A Review of Virtual Reality Technologies in the Field of Communication Disability: Implications for Practice and Research

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Disability and Rehabilitation: Assistive Technology

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Abstract:

Background: Technology devices and applications including Virtual Reality (VR) are increasingly used in healthcare research and practice as tools to promote health and wellbeing. However, there is limited research examining the potential for VR to enable improved communication for people with communication disability.

Aims: To review: (a) current research using VR in speech-language pathology; and (b) the ethical and safety considerations of VR research, to inform an agenda for future research applying VR in the field of speech-language pathology.

Main Contribution: This review reveals that there is an emergent body of literature applying VR to improve or develop physical, psychological, and communication interventions. Use of non-immersive virtual environments to provide speech-language pathology assessment or intervention for people with communication disability has demonstrated positive outcomes, with emerging evidence of the transfer of functional communication skills from virtual to real-world environments. However, the use of VR technology and immersive virtual environments in communication disability practice and research introduces safety and ethical issues that must be carefully considered.

Conclusions: Research employing VR is in its infancy in the field of speech-language pathology. Early evidence from other healthcare disciplines suggests that VR is an engaging means of delivering immersive and interactive training to build functional skills that can be generalised to the real world. While the introduction of new technology requires careful consideration of research ethics and patient safety, future VR communication research could proceed safely with adequate engagement of interdisciplinary teams and technology specialists.

Keywords: communication, disability, Virtual Reality, technology, speech-language pathology

Implications for Rehabilitation

- Immersive Virtual Reality may be used in rehabilitation to simulate natural environments to practice and develop communication skills
- The sense of immersion that can be achieved using Virtual Reality may promote the generalisation of skills learnt during clinical rehabilitation settings to real-world situations
- Ethical and safety considerations, including cybersecurity and cybersickness, must be carefully monitored during all Virtual Reality research

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Introduction

Over the past decade, there have been significant developments in healthcare research and practice in relation to technological solutions to organisational and therapeutic problems [1]. In recent years, Virtual Reality (VR) technologies have emerged as potentially beneficial clinical tools in health and wellbeing [2, 3]. VR technologies operate by constructing computer-generated environments that mimic the human experience through auditory, visual, and tactile feedback [4]. These computer-generated environments use different methods to display virtual worlds to the user; and allow different degrees of immersion in, and interaction with, virtual environments.

Despite the potential benefits and affordances that recent improvements in human-computer interaction bring to health interventions (e.g., Bateman, Srinivas [5]), to date there is little research literature examining how professionals working with individuals with communication disability might use VR to enhance communication opportunities or increase avenues for social engagement. People with communication disability have a range of health conditions and impairments affecting speech, language, voice, and fluency, with associated limitations and restrictions over communication activities and participation [6]. VR has the potential to support the capture and recreation of communicative interactions in virtual environments, and would therefore have implications for communication assessment and intervention. In addition, virtual environments in VR potentially offer speech-language pathologists a unique means to deliver communication interventions to a wider variety and larger number of people who currently lack access to adequate interventions [7].

The differing levels of immersion in VR

There are several types of VR that hold significant potential in working with people with communication disability. Through virtually simulated environments, specifically tailored and safe settings could allow for and facilitate repeated practice of social and functional communication skills [8, 9]. Such virtual environments might allow individuals with communication disability to enter VR to interact only with the environment itself, with a clinician, and/or with a computer-generated and programmed avatar - a virtual representation of a person - to offer a unique and highly motivational therapy tool. In addition, a VR intervention may employ a multi-user interface, whereby multiple users enter and interact within a virtual environment, creating a unique medium for communication in social and interactive contexts, bringing users together while they remain physically separated (e.g., in separate rooms, cities, or countries) [10]. In this way, VR operates as a complex social platform that generates a tangible social and physical presence for users [11].

