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Inclusive gaming through AI: a perspective for identifying opportunities and obstacles through co-design with people living with MND

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This interdisciplinary research initiative seeks to enhance the accessibility of video gaming for individuals living with Motor Neurone Disease (MND), a condition characterized by progressive muscle weakness. Gaming serves as a social and recreational outlet for many, connecting friends, family, and even strangers through collaboration and competition. However, MND's disease progression, including muscle weakness and paralysis, severely limit the ability to engage in gaming. In this paper, we desscribe our exploration of AI solutions to improve accessibility to gaming. We argue that any application of accessible AI must be led by lived experience. Notably, we found in our previous scoping review, existing academic research into video games for those living with MND largely neglects the experiences of MND patients in the context of video games and AI, which was a prompt for us to address this critical gap.

KEYWORDS

accessibility, accessible AI, gaming AI, participatory design, MND

1 Introduction

For many people, playing video games is a social experience that connects friends, family and strangers through collaboration and competition, but research finds that not everyone finds them easy to play (O'Mara et al., 2021; Kremsner et al., 2022). Our interdisciplinary research collective is seeking to make gaming more accessible for people living with motor neurone disease (MND), a condition that causes progressive muscle weakness and disability (Lau et al., 2018). Muscle weakness and paralysis can severely limit the ability to engage in recreational activities such as gaming. There is also a lack of opportunities in the broader community and games development that are inclusive of people living with MND, which risks further excluding them from daily life (O'Mara et al., 2024). The lack of opportunities is despite the fact that people with MND have expressed interest in gaming (Nuyujukian et al., 2018; McEvoy et al., 2020).

We aim to improve access to gaming from several perspectives, all led by the voice of lived experience of those affected by MND, including advocating with policy makers and researchers

to help make gaming accessible, influencing the games industry to take accessibility more seriously, and working with the games industry to help them understand specific barriers to successful game play. A critical step is to better understand what helps make gaming more inclusive with players with MND. Therefore, our research has explored past and current work involving a range of software and hardware technologies that may help play games with MND, from customized software for adjusting game speeds, to eye-tracking sensors and hands-free input devices.

Evidence suggests that people living with Motor Neurone Disease (MND), a terminal illness with no cure, enjoy playing video games purely for enjoyment, alone and as a social experience (Nuyujukian et al., 2018; McEvoy et al., 2020; MND Australia, 2021). However, significant barriers associated with MND can make playing video games much harder and risk worsening feelings of boredom, stress, isolation and a lack of choice and control in daily life. More fun games that are easier play could help players with MND spend time doing something they enjoy during a difficult time, and feel more connected to daily life and their friends and family.

One pertinent form of technology we are exploring is artificial intelligence (AI). AI is a contested term, but it generally refers to computer systems capable of learning that perform tasks requiring intelligence and emulating human behavior and decision making with usually little or no human participation (Tambe and Rice, 2018). Examples of application of AI include systems that detect and collect information from the environment and process it to solve calculations or complex problems (Aler Tubella et al., 2023). The recent and rapid increase in use of various forms of AI in the games industry (Carpenter, 2024) suggests important opportunities and challenges for helping make games easier to play with people living with MND.

2 Related work

2.1 People living with MND and gaming

To explore the barriers to gaming with MND, we conducted a review in which we scoped the evidence to describe what may help reduce barriers to playing games with the MND community (O'Mara et al., 2024). Past research and practice in gaming and MND is very limited in its depth and quality, but it does suggest important areas of focus for future work. Peer-reviewed studies exploring the experiences of people with MND with brain computer interfaces (BCI) have found that neural activity was used to control software for the use recreational applications, including games, and for communicating with others (Liberati et al., 2015; Nuyujukian et al., 2018; Versalovic et al., 2022). Gray literature, including nonprofit reporting, information resources, blogs and guidelines, indicate that eye tracking devices, wearables, tablets, smartphones, computers, hand controllers, customized rooms and seating and modifications to game settings (e.g., speed and level of difficulty) and software could make gaming easier with MND (Game Accessibility Guidelines, 2012; McEvoy et al., 2020; AbleGamers, 2021; Microsoft, 2021; MND Australia, 2021).

