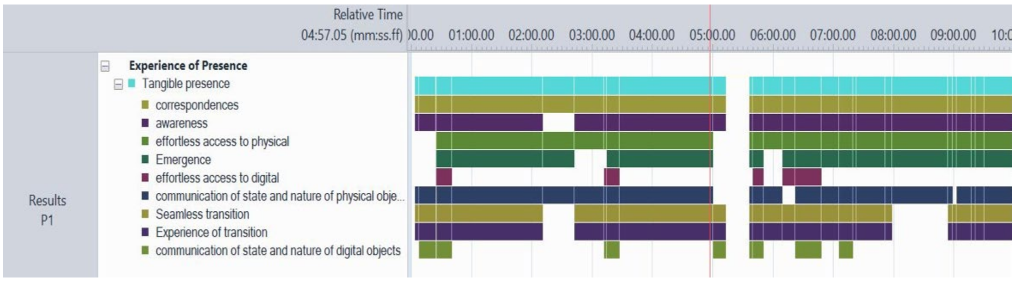
4 Results and Findings

Four themes representing experience of presence emerged from the analysis, shown in **Table 1**.

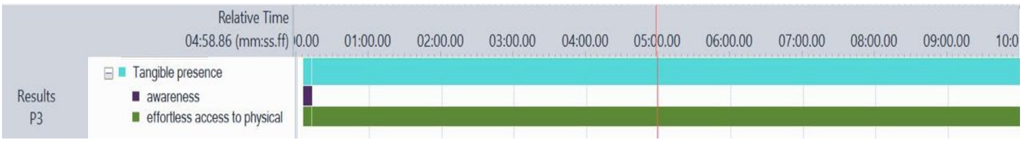
Table 1. Factors impacting experience of presence in PwD with MRTs

Themes	Sub-themes
Correspondences	– Communication of state and nature of physical objects – Communication of state and nature of digital objects – Experience of transition – Seamless transition
Awareness	
Effortless access -	– Physical – Digital
Emergence	

Correspondences between the physical and digital spaces represent the physical and cognitive coupling between the physical and digital content. The coupling is achieved through technology (sensors and computing resources) and the media content that prompts PwD to transition between the two spaces. Physical coupling represents the movements of PwD through interactions such as gestures and gaze. Technologies facilitate physical coupling in both the technologies – Osmo and HoloLens through sensors and computing resources as discussed above in sections 3.1 and 3.2. However, effective correspondences also require cognitive coupling achieved through appropriate prompting in the physical and digital spaces that steer PwD between the two worlds. At the same time, the prompts should also ensure that PwD are aware of the transition made into another world and the transition is smooth and seamless. Thus, the effectiveness of the correspondences depends on the communication of state and nature of physical and digital objects to PwD, experience of transition (the user should be aware of their movement from one space to another) and seamless transition. Contrary to the requirement of an experience of illusion in Virtual reality, Blended environments such as MRTs require PwD to be aware of the reality of the space that they are in at any given instant during their interactions with the technology. The theme of effortless access to physical and digital content in the two spaces covers interaction modalities that PwD are comfortable with in the perception action loops of interactions. Emergence, term introduced by Desai et al. (2019) in interaction design, defines the ability of the technology to afford change in the environment (physical or digital or both) brought about the user (PwD in this study). The factors impacting presence in PwD interacting with apps - Tangram in Osmo and Young conker in HoloLens are shown in a visualisation along time scale (**Fig. 8**)



(a)



(b)

Fig. 8. Visualisation of experience of presence with factors impacting it in PwD with (a) Augmented Virtuality - Osmo (b) Augmented Reality - HoloLens

5 Discussion

Experience of presence, in the true definition in the context of blended environments, is important for engagement of PwD with MRTs as assistive technologies to support in their everyday activities. This study aimed to understand factors that contribute to experience of presence in PwD, found four main factors – correspondences between physical and digital, awareness of the reality, effortless access to the spaces and emergence. The objective of the study was not to compare the two types of augmentations, but to develop a better understanding of the factors contributing to presence in both augmentations. We used two off the shelf technologies as case studies to understand experience of PwD with the technologies.

5.1 Presence in Augmented Virtuality – Osmo

PwD were comfortable interacting with Osmo, they described their experience with the technology as fun and easy. Participant P1_2001 continued playing the game of Tangram beyond the time limit of 60 minutes and said,
"I play lot of puzzles on my phone. But this is different. I enjoyed it, the hard level was difficult, but I like a challenge. It was nice to see that I could solve it."

The participant added that she would like to play the game again and collected information about Osmo and where to buy from. **Fig. 8** (a) shows that the factors affecting experience of presence in PwD were consistently valid for the entire game play with Osmo.

Manipulation with physical objects, tans, in the physical space provided avenues for communication of the state and nature of the physical objects. The direct interaction with the objects ensured that PwD have effortless access to the space. PwD used touch interactions with tans to receive spatial and visual feedback in return, making perception action loops continuous and effortless. The sub-theme, *Communication of state and nature of physical objects*, part of the theme, *correspondences* was predominantly valid throughout the game play. The direct interaction with the physical objects contributed to the consistently valid theme '*effortless access to the physical*'.

On the other hand, PwD had problems understanding the meaning of some digital objects such as coloured circles representing easy, medium and hard levels of the game. They also could not understand technical language used in a text prompt, 'flip', meaning to turn over the tan. When PwD were prompted with an intervention from the researcher to 'turn over', they immediately understood the meaning. Some prompts such as music tones to represent popping of a prompt or successful placement of the correct tan in the right place in the given puzzle, went un-noticed. This explains consistent absence of the sub-theme, *Communication of state and nature of digital objects*, part of the theme, Correspondences, throughout the game play.