Immersive VR systems (e.g., Oculus Rift™ or HTC Vive Pro™) provide multi-sensory feedback via the user wearing a Head-Mounted Display (HMD), designed to exclude visual and auditory input from the user's real-world environment. These systems typically incorporate motion detection, and allow the user to interact with a responsive virtual world. As with many other technological developments, immersive VR is becoming more accessible through the availability of smartphone-compatible VR devices (e.g., Google Daydream™ and Google Cardboard™ Merge VR™ goggles, Zeiss One Plus™ Samsung Gear VR™). Immersion may also be achieved through the use of a Computer Automated Virtual Environment or CAVE [12], which operates through the projection of a virtual environment on all surfaces within an enclosed space (i.e., the floor, ceiling, and at least three walls of a room). VR via a CAVE differs from a HMD in that the user has an unobstructed view of their own body and immediate real world environment, creating what is sometimes known as a mixed reality [13]. Nonetheless, this mode of VR still creates a sense of immersion in the virtual environment [14].

In contrast, non-immersive VR does not fully situate the user within the virtual environment, but enables interaction with it through the use of an avatar and a standard computer interface [4]. Non-immersive VR includes Massive Multiplayer Online Games (MMOGs) sustained on many popular gaming platforms [15], and desktop-based “window to world” VR [10]. With the growth in portable technologies such as the smartphone, Augmented Reality (AR) has also expanded, where computer generated objects are overlaid on the real world of the user, and allow differing degrees of interaction (the most well-known example of this may be Pokémon™ Go). This spectrum of technologies, from immersive VR to AR, may be referred to more generally as Extended Reality (xR) [16].

Applications of VR in health interventions

The use of immersive VR applications is emerging in several fields of healthcare practice and research, including rehabilitation interventions, particularly in physiotherapy and psychology. Characteristics of the studies reviewed in this paper are presented in Table 1. There is some evidence that VR, and in particular virtual games, offer an interactive means to engage people in play-based activities to train physical and motor skills [3, 17, 18]. In a systematic review of 11 studies on VR interventions for children with cerebral palsy, Snider, Majnemer [17] reported that therapy provided in VR “provides opportunity for repeated practice and positive feedback” (p. 121) to improve independence and participation in functional tasks. They also concluded that VR had a positive impact on motivation, enjoyment, and interest in physical rehabilitation therapy for children with cerebral palsy even though the evidence for the effects of VR therapy on body structures, functions, activities and participation showed limited differences to non-VR therapy [17]. Similarly, a systematic review and meta-analysis of 50 studies investigating VR therapies in limb rehabilitation for people who had experienced a stroke showed that, although select studies indicated significant benefits of VR training (e.g., Housman, Scott [19], Shin, Park [20], Ucar, Paker [21]), there were no statistically significant differences when comparing VR and conventional therapy for upper limb function, balance or gait speed. Overall, the review identified significant improvements in activity limitations when VR therapy was used as an alternative or as an addition to conventional interventions [3].

Positive outcomes of VR were also found when delivering attention-based therapy to people with dementia [22], and cognitive interventions for memory, attention, executive function, learning, and problem solving for people who had experienced a traumatic brain injury (TBI) [9]. In a systematic review of 13 studies applying VR in TBI therapy, Manivannan and colleagues [9] reported some positive intervention effects in relation to VR, but could not draw definitive conclusions due to the variation and quality of the included studies. VR has also been used effectively in the field of psychology for the treatment of anxiety disorders and phobias [23, 24]. Through the use of immersive VR, exposure therapy can be safely delivered to provoke anxiety and induce extinction of severe anxiety responses [23]. For example, Walkom [25] applied the same principle to the treatment of social anxiety in people who stutter in a study involving six participants being immersed in a public speaking environment using CAVE and HMD VR to deliver an address to an audience. The immersion in the speaking environment lowered anxiety and improved speech fluency for two of four participants. VR applications for exposure therapy have had mixed effects, with studies generally indicating that for individuals who were able to experience immersion and a sense of presence in the virtual environment, positive treatment outcomes could be achieved [23].