Furthermore, peer-reviewed studies and gray literature exploring the experiences of people with various forms of disability and movement and motor impairment, such as those with cerebral palsy, muscular dystrophy and paralysis, suggest similarities in their gaming experiences to those of people with MND (Holz et al., 2013; Scherer et al., 2016; Hernández et al., 2018). Customized videogame software (including accessibility features in games and gameplay) and hardware (including modified controllers and equipment) can reduce issues with hand, arm and other physical control of interfaces for gameplay. Enhanced leisure programs and support may also help to better include people with MND in gameplay and gaming communities through more affordable access to interface technology, games and computers and consoles, as well as opportunities to play with others (Lancioni et al., 2017). For many people, playing video games is a social experience that connects friends, family and strangers through collaboration and competition.

While there is much promise for more inclusive games with MND, the existing evidence base also shows significant challenges. Game playability and limitations with holding and controlling devices and use accessibility tools were problems, including the weight of some technology and latency issues (Holz et al., 2013; Scherer et al., 2016; Hernández et al., 2018; Nuyujukian et al., 2018; MND Australia, 2021). There are gaps in the games industry processes for developing more inclusive games with people with disability (Gaddes, 2018). Gaps in practice and research also suggest little information and awareness of what helps is available to support people with MND who play games. The affordability and availability of technology that suits the changing abilities from progression of the disease (Mackenzie et al., 2016; AbleGamers, 2021) continues to be a major challenge, including, BCIs, robotics, VR and eye tracking devices. Very few people with MND have been involved in game development processes and they tend to have varying levels of understanding, confidence and skills in the use of technology, and sometimes limited support for carers (O'Mara et al., 2021). Games and gameplay, and what makes them enjoyable and fun as entertainment activities, are also not the focus of many interface technology studies. Studies tend to focus on the feasibility of interfaces (Holz et al., 2013; Scherer et al., 2016; Hernández et al., 2018; Nuyujukian et al., 2018). Similarly, there is little or no in-depth study of AI, games and MND. We have identified ways, however, to apply the lessons from past work involving people living with MND to the new contexts rapidly emerging from AI and game developments.

2.2 Trends in AI and inclusive gaming

Recent AI developments, highlighted by progress in predictive and generative AI technologies, mark a break from previous innovation trajectories and is a 'gamechanger' (Chakraborty et al., 2023). Castrodale (2022) argues AI can 'enable innovative engagements and entanglements in our world, transforming our social relations'. AI could be impactful because the technology has 'sensory-spatio-temporal implications' and connects to our embodied human form(s) (Castrodale, 2022). Through greater entanglement and innovation with AI there is potential for research and practice to help better support participation in games by people living with MND through processes of automation. Innovation through automation, with appropriate permissions and input from people living with MND (Versalovic et al., 2022), can work to reduce the burden associated with physical movement when controlling interfaces, difficult gameplay and game speeds, searching for and making sense of game information. Critically, automation may also be important for making it easier when communicating with friends and family.

From a global social justice perspective, the use of AI tools may also prove to be an important leveler, and we see an immense opportunity. Although 15% of the world's population lives with a form of disability, only one out of ten can obtain accessible technology solutions (Chakraborty et al., 2023). AI and other technology developments can offer more powerful solutions that are less expensive to access. For instance, high fidelity eye-tracking solutions were traditionally possible only through custom and expensive set-ups such as the Tobii Pro range. Recent advances have produced eye-tracking solutions that are now possible through a user's domestic web browser, such as Chrome. The response may not be as impressive as more expensive technology but the more affordable entry point could allow a range of users access to content that was not previously possible (Kremsner et al., 2022). Many people with MND and others with disability may also not be aware of these affordable technology options (Mackenzie et al., 2016).