PwD transitioned between physical and digital spaces most often without any issues. They were most often aware that they are moving from one space to another. Some PwD got engrossed in solving the puzzle with the objects in the physical space and completely forgot to check the prompts in the digital space. They were able to solve the puzzle only through physical manipulations and did not look into the digital space for prompts. The participant had to be prompted to check for the prompts by the researcher. This affected their movement from physical to digital space. This explains the gap in the sub-themes of the theme '*correspondences*' - '*seamless transition*' and '*experience of transition*' in **Fig. 8** (a).

The material, spatial and visual properties of the physical objects contrinuted to the realization in PwD that they are interacting with the physical world. PwD associated the screen-based interaction on the Ipad to the digital world. Thus, the physical properties (materiality, spatiality and visual features) of the physical objects and the materiality of Ipad contributed to the consistent theme '*awareness*' throughout the game play. The small gap in the theme is because the '*seamless transition*' to digital world and '*experience of transition*' was lost at the same time.

Emergence which represents dynamic nature of the system, was consistently valid for the entire game play. The effortless manipulations of the physical objects resulted in changes in the physical and digital world. The new setup means new perceptions and actions. Emergence ensures continuous engaging perception and action loops. The period when emergence was absent in **Fig. 8** (a). remains unexplained.

Pwd had positive engaging experience interacting with Osmo and the factors affecting experience of presence in PwD were present throughout the game play. However, the ineffectiveness of prompts in the digital space in facilitating effortless perception, transitions and communication of the information to PwD impacted the experience of presence and engagement to some extent.

5.2 Presence in Augmented Reality – HoloLens

Most PwD were very excited to use a new emerging technology, HoloLens, however lacked confidence to use it correctly. Almost all PwD described their experience with HoloLens as confusing and difficult. Participant P3_2003 said,
"*This is new for me. Sorry, I am not good at this. I could not understand what that animal [conker] was saying. I could not understand what was happening. Is it [HoloLens] spoilt?*"

The participant said that she would not play the game again. Participants felt that either they were doing something wrong or there was some malfunction in the technology. **Fig. 8** (b) shows that all factors affecting experience of presence in PwD were consistently absent for the entire game play with HoloLens except for one theme, '*effortless access to physical*'. PwD were found to be interacting with the physical space through gestures and movements across the room. However, they could not understand the prompts presented to them through the digital space. For example, arrows pointing in the direction of the prompt, suggesting that the user should look in that direction could not be mapped into appropriate gaze and head movements. The voice of the conker was not clear to PwD. Although, audio prompts are more effective in successful perception in PwD (Desai et al., 2020), clear human voice is preferred. Graphic icons such as tap icon were also difficult to understand. Thus, the theme '*effortless access to digital*' was absent throughout the game play.

'*Awareness*' of physical and digital spaces was seen very briefly at the start of the game play. PwD for most of the game play thought that they were interacting with a computer mounted on their head. The reality that they are present in both the spaces at any given time is lost after that initial period. We think this is partly because of the lack of effortless access to the digital content. '*Emergence*' was not possible in the game play as perception action loops were not possible.

The '*correspondences*' between physical and digital spaces in HoloLens were completely missing from the entire game play. PwD could not get any information about the state and nature of the physical and digital objects in the two spaces. PwD were often seen blindly using 'air tap' gesture in the hope that something will happen. Transitions between the physical and digital spaces was not seamless and most often the transition was not experienced by PwD. This is due to lack of awareness of the reality in which PwD are interacting at a given instant.

The experience of PwD with HoloLens was not positive, although they are keen to use the technology but not in the current state. They could not engage with the 'Young conker' app and HoloLens due to lack of experience of presence. Designing correspondences for seamless transition experience and clear communication channels that provide information about the content in the two spaces to PwD. This requires appropriate design of prompts in the digital space for PwD.

5.3 Design recommendations

It is evident from the two case studies with Osmo and HoloLens that careful approach is required to design correspondences between physical and digital spaces. We recommend following guidelines:

- The prompts in the digital spaces should be designed for effortless perception in PwD resulting in actions that PwD are comfortable with. Successful perception ensures that PwD have constant information about the state and nature of the digital content and elements.
- Interactions with the physical content should be embodied through the sensory systems of PwD.
- Interactions with the physical and digital content should be direct through the use of physical affordances of the content. Use of metaphors or symbolic processing should be avoided as much as possible.
- Prompts to direct PwD to experience seamless transitions between physical and digital spaces should be incorporated. For example, use of verbal narratives to steer people between the two worlds.

Other than correspondences, awareness of the reality of space is possible through sensory feedback from each of the spaces. Well-designed correspondences ensure successful perception action loops, resulting in emergence which could add to the engagement with the technology.

6 Conclusion

There is a need to design assistive technologies to support PwD in their everyday activities using human centred methods. Blended environments such as MRTs could provide scalable and deployable options to support PwD. However, it is important to understand experiences and interactions of PwD with these emerging technologies. Ongoing adoption and use of these technologies require PwD to engage with the technology. For this, PwD should experience presence in their interactions with MRTs. This study thus aimed at understanding the factors that impact experience of presence in PwD.

The study found that it is critical to design correspondences between physical and digital spaces such that PwD have access to information about the state and nature of the physical and digital objects. PwD should experience seamless transitions between the two spaces. Experience of presence requires awareness of the reality of the space in which PwD are interacting at any given instant. This is done through appropriate digital prompts and sensory feedback from the physical space. The findings from this study have resulted in recommendations and guidelines for designing experience of presence in MRTs for PwD. We are working on translating these encouraging outcomes into prototypes for evaluation with PwD.

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