Although there is emerging evidence examining the potential for VR in the field of communication disability, to date there is no review of recent research to inform new VR interventions with this group (e.g., to promote greater communication access, increased awareness of communication disability, or improved communication interventions for people with communication disability, their families, support workers, and health professionals). If VR is to fulfil at least some of its potential in these areas, it is important that relevant research be reviewed to identify potential areas for early research endeavour, and that the unique practical and ethical challenges and opportunities inherent in the use of VR technology with individuals with communication disability are examined. Therefore, the aim of this review was to (a) examine current research using VR in the field of communication disability in speech-language pathology, including any use of VR for speech, language, voice, fluency, or communication assessment or intervention, to identify gaps in the research and directions for future research; and (b) identify the ethical and safety considerations of VR research, particularly involving people with communication disability, to inform an agenda for future research applying VR to communication interventions for important group. When discussing VR in this review, we refer to technology used to completely immerse users in a virtual environment with which they can interact. This excludes desktop video displays used to provide visual cues, visual stimuli or visual feedback during interventions.

Table 1: Characteristics of reviewed studies using Virtual Reality in health disciplines and speech-language pathology

First Author	Ref.	Field	Article Type	Method	Target Skills	Participant Population	Intervention	VR Experience
Applications of VR in health interventions								
Laver	3	Physio	Review	Cochrane systematic review – 72 studies (50 included in meta-analysis)	Upper limb function	People with limb weakness following stroke	Physical interventions	HMD, CAVE and desktop
Manivannan	9	Medicine / Neuro-science	Review	Systematic review – 13 studies	Memory, attention, executive function, learning, and problem solving	People with a traumatic brain injury (TBI)	Cognitive tasks in interactive environments	HMD, CAVE and desktop
Snider	17	Physio	Review	Systematic review – 11 studies	Motor function, activity and participation, personal factors	Children with cerebral palsy	Virtual games requiring physical movement	Desktop-style video games
Manera	22	Psychology	Original research	AB descriptive design	Sustained attention	29 people with dementia 38 people with mild cognitive impairment	VR attention-distractor task. Compared to paper-based task	Desktop non-immersive computer display
Krijn	23	Psychology	Review	Narrative review	Anxiety	People with anxiety	Exposure therapy	HMD and CAVE
Parsons	24	Psychology	Review	Systematic review – 52 studies	Anxiety	People with phobias	Exposure therapy	Immersive (exact nature unknown)
Walkom	25	Psychology	Original research	Intervention – pre/post design	Social anxiety	4 adults who stutter	Exposure therapy	HMD

Applications of VR for speech-language pathology								
Kandalaft	8	Psychiatry	Original research	Intervention – pre/post design	Emotional recognition, social perception (auditory and visual), theory of mind, conversational skills	8 young adults with autism	Social cognition training and social skills intervention	Desktop (Second Life)
Stendal	11	SLP	Original research	Qualitative – interview and case study	Experience of virtual worlds	1 adult with autism	Social use of virtual world – dedicated island for people with autism	Desktop (Second Life)
Halabi	14	Education	Original research	Intervention – pre/post design	Speech and gesture recognition and response, turn-taking	3 children with autism 7 typically developing children	Role play scenario and training for social greeting	HMD, CAVE and desktop
Marshall	27	SLP	Original research	Intervention – quasi-experimental design	Verbal fluency, word finding, narrative production, communication confidence, feelings of social isolation	20 people with aphasia	Supported language stimulation	Desktop (EVA Park)
Carragher	28	SLP	Original research	Intervention – pre/post design Case studies	Storytelling (content and understanding)	3 people with aphasia	Narrative generation to video stimuli	Desktop (EVA Park)
Marshall	29	SLP	Original research	Intervention – pre/post design, case studies	Word retrieval	2 people with aphasia	Cued naming, modified Semantic Feature Analysis, modified Verb Network Strengthening Training	Desktop (EVA Park)
Galliers	30	SLP	Original research	Qualitative – interviews	User experience	20 people with aphasia	Supported language stimulation	Desktop (EVA Park)
Amaya	31	SLP	Original research	Qualitative – interviews	Views of Intervention	20 people with aphasia	Supported language stimulation	Desktop (EVA Park)

Communication training in immersive VR								
Maicher	38	OB/GYN	Original research	Descriptive design	Case history interviewing	Medical students	Virtual patient simulation, case history interview	Desktop
Foronda	39	Nursing	Original research	Within-group times series design	Inter-professional communication skills	8 nursing students	Virtual clinical simulation, inter-professional communication	Desktop

