Experiencing EVA Park, A Multi-User Virtual World For People With Aphasia

JULIA GALLIERS,
STEPHANIE WILSON,
JANE MARSHALL,
RICHARD TALBOT,
NIAMH DEVANE,
TRACEY BOOTH,
CELIA WOOLF,
HELEN GREENWOOD,
City, University of London, London, UK

ABSTRACT

Virtual worlds are used in wide-ranging ways by many people with long-term health conditions but their use by people with aphasia (PWA) has been limited. In contrast, this paper reports the use of EVA Park, a multi-user virtual world designed for PWA to practice conversations, focusing on people's emotional, social, and conversational experiences. An analysis of observation and interview data collected from 20 people with aphasia who participated in a 5 week therapy intervention revealed key themes related to user experience. The themes offer a rich insight into aspects of the virtual world experience for PWA that go beyond therapeutic outcomes. They are: affect (positive and negative), types of conversation, miscommunication and misunderstanding, immersion in the virtual world, social presence and initiative and flow. Overall, the study showed that participants experienced positive emotional and social outcomes. We argue that this was achieved as a consequence of EVA Park being not only accessible but also a varied and entertaining environment within which PWA experienced both the realistic and the quirky whilst engaging with others and having fun.

Categories and Subject Descriptors:

Human-centered computing; Empirical studies in accessibility

Additional Key Words and Phrases:

Aphasia; Field evaluation; Accessibility; Virtual worlds

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1.INTRODUCTION

1.1 Aphasia

Aphasia is a communication disorder most commonly caused by a stroke. It occurs in 45% of strokes, with 24% of people having persistent symptoms [1]. People with aphasia have

difficulties with using language; their ability to speak, comprehend speech, read and write may all be affected. For some people, speech is impossible or limited to a few words; others may have speech that is fluent but full of errors. Difficulties with reading, writing and understanding also vary in presentation. These problems can prevent the expression of everyday needs and derail conversation e.g. [6]. Individuals face exclusion from language dependent activities and this has implications for many aspects of their emotional and social well-being [18]. One example is the loss of leisure and work roles [51]. Aphasia also has implications for access to digital technology as this relies primarily on language-based communication [37]. People with aphasia report shrinking social networks following their stroke [52] with loss of friends being a particular problem [46]. Reduced opportunities for conversation and social exchange are deeply regretted by those affected with the condition [20]. Perhaps not unsurprisingly, disorders of mood are common. For example, while depression affects about 31% of stroke survivors [28], rates amongst those with aphasia are even higher [53], with some estimates putting the figure above 60% [66].

Digital technologies offer exciting opportunities to many people who live with long-term health conditions [56]. However, this potential has not yet been fully realised in the case of people with aphasia: the kinds of technology and the ways in which they have been used have been limited. This paper extends this work by exploring the use of one particular digital technology, a virtual world, by people with aphasia. The aim was to investigate the general experience of people with aphasia using a virtual world and their more specific experience of using a virtual world for therapeutic purposes. The results have implications for the future development of virtual technologies and for delivering clinical interventions to people with aphasia in a virtual setting.

1.2 EVA Park

EVA Park is a multi-user virtual world that we created for people with aphasia. It was created as a platform that we could use to investigate whether a virtual world would enable people with moderate aphasia to practice speech successfully with one or more conversational partners, independently and whilst at home. EVA Park is a non-immersive virtual world, accessed via a desktop or laptop computer. It was built on the OpenSimulator platform (http://www.opensimulator.org) and runs in the FireStorm viewer (http://www.firestormviewer.org/). Each user is represented in the virtual world by a personalised avatar (Figure 1) and controls movement of their avatar using a specialised minimal keypad. Users communicate by talking normally using microphones and headphones. There are 'sound parcels' in the virtual world so that conversations can be private: these are bounded virtual areas where any sound generated within the area does not travel beyond its boundaries.

EVA Park was developed through a process of codesign with 5 people with aphasia [65]. The aim was to create a virtual world that was both accessible to people with moderate aphasia and also stimulating and engaging. The result is a virtual world that has a variety of different areas and elements. For example, there is a town square comprising shops, restaurant, cafe, hairdressers and health centre. There are houses, boats, a treehouse, caravan, island bar and disco. There are fantastical elements, such as elephants that avatars can sit on, a giant rubber duck to meditate on, mermaids and a turtle to ride on under the lake, even a Tardis (the time machine in the television programme, Doctor Who); all of these stimulate fun and creativity. Users interact with these elements of the virtual world, e.g. to sit on a chair or dive into a lake, via a single click from a mouse or clickable trackpad. In addition, a heads-up display (the icons seen near the top of the screen in Figure 1) contains buttons that users can click to cause their avatars to make a gesture e.g. to wave, laugh, or dance. There are 4 video screens around EVA Park which show short films; these change on a regular basis to provide entertainment and

talking points. For example, one screen has shown a flash mob of dancers at St Pancras station in London.

Figure 1: An avatar in the town square of EVA Park.

1.3 Research Questions

We investigated the therapeutic benefits and user experience of EVA Park in a study with 20 people who had moderate aphasia. The therapeutic benefits included well maintained and significant gains on a measure of everyday communication. These are reported in [43]. This paper focuses on the user experience, reporting the results of a detailed thematic analysis of observational video data collected during 37[1] therapy sessions in EVA Park, plus 40 post-observation interviews. The aim was to investigate participants' general experience of a virtual world and their more specific experience of practising speech in a virtual world by answering the following research questions:

- Affect: What emotions, both positive and negative, do participants experience when using EVA Park; how do the number of positive and negative instances of emotional experience compare and does this change over time?
- Types of conversation: What are the main types of conversation employed in EVA Park? To what extent are they grounded in the real world compared with the virtual world and does this change over time?
- Miscommunication and misunderstandings: What types of miscommunications and misunderstandings occur and to what extent are they stimulated by aspects of the virtual world?

[1] Technical issues with the screen recording software at the beginning of the study resulted in the corruption of 3 videos. Thus the total number of videos analysed was 37 instead of 40.

- Immersion in the virtual world: Do participants engage with the virtual world including their avatar?
- Social presence: Do participants form successful/enjoyable relationships with others within the virtual world? How does this change over time?
- Initiative and Flow: Do participants take conversational initiative when interacting with a conversation partner in the virtual world and how does this change over time? What types of interruptions break the flow of a session and does this change over time?

2. Previous research

Digital technology has begun to augment the rehabilitation of PWA. However, many approaches are digital versions of traditional speech therapy tasks (see [60] for a review). Personally tailored therapy exercises delivered via a computer have been shown to benefit word retrieval [21, 48] verb production [23], sentence building [59, 42], and speech comprehension [5]. They enable self-directed practice which can raise the treatment dose [47] and users have responded positively [63, 48, 14]. A new and different approach explores head-worn displays for vocabulary support for PWA [67].

A few studies have explored the opportunities for conversation and social interaction that can be engendered by digital technology. For example, [2] studied email as a means of enhancing communication between older PWA and their therapists. [69] designed a touch screen application called Camelendar to support expressive storytelling for PWA. Another approach is to harness virtual reality; virtual reality applications have been explored with other communication disorders such as stuttering [10], speaking phobias [4, 29], autism [49] and Asperger Syndrome [44].]. However, to date, there has been little work to investigate the potential of virtual reality for PWA. Stark et al. [55] developed a virtual house to promote individual language practice. Two other applications, Orla and AphasiaScripts [15, 61] have used a virtual speech and language therapist. None of the above examples provided a multi-user 3D environment or supported multi-user conversation practice.

Prior to the development of EVA Park, [26] reported a small study investigating the accessibility of a multi-user virtual world, Second Life, for PWA. This included an informal comparison of Second Life against existing guidance on how to design accessible digital technologies for PWA. Second Life was found to comply with just 5% (two out of forty) guidelines of relevance to multi-user virtual worlds. This suggested very limited accessibility for PWA. However, the results of the study carried out by Galliers and Wilson [26] revealed an apparent contradiction: the participants reported a positive user experience despite poor accessibility. They found the experience challenging but they also found it engaging and motivating. This work helped inform the development of EVA Park i.e. EVA Park was designed to be engaging and motivating whilst also being accessible to PWA. We are not aware of any other work that has investigated the user experience of PWA in virtual worlds.

The majority of previous research into user experience in virtual worlds has entailed users self-reporting via surveys and/or questionnaires e.g. [52, 27, 70]. This is also the case with studies of gaming, for example, studies have employed the User Engagement Scale (UES) [64] and the Game Experience Questionnaire (GEQ) [9, 36]. However, the restricted communication capabilities of people with aphasia presents challenges for this approach. Kohler et al. [39] used a combination of observations and interviews (amongst other techniques) in their action research approach to the co-creation of virtual systems in Second Life, their aim being to improve virtual customer experience. Participant observation in virtual worlds is a method also used in virtual ethnography [7]. In the study reported here, we chose a method primarily based

on observations of participant behaviour in the virtual world, supplemented with limited self-reporting.

3. METHOD

3.1 Study Design

We undertook a study with 20 people with aphasia to investigate the therapeutic benefits and user experience of EVA Park. Each participant used EVA Park for 5 weeks, accessing it from home. The 20 participants were organised into 4 groups of 5 people. This was solely for the purpose of managing the study: it was not feasible to run more than 5 participants simultaneously due to resource constraints. Each group had continuous access to EVA Park for the 5 weeks, during which they could log in at any time for as long as they wanted. They were also asked to log in at a scheduled time for one hour a day, five days a week – a total of 25 hour across the five weeks. Each participant was paired with a "support worker" (SW) for these scheduled sessions. During the scheduled sessions, participants explored EVA Park, worked towards specific conversation goals with their SW (often involving role-playing activities) and interacted with other users. These supervised sessions comprised the active therapy intervention upon which the majority of the results described in this paper are based.

Twenty SWs participated in the study - nineteen were qualified speech and language therapists, one was an experienced Stroke Association volunteer. In addition, one floating SW covered sessions when other SWs were away. This person was also unqualified but experienced as a Stroke Association volunteer. Eighteen participants met with the same SW at each session; only two experienced a change in SW during their therapy period. None of the participants and SWs knew each other prior to the study but they met in person at an initial 'meet and greet' session before their therapy period began.