Despite the innovative potential, previous work, in both academic and gray literature, demonstrates that AI has limitations and can be problematic. For example, in game-based environments, what is often termed as Reactive AI models are often self-contained or siloed algorithms, with the computer-controlled opponents in the real time strategy game *Starcraft 2* treating each match as an individual event and reacting in a predetermined way based on the actions of the human player. Alternatively, Limited Memory AI models, such as the natural language models made famous by ChatGPT, draw and build on the subsequent analysis of external data. As the technology relies on a massive dataset from previous relations, historical biases can be baked into reasoning and outputs of the technology, practitioners now are working to argue for fairer systems (Buolamwini, 2023). Alternatively, data from people living with a disability and their communities might not be included in automation models, meaning that people with disabilities will be excluded by benefits. For instance, journalist Tony Polanco in Brandt et al. (2022) provides an example of a problem of AI gaming in reference to VR technology. Two Sony PlayStation VR titles, *Batman Arkham VR* and *Dying Reborn* assumed the player was standing and not in a wheelchair, as the writer was at the time of play. The game's camera did not accurately track their movements.

People with MND and other forms of disability who use AI may also experience risks associated with privacy and informed consent (Wald, 2021). The risks may lead some users to distrust the technology. As we have argued, conceptualizing new technologies using a collaborative process between industry and the MND community develops is key to the mitigation of risks, and more likely to produce a prototype product that is fit for purpose and reduces the likelihood of retrospective fixes later in the development cycle.

Following important advances in AI and games development for players with disability, we believe that there is significant potential for AI to support players in direct gameplay, serving as a co-pilot to reduce the frustration of macro level control while still empowering the player to be making the critical decisions. This is not a revolutionary idea, as there have been numerous examples of games allowing the player to enable AI to automate micromanagement of actions and allowing them to instead focus on the macro level decision making. Classic 1990s real-time strategy games such as *Warzone 2,100* and *Dark Reign* featured the option of using AI assistants for controlling individual units to complete tasks such as scouting or automatically retreating when units had received a certain amount of damage. This genre of game is usually played with a mouse, requiring a high level of fine motor skills and dexterity. Obviously, this would prevent many people living with MND from playing a game, but the use of more comprehensive AI assistants can allow them to strategise and give directions without the need to complete repetitive tasks with a mouse. In more recent times, the SpringRTS engine allows for a high degree of customization including the use of AI to take on micromanagement tasks, such as base building, traditionally performed by players.

Shifting genres from real time strategy games to sports titles, in many soccer/football games such as *FIFA23 AI* players can take control of individual players. Rather than directly controlling Messi or Ronaldo, the player can serve as a coach shifting strategies and formations in response to what they see during play. For both real time strategy games and sports titles, the speed at which a game unfolds is an issue, so rather than slowing down the play for everyone and fundamentally changing the game, predictive co-piloting AI could be used to look for patterns in play over a longer period of time and assist by predicting a user's intention or next move. What we do not know is how this transfer of control from the player to AI would be received by the community, and whether they would still enjoy playing these games with a reduced level of agency.

2.3 Involving people living with MND in co-design of more inclusive AI and gaming

Due to the significant gaps in knowledge about MND and supporting play on existing gaming platforms with AI in a range of technical and social requirements, involving people living with MND in designing the approach to learning and development is important. Evidence suggests that developing participatory processes for involving people with MND is a viable way to learn what may work best for developing games more inclusive and easier to play with MND (Gunton et al., 2021). A viable approach to supporting participation is Community Participatory Action Research (CPAR), which has been used with people with MND in technology development settings to ensure they were central to decision making and design, including creation of more effective devices (Reed et al., 2014; Gunton et al., 2021).