* SLP = Speech-Language Pathology; VR = Virtual Reality; HMD = Head-Mounted Display; CAVE = CAVE Automated Virtual Environment; OB/GYN = Obstetrics/Gynaecology

Applications of VR for speech-language pathology

Use of non-immersive VR has grown in speech-language pathology in recent years through programs such as Second Life® and EVA Park [26]; both virtual environments that were developed and implemented to encourage social interaction and provide tele-therapy for people with acquired and lifelong communication disability. EVA Park offers a non-immersive virtual world for people with aphasia and their therapists to interact, receive therapy, and practice communication skills [26]. Therapy delivered through the EVA Park virtual world has had mixed effects on communication outcomes. Marshall and colleagues [27] delivered supported language stimulation to 20 people with aphasia over five weeks in the virtual world. Engagement in therapy within the virtual world supported improvements in communicative activities of daily living. However, the intervention had minimal effect on specific language outcomes including verbal fluency, word finding, narrative production, communication confidence, and feelings of social isolation [27]. In a narrative story-telling intervention delivered via EVA Park involving three people with non-fluent aphasia, participants' proportion of content words during story retell tasks increased following the VR intervention [28]. However, word finding interventions including cued naming, modified Semantic Feature Analysis and modified Verb Network Strengthening Training had mixed results when delivered in EVA Park. A case study of two people with aphasia achieved significant improvements on retrieval of treated words but lack of generalization to untreated items [29]. Despite the limited therapy gains as a result of these interventions, VR studies in EVA Park showed high levels of compliance to therapy delivered using VR [27, 29]. Research on the user experience revealed that the VR environment provided a positive therapy experience, in that participants reported enjoyment in engaging with other individuals including support workers in the virtual world [30, 31]. However, greater interactive behaviour with others appeared to be associated with higher levels of prior experience using a VR system [30].

Researchers using Second Life®, another non-immersive VR environment, have also reported positive benefits for communicative function and participation for people with autism and communication disability [8, 11, 32]. Kandalaft and colleagues [8] implemented Social Cognition Training with eight adults with autism using a dedicated virtual island within Second Life®. Participants engaged in virtual simulated scenarios such as meeting new people, being in job interviews, conflict resolution, and financial and social decision-making (e.g., where and when to sit when entering a job interview). The VR intervention aimed to provide a ‘safe space’ for ongoing practice, reflection, and feedback to recognise and use social cues to assist in social functioning. Within VR, participants demonstrated improved ‘theory of mind’ and recognition of emotion through voice and gestural cues. Moreover, gains were also observed in real world social functioning. These outcomes lend support to the suggestion made by Stendal and Balandin [11] that for people with autism there may be some potential for communicative and social skills developed in VR to translate into real world interactions.

Despite their potential benefits, non-immersive VR worlds such as EVA Park and Second Life® rely on a point-and-click interface to connect and integrate the user with the virtual environment, and so limit the potential for the user’s full immersion in the communicative experiences of VR. Additionally, the complexity of the technological knowledge needed to engage with non-immersive VR may be a barrier for people with intellectual disability [32]. While there may be some potential for communicative and social skills learned in non-immersive VR to translate to the real world, Jones, Kennedy and

Stanney [33] suggested that full immersion in VR and the accompanying “feeling of presence” (p.590) may further promote the generalisation of communication skills to real-world situations.

This assertion was supported by a study that trialled a social communication task with children with autism across three VR modalities: immersive VR via an HMD, immersive VR via CAVE, and non-immersive desktop VR [14]. In an intervention study, three children with autism and seven peers without autism engaged in two VR sessions teaching verbal and non-verbal greetings in a virtual classroom environment. In the first session, participants were familiarised with the technology and engaged in the greeting task using each of the VR modalities. In the second session, the time taken to respond to a greeting using words and gesture (i.e., waving) was measured, and participants were interviewed about VR usability and immersion in each VR condition. The immersive VR modalities, HMD and CAVE, were identified as the most engaging technologies and received the highest satisfaction ratings from participants, and were most effective in promoting positive behaviour change and communication skill development. Of these different VR formats, the CAVE was the most satisfactory method of therapy delivery with faster response times to deliver a response greeting observed for both children with autism and their peers without autism [14].

Thus, research to date provides preliminary support for the notion that immersive VR may be an effective tool in communication interventions for people with communication disability. However, further research is needed to fully understand how interventions delivered within an immersive virtual environment impact on the development or rehabilitation of communication skills, and how these might then move to being used in the real world. Such interventions might expand on those already delivered in non-immersive VR, [28, 29] by simulating real-world everyday communicative situations which make demands on discourse skills (e.g., answering questions at an interview, ordering items at a café, or engaging with checkout operators at a supermarket). The interaction that could be achieved using VR might also facilitate assessment and intervention at the discourse level within simulated natural environments. This could enable a more accurate representation of language-in-use that is not limited to clinic-based conversational interactions and assessments [34, 35].

Communication training in immersive VR

In addition to providing communication interventions for people with communication disability, VR potentially provides a way for communication partners and the public to engage with people with communication disability in VR, to improve skills of communication partners, and to raise awareness and knowledge of communication disability and improve communication access in the community. VR might also be particularly useful for teaching health professionals how to communicate with people with communication disability. In relation to this, real-world interventions may be limited by the communicative environment being difficult to predict or control (e.g., the pre-hospital or emergency department settings). In some environments, planning for the necessary communication intervention may be difficult and the delivery of additional interventions for the purposes of research may interfere with the delivery of life-saving care [36]. The integration of VR systems into medical and other health professional education and training could increase the capacity for the health professional's immersion in virtual communicative interactions in healthcare situations. This could improve the learning experience [36, 37], by the learner having more opportunities for interaction with virtual patients with communication disability; experiencing the consequences of poor communication (e.g., failure to ask an important question, or not clearly explaining an instruction to a person with communication disability); and responding more appropriately.

The use of VR in medical students' education can also help to develop their communication skills (e.g., in history-taking during a patient interview). Maicher and colleagues [38] employed virtual standardised patients to provide a simulated teaching experience to medical students. Using VR and natural language processing software that controlled the virtual conversation, students were able to interact with three-dimensional characters to establish a case history and differential diagnosis. The findings indicated that the virtual patients could engage in "contextually appropriate dialogue and display natural movement and emotions appropriate for questions being asked" (p.130). While such virtual simulations might not completely replace authentic and real-world clinical communicative exchanges, they might offer safe and non-threatening environments in which to practice and develop early communication skills [38]. Foronda and colleagues [39] employed similar virtual simulation for communication training in the education of nurses, and results suggested that the experiential and immersive learning of VR led to improved inter-professional communication skills and better understanding of communication protocols (e.g., ISBAR: Introduction, Situation, Background, Assessment, Recommendation) [39]. The success of these studies supporting the feasibility of using virtual, computer-programmed avatars in training medical interactions, could form a foundation for the implementation of similar training scenarios using avatars depicting people with communication disability. This type of application of VR to speech-language pathology could potentially support the training of both people with communication disability and communication partners, enabling them multiple opportunities to better understand one another and interact effectively.

Ethical considerations in VR research

While the application of VR to research involving people with communication disability holds significant potential, there are several ethical issues that must be considered in the design of future studies. First, there is the issue arising in relation to the ethical nature of the acts taking place in the virtual environment. Brey [40] discussed the moral and ethical issues associated with violent acts (e.g., murder) performed in video games, and the censorship or otherwise of games that allow users to perform unethical acts. He argued that the development of similar games into highly immersive VR experiences has more significant implications as users experience what it is like to perform such actions. As such, it is the responsibility of VR application developers to monitor the ethical actions within the applications they design [40]. Psychological stress that may be induced through immersion in virtual scenarios. Slater and colleagues [41] identified that experiences in VR elicited the same psychological stress responses as real-world activities, even when participants were aware that they were viewing a computer-generated image that was not ‘real’. When considering these issues for VR research, then, it is important for researchers to be aware of the applications and experiences to which they expose research participants. Scenarios to which research participants are exposed in VR should not differ from those to which they can ethically experience in the real word.