A typical scheduled session in EVA Park started with the participant meeting their SW by navigating their avatar to a pre-arranged place at a pre-arranged time, most often beside the fountain in the town square. Participants and SWs would sit their avatars on a nearby bench and chat briefly before navigating their avatars to other locations in EVA Park to start on the day's conversational tasks. Conversational tasks included role-playing a situation, creating a story narrative about some element of the virtual world, discussing how to describe their avatar to a friend, practicing words or phrases etc. Conversational topics would flow naturally. Breaks in conversation would be taken by visiting a different virtual place and interacting with elements of the world; this would spark new conversation topics. At the end of the session, arrangements were made for when and where to meet the next day. The Friday session of each week was a group session involving all 5 participants. On one occasion, the group session was a sports day where participants raced their avatars around EVA Park, followed by a prize giving and speeches; on another occasion, a participant played his guitar at home and the group sang Beatles songs together whilst their avatars 'played' virtual instruments on the bandstand.

3.2 Participants

Eleven of the 20 participants were male; 9 were female. Ages ranged from 36 to 81 years (M = *57.8*). Mean time post-stroke was 62.1 months; SD=53.56. Participants were screened initially to ensure that they had sufficient spoken language to participate in a virtual world where they would communicate using speech while demonstrating impairments consistent with mild to moderate aphasia. All participants were able to speak in short phrases but their fluency varied. Most had limited ability to read and write. Table 1 provides the scores of individual participants

on the screening measures. Unimpaired language users score at, or close to, maximum for all the measures described.

Participant	Spoken picture naming[1]	Spoken word to picture matching[2]	Spoken sentence to picture matching[3]	Mean fluency score	CADL-2 Percentile Score
M	97.9%	100%	72%	4.7	72
I	100%	100%	96%	12.8	99
MK	65%	83%	75%	3.5	32
J	79%	90%	90%	9.2	94
R	85%	93%	84%	7.3	54
S	85%	90%	81%	4.0	84
Y	79%	100%	94%	4.8	67
D	72%	83%	47%	5.3	51
O	44%	80%	47%	2.9	38
P	81%	86%	93%	6.2	90
PE	81%	100%	63%	7.0	94
LO	66%	97%	72%	4.3	89
T	27%	83%	56%	4.2	49
SA	85%	97%	75%	12.1	65
W	69%	80%	87%	9	96
L	79%	97%	72%	10.2	86
DI	84%	74%	81%	4.0	55
A	65%	90%	69%	6.5	65
V	79%	86%	87%	5.8	62
B	79%	86%	93%	4.9	86
Mean	75.10%	90%	77%	6.435	71.4

Table 1. Results of language and communication tests for the 20 participants; [1] the person is shown a drawing of an object and asked to name it; [2] the person has to match a spoken word to one of 5 pictures; [3] the person has to match a spoken sentence to one of 3 pictures

Participants' scores in spoken picture naming ranged from 27% - 100% correct. Understanding of spoken words, as assessed by the word to picture matching task, was relatively unimpaired, with no participant making more than 6 errors. However, all participants were impaired on the sentence to picture matching task, and five made 10 or more errors (chance on this task is 33%). The two additional scores in table 1 are from a battery of experimental measures used for treatment evaluation (see [43]). Both scores are from the first, pre-therapy administrations. In the fluency task, participants were given one minute to name as many items as possible from 10 different categories, such as things you see in a kitchen or in a supermarket. The score is the mean across the categories; i.e. participant M named, on average, 4.7 items per category. Unimpaired language users name about 20 items per minute in comparable fluency tasks [30, 38]. The participants scored well below this level, reflecting the word retrieval problems that are typical of aphasia. The final column gives the percentile score from the Communication in Daily Living -2 assessment [32]. This assesses the person's ability to communicate in everyday

situations, such as going to the doctor. While some participants demonstrated good functional skills on this test (e.g. participants I, PE, W) several showed marked impairments (e.g. MK, R, D, O, T).

3.3 Equipment

Each participant was provided with a laptop running a "ready-to-run" installation of EVA Park including a personalized avatar with the gender, features and clothes they had previously selected using ''tangible avatars' [65]. A researcher visited each participant at home at the outset of the study to install the hardware and software, train them to use it, and to ensure that, as far as possible, there were no technical difficulties. Regular remote and/or face-to-face support was provided when needed.

3.4 Data Collection

Observations and interviews were conducted with each participant in week 2 (OBS 1) and week 5 (OBS 2). A researcher visited the participant at home to observe and record one of the regular daily scheduled hour-long sessions with the SW. Two video recordings were taken: one (via a camcorder) recorded the participant interacting with EVA Park, and the other (using screen recording software) simultaneously recorded what was happening in the virtual world. The 20 participants completed all their sessions, however initial problems with the screen recording software resulted in only 17 videos for OBS 1 but a full set of 20 videos for OBS 2.

Interviews took place immediately after the observed sessions. The aim of the interviews was to record the user's own perception of that day's session – what was easy, what was difficult, what was enjoyed, what was not enjoyed, etc. Given the participants' limitations with spoken language, several questions employed a visual 5 point scale to which they could point. In week 5, the participant's carer (for those that had one) was interviewed for their views regarding the participant's experiences over the 5 week period.

We also logged how long participants spent in EVA Park outside of scheduled sessions.

3.5 Data Analysis

A thematic analysis of the video data was undertaken to identify key themes related to participants' general experience of a virtual world and their experience of therapy in a virtual world. This was supplemented with supporting evidence from analysis of the post-observation interview data.

Coding scheme. The thematic analysis commenced with the development of an initial coding scheme. An initial set of codes and sub-codes was derived from two sources. Firstly, codes were taken from relevant games literature to answer the research questions that concerned the general experience of a virtual world: Poels et al's categorisation of digital game experience [50]and the GEQ [9, 36]. These codes were: positive affect, negative affect, social presence, immersion, and flow. Relevant sub-codes from the same literature were also included. Secondly, two codes specifically related to using EVA Park for conversation practice were included: types of conversation (with sub-codes: conversations grounded in the virtual world, conversations grounded in the real world, conversations about EVA Park, and role play) and miscommunication and misunderstanding.

Two independent coders then independently analysed a video of an EVA Park session using the initial coding scheme and adding emergent codes. The results were discussed between the two coders and a common set of codes was agreed. The first author (JG) then analysed the remaining videos using this coding framework, adding additional sub-codes as appropriate. The

final coding scheme is given in Table 2 with the codes and sub-codes that arose during analysis marked with an asterix (*). The additions included 'relief' (A+ v), 'worry' (A- v) and 'playfulness' (A+ ii) as sub-codes of affect. Some types of conversation occurred only once and so were included in the sub-code 'other' (B v) e.g. playing a word game, or giving the back history of a character in a book. A specific sub-code of miscommunication was added to describe instances where misunderstanding arose from the SW not being able to see what the participant was seeing or what they were doing, for example gesturing in the real world or pointing to something on the screen not seen by the other (C iii). Another sub-code (G ii) related to flow emerged from the analysis to cover interruptions e.g. when the participant felt ill and needed to stop, or the phone rang, or the participant's child interrupted the session.

Video Analysis . For each session, the two separate videos – of the participant using EVA Park and the screen recording of what was happening at the time – were merged into one PIP (picture in picture) video. In this way, it was possible to see the participant's face, hands and body as they conversed and reacted to events in the virtual world. Each PIP video was then transcribed to include a description of what the participant was doing and what was happening in EVA Park at the same time, along with the detail of the conversations and relevant PIP video time codes.

The transcripts were coded as described above. The size of individual textual units of analysis varied from a word to a paragraph. It was determined by meaning and the ability of the participant to express an idea using language e.g. for one participant, an 'Oh!' said with an expression of surprise formed one unit of analysis. A participant with milder aphasia may have used more words to express their surprise. Meaning also determined whether one or more incidences of a sub-code occurred. For example, a conversation about participant D taking a pottery class was coded as two separate incidents of a conversation based in the real world because at first it was focused on what D was making but then it changed to the other people in the class also being disabled i.e. the focus changed to the class itself. However, an exact and immediate repetition with the same intended meaning was not considered a new incident. For example, participant O clicked on the cash till in the café to make it ping when her SW role-played a waitress and asked for payment for two coffees. This was coded as 'positive affect, playfulness'. O immediately repeated the action and this was coded as the same incident. Their subsequent laughter however, was coded as a separate incident of 'positive affect, pleasure/fun'. When coding was complete, the number of incidences of each code and sub-code were calculated for each participant.

Assigning codes and sub-codes to units of analysis was not always clear cut and inevitably occasionally involved the subjective interpretation of the coder. For example, some misunderstandings may have been due to the SW not being able to see what the participant could see or due to misunderstood instructions and/or the participant's own misinterpretation of EVA Park and how it worked. A SW suggesting to a participant that they move their avatars to somewhere else in EVA Park could be breaking up the session or alternatively, taking the initiative. Expressions of negative emotion were particularly difficult to assign. For example, was a certain sigh or a bowing of the head frustration, or was it irritation? Likewise, when a participant said 'hooray' upon achieving something, was this indicative of pride or something else? Moreover, some participants displayed no emotion at all.

Ten percent of the data (4 transcripts) was subject to intra and inter-rater reliability checks. The first rater (JG) coded one set of transcripts twice, separated by 2-12 months. Scores for each sub-code were correlated over the two occasions. When all sub-codes were included in the analysis, the Intraclass Correlation Coefficient (absolute agreement, mixed model) was 0.94. A second analysis excluded sub-codes that scored 0 (did not appear in the sample) on both coding occasions as these rarely occurring codes might inflate the correlation. The ICC was still excellent; ICC = 0.92; 95% confidence interval between 0.84 and 0.95. A different sample was

coded by a second rater (HG), to check inter-rater reliability. Scores across the two raters correlated highly. For all codes, the ICC was 0.873 (95% CI between 0.821 and 0.909). Omitting sub-codes that repeatedly scored 0 reduced the ICC to 0.74 (95% CI between 0.55 and 0.89). These values point to excellent intra-rater reliability and good inter-rater reliability.

Interview Analysis . The post observation interviews comprised 24 questions designed to elicit feedback about a broad range of issues. There were questions about use of the keypad and mouse, the buttons and whether the participant felt in control. Other questions explored enjoyment, things that the participant found easy or hard, liked or did not like, how they felt about being in EVA Park outside of the scheduled sessions as well as during the SW led sessions, and also the weekly group sessions. Nine of the questions were relevant to the research questions set out above and are reported in this paper. Six of these questions were supported by a 5 point visual rating scale, as explained above. Mean rating values for these six questions were analysed at OBS 1 and OBS 2.

4. RESULTS

This section is in two parts. In the first, we describe the key themes that emerged from the coding exercise; the intent is to paint a rich picture of participants' experience of EVA Park. In the second, we report results from the post-observation interviews.