CPAR is a novel and collaborative process for bringing together socially marginalized communities, organizations and other stakeholders to find ways of improving an issue through social change and action (Reed et al., 2014; Gunton et al., 2021). CPAR can be used for participant-researchers with lived experiences, as well as game and technology developers, and as a way of employing co-design for allowing researchers to better understand the condition in which micromanagement can be automated while still maintaining a sense of participation and joy.

3 Co-design as an essential component to harness the affordances of AI for inclusive gaming interfaces

Our review found that academic literature about MND and gaming overlooked the importance of community participation in

research and co-design (O'Mara et al., 2024). The finding was surprising because guidelines in Australia and across the world stress the importance of engaging with lived experience for research and development, including technology related work (UNCRPD, 2008; Consumers Health Forum of Australia, 2016). As such, finding ways to learn from voices of the MND community is crucial to any AI development to mitigate barriers to gaming. Co-design is a valuable technique for learning and its practical application with the MND community.

The disability rights movement has emphasized the importance of amplifying the voices of individuals who have firsthand experience, highlighting the central message that empowered decision-making should always involve those directly affected, encapsulated by the principle 'Nothing should be decided about us without us' (UNCRPD, 2008). However, given there is no comprehensive research into AI, interaction, videogames and MND, the gap highlights an urgent need for the involvement of people with MND in future work. The gap in academic study that supports the participation of those with lived experience is despite the fact that, in Australia, research finds that 81% of all Australians play video games. Furthermore, anecdotal evidence (MND Australia, 2021), non-profit reporting (McEvoy et al., 2020) and other evidence from gray literature suggests many people with MND are interested in playing videogames, including for their pleasures and the possibilities of social connection.

We argue that this is a massive oversight in the academic research of inclusive technologies, as positioning end users as co-researchers will help to ensure that the use of AI is not only technically functional but is an enjoyable experience. In our minds, joyful experience or the lack of joy is the single most central consideration in determining the widespread adaptation of assistive technologies. We believe that design *for* the community has hindered the widespread adaptation of brain-computer interfaces while those who have engaged design *with* the community, such as Microsoft's adaptive controller have been incredibly well received by the intended end users and the game industry as a whole. For AI technologies to be successful, it is important to ensure that co-design is adopted through participatory methods of software development and research that include people living with MND (Reed et al., 2014; Gunton et al., 2021).

Building on past work involving people with MND and technology, the technique of co-design can be used as part of a broader CPAR process in order to develop more enjoyable and inclusive games with MND. Generally, co-design involves a team of experts, including people with lived experience of a health issue like MND, working collaboratively to co-design workshops and other aspects of a project (Anderson et al., 2024). Team members are actively engaged in the conceptualisation and design process itself to share their experiences and insights for application. The process is iterative and allows multiple revisions, ongoing feedback and refinements, in a collaborative way, to help work toward project goals and ensure participant satisfaction, ease-of-use and enjoyment. Co-design suggests promise for the practical application of learning from people with MND to develop more inclusive gaming with AI.

Including people living with MND in making decisions around which forms of AI to explore for gaming also helps to keep the focus on a capabilities-based approach to inclusive play. By adopting a model that is affirmative and encourages recognition of a person's abilities and strengths (Raley et al., 2021; MND Association, 2024), it starts with the assumption that everyone can play and builds from what individuals can do, including their specific capabilities when using technology. This approach identifies problems lying in the social fabric that builds in barriers for those who do not fit physio-normative assumptions (Mackenzie et al., 2016; Kremsner et al., 2022). Technology can be an excellent means to improve lives of people living with a disability (Chakraborty et al., 2023), and there is a long practice of doing so (Castrodale, 2022) when the barriers they experience are fully understood. Most importantly, people living with MND have reported a willingness to use technology for everyday activities and for communication to develop and maintain social relationships (Mackenzie et al., 2016).