Ethical issues arise when creating virtual worlds for the purposes of training. One study, currently underway in the Netherlands, represents an early attempt to represent communication disability in a virtual world. The study involves an immersive VR simulation to educate carers of people with dementia, by providing them with a virtual experience of living with dementia [42]. Such experiences include the participants being placed in a home environment where they are unable to work basic devices such as a radio, and experience the frustration of other people (represented as avatars) within the environment. Activities that simulate disability in the hope of building awareness have long been criticised by disability advocates [43]. Recent work by Nario-Redmond, Gospodinov, and Cobb [44] further support the argument that the negative outcomes of 'empathy' tasks outweigh the purported benefits and indeed distort the often long-term realities of living with disability. As such, simulations that place users in the position of people with communication disability might not be suitable as a means to increase awareness of living with communication disability. Rather, interactive education and communication practice opportunities for communication partners to interact with people with communication disability should be provided (e.g., [45-47]). Such interaction might be facilitated by use of a virtual environment.

When considering the depiction of people with communication disability in VR, Brey [40] argued that the people and places in VR should be portrayed ethically and care should be taken not to misrepresent reality. The portrayal of cultural or gender characteristics, or indeed characteristics of disability, for simulated individuals should also be considered carefully, as within forms of VR in which the user embodies an avatar, additional ethical issues arise. Madary and Metzinger [13] noted that the embodiment of an avatar as a representation of the self or another is of particular ethical interest. A unique feature of immersive VR, the complete absorption in the virtual environment, creates "the strong illusion of owning and controlling a body that is not your own" (p. 2). This capability to assume a body other than the user's own has the potential to influence behaviour. For example, Peck and colleagues [48] identified reduced intrinsic racial bias immediately following immersion as an avatar with a dark skin colour. Similarly, Hershfield and colleagues [49] identified that embodying an older avatar version of the user's self, resulted in greater concern and saving for retirement. With the capacity for behavioural manipulation, steps should be taken to maintain the autonomy of any person immersed in VR for healthcare research. To ensure no undue manipulation, this may involve the user being given full control of the design of their own avatar.

In addition to the ethical considerations that apply to the content displayed within VR, Whally [50] argued that the use of this innovative technology in medical research must be treated with caution. Although new technologies such as VR may open avenues for medical discovery, healthcare research must focus on the best interests of the target population. People who are to be immersed in VR environments must be provided with sufficient information to provide informed consent, and care must be taken to ensure "their own curiosity and excitement about the technology" [50] does not impact on their judgement and decision to partake in the research. Additionally, care must be taken to ensure that patients in healthcare are not given any false hope that new technology may provide an avenue for complete recovery of lost function [13]. Given the commercial availability of VR hardware and software, care is also needed to emphasise the role of the therapist in any healthcare delivered using VR applications to counter any misconception that the use of VR in rehabilitation can replace a qualified therapist. In order to support this aim, clear and accurate reporting of any research utilising VR is necessary so as to not overstate findings and capabilities of the technology [13].

The process of data collection throughout the research process also carries unique ethical considerations relating to privacy and confidentiality when using VR due to the types of personal information collected from research participants [13]. For example, a researcher using VR may record information including actions and reactions within the virtual environment, emotions, facial expressions, eye movements, and body movements, allowing the ”kinematic fingerprint” (p.1540) [51] of users to be mapped. This concern may also extend beyond the data collection performed by the researcher to the data collected by the company delivering the VR software. For example, Oculus, owned by Facebook, states in its privacy policy that information may be collected about the apps used in VR, its location, physical movements of the user, and dimensions of the play space [52]. As per any research, participants will need to be made aware of all data collection that will occur during use of VR in order to provide informed consent for research participation.

Safety considerations in VR research

There are acknowledged safety risks that may be associated with the use of VR. These risks are not prohibitive, but must be carefully considered and managed in the design of future research in this area. One common safety risk that must be considered is the potential for VR experiences to induce motion sickness in users [33, 53]. Also termed “cybersickness”[33], users of VR may experience nausea, fatigue, dizziness, bodily disorientation, and eye strain [51, 54]. Postural instability may contribute to this experience [53], and can last for a short time following exposure to immersive VR [33]. The risk of cybersickness must be carefully considered prior to VR exposure, particularly for individuals who may experience balance disturbances as a result of stroke [3], neurodegenerative conditions such as Parkinson’s disease [55], or developmental disability such as cerebral palsy [56]. As such, the participant's balance will be an important safety factor in speech-language pathology research that utilises VR. Motion sickness may be minimised through the use of postural supports and balance screening [33], by having participants remain in a seated position [53], by limiting the duration of continuous time spent within a simulated VR environment [33], and by allowing the participant to take active control of movement within the virtual environment [54]. Risk assessment prior to research participation may alert the researcher to the need for such measures, and can be achieved through the use of a predictive questionnaire such as the Motion Sickness Susceptibility Questionnaire (MSSQ-Short) [57] or Simulator Sickness Questionnaire (SSQ) [58]. Collaboration with physiotherapists or occupational therapists might be necessary to ensure posture and balance are adequately supported while engaging people with communication disability in VR.

While limiting the time that participants are continually exposed to VR might be important in minimising cybersickness, it might also help to ensure the psychological safety of VR users. The feelings of disorientation that may be experienced following exposure to VR, in severe cases, may be likened to conditions such as depersonalisation or dissociation from the physical self [51]. Madary and Metzinger [13] reinforced this safety concern, suggesting the extended periods of immersion could be associated with anxiety and depression similar to that reported in individuals who engage in excessive use of video games. Whally [50] highlighted these risks for individuals who gain access to activities through VR that may be restricted in their real life. While noting that these risks are not unique to VR, both Madary and Metzinger [13] and Spiegel [51] link these risks of dissociation and disorientation to extended and continuous use of gaming technologies. Extended use of VR could also have safety risks associated with continuous noise exposure from HMDs, and repetitious movements used in gaming [59]. In order to minimise such risks to research participants, relatively short durations of exposure (e.g., in minutes rather than hours) should be maintained in research environments, with monitoring to ensure that participants maintain their personal sense of agency.

In the case of VR Massive Multiplayer Online Games for people with communication disability or their communication partners, similar safety considerations apply as for any form of online social networking, with associated risks of trolling, cyberbullying, fraud, or victimisation [60]. These safety risks may be exacerbated for individuals with communication disability due to difficulties in comprehension [61], social awareness, or behaviour [62, 63]. Indeed, the potential safety risks associated with trolling, cyberbullying, or online victimisation might be exacerbated in an online VR platform due to a sense of embodiment achieved through total immersion, also increasing the impact of these experiences. While some individuals with technical proficiency may be able to exert environmental controls to protect themselves against harm (e.g., setting user controls) or to recover from any adverse events (e.g., reporting cyberbullies), it is unlikely that all users would have the technical expertise required to perform such protective actions [11]. As such, participants in research would to be able to immediately cease the immersive experience through removing themselves from the technology and switching it off.

Conclusion

While the introduction of new VR technology into communication disability research requires careful consideration of ethics and safety, studies to date suggests that research can proceed successfully with adequate engagement of appropriately trained interdisciplinary teams and the involvement of VR technologists. Researchers need to provide adequate supports for people who are engaged in VR experiences to maintain their postural stability, and ensure that the duration of exposure in VR is appropriate. Researchers must also be mindful of and attend to the cybersecurity of VR systems, and ensure that participants are not exposed to undue influence to participate in VR research simply because it is a new technology or through having false hope about its effects.

This review highlights that research employing VR technology in the field of speech-language pathology is in its infancy, with very few studies examining its impact in relation to the assessment of development of communication skills. Early studies using non-immersive VR have demonstrated positive outcomes with emerging evidence of generalisation of some functional communication skills from the virtual environment to the physical world. Additional evidence from physical and cognitive therapies suggest that the VR modality may be highly motivating for those who need to maintain an extended interest and motivation in therapy in long-term rehabilitation. VR-based interventions may also aid in the training of health professionals and other communication partners; supporting immersive and interactive training for these communication partners to establish and practice effective, functional, and meaningful interactions with people with communication disability in a safe environment. If effective, VR training that targets improved patient-provider communication in healthcare settings could serve to improve the quality and safety of health services for people with communication disability.

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