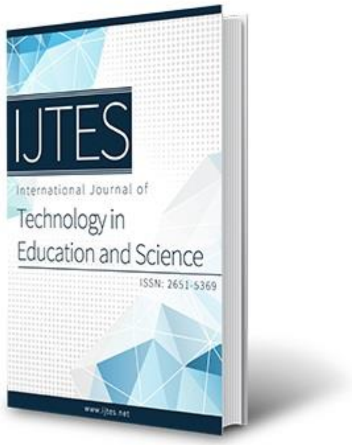

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Neuroaffirmative Approaches to Extended Reality: Empowering Individuals with Autism Spectrum Condition through Immersive Learning Environments

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Neuroaffirmative Approaches to Extended Reality: Empowering Individuals with Autism Spectrum Condition through Immersive Learning Environments

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Abstract

Traditional teaching and working environments often prioritize extroverted qualities, disadvantaging individuals with conditions that impact social engagement, such as autism spectrum condition (ASC). These individuals usually thrive in calmer, low-key learning environments but face challenges in lecture-style classes, and traditional office environments leading to marginalization in academic and professional settings. This study explores the neuroaffirming potential of extended reality (XR) in creating immersive learning and working environments tailored to the unique needs of individuals with ASC. By focusing on four key factors—indirect social engagement, digital communication preferences, sensory sensitivity, and avatar-based communication—XR technologies can provide a supportive and accommodating environment for those with sensory processing disorders (SPD). As the metaverse and virtual reality (VR) technology advances, education and industry can harness social VR to prepare students for a future of work defined by virtual collaboration. This research investigates the transformative role of XR and the metaverse in promoting a more inclusive educational and professional landscape by adapting environments to empower individuals with ASC, enabling them to reach their full potential in a neuroaffirmative manner.

Introduction

In 2020, the COVID-19 pandemic prompted a rapid transition from traditional office work and face-to-face classes to online and asynchronous learning in higher education along with remote work for those in industry. The sudden shift compelled educators and employers to explore innovative solutions, including emerging technologies, to overcome the challenges associated with remote instruction and work. Consequently, immersive realities such as Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MxR), which were once confined to computer science programs or gaming, gained widespread recognition, particularly with Facebook's announcement to establish the "metaverse" (Kraus, Kanbach, Krysta, Steinhoff, and Tomini, 2022). Advancements in Head-Mounted Displays (HMDs), which facilitate audio and visual immersion, along with the growth of educational applications and reduced costs, have diminished the barriers that previously hindered academia's adoption of these technologies (Bekele & Champion, 2019). The adoption has to date, however, been only nominally adopted across both areas (Ales, 2023; Koh et al., 2023). Yet, the potential of extended reality (XR) in redefining the landscapes of education and work, particularly for individuals with Autism Spectrum Condition (ASC), is demonstrable, though misused to this point only to modify behaviors whereas this article will argue the technologies can be used to promote inclusivity and facilitate virtual collaboration through environmental adjustments and modulation of sensory input (George et al., 2023).

As virtual reality (VR) technology and its associated hardware (head-mounted displays or HMDs) and software (applications) become increasingly accessible, specialists, secondary education, and industry have started developing resources to address mental health issues within various populations. Historically, applications such as Ovation, a public speaking application, aimed to modify or alter behavior by reducing anxiety prevalent in 77% of the population and enhancing performance (Correia et al., 2023). While engagement with avatars in immersive social environments has been reported as comfortable for all demographics, these applications primarily focused on boosting confidence and public speaking skills for introverts, potentially expanding their contributions across industries and roles.

Similarly, past applications for mental and behavioral health targeting individuals with autism spectrum condition (ASC), formerly autism spectrum disorder (ASD) (Scott, 2023), were designed with behavior change in mind. For instance, Floreo VR sought to improve social, behavioral, communication, and life skills for those on the spectrum (Hutson, 2022). However, recent advancements in the field emphasize the importance of adjusting environments to accommodate users' needs, rather than solely attempting to alter their behavior (Scott, 2023). By adopting a more inclusive and neuroaffirmative approach, these technologies can empower individuals with diverse mental health and neurological profiles, fostering a supportive and adaptable landscape for personal and professional growth (Roux et al., 2023).