4 Future work

Our research group was recently funded to research and develop more inclusive games for improved quality of life through the "Game on for MND" project. In the project, we aim to improve access to gaming from several perspectives, all led by the voice of lived experience of those affected by MND, in collaboration with game and technology developers, including advocating with policy makers and researchers to help make gaming accessible, influencing the games industry to take accessibility more seriously, and working with the games industry to help them understand specific barriers to successful game play. Building on past research and practice (O'Mara et al., 2024), we are currently exploring a range of software and hardware technologies for games, from customized software for adjusting game speeds, eye-tracking sensor and hands-free input devices. AI is a significant part of the research. We are also working closely with people living with MND and others from the MND community to develop and implement an enhanced form of co-design and CPAR for better understanding what may or may not help games more fun and easier to play with MND, including the role of AI.

While there is little or no comprehensive study of co-design, games and artificial intelligence, use of this approach still shows viability for better understanding the challenges and opportunities of AI. Through dedicated workshops and other opportunities for feedback, co-design offers an opportunity for people with MND to share their views and preferences on how AI, along with a range of other forms of technology for playing games, can reduce barriers they experience to gameplay, and support more fun and inclusive games. Such insights can then be practically applied to changes for software and hardware, and evaluated through ongoing feedback provided by people with MND as part of a cycle of review. Lessons learned from refinements to co-design and CPAR more broadly, including the sharing of participant views and information supported by AI in a practical sense, may also help to guide future research and development that better integrates AI into methodological processes, with the consent and input of community members. For example, building prototypes, referred to by the field as 'technology probes' (Graham et al., 2007), which work as props for discussion, which itself is also supported by AI, can help to focus co-design and participatory processes. Co-designing prototypes, and in turn workshopping, revising and refining them with a collaborative team, may help create much more fun and inclusive games that use AI with people with MND.

5 Conclusion

Our approach to AI is opportunistic, building on our broader analysis of the literature around digital technologies and their potential for removing barriers to play for people with physical disability. In exploring the affordances and the possibilities of AI as part of a larger body of research, we are cautiously optimistic that AI can be positioned to reduce the barriers while managing the risks under the right conditions. But most importantly, is an AI solution that individuals in the MND community want for themselves? If it is useful, how can we fine-tune the prototype to improve it? What problems do they foresee and what can be done to mitigate these issues? Drawing on our suggestions and approaches suggested here, we will report our findings in our future research, and to help players "Game on with MND."

We hope that the participatory research and its use of co-design described here identifies numerous potential benefits in developing AI-augmented solutions for inclusive play. The needs, interests and the everyday context of users must remain present in the foreground of a design exploration. To do this, research teams must include researcher-participants making critical decisions to ensure there is an emphasis on the sense making by end users. This includes understanding how a user operates an interface in 'real life' as part of their daily routines (Ward, 2023). When addressing an accessibility barrier, no design decisions can be made without the central participation of those with lived experience. As Hassan (2024) points out, researchers can have 'blind spots' when considering the capacities users might have. Currently, game researchers are paying less attention toward motor and auditory accessibility. Based on insights from research and practice, we feel that development, including that for games and AI, must empower individuals with a disability, and not to normalize based on an outsider's view (Brandt et al., 2022).

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

ND: Conceptualization, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. MH: Conceptualization, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. BO'M: Conceptualization, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. KH: Conceptualization, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

AbleGamers. (2021). "Gaming with a progressive disease". https://ablegamers.org/knowledge-base/gaming-with-a-progressive-disease/

Aler Tubella, A., Mora-Cantallops, M., and Nieves, J. (2023). How to teach responsible AI in higher education: challenges and opportunities. *Ethics Inf. Technol.* 26:3. doi: 10.1007/s10676-023-09733-7

Anderson, T., Prue, G., McDowell, G., Stark, P., Brown Wilson, C., Graham Wisener, L., et al. (2024). Co-design and evaluation of a digital serious game to promote public awareness about pancreatic Cancer. *BMC Public Health* 24:570. doi: 10.1186/s12889-024-18050-7

Brandt, M., Reddan, M., and Kiryakoza, M. (2022). "The ultimate medium for people with disabilities?: re-Centring the human in virtual reality visions of play, care, and empathy" in *Gaming Disability*. eds. K. Ellis, T. Leaver and M. Kent (New York: Routledge), 132–143.