4.1 Results from the Coding

Table 2 summarises the codes and sub-codes and describes what was observed in order to count as an instance of that sub-code. NB. Body language was coded directly from the video.

Theme codes and sub-codes		**Observation**
A+ Affect (Positive)		
A+ i	pleasure/fun	P laughs
A+ ii	playfulness / making a joke *	P does/says something to make another laugh
A+ iii	pride	P's words and/or body language
A+ iv	positive surprise *	e.g. 'Oh!' 'Wowee' plus P's tone of voice
A+ v	relief *	e.g. 'Phew', and P's body language
A- Affect (Negative)		
A- i	displeasure	P's body language eg. shaking head
A- ii	frustration	e.g. P sighing, body language
A- iii	irritation	P's words, and/or body language
A- iv	negative surprise *	e.g. Oh! plus P's tone of voice
A- v	worry *	P's body language
A-vi	negative passivity (unwillingness to help/try) *	P's words and body language
B Types of conversation		
B i	grounded in/stimulated by activities/events in the virtual world	P and SW converse and topic arose via an element of EVA Park e.g. the elephants
B ii	grounded in/stimulated by activities/events the real world	P and SW converse and topic concerns the real world e.g. relatives, holidays..
B iii	about using EVA Park	P and SW converse about how to use the controls to e.g. fly or teleport
B iv	role play of real world activity in EVA Park	P and SW play roles to act out e.g. booking a haircut in the salon
B v	other *	e.g.P reading to SW from a book, P and SW playing a word game…

B vi	about EVA Park itself *	P and SW discuss what EVA Park is, or what an avatar is.
C Miscommunication and Misunderstanding		
C i	miscommunication between SW and P related to language *	P or SW misunderstands what the other says
C ii	P misunderstanding some element of the world/controls*	P misunderstands how to do something e.g sit their avatar or fly
C iii	SW misunderstanding what P can see / is doing *	words/actions indicate SW misunderstands what P is trying to do/seeing
D Immersion		
D i	absorption in the virtual world	P's words indicating s/he feels s/he really is in EVA Park
D ii	detachment/disengagement from the virtual world	P 's words indicating a separateness, being outside EVA Park
E Social Presence		
E i	seeking/enjoying being with others	P seeks out another P in EVA Park
E ii	wanting to be alone	P moves their avatar away from other Ps
F Initiative *		
F i	P taking initiative *	P suggests an activity to SW
F ii	SW taking initiative *	SW suggests an activity to P
F iii	SW enabling P to take the initiative *	SW asks P where they should go/what they should do next.
G Flow		
G i	breaking up conversations e.g. by going somewhere else *	SW suggests another activity/place and it is clearly a break from conversation
G ii	break in session *	Any interruption e.g. P feeling ill, child requiring attention, doorbell…

Table 2: Summary of the codes (* = emerged from analysis. P = participant)

The key themes are: affect (positive and negative), types of conversation, miscommunication and misunderstanding, immersion in the virtual world, social presence, and initiative and flow. These correspond to the main codes, apart from the affect theme which is addressed by 2 codes – positive affect and negative affect. Each theme is discussed below, with additional detail about how the contributing codes and sub-codes were recognised and distinguished. This is supplemented with tables showing the total, mean per session, and range of incidences of codes over the 17 recorded sessions at OBS 1 (week 2) and the 20 recorded sessions at OBS 2 (week 5).

Theme A: Affect (Positive and negative). Table 3 compares incidences of positive affect and negative affect; statistical analyses of the data follows a summary of each code. Distinguishing between positive and negative emotion involved considering tone and expression e.g. positive surprise might involve a laugh or a high tone of voice accompanying an 'Oh!' for example, but negative surprise might involve an utterance that was low in pitch e.g. when O jumped and said, 'Oh God!' when the SW's voice was louder than she expected at the start of their conversation.

Positive affect (A+). The sub-codes for positive affect were: pleasure/fun, playfulness/joking, pride, surprise and relief. As can be seen from Table 3, incidences of pleasure/fun (A+ i) and playfulness/making a joke (A+ii) were by far the most frequent affect sub-codes. These were distinguished by (A+ i) being about the participant themselves laughing, whereas playfulness / making a joke (A+ ii) was more about the participant trying to make the SW laugh. For example, this happened when participant B 'stroked' a cat in EVA Park (by clicking on it) which made a 'meow' sound at which the SW laughed. Participant P responded: ': Oo, Too much ups!' when

her SW suggested she should do 'sit ups and push ups'. Participant P also provided a lovely example of pride (A+ iii): she explained to her SW that for the first time since her stroke, she had finally bought something using internet shopping. 'Many years I trying… 4 years I'm trying. I'm trying since last week. And yesterday... I try every day. And yesterday I could. I bought it. I waiting. From China.' Her voice was high and excited.

Negative affect (A-). The sub-codes for negative affect were: displeasure, frustration, irritation, surprise, worry and negative passivity. The majority of these incidences were accompanied by indicative body language or tone of voice. For example, sighing or leaning back and folding arms. On one occasion, participant W put her hand out in a way that indicated she could not manage when the phone rang and the SW had not realised and continued talking to her. This was coded as A- i i.e. displeasure. An example of frustration (A- ii) was when Participant O was trying to stop flying but pressed the button that moved her avatar backwards instead, and she placed her head in her hands and said: 'Oh God. No.' There was only one example of the worry (A- v) sub-code. This was when L put her hands on her head in a sudden movement and her face seemed worried rather than, say, frustrated. She was trying to spell a word in the chat bar and repeating the word but writing a different one. Negative passivity (A- vi) was a sub-code that was used for just one participant, S. It was used when he was unwilling to try. For example, on one occasion, at the disco, the SW suggested that he should click on the dance ball to make his avatar dance. He clicked but not on the ball. SW asked him: 'What happens when you press it?' S: 'Nothing' and he folded his arms. The more usual response to such events from other participants was to try again. Similarly, when he had not clicked the button to switch on his microphone at the start of both recorded sessions, the SW could not hear him. His response was: 'Well I'm plugged in and that's that.'

As can be seen from Table 3, the most frequently occurring sub-code of negative affect was frustration. Delving a little deeper into the causes of this showed that the majority of incidences were language related i.e. trying to find a word or getting frustrated with not being understood. However, as described above, there were some incidences of frustration expressed with EVA Park itself.

A+ Positive affect		**Incidences at OBS 1 (week 2)**			**Incidences at OBS 2 (week 5)**			**Totals**
		Total	Mean/ session	Range	Total	Mean/ session	Range	Total
A+ i	pleasure/fun	51	3	0-13	44	2.2	0-6	95
A+ ii	playfulness / making a joke	25	1.47	0-9	25	1.25	0-5	50
A+ iii	pride	7	0.41	0-2	5	0.25	0-1	12
A+ iv	positive surprise	4	0.23	0-2	1	0.05	0-1	5
A+ v	relief	2	0.11	0-1	1	0.05	0-1	3
		89			76			165
A- Negative affect								**Totals**
A- i	displeasure	7	0.41	0-4	2	0.1	0-1	9
A- ii	frustration	12	0.7	0-2	7	0.35	0-2	19
A- iii	irritation	1	0.05	0-1	2	0.1	0-2	3

A- iv	negative surprise	1	0.05	0-1	2	0.1	0-1	3
A- v	worry	1	0.05	0-1	0	0	0-0	1
A-vi	negative passivity	3	017	0-3	2	0.1	0-2	5
		25			15			40

Table 3: Total, mean and range (in any one session) of incidences for positive and negative affect

The affect data were analysed statistically to determine whether there was a significant difference between instances of positive and negative affect, and whether this changed over time. Comparisons were conducted on the pooled positive and negative affect data; i.e. each subcategory was not analysed separately. Data from 17 participants were entered into the analysis, where there were both week 1 and week 5 observations. As was the case for all data in this results section, there was a significant result on the Shapiro-Wilk test of normality. Therefore non parametric comparisons were run (Wilcoxson &/or Friedman tests).

Taking time first, results showed that instances of positive and negative affect did not reduce significantly over time (for the positive data, Z=.655, p=.51; for the negative data Z = 1.39, p =.16). Although neither result was significant, there was a marginally greater tendency for instances of negative affect to reduce, compared to instances of positive affect.

The comparison between the positive and negative data was highly significant at OBS 1 (Z = 2.8, p = .005) and OBS 2 (Z = 3.07, p = .002). Thus, at both time points there were significantly more behaviours coded for positive than negative affect. Non parametric statistics do not explore interactions. However, the raw data and p values suggest that the difference between positive and negative affect was marginally greater at OBS 2 than at OBS 1.

Theme B: Types of Conversations . Conversation topics were determined by the SW and the participant and covered an interesting variety of subjects. Often they were related to a participant's goals that had been set at the start of the therapy sessions, such as role-playing buying a cinema ticket or dealing with people coming to the door (B iv). In some of these role-plays, the SW might ask another SW to join them in EVA Park to play a certain character. Other participants wanted to practice general conversations in a crowded or noisy atmosphere such as a bar – this poses challenges for many people with aphasia. For these, the SW could switch on background noise in EVA Park. Conversations also varied in length from just 2 or 3 exchanges lasting a matter of seconds to 10 minutes or more. Many conversations were about what the participants were experiencing in their lives at the time (B ii) such as issues with family, or holidays or visits from relatives. Other conversations were stimulated by the environment in EVA Park (B i). For example, when passing the elephants, T noticed some chickens. He tried to say the word. When his SW then asked him if he had ever kept any animals, a real world conversation ensued, which was then coded as B ii. Conversations about using EVA Park (B iii) - how to use the controls to fly for example – differed from conversations about EVA Park itself (B vi). Examples of the latter included a participant and his SW discussing how to describe EVA Park to a friend.

B Types of Conversation		**Incidences at OBS 1**			**Incidences at OBS 2**			**Totals**
		Total	Mean/ session	Range	Total	Mean/ session	Range	
B i	grounded in/stimulated by	109	6.4	2-14	120	6	2-12	229

	activities/events in the virtual world							
B ii	grounded in/stimulated by activities/events the real world	99	5.8	1-12	123	6.15	1-16	222
B iii	about using EVA Park	85	5	1-18	70	3.5	1-11	155
B iv	role play of real world activity in EVA Park	5	0.29	0-3	14	0.7	0-6	19
B v	other eg. playing a word game, reading…	4	0.23	0-2	6	0.3	0-4	10
B vi	about EVA Park itself	2	0.11	0-2	5	0.25	0-3	7
		304			338			642

Table 4: Total, mean and range (in any one session) of incidences for the various conversation types

The results in Table 4 show that participants and their SWs covered a range of conversational topics per hour. The vast majority of these were inspired by events or activities in EVA Park (B i) or by events or activities in the participants' real world lives (B ii). Slightly fewer were about using EVA Park itself (B iii). The remaining categories (B iv – B vi) featured much more rarely. Role play conversations (B iv) were surprisingly low in frequency in the observed sessions; but they were only coded as role play if they were planned as such with the SW. Examples were D role-playing reporting an incident to the police and L practising saying no to charity cold callers. Conversations in the café or restaurant which included an element of role play, such as ordering a pizza, were coded as B i, i.e. stimulated by activities in the virtual world. There was a marginal, but non-significant ($Z = .73$, $p = .5$) increase in the number of role plays at OBS 2.

The three most common categories (B i – B iii) were subject to statistical comparison. There was no difference in the frequency of these categories at OBS 1 (Friedman Chi square = 2.47, df = 2, $p = .29$). However, there was at OBS 2 (Friedman Chi square = 9.71, df = 2, $p = .008$). Now, conversations about using EVA Park occurred more rarely than conversations stimulated by the virtual (B i vs B iii; $Z = 2.52$, $p = .012$) and real (B ii vs B iii; $Z = 2.50$, $p = .012$) world. The comparison between B i and B ii at OBS 2 was not significant ($p = .9$).

Theme C: Miscommunication and Misunderstanding . Three kinds of miscommunications and misunderstandings were identified in the analysis: i) miscommunications related to language, ii) miscommunications related to EVA Park or the browser controls and iii) misunderstanding on the part of the SW because he/she couldn't see what the participant could see or what the participant was doing.

Misunderstandings related to language (C i) occurred when either communication partner misunderstood something the other said. For example, PE misunderstood a question from his SW about whether it was easier for him to understand language when it was also written down. His response indicated that he had understood that the question was about whether writing things down for himself is helpful. Misunderstandings related to aspects of the use of EVA Park or browser controls (C ii) occurred when the SW was trying to help the participant to do something such as fly or use the teleport or turn the microphone on, and the participant clicked

or pressed on something other than what they had been instructed. There were also some misunderstandings related to the SW not seeing what the participant sees (C iii). For example, when V and her SW were discussing the mayoral candidates, the SW asked: 'What about Pebble Beach [one of the candidates]?' in response to V having said she did not trust Boggis (another candidate.) The SW could not see that V was still scrolling down the news-board at the time. V responded by looking for information in the news-board about Pebble Beach (which was not there). Her eventual response was: 'It's not working'. Her SW could not see what 'wasn't working' and instructed her to do something that she was not trying to do.

C Miscommunication and Misunderstanding		**Incidences at OBS 1**			**Incidences at OBS 2**			**Totals**
		Total	Mean/ session	Range	Total	Mean/ session	Range	
C i	miscommunication between SW and P related to language	23	1.35	0-4	28	1.4	0-6	51
C ii	P misunderstanding some element of the world/controls	13	0.76	0-4	10	0.5	0-3	23
C iii	SW misunderstanding what P can see / is doing	8	0.47	0-3	11	0.55	0-5	19
		44			49			93

Table 5: Total, mean and range (in any one session) of incidences for miscommunications/ misunderstandings

Table 5 shows that the majority of the miscommunications/ misunderstandings arose because the language used by either the SW or the participant was not understood by the other (category C i). C ii misunderstandings about how to use EVA Park or the controls were rare (on average <1 per session). Those participants who very quickly became familiar with navigating their avatar around EVA Park and using the controls had very few C ii misunderstandings, and no-one experienced more than 4 in a session. Misunderstandings related to the SW not seeing what the participant was seeing (C iii) were less common than expected. Only 19 incidents in total were logged across the 37 recorded sessions.

The categories of misunderstanding were compared statistically for both OBS 1 and OBS 2. Results were only significant for OBS 1 (Friedman Chi Square = 12.46, df = 2, p = .002). Pairwise comparisons showed that misunderstandings related to language were significantly more common than misunderstandings arising from the SW's different perspective (C i vs C iii; Z = 2.8, p = .005). The comparison between C i (language) and C ii (how to use EVA Park) was not significant (p = .053). None of the changes over time in any category was significant.

Theme D: Immersion . Two aspects of immersion were coded: evidence of absorption (D i) and detachment (D ii) from the virtual world. There were only a few instances of each, as shown in Table 6. One example of absorption was when B said something 'was weird last night' referring to their session the previous day. When the SW queried B, he remembered that the incident had occurred during night-time in EVA Park, but it had been daytime in the real world. Another example was when the SW asked V if she had ever been to a disco (whilst her avatar was dancing). She replied: 'No. Doing it now though'. And when the SW asked DI to move nearer to the microphone, he moved his avatar nearer to hers. The relatively low occurrence of the absorption sub-code is explained in part by the fact that comments such as it being too early

in the day for a gin and tonic, or 'I've just washed my hair' when asked if they wanted to dive from the diving board, were coded as jokes or playfulness.

There were even fewer examples of detachment. One was when B was positioning his avatar under the leaping whales, his SW asked if he was scared of whales and he said: 'Well not this one, but yes, of course.' The remaining 7 of the total of 8 incidences of detachment were exhibited by just one participant, S, the participant referred to above in the section on negative passivity. They included him saying 'no' when asked if he wanted to eat or drink something, and comments about not seeing the point when asked if he can see the whales in the distance.

D Immersion		**Incidences at OBS 1**			**Incidences at OBS 2**			**Totals**
		Total	Mean/ session	Range	Total	Mean/ session	Range	
D i	absorption in the virtual world	6	0.35	0-2	7	0.35	0-2	13
D ii	detachment/disengagement from the virtual world	3	0.17	0-2	5	0.25	0-5	8
		9			12			21

Table 6: Total, mean and range of incidences for immersion: absorption or detachment from the virtual world

The comparisons between absorption and detachment were not significant at either observation. This is unsurprising given the small number of instances.

Theme E: Social Presence . If a participant saw another participant and made an effort to join them or say 'hello', this was coded as E i i.e. actively seeking others. Conversely, if they saw another participant and navigated their avatar in another direction, or suggested to their SW, 'Lets go' for example, this would be coded as E ii i.e. avoiding others. It should be noted however, that the opportunities for bumping into others during the observed sessions was limited, as these times were set aside for individual therapy with the SW. The total, mean and range of these incidences are shown in Table 7 below:

E Social Presence		**Incidences at OBS 1**			**Incidences at OBS 2**			**Totals**
		Total	Mean/ session	Range	Total	Mean/ session	Range	
E i	seeking/enjoying being with others	8	0.47	0-2	18	0.9	0-5	26
E ii	avoiding others	3	0.17	0-1	1	0.05	0-1	4
		11			19			30

Table 7: Total, mean and range of incidences for social presence: seeking others or avoiding others

Table 7 shows that seeking to interact with others occurred more often than avoiding others in the observed sessions. This comparison was not significant at OBS 1 ($Z = 1.5$, $p = .13$), but was at OBS 2 ($Z = 2.54$, $p = .011$), when presumably participants were more familiar both with EVA Park and each other. The very low number of instances in which participants avoided others at OBS 2 is striking. The analysis is based on a full set of 20 videos; and the fact that

there were 18 instances in which contact with others was actively sought shows that there were opportunities for the contrary behaviour to arise.

Theme F: Initiative and Flow . Incidences were noted when the SW (F i) or the participant (F ii) took the initiative to e.g. change the topic or suggested going somewhere/doing something different in EVA Park. Also, it was noted when the SW enabled the participant to take the initiative (F iii) by e.g. asking the participant where they should go to have a chat.

F Initiative		**Incidences at OBS 1**			**Incidences at OBS 2**			**Totals**
		Total	Mean/ session	Range	Total	Mean/ session	Range	
F i	P taking initiative	18	1.05	0-5	23	1.15	0-4	41
F ii	SW taking initiative	50	2.94	0-8	33	1.65	0-5	83
F iii	SW enabling P to take the initiative	21	1.23	0-4	21	1.05	0-4	42
		89			77			166

Table 8: Total, mean and range (in any one session) of incidences for initiative taking

Table 8 reports instances of initiative taking. At OBS 1 there was a significant difference between the categories (Friedman Chi Square = 10.03, df = 2, p = .007). Pairwise comparisons showed that the SWs were significantly more likely to take the initiative than participants (F i vs F ii; Z= 3.2, p = .001). There were also significantly more instances of SWs taking the initiative than enabling the participants to do so (F i vs F iii; Z = 2.35, p = .019). The comparison between F ii and F iii was not significant. Interestingly, at OBS 2 the difference between categories was no longer significant (Friedman Chi Square = 1.67, df = 2, p = .43). As is evident in Table 8, the profile of initiative taking was now more even. The change was largely due to a reduction in the instances in which SWs took the initiative, although this reduction was not significant (p = .059).

It was sometimes hard to distinguish incidences of taking initiative from those classified as 'breaking up the session'. The 'breaking up the session' (G i) code was used when it was clear that the SW wanted to release the tension of a challenging conversation or task by suggesting they go somewhere else in EVA Park. Table 9 shows that 46 such incidences were recorded. Breaks in the session for interruptions eg. phone calls, doorbells, children returning or the participant feeling ill and needing time out, were also coded (G ii). The frequency of session breaks did not change over time for either category (Gi OBS1 vs OBS 2, Z = 1.32, p = .19; G ii OBS1 vs OBS 2, Z = .92, p = .36).

G Flow		**Incidences at OBS 1**			**Incidences at OBS 2**			**Totals**
		Total	Mean/ session	Range	Total	Mean/ session	Range	
G i	breaking up conversations eg. by going somewhere else	17	1.0	0-2	29	1.45	0-4	46
G ii	break in session eg. Illness. Interruption	19	1.11	0-6	15	0.75	0-4	34
		36			44			80

Table 9: Total, mean and range (in any one session) of incidences for breaks in the flow of the session

4.2 Results from Post-Observation Interviews

This section presents results from the 9 questions in the post observation interviews that related to the research questions addressed in this paper. Responses to six of these questions were delivered on a 1 – 5 rating scale, where 1 was most negative and 5 most positive. Rating results are reported in Table 10 below. The other three questions were open, two relating to enjoyment and one to immersion.