These applications have been developed to address or modify specific characteristics and behaviors in targeted populations, such as those with ASC, and introverted individuals. Both ASC and introversion have historically been the focus of research and have been perceived as conditions requiring treatment, akin to other mental disorders. Jacobs (2014) highlighted the stigmatization of introversion, particularly in Western society, while Barnard (2002) discussed the "Crisis of Autism." Moreover, studies have shown that teachers and employers often prefer extroverts in classrooms and workplaces for various reasons (Murphy, Eduljee, Croteau, and Parkman, 2017). Interestingly, what is often overlooked in the scholarship of teaching and learning is the fact that many individuals who value extroverted qualities in educational and professional settings are themselves introverts or on the spectrum (Neuhaus, 2019). As our understanding of ASC and introversion evolves, it is crucial to shift the focus from merely treating or modifying these characteristics to creating inclusive and neuroaffirmative environments that accommodate diverse needs and empower individuals to thrive.

The traditional perception of introverted individuals or those diagnosed with ASC, as well as the prescribed use of virtual reality (VR) for them, overlooks the transformative societal impact of the metaverse and emerging technologies (Darwish, Kamel, & Assem, 2023; Harborth & Kümpers, 2022). The driving force behind creating applications like Ovation and Floreo VR has been the assumption that these populations require intervention and support to engage in socially prescribed activities alongside the general population (Ravindran et al., 2019). However, this perspective fails to recognize the potential of immersive reality and virtual learning environments (VLE) to empower these individuals by leveraging their existing skills and talents in ways that face-to-face interaction or even virtual engagement through video conferencing cannot provide.

Instead of focusing on using technology to help those considered unable to conform to social norms, researchers should explore how the metaverse can be utilized to create a level playing field, fostering a more inclusive and equitable environment (Hutson, 2022). As the future of work transitions towards hybrid and remote models, the psychological effects of these technologies could lead to fewer introverts being overlooked for advancement and promotion (Fan & Moen, 2023). By embracing the capabilities of immersive technologies, we can redefine education and work to accommodate diverse needs, ultimately promoting inclusivity and equal opportunities for all.

Moving forward with one of the most disruptive decades, daily interactions are continually transforming, and this evolution will persist as adoption of artificial intelligence (AI), machine learning (ML), and XR technologies expands. A new digital body language is poised to replace traditional face-to-face social exchanges (Dhawan, 2021). Extroverts are now facing challenges in adapting to this new virtual environment, leading to increased cases of depression and anxiety during the pandemic (Colloca, Thomas, Yin, Haycock, and Wang, 2021; Entringer and Gosling, 2021). In this context, the introverts of today may become the extraverts of the virtual tomorrow.

With the rise of the metaverse and democratization of XR technology, education is particularly well-positioned to capitalize on the immersive learning environments that social VR offers, while industry can bring various continents and stakeholders together more instantaneously than ever before to collaborate (Yang et al., 2022). By accommodating the preferences of individuals with ASC through the use of XR, such as their comfort with indirect social engagement, preference for digital communication, sensory sensitivity awareness, and inclination towards avatar-based communication, sensory processing challenges can be mitigated (Waizbard-Bartov et al., 2022). Rather than perceiving introversion or ASC as traits that need mediation or “correcting,” immersive technology enables the unique skills and insights of these individuals to be accessed and shared, benefiting not only the individuals themselves but society as a whole (Cope & Remington, 2022). Embracing a diverse range of perspectives and insights will lead to innovative solutions for the complex challenges that will continue to emerge in the digital age. In order to achieve this end, the following paper will demonstrate how immersive experiences can be tailored to mitigate four specific symptomatic areas of ASC by aligning extended reality technologies with the needs and preferences of individuals with ASC. Drawing upon clinical research, the potential of these immersive experiences to create a more inclusive and supportive learning and working environment shall be demonstrated, ultimately empowering individuals with ASC to thrive in the evolving digital landscape.

ASC Symptoms

Individuals with autism spectrum condition (ASC) often exhibit behaviors that deviate from societal norms in areas such as social approach, back-and-forth conversation, interpretation of behavior and facial expressions, and initiation or response to social interactions (American Psychiatric Association, 2022). Common features of the autism spectrum include limited integration of verbal and nonverbal communication, atypical eye contact and body language, and a reduced understanding and utilization of gestures (American Psychiatric Association, 2002; Marco et al., 2011). However, recent research suggests that difficulties in social-emotional reciprocity and social communication are not consistent across all social contexts for those with ASC.