Buolamwini, J. (2023). *Unmasking AI: A story of hope and justice in a world of machines*. New York: Random House.

Carpenter, N. (2024) "Video game industry layoffs, AI ethics are top concerns for workers, new survey says". Available at: https://www.polygon.com/24043293/game-developers-conference-gdc-survey-2024

Castrodale, M. (2022). "Dis/abling androids: gaming, Posthumanism, and critical disability studies" in *Gaming Disability*. eds. K. Ellis, T. Leaver and M. Kent (New York: Routledge), 31–40.

Chakraborty, N., Mishra, Y., Bhattacharya, R., and Bhattacharya, B. (2023). Artificial intelligence: the road ahead for the accessibility of persons with disability. *Mater. Today Proc.* 80, 3757–3761. doi: 10.1016/j.matpr.2021.07.374

Consumers Health Forum of Australia, (2016). "Statement on consumer and community involvement in health and medical research," National Health and Medical Research Council. Available at: https://www.nhmrc.gov.au/about-us/publications/statement-consumer-and-community-involvement-health-and-medical-research

Gaddes, M. "5 ways accessibility in video games is evolving" (2018). Available at: https://abilitynet.org.uk/news-blogs/5-ways-accessibility-video-games-evolving.

Game Accessibility Guidelines. (2012). Game Accessibility Guidelines. Available at: https://gameaccessibilityguidelines.com/

Graham, C., Rouncefield, M., Gibbs, M., Vetere, F., and Cheverst, K. (2007). How probes work. in Proceedings of the 2007 Australasian Computer-Human Interaction Conference. OZCHI, Adelaide, Australia

Gunton, A., Hansen, G., and Schellenberg, K. (2021). Photovoice as a participatory research tool in amyotrophic lateral sclerosis. *J. Neuromuscul. Dis.* 8, 91–99. doi: 10.3233/JND-200537

Hassan, L.. (2024). "Accessibility of educational games and game-based approaches to people with learning and physical disabilities: a systematic literature review." https://hdl.handle.net/10125/106580.scholarspace.manoa.hawaii.edu

Hernández, H. A., Khan, A., Fay, L., Roy, J. S., and Biddiss, E. (2018). Force resistance training in hand grasp and arm therapy: feasibility of a low-cost videogame controller. *Games Health J.* 7, 277–287. doi: 10.1089/g4h.2017.0193

Holz, E. M., Höhne, J., Staiger-Sälzer, P., Tangermann, M., and Kübler, A. (2013). Brain-computer interface controlled gaming: evaluation of usability by severely motor restricted end-users. *Artif. Intell. Med.* 59, 111–120. doi: 10.1016/j.artmed.2013.08.001

Kremsner, G., Schmoelz, A., and Proyer, M. (2022). "A (dis-) abling gaming model for playful inclusion: playing (digital) games with persons with and without learning difficulties and dis/abilities" in *Gaming Disability*. eds. K. Ellis, T. Leaver and M. Kent (London: Routledge), 183–195.

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., D'Amico, F., Ferlisi, G., et al. (2017). A basic technology-aided programme for leisure and communication of persons with advanced amyotrophic lateral sclerosis: performance and social rating. *Disabil. Rehabil. Assist. Technol.* 12, 145–152. doi: 10.3109/17483107.2015.1104561

Lau, F., Brennan, F., and Gardiner, M. (2018). Multidisciplinary management of motor neurone disease. *Aust. J. Gen. Pract.* 47, 593–597. doi: 10.31128/AJGP-02-18-4495

Liberati, G., Pizzimenti, A., Simione, L., Riccio, A., Schettini, F., Inghilleri, M., et al. (2015). Developing brain-computer interfaces from a user-centered perspective: assessing the needs of persons with amyotrophic lateral sclerosis, caregivers, and professionals. *Appl. Ergon.* 50, 139–146. doi: 10.1016/j.apergo.2015.03.012

Mackenzie, L., Bhuta, P., Rusten, K., Devine, J., Love, A., and Waterson, P. (2016). Communications technology and motor neuron disease: an Australian survey of people with motor neuron disease. *JMIR Rehabil. Assist. Technol.* 3:e2. doi: 10.2196/rehab.4017

McEvoy, R., Olive, D., and Gomizel, K. (2020). "Why is your iPad sitting Unused in the Corner? Collaborative iPad Review". Paper presented at the Allied Professionals Forum, International Alliance of ALS/MND Associations. Available at: https://www.youtube.com/watch?v=x0RZ7mRP2n8

Microsoft. "Gaming and disability player experience guide". (2021). Available at: https://learn.microsoft.com/en-us/gaming/accessibility/gadpeg

MND Association. (2024). "*Augmentative and alternative communication (AAC) for MND*." Northampton, United Kingdom

MND Australia. (2021). "Why videogames matter for MND these holidays." Available at: https://www.mndaustralia.org.au/articles/why-videogames-matter-for-mnd-these-holidays

Nuyujukian, P., Albites Sanabria, J., Saab, J., Pandarinath, C., Jarosiewicz, B., Blabe, C. H., et al. (2018). Cortical control of a tablet computer by people with paralysis. *PLoS One* 13:e0204566. doi: 10.1371/journal.pone.0204566

O'Mara, B., Harrison, M., Dwyer, N., and Harley, K. (2021). Making videogames more inclusive for people living with MND: protocol for a scoping review. *Games Change Asia-Pac.* 1, 127–146.

O'Mara, B., Harrison, M., Dwyer, N., and Harley, K. (2024). Making video games more inclusive for people living with motor Neurone disease (MND): a scoping review (under consideration). *Games Change Asia-Pac. J.* 1, 127–145.

Raley, S., Shogren, K., and Cole, B. (2021). Positive psychology and education of students with disabilities: the way forward for assessment and intervention. *Adv. Neurodev. Disord.* 5, 11–20. doi: 10.1007/s41252-020-00181-8

Reed, H., Langley, J., Stanton, A., Heron, N., Clarke, Z., Judge, S., et al. (2014). Head-up: an interdisciplinary, participatory and co-design process informing the development of a novel head and neck support for people living with progressive neck muscle weakness. *J. Med. Eng. Technol.* 39, 404–410. doi: 10.3109/03091902.2015.1088092

Scherer, R., Schwarz, A., Muller-Putz, G. R., et al. (2016). Lets play tic-tac-toe: a brain-computer Interface case study in cerebral palsy. The Institute of Electrical and Electronics Engineers, Inc (IEEE) Conference Proceedings: IEEE: Budapest, Hungary. 3736–3741.

Tambe, M., and Rice, E. (2018). *Artificial intelligence and social work*. Cambridge: Cambridge University Press.

UNCRPD. Convention on the rights of persons with disabilities. (2008). Available at: https://humanrights.gov.au/our-work/disability-rights/united-nations-convention-rights-persons-disabilities-uncrpd

Versalovic, E., Diamond, M., and Klein, E. (2022). Re-identifying yourself: a qualitative study of veteran views on implantable BCI for mobility and communication in ALS. *Disabil. Rehabil. Assist. Technol.* 17, 807–814. doi: 10.1080/17483107.2020.1817991

Wald, M. (2021). AI data-driven personalisation and disability inclusion. *Front. Artif. Intell.* 3:571955. doi: 10.3389/frai.2020.571955

Ward, A. (2023). The development of a modular accessible musical instrument technology toolkit using action research. *Front. Comput. Sci.* 5:1113078. doi: 10.3389/fcomp.2023.1113078