Question topic/Observation	N*	Mean	Median	Interquartile range	Range (SD)
Overall enjoyment/OBS 1	20	4.5	5	1	3 - 5 (.68)
Overall enjoyment/OBS 2	20	4.6	5	.88	2.5 – 5(.74)
Enjoyment of gestures/OBS 1	19	4.3	5	1	1 – 5 (1.04)
Enjoyment of gestures/OBS 2	20	4.3	5	1.38	1 – 5 (1.1)
Using EVA Park on your own/OBS 1	17	3.8	4	1	1 – 5 (.97)
Using EVA Park on your own/OBS 2	18	4.2	4.75	2	3 – 5 (.89)
Being with your support worker/OBS 1	20	4.9	5	0	3.5 – 5(.33)
Being with your support worker/OBS 2	19	4.9	5	0	4 – 5 (.25)
Being with 3 or more avatars/OBS1	15	3.3	3	1	1 – 5 (1.11)
Being with 3 or more avatars/OBS 2	18	4.2	4	1.25	2.5 – 5(.86)
Election narrative/OBS 1	17	3.3	3	1	1 – 5 (1.06)
Election narrative/OBS 2	19	3.2	3	2	1 – 5 (1.17)

*Number of participants who provided a rating

Table 10: Rating Responses to Interview Questions at Observations (OBS) 1 and 2

Enjoyment (Affect). Four interview questions related to enjoyment. Firstly, participants were asked to rate their level of enjoyment of the day's session ('Overall enjoyment' in Table 10). The scale was: 5 for really enjoyed, 3 was neither enjoyed nor not enjoyed and 1 was not enjoyed. The results show that the participants overwhelmingly reported a positive experience, with no negative ratings. Ratings at observations 1 and 2 did not differ (Z = .53, p =.6).

The second enjoyment question asked: 'How do you find using the gestures', using the same enjoyment scale as above ('Enjoyment of gestures' in Table 10). Again, ratings were high, although one person gave a negative rating on each occasion. Ratings did not differ across the observations (Z=.07, p=.9).

Two open questions asked if there was anything participants particularly disliked in that day's session; and if there was anything they did not like or found boring when visiting EVA Park in between sessions. Most participants said there was nothing. One participant did not like the Tardis and another indicated that she did not like the group sessions.

Social Presence . Three interview questions explored social presence. Participants were asked: 'How do you find being in EVA Park on your own?'; 'How do you find being in EVA Park with your support worker?'; and 'How do you find being in EVA Park with 3 or 4 avatars at the same time?' These questions were targeted at their general experiences thus far i.e. not restricted to the session that day.

At both observations, ratings for the three questions differed (OBS 1 Friedman Chi Square = 18.17, df =2, p <.001; OBS 2 Friedman Chi Square = 8.14, df = 2, p = .017). Table 10 shows that ratings were highest for being with the support worker. Indeed, at both observations, there was only one participant who rated this below 5; and on both occasions, being with the support worker was rated higher than being alone in EVA Park (OBS 1, Z = 3.31, p =.001; OBS 2, Z = 2.6,

p =.009) and being with three or more avatars (OBS 1, Z = 3.22, p = .001; OBS 2, Z = 2.87, p = .004). Ratings for being with the support worker did not change between observation 1 and 2.

Ratings for being alone in EVA Park were more varied, although only one participant scored this negatively (at OBS 1). As reported above, being alone was rated lower than being with the support worker at both observations. Ratings for being alone and being with three or more avatars did not differ significantly at either time point. Ratings for being alone increased marginally at OBS 2, although the difference was not significant (Z = 1.5, p = .14).

The question: 'How do you find being in EVA Park on your own?' was the only question related to unsupervised visits to EVA Park. Although we did not collect data regarding what participants did in the unsupervised visits to EVA Park, our understanding from informal feedback was that it was mainly solitary and involved navigating their avatar around the island, familiarising themselves with places and the controls, or just exploring the island. Several participants particularly enjoyed watching the video clips that were on the screens dotted about the island and would check in regularly to see when the clips changed. The log data shows that time spent in EVA Park outside of scheduled sessions varied. On average participants spent 16.9 hours outside of scheduled sessions, with the greatest length of time being 76.8 additional hours and the least being 1.0 additional hour.

Being with three or more avatars received the lowest ratings at observation 1. However, scores for this question increased significantly at OBS 2 (Z = 2.44, p = .015). Thus, interacting with a group in EVA Park became increasingly enjoyable over time.

The Election Narrative . One rating question concerned the election storyline: 'How do you find talking about the candidates in the election?'. Table 10 shows that mean scores for this question were neutral; and, indeed, at both observations the mode score was 3. Ratings for this question did not change over time (Z = .517, p = .61). The ranges indicate that a few participants really enjoyed the election narrative. These individuals could become quite heated about, for example, whether having an affair with another candidate's sister was a cause for concern in an election. The UK 2015 general election was happening whilst one group of participants was in world, and so inevitably, there were election conversations which spanned both EVA Park and the real world.

Attitudes Towards the Avatar (Immersion). The final, open question asked: 'What do you think of your avatar?' Many said that they liked their avatars because e.g. they were a slimmer, younger version of themselves. One participant, P, assigned her avatar emotions: 'I don't know why sometimes she put her head like something happened.' [looks down/sad]. 'I thought, Oh my god, maybe she has feelings!' And a second, W, suggested her avatar should learn: 'Sometimes doesn't behave herself. She keeps falling in the water. She could learn to be more… able.'

Most participants answered the above question using the third person i.e. detached. However, when asked: Where does your avatar like to hang out most? some participants used the first person. For example: 'I sometimes leave myself sitting at the table outside. Yesterday I sat there with a pizza.'

5. Discussion and conclusions

This study investigated the emotional, social, and conversational experiences of PWA whilst using a virtual world, using a thematic analysis of observational data supplemented with findings from interviews. We now summarise the findings against the research questions and then discuss the technological and clinical implications.

Affect: What emotions, both positive and negative, do participants experience when using EVA Park; how do the number of positive and negative instances of emotional experience compare and does this change over time?

Results showed that users' experiences of EVA Park were strongly associated with positive rather than negative affect, e.g. marked by playfulness, joking and laughter, and that enjoyment was rated highly. Instances of positive affect and high ratings for enjoyment did not diminish over time. Comments from carers corroborated these findings, for example: 'I've noticed I hear a lot of laughter when he's online'; 'I can hear him laughing away. It's been really good for him'; 'It's lovely hearing J laugh'.

Types of Conversation: What are the main types of conversation employed in EVA Park? To what extent are they grounded in the real world compared with the virtual world and does this change over time?

The majority of conversations were either about aspects of the real world, and particularly the participants' own lives, or about aspects of the virtual world. Slightly fewer were about using EVA Park itself and these reduced over time, presumably because participants became more adept as users. The virtual conversations often reflected the engaging characteristics of EVA Park and the novel elements that were designed to stimulate conversation, such as the news board updates about the scandalous behaviour of the election candidates and the contents of the video screens dotted around the park. The data show that conversations transitioned easily between the real and the virtual world. Indeed, some participants even played with the dual presence of reality and virtual reality e.g. L replied 'I've just washed my hair' when asked if she wanted to dive from the virtual diving board.

Miscommunication and misunderstanding: What types of miscommunications and misunderstandings occur and to what extent are they stimulated by aspects of the virtual world?

The most common category of misunderstanding related to language. Given that such misunderstandings are a frequent consequence of aphasia eg.[6] this is not surprising. Whether language related misunderstandings are more common in virtual, rather than face-to-face exchanges is not revealed by our data. No participant experienced more than 4 language misunderstandings per session, and the mean was less than 2. Misunderstandings arising from the technology, or the remote nature of the interactions were rare, with a mean of less than one instance per session. When these did occur, they were often an opportunity for further language practice. For example, participants occasionally responded to questions from their SW by using non-specific pronouns (such as 'there') or pointing to a feature of EVA Park on their screen. They would then need to provide more verbal information, or answer further questions for their communication to be clear. People with aphasia benefit from visual cues during conversation, e.g. arising from facial expression and gesture [24]. We wondered, therefore, if communication would be hampered by the fact that PWA were not able to see their SW's face or hands. In fact this was not the case.

Immersion in the virtual world: Do participants engage with the virtual aspects of the world including their avatar?

There were very few coded instances of absorption in our data. Nevertheless, the affect findings and the overall willingness of participants to engage with the interactive opportunities of EVA Park suggest immersion. For example, all participants bar one enjoyed making their avatar dance and engaged in virtual experiences, such as diving from the diving board, playing in a band, flying, taking part in a virtual race, and riding an elephant. Participants also enjoyed being represented by an avatar, with some expressing feelings of identification with their avatar. Some played with the representational opportunities that avatars provided, for example one participant switched gender, and others chose to have wings or a very different 'look' to their real selves. Only one participant, S, showed less signs of immersion. Indeed, 7 of the 8 recorded incidences of detachment were exhibited by this participant. S's seemingly reduced level of engagement may have been due to personality factors, or possibly indicative of a low mood. Compared to the group as a whole, his stroke was relatively recent, having occurred 8 months

prior to the study. Others in the group, therefore, had longer to come to terms with their aphasia.

Social presence: Do participants form successful/enjoyable relationships with others within the virtual world? How does this change over time?

Taking interview findings first, the results indicated that participants were able to formulate a successful working relationship with their support worker, with ratings at both observations showing that this relationship was highly prized. Other encounters were more valued as time progressed. Initially, participants avoided others as often as seeking them out. However this was this was not the case at OBS2, when seeking others became the more frequent behaviour. In line with this, ratings for interacting with three or more avatars increased significantly at OBS2. It seems therefore, that people could sustain a 1:1 relationship in EVA Park from the outset, while interactions with the wider group perhaps depended on growing familiarity and confidence. Therapeutic relationships are perceived as central to treatment success in stroke rehabilitation [40]. In the context of speech and language therapy such relationships allow for supportive communication practice and can foster feelings of being understood and empowered [25]. Our findings suggest that the benefits of a therapeutic relationship can be delivered in a virtual as well as real world environment.

Initiative and flow: Do participants take conversational initiative when interacting with a conversation partner in the virtual world and how does this change over time? What types of interruptions break the flow of a session and does this change over time?

Perhaps not surprisingly, the support workers were most likely to take initiative at OBS 1, e.g. by suggesting new activities or places to visit. However, initiative taking was more even at OBS 2; now participants were as likely to initiate a change as their SW. It is difficult to speculate about why patterns of initiative taking changed. Increased familiarity with the environment on the part of the participants with aphasia is a likely factor. Support workers may also have reduced their input over time, as a deliberate rehabilitative strategy. A companion study [3] used interviews to explore participants' responses to the EVA Park intervention. Many flagged increased confidence as a benefit. The increased initiative taking evident here may reflect this growth in confidence.

Some breaks in sessions were stimulated by events in participants' lives, such as the need to answer the doorbell. Breaks were also taken, however, when the participants needed a rest. PWA often need such breaks, given that fatigue is a very common symptom of stroke [35]. Rest breaks typically involved an interlude of fun, e.g. by clicking on something funny such as the different mats in the health centre on which the avatar can do ballet, yoga or boxing moves; or 'dancing' their avatar at the disco. The frequency of session breaks did not change over time for either category.

The analysis reported here investigated four themes related to general experience of virtual worlds (affect, miscommunication and misunderstanding, immersion, social presence), alongside two themes more specifically focused on virtual speech therapy (types of conversations, initiative and flow). These have general implications for virtual reality as a technology for people with aphasia and more specific clinical implications. The growth in popularity of multi-user virtual worlds demonstrates that many people enjoy virtual experiences. However, despite reports of the value of virtual worlds for people with disabilities, there has been little evidence of use by people with aphasia, for example, aphasia is not mentioned in Stendal's review [57]. This study has shown that PWA can use a virtual world successfully and, like other user groups, will enjoy doing so. We were concerned that challenges of verbal communication, and the inability to see the person with whom you are communicating, may give rise to many misunderstandings and negative affect but this was not borne out by the findings. On the other hand the low numbers of incidences of immersion and social presence might suggest that participants did not

have a strong sense of presence in EVA Park. However it is more likely that this is a limitation of our coding approach. The definition of immersion we used is broadly similar to what others, such as [11], have termed "place presence" – the sense of being in the virtual place. We only coded incidences of immersion (as absorption) when a unit of analysis had not been assigned another code (e.g. one of the affect codes). The coding of social presence focused on a limited set of behaviours rather than the more familiar self reports.

Turning to clinical implications, the findings suggest that, as a therapy environment, EVA Park has the potential to address many of the symptoms and co-morbidities of aphasia. First, it can clearly support language practice. Participants engaged in and enjoyed a range of conversations, and importantly neither the technology nor the remote nature of the interactions were significant barriers in these conversations. As conversation is a frequent casualty of aphasia [20], this is an important finding. The opportunities to situate the conversations in simulated environments, such as the EVA Park restaurant or hair dressers, may augment the therapy benefit. Generalising skills gained in therapy to the real world can be difficult for people with aphasia e.g. [16, 13]. Such generalisation may be promoted by the situated practice offered by EVA Park. We are currently exploring the potential of EVA Park to sustain a wider range of therapeutic exchanges. These include therapist-led language exercises to address specific linguistic skills, and social support groups.

The findings with respect to initiative taking have more to say about the therapeutic potential of EVA Park. Analyses of interactions during conventional language therapy [33] indicate that control is largely exerted by the therapist, and concerns have been expressed that this casts the person with aphasia into a passive role [54]. We wondered whether the varied opportunities available in EVA Park, in terms of places to visit and activities to take part in, may enable people with aphasia to express more initiative and help to prevent patterns of passivity. There was some evidence that this was the case, given that by OBS 2 instances of initiative taking were evenly spread between participants and their support workers.

The strong association of EVA Park with fun and enjoyment suggests that EVA Park might play a role in addressing some of the emotional consequences of aphasia. Some estimates suggest that over 50% of people with aphasia experience depression [66]. It is perhaps not surprising, therefore, that carers so valued the frequency of laughter in EVA Park sessions. In future studies we plan to include an evaluation of mood to determine if this is responsive to EVA Park intervention. Sustaining motivation in aphasia therapy and inhibiting drop out can be a concern [8]. The sheer enjoyment of EVA Park might help to counter these problems.

The social presence results are also very positive. People with aphasia are known to lose friends post stroke [45, 19], with reduced social networks [62] and community integration [41]. A key aim for rehabilitation is therefore maintaining and building new social relationships. While EVA Park can bring people together, it was a potential concern that virtual contacts might not be valued. However, this was clearly not the case. Just as face to face therapeutic relationships are highly prized [22], so were interactions with the EVA Park support workers; and, increasingly, this extended to interactions with other users. This suggests that EVA Park could deliver different models of social rehabilitation, ranging from one to one interactions with a therapist or conversation partner to group interventions and possibly peer support.

Despite the many positive findings there are potential limitations for clinical practice. EVA Park has not been tested with people who have severe aphasia. Such individuals might struggle to use EVA Park, given that it is largely speech dependent. Like most people with aphasia [31], the participants did not display severe cognitive difficulties, e.g. affecting memory or orientation. As a result, they could master the technology and segue easily between reality and virtual reality. Most embraced, and even revelled in the more outlandish features of the environment, such as the presence of a mermaid in the lake and a giant octopus on the disco. For

people with cognitive impairments or co-morbidities such features might be less well accommodated and even confusing.

This study generated valuable insights into patterns of behaviour elicited by a virtual intervention for aphasia. Without further data, it is not always possible to account for these behaviours. For example, we cannot be sure why patterns of initiative taking changed over time, or indeed why any of the changes that we detected occurred. A separate interview study was conducted with the participants with aphasia [3], which offers valuable insights here. For example, this also showed that EVA Park was strongly associated with fun and enjoyment, and corroborated the importance of the therapeutic relationship with support workers. During the interviews, participants also identified impacts of the intervention on their communication skills, activity levels and feelings of confidence. This suggests that the changes over time perceived in the data here might reflect rehabilitation benefits, rather than more inconsequential factors, such as increased familiarity with the world. It would have been interesting similarly to explore the views of the Support Workers about their role but unfortunately, this was not done.

In summary, this paper has explored how people with aphasia experienced a customised virtual world. The findings have general implications for the use of virtual worlds by people with aphasia and more specific implications for the clinical potential of the technology. EVA Park is not a game but it is an engaging virtual space, accessible to people with aphasia, that can potentially be used for a wide variety of activities.

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REFERENCES

<bib id="bib1" type="Other"><number>[1]</number><bib id="bib1"><bib id="bib1"><number>[1]</number>Myzoon Ali, Patrick Lyden, and Marian Brady. 2015. Aphasia and dysarthria in acute stroke: recovery and functional outcome. *International Journal of Stroke, 10* (3), 400-406.</bib></bib></bib>
<bib id="bib2" type="Other"><number>[2]</number><bib id="bib2"><bib id="bib2"><number>[2]</number>Abdullah Al Mahmud and Jean-Bernard Martens. 2016. Social networking through email: studying email usage patterns of persons with aphasia. *Aphasiology, 30* (2-3), 186-210.</bib></bib></bib>
<bib id="bib3" type="Other"><number>[3]</number><bib id="bib3"><bib id="bib3"><number>[3]</number>Ana Amaya, Celia Woolf, Niamh Devane, Julia Galliers, Richard Talbot, Stephanie Wilson, and Jane Marshall. Submitted. Receiving Aphasia Intervention in a Virtual Environment: The Participants' Perspective.</bib></bib></bib>
<bib id="bib4" type="Other"><number>[4]</number><bib id="bib4"><bib id="bib4"><number>[4]</number>Page L. Anderson, Elana Zimand, Larry F. Hodges and B. Rothbaum. 2005. Cognitive behavioural therapy for public-speaking anxiety using virtual reality for exposure. *Depression and Anxiety*, 22(3), 156-158.</bib></bib></bib>
<bib id="bib5" type="Other"><number>[5]</number><bib id="bib5"><bib id="bib5"><number>[5]</number>Lisa MD. Archibald, Joseph B. Orange and Donald J. Jamieson. 2009. Implementation of computer-based language therapy in aphasia. *Therapy Archives of Neurological Disorders*.2, 299-311.</bib></bib></bib>
<bib id="bib6" type="Other"><number>[6]</number><bib id="bib6"><bib id="bib6"><number>[6]</number>Suzanne Beeke, Firle Beckley, Wendy Best, Fiona Johnson, Susan Edwards and Jane Maxim. 2013. Extended turn construction and test question sequences in the conversations of three speakers with agrammatic aphasia. *Clinical Linguistics and Phonetics* 27 (10-11), 784–804.</bib></bib></bib>
<bib id="bib7" type="Other"><number>[7]</number><bib id="bib7"><bib id="bib7"><number>[7]</number>Tom Boellstorff. 2012. *Ethnography and virtual worlds: A handbook of method*. Princeton University Press.</bib></bib></bib>
<bib id="bib8" type="Other"><number>[8]</number><bib id="bib8"><bib id="bib8"><number>[8]</number>Marian C. Brady, Helen Kelly, Jon Godwin and Pam Enderby. 2016. Speech and language therapy for aphasia following stroke. *Cochrane Database of Systematic Reviews*, 6, CD000425.</bib></bib></bib>
<bib id="bib9" type="Other"><number>[9]</number><bib id="bib9"><bib id="bib9"><number>[9]</number>Jeanne H. Brockmyer, Christine M. Fox, Kathleen A. Curtiss, Evan McBroom, Kimberly M. Burkhart, and Jacquelyn N. Pidruzny.

2009. The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing. *Journal of Experimental Social Psychology* 45(4), 624-634.</bib></bib></bib>
<bib id="bib10" type="Other"><number>[10]</number><bib id="bib10"><bib id="bib10"><number>[10]</number>Shelley B. Brundage and Adrienne B. Hancock. 2015. Real enough: Using virtual public speaking environments to evoke feelings and behaviours targeted in stuttering assessment and treatment. *American Journal of Speech-Language Pathology*,24, 139-149.</bib></bib></bib>
<bib id="bib11" type="Other"><number>[11]</number><bib id="bib11"><bib id="bib11"><number>[11]</number>Saniye T. Bulu. 2012. Place presence, social presence, co-presence, and satisfaction in virtual worlds, *Computers and Education*, 58(1), 154-161.</bib></bib></bib>
<bib id="bib12" type="Other"><number>[12]</number><bib id="bib12"><bib id="bib12"><number>[12]</number>Paul Cairns, Anna L. Cox, Nadia Berthouze, Charlene Jennett and S. Dhoparee. 2006. Quantifying the experience of immersion in games. In *CogSci 2006 Workshop: Cognitive Science of Games and Gameplay*.</bib></bib></bib>
<bib id="bib13" type="Other"><number>[13]</number><bib id="bib13"><bib id="bib13"><number>[13]</number>Marcella Carragher, Paul Conroy, Karen Sage and Ray Wilkinson. 2012. Can impairment-focused therapy change the everyday conversations of people with aphasia? A review of the literature and future directions. *Aphasiology*,26, 7, doi.org/10.1080/02687038.2012.676164</bib></bib></bib>
<bib id="bib14" type="Other"><number>[14]</number><bib id="bib14"><bib id="bib14"><number>[14]</number>Leora R. Cherney, Anita S. Halper and Rosalind C. Kaye. 2011. Computer based script training for aphasia: emerging themes from post-treatment interviews. *Journal of Communication Disorders*, 44, 493-501.</bib></bib></bib>
<bib id="bib15" type="Other"><number>[15]</number><bib id="bib15"><bib id="bib15"><number>[15]</number>Leora R. Cherney and Sarel Van Vuuren. 2012. Telerehabilitation, virtual therapists, and acquired neurologic speech and language disorders. *Seminars in Speech and Language*, 33, 243-257.</bib></bib></bib>
<bib id="bib16" type="Other"><number>[16]</number><bib id="bib16"><bib id="bib16"><number>[16]</number>Paul Conroy, Karen Sage and Matt Lambon-Ralph. 2009. Improved vocabulary production after naming therapy in aphasia: can gains in picture naming generalise to connected speech? *International Journal of Language and Communication Disorders*, 44, 6, 1036–1062</bib></bib></bib>
<bib id="bib17" type="Other"><number>[17]</number><bib id="bib17"><bib id="bib17"><number>[17]</number>COSPATIAL. ND. http://www.birmingham.ac.uk/Documents/college-social-sciences/education/CospatialflyerforESRCwebsite.pdf, Last accessed 15 th December 2016.</bib></bib></bib>
<bib id="bib18" type="Other"><number>[18]</number><bib id="bib18"><bib id="bib18"><number>[18]</number>Madeleine Cruice, Linda Worrall and Louise Hickson. 2010. Reporting on psychological well-being of older adults with chronic aphasia in the context of unaffected peers. *Disability and Rehabilitation*, 33(3) 219-228.</bib></bib></bib>
<bib id="bib19" type="Other"><number>[19]</number><bib id="bib19"><bib id="bib19"><number>[19]</number>Madeleine Cruice, Linda Worrall and Louise Hickson. 2006. Quantifying aphasic people's social lives in the context of non-aphasic peers. *Aphasiology*, 20, 1210-1225.</bib></bib></bib>
<bib id="bib20" type="Other"><number>[20]</number><bib id="bib20"><bib id="bib20"><number>[20]</number>Bronwyn Davidson, Linda Worrall and Louise Hickson. 2008. Exploring the interactional dimension of social communication: A collective case study of older people with aphasia. *Aphasiology*, 22(3), 235-257.</bib></bib></bib>
<bib id="bib21" type="Other"><number>[21]</number><bib id="bib21"><bib id="bib21"><number>[21]</number>Suzanne Doesborgh, Mieke van de Sandt-Koenderman, Diederik Dippel, Frans van Harskamp, Peter Koudstaal, Evy Visch-Brink. 2004. Cues on request: The efficacy of Multicue, a computer program for wordfinding therapy. *Aphasiology*, 18, 213-222.</bib></bib></bib>
<bib id="bib22" type="Other"><number>[22]</number><bib id="bib22"><bib id="bib22"><number>[22]</number>Judith F. Duchan and Dana Kovarsky. 2011. Rapport and Relationships in Clinical Interactions. *Topics in Language Disorders*, 31(4), 297–299.</bib></bib></bib>
<bib id="bib23" type="Other"><number>[23]</number><bib id="bib23"><bib id="bib23"><number>[23]</number>Daniel W. Furnas and Lisa A. Edmonds. 2014. The Effect of Computerized Verb Network Strengthening Treatment on Lexical Retrieval in Aphasia. *Aphasiology*, 28, 401-420.</bib></bib></bib>
<bib id="bib24" type="Other"><number>[24]</number><bib id="bib24"><bib id="bib24"><number>[24]</number>Noëmi Eggenberger, Basil C. Preisig, Rahel Schumacher, Simone Hopfner, Tim Vanbellingen, Thomas Nyffeler. 2016. Comprehension of Co-Speech Gestures in Aphasic Patients: An Eye Movement Study. PLoS ONE 11(1): e0146583. doi:10.1371/journal.pone.0146583.</bib></bib></bib>
<bib id="bib25" type="Other"><number>[25]</number><bib id="bib25"><bib id="bib25"><number>[25]</number>Robert J. Fourie. 2009. Qualitative study of the therapeutic relationship in speech and language therapy: Perspectives of adults with acquired communication and swallowing disorders. *International journal of language & communication disorders* 44(6), 979-999.</bib></bib></bib>

<bib id="bib26" type="Other"><number>[26]</number><bib id="bib26"><bib id="bib26"><number>[26]</number>Julia Galliers and Stephanie Wilson. 2013. An exploratory study into the accessibility of a multi-user virtual world for young people with aphasia. *Proceedings of the 27th International BCS Human Computer Interaction Conference*. British Computer Society.</bib></bib></bib>
<bib id="bib27" type="Other"><number>[27]</number><bib id="bib27"><bib id="bib27"><number>[27]</number>Alessandra Gorini, Claret S. Capideville, Giannucia De Leo, Fabrizia Mantovani and Giuseppe Riva. 2011. The role of immersion and narrative in mediated presence: the virtual hospital experience. *Cyberpsychology, Behavior, and Social Networking*, *14* (3), 99-105.</bib></bib></bib>
<bib id="bib28" type="Other"><number>[28]</number><bib id="bib28"><bib id="bib28"><number>[28]</number>Maree L. Hackett and Kristen Pickles. 2014. Part I: frequency of depression after stroke: an updated systematic review and meta-analysis of observational studies. *International Journal of Stroke*. 9(8):1017–25</bib></bib></bib>
<bib id="bib29" type="Other"><number>[29]</number><bib id="bib29"><bib id="bib29"><number>[29]</number>Sandra R. Harris, Robert L. Kemmerling and Max M. North. 2002. Brief virtual reality therapy for public speaking anxiety. *CyberPsychology and Behavior*, 5, 543-550.</bib></bib></bib>
<bib id="bib30" type="Other"><number>[30]</number><bib id="bib30"><bib id="bib30"><number>[30]</number>John E. Harrison, Pauline Buxton, Masud Husain, and Richard Wise. 2000. Short test of semantic and phonological fluency: Normal performance, validity and test-retest reliability. *British Journal of Clinical Psychology*, 39, 181 – 191.</bib></bib></bib>
<bib id="bib31" type="Other"><number>[31]</number><bib id="bib31"><bib id="bib31"><number>[31]</number>Nancy Helm-Estabrooks. 2002. Cognition and aphasia: a discussion and a study, *Journal of Communication Disorders*, 35, 2, 171–186.</bib></bib></bib>
<bib id="bib32" type="Other"><number>[32]</number><bib id="bib32"><bib id="bib32"><number>[32]</number>Audrey L. Holland, Carol Frattali and Davida Fromm. 1999. *Communication activities of daily living: CADL-2*.</bib></bib></bib>
<bib id="bib33" type="Other"><number>[33]</number><bib id="bib33"><bib id="bib33"><number>[33]</number>Simon Horton. 2008. Learning-in-interaction: Resourceful work by people with aphasia and therapists in the course of language impairment therapy. Aphasiology, 22(9), 985–1014.</bib></bib></bib>
<bib id="bib34" type="Other"><number>[34]</number><bib id="bib34"><bib id="bib34"><number>[34]</number>Guangying Hua and Dominique Haughton. 2009. Virtual worlds adoption: A research framework and empirical study. *Online Information Review*, 33(5), 889-900.</bib></bib></bib>
<bib id="bib35" type="Other"><number>[35]</number><bib id="bib35"><bib id="bib35"><number>[35]</number>Janet L. Ingles, Gail A. Eskes and Stephen J. Phillips.1999. Fatigue after stroke. *Archives of Physical Medicine and Rehabilitation*, 80 (2) 173-178.</bib></bib></bib>
<bib id="bib36" type="Other"><number>[36]</number><bib id="bib36"><bib id="bib36"><number>[36]</number>Wijnand IJsselsteijn, Wouter Van Den Hoogen, Christoph Klimmt, Yvonne De Kort, Craig Lindley, Klaus Mathiak, Karolien Poels, Niklas Ravaja, Marko Turpeinen and Peter Vorderer. 2008. Measuring the experience of digital game enjoyment. In Proceedings of Measuring Behavior. Netherlands: Maastricht.</bib></bib></bib>
<bib id="bib37" type="Other"><number>[37]</number><bib id="bib37"><bib id="bib37"><number>[37]</number>Faustina Hwang and Christos Salis. 2016. Digital technology and aphasia. *Aphasiology*, 30(2-3), 109-111.</bib></bib></bib>
<bib id="bib38" type="Other"><number>[38]</number><bib id="bib38"><bib id="bib38"><number>[38]</number>Gitit Kave. 2005. Phonemic fluency, semantic fluency, and difference scores: Normative data for adult Hebrew speakers. *Journal of Clinical and Experimental Neuropsychology*, 27, 690 – 699.</bib></bib></bib>
<bib id="bib39" type="Other"><number>[39]</number><bib id="bib39"><bib id="bib39"><number>[39]</number>Thomas Kohler, Johann Fueller, Kurt Matzler, Daniel Stieger, and Johann Füller. 2011. Co-creation in virtual worlds: the design of the user experience. *MIS quarterly*, 35(3), 773-788.</bib></bib></bib>
<bib id="bib40" type="Other"><number>[40]</number><bib id="bib40"><bib id="bib40"><number>[40]</number>Michelle Lawton, Gillian Haddock, Paul Conroy, and Karen Sage. 2016. Therapeutic alliances in stroke rehabilitation: a meta-ethnography. *Archives of physical medicine and rehabilitation* 97(11), 1979-1993.</bib></bib></bib>
<bib id="bib41" type="Other"><number>[41]</number><bib id="bib41"><bib id="bib41"><number>[41]</number>Hyejin Lee, Yuna Lee, Hyunsoo Choi, and Sung-Bom Pyun. 2015. Community integration and quality of life in aphasia after stroke. *Yonsei Medical Journal*, 56(6), 1694-1702.</bib></bib></bib>
<bib id="bib42" type="Other"><number>[42]</number><bib id="bib42"><bib id="bib42"><number>[42]</number>Marcia Linebarger, Denise McCall, Telana Virata, and Rita Sloan Berndt. 2007. Widening the temporal window: Processing support in the treatment of aphasic language production. *Brain and Language*, 100, 53-68.</bib></bib></bib>
<bib id="bib43" type="Other"><number>[43]</number><bib id="bib43"><bib id="bib43"><number>[43]</number>Jane Marshall, Tracey Booth, Niamh Devane, Julia Galliers, Helen Greenwood, Katerina Hilari, Richard Talbot, Stephanie Wilson and Celia Woolf. 2016. Evaluating the Benefits of Aphasia Intervention Delivered in Virtual Reality: Results of a Quasi-Randomised Study. *PLoS ONE* 11(8): e0160381. doi:10.1371/journal.pone.0160381</bib></bib></bib>

<bib id="bib44" type="Other"><number>[44]</number><bib id="bib44"><bib id="bib44"><number>[44]</number>Laura Millen, Rob Edlin-White and Sue Cobb. 2010. The development of educational collaborative virtual environments for children with autism. In *Proceedings of the 5th Cambridge Workshop on Universal Access and Assistive Technology*, *Cambridge* 1 7.</bib></bib></bib>
<bib id="bib45" type="Other"><number>[45]</number><bib id="bib45"><bib id="bib45"><number>[45]</number>Sarah Northcott and Katerina Hilari. 2011. Why do people lose their friends after a stroke? *Int J Lang Commun Disord*, 6(5), 524-534.</bib></bib></bib>
<bib id="bib46" type="Other"><number>[46]</number><bib id="bib46"><bib id="bib46"><number>[46]</number>Sarah Northcott, Jane Marshall and Katerina Hilari. 2016. What Factors Predict Who Will Have a Strong Social Network Following a Stroke? *Journal Of Speech, Language, And Hearing Research (JSLHR)*, *59* (4), 772-783.</bib></bib></bib>
<bib id="bib47" type="Other"><number>[47]</number><bib id="bib47"><bib id="bib47"><number>[47]</number>Rebecca Palmer, Pam Enderby, Cindy Cooper, Nick Latimer, Stephen Julious, Gail Paterson, Munyaradzi Dimairo. 2012. Computer therapy compared with usual care for people with long-standing aphasia poststroke: a pilot randomized controlled trial. *Stroke*, 43, 1904-1911, </bib></bib></bib>
<bib id="bib48" type="Other"><number>[48]</number><bib id="bib48"><bib id="bib48"><number>[48]</number>Rebecca Palmer, Pam Enderby and Gail Paterson. 2013. Using computers to enable self management of aphasia therapy exercises for word finding. *Int J Lang Commun Disord*, 48, 508-521.</bib></bib></bib>
<bib id="bib49" type="Other"><number>[49]</number><bib id="bib49"><bib id="bib49"><number>[49]</number>Sarah Parsons and Sue Cobb. 2011. State-of-the-art of Virtual Reality technologies for children on the autism spectrum. *European Journal of Special Needs Education*, 26(3), 355-366.</bib></bib></bib>
<bib id="bib50" type="Other"><number>[50]</number><bib id="bib50"><bib id="bib50"><number>[50]</number>Karolien Poels, Yvonne de Kort and Wijnand Ijsselsteijn. 2007. It is always a lot of fun!: exploring dimensions of digital game experience using focus group methodology. In *Proceedings of the 2007 Conference on Future Play*. ACM.</bib></bib></bib>
<bib id="bib51" type="Other"><number>[51]</number><bib id="bib51"><bib id="bib51"><number>[51]</number>S. Ramsing, C. Blomstrand, and M. Sullivan. 1991. Prognostic factors for return to work in stroke patients with aphasia. *Aphasiology*, 5(6), 583–588.</bib></bib></bib>
<bib id="bib52" type="Other"><number>[52]</number><bib id="bib52"><bib id="bib52"><number>[52]</number>Giuseppe Riva, Fabrizia Mantovani, Claret Samantha Capideville, Alessandra Preziosa, Francesca Morganti, Daniela Villani, Andrea Gaggioli, Cristina Botella, and Mariano Alcañiz. 2007. Affective interactions using virtual reality: the link between presence and emotions. *CyberPsychology & Behavior*, 10(1), 45-56.</bib></bib></bib>
<bib id="bib53" type="Other"><number>[53]</number><bib id="bib53"><bib id="bib53"><number>[53]</number>Ghaydaa Shehata, Taha El Mistikawi, Risha, Al Sayed and Huda S. Hassan. 2015. The effect of aphasia upon personality traits, depression and anxiety among stroke patients. *Journal Of Affective Disorders*, 172312-314. doi:10.1016/j.jad.2014.10.027</bib></bib></bib>
<bib id="bib54" type="Other"><number>[54]</number><bib id="bib54"><bib id="bib54"><number>[54]</number>Nina N. Simmons-Mackie, and Jack S. Damico. 2007. Access and social inclusion in aphasia: Interactional principles and applications. *Aphasiology* 21(1) 81-97.</bib></bib></bib>
<bib id="bib55" type="Other"><number>[55]</number><bib id="bib55"><bib id="bib55"><number>[55]</number>Jacqueline Stark, Christiane Pons and Csaba Daniel. 2013. Integrating face to face language therapy with virtual reality applications for persons with aphasia. *International Conference on Virtual Reality*, Philadelphia.</bib></bib></bib>
<bib id="bib56" type="Other"><number>[56]</number><bib id="bib56"><bib id="bib56"><number>[56]</number>Karen Stendal, Susan Balandin and Judith Molka-Danielsen. 2011. Virtual worlds: A new opportunity for people with lifelong disability? *Journal of Intellectual and Development Disability*, 36 (1) </bib></bib></bib>
<bib id="bib57" type="Other"><number>[57]</number><bib id="bib57"><bib id="bib57"><number>[57]</number>Karen Stendal. 2012. How do People with Disability Use and Experience Virtual Worlds and ICT: A Literature Review. Journal For Virtual Worlds Research, doi: http://dx.doi.org/10.4101/jvwr.v5i1.6173.</bib></bib></bib>
<bib id="bib58" type="Other"><number>[58]</number><bib id="bib58"><bib id="bib58"><number>[58]</number>Kate Swinburn, Gillian Porter and David Howard. 2004. *Comprehensive Aphasia Test*. Hove: Psychology Press.</bib></bib></bib>
<bib id="bib59" type="Other"><number>[59]</number><bib id="bib59"><bib id="bib59"><number>[59]</number>Cynthia K. Thompson, JungWon J. Choy, Audrey Holland and Ronald Cole. 2010. Sentactics®: Computer-Automated Treatment of Underlying Forms. *Aphasiology*, 24, 1242-1266.</bib></bib></bib>
<bib id="bib60" type="Other"><number>[60]</number><bib id="bib60"><bib id="bib60"><number>[60]</number>Mieke Van De Sandt-Koenderman. 2011. Aphasia rehabilitation and the role of computer technology: Can we keep up with the times? *Int J of Speech-Language Pathology*, 13, 21-27.</bib></bib></bib>

<bib id="bib61" type="Other"><number>[61]</number><bib id="bib61"><bib id="bib61"><number>[61]</number>Sarel Van Vuuren and Leora R. Cherney. 2014. A virtual therapist for speech and language therapy. Lecture Notes in Computer Science. 8637 LNAI:438-448.</bib></bib></bib>
<bib id="bib62" type="Other"><number>[62]</number><bib id="bib62"><bib id="bib62"><number>[62]</number>Candace P. Vickers. 2010. Social networks after the onset of aphasia: The impact of aphasia group attendance. *Aphasiology*, 24, 902-913.</bib></bib></bib>
<bib id="bib63" type="Other"><number>[63]</number><bib id="bib63"><bib id="bib63"><number>[63]</number>Julia Wade and Jane Mortley. 2003. Talk about IT: views of people with aphasia and their partners on receiving remotely monitored computer-based word finding therapy. *Aphasiology*, 17, 1031-1056.</bib></bib></bib>
<bib id="bib64" type="Other"><number>[64]</number><bib id="bib64"><bib id="bib64"><number>[64]</number>Eric N. Wiebe, Allison Lamb, Megan Hardy and David Sharek. 2014. Measuring engagement in video game-based environments: Investigation of the User Engagement Scale. *Computers in Human Behavior*, *32*, 123-132.</bib></bib></bib>
<bib id="bib65" type="Other"><number>[65]</number><bib id="bib65"><bib id="bib65"><number>[65]</number>Stephanie Wilson, Abi Roper, Jane Marshall, Julia Galliers, Niamh Devane, Tracey Booth and Celia Woolf. 2015. Codesign for People with AphasiaThrough Tangible Design Languages. *CoDesign*, 11(1), 21-34.</bib></bib></bib>
<bib id="bib66" type="Other"><number>[66]</number><bib id="bib66"><bib id="bib66"><number>[66]</number>Linda Worrall, Brooke Ryan, Kyla Hudson, Ian Kneebone, Nina Simmons-Mackie, Asaduzzaman Khan, Tammy Hoffmann, Emma Power, Leanne Togher, and Miranda Rose. 2016. Reducing the psychosocial impact of aphasia on mood and quality of life in people with aphasia and the impact of caregiving in family members through the Aphasia Action Success Knowledge (Aphasia ASK) program: study protocol for a randomized controlled trial. *Trials*,171 (7). doi:10.1186/s13063-016-1257-9</bib></bib></bib>
<bib id="bib67" type="Other"><number>[67]</number><bib id="bib67"><bib id="bib67"><number>[67]</number>Kristin Williams, Karyn Moffatt, Denise McCall and Leah Findlater. 2015. Designing conversation cues on a head-worn display to support persons with aphasia. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. 231-240.</bib></bib></bib>
<bib id="bib68" type="Other"><number>[68]</number><bib id="bib68"><bib id="bib68"><number>[68]</number>Celia Woolf, Anna Caute, Zula Haigh, Julia Galliers, Stephanie Wilson, Awurabena Kessie, Shashi Hirani, Barbara Hegarty and Jane Marshall. 2016. A comparison of remote therapy, face to face therapy and an attention control intervention for people with aphasia: A quasi-randomised controlled feasibility study. *Clinical rehabilitation*, 30(4), 359-373</bib></bib></bib>
<bib id="bib69" type="Other"><number>[69]</number><bib id="bib69"><bib id="bib69"><number>[69]</number>Maarten Woudstra, Abdullah Al Mahmud and Jean-Bernard Martens. 2011. A snapshot diary to support conversational storytelling for persons with aphasia. In *Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services* 641-646. ACM.</bib></bib></bib>
<bib id="bib70" type="Other"><number>[70]</number><bib id="bib70"><bib id="bib70"><number>[70]</number>Nick Yee. 2006. The demographics, motivations, and derived experiences of users of massively multi-user online graphical environments. *Presence* 15(3) 309-329.</bib></bib></bib>