Adults with ASC display varying communication preferences, often favoring indirect engagement and written modes of communication over face-to-face interactions and preferring face-to-face communication to phone calls (Howard and Sedgewick, 2021). Sensitivity to sensory stimuli, such as adverse reactions to specific sounds, textures, lights, and smells (American Psychiatric Association, 2022; Marco et al., 2011), as well as distinct gaze behavior compared to individuals without ASC, can make direct communication during live social interactions challenging, uncomfortable, and less appealing for those with ASC (Grossman et al., 2019). Consequently, indirect engagements may be the preferred mode of communication for this population. As such, this study will concentrate on four primary symptomatic areas related to individuals with ASC:

1. Greater comfort with indirect social engagement
2. Preference for digital communication over face-to-face interaction
3. Sensitivity to sensory stimuli (e.g., light, sound, smell, etc.)
4. Preference for avatar-based communication (reducing the need to mask)

Harold and Sedgewick (2021) investigated the communication preferences of autistic adults in a variety of social contexts in individuals medically diagnosed with ASC (110 autism spectrum disorder, 92 Asperger’s syndrome, 2 Pervasive developmental disorder, and 1 on a waiting list or mid-assessment) or self-identified with ASC (20 autism spectrum disorder, 9 Asperger’s syndrome, 6 on a waiting list or mid-assessment and 5 did not specify). The study, which was the first large-scale exploration of the communication mode preferences of autistic adults in a range of everyday scenarios, recruited two hundred and forty-five autistic adults (M age = 40.44 years, standard deviation (SD) = 13.14, range = 16–74, with 92% of the sample exhibiting clinical levels of autism) who completed a novel questionnaire that required six communication modes to be ranked in order of preference across seven different scenarios— accessing services, employment, education, research, family, friends, and customer support—and found that indirect, digital communication was preferred in most social settings independent of age and gender (Harold and Sedgewick, 2021).

In sum, the communication modality of email had the largest spread of number one rankings for accessing services, seeking customer support, and communicating about employment. Similarly, communicating with family, friends, in employment and in education, both face-to-face and written digital modes (email or text message) were preferred, supporting the notion that autistic individual prefer and prioritize indirect social engagement and digital, structured communication (Harold and Sedgewick, 2021). Face-to-face communication was dependent upon the closeness and comfortability of the relationship (Harold and Sedgewick, 2021). The data was further visualized by Harold and Sedgewick (2021), as a violin plot to investigate both the density of the ranking preferences and the summary statistic of the median ranking preference (see Figure 1).

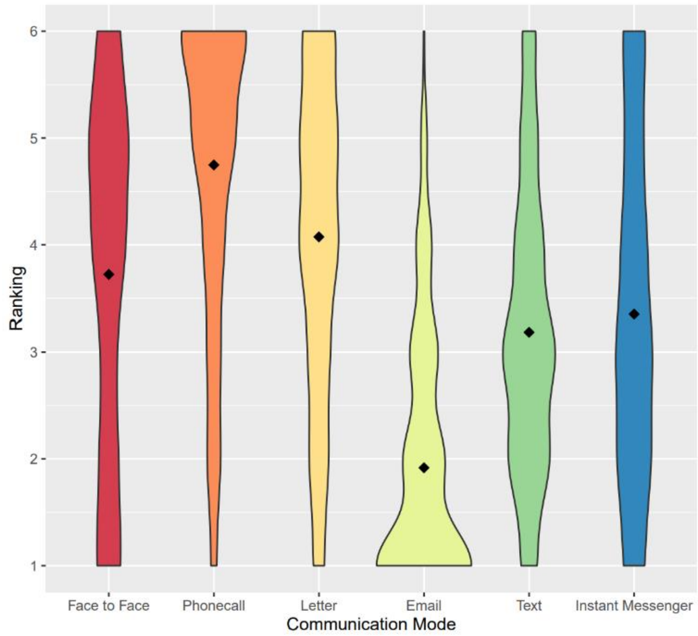

Figure 1. Comparing Ranking Preferences of Autistic Adulsts by Communication Mode (Harold and Sedgewick, 2021)

In Harold and Sedgewick's qualitative data that gathered explanations for participants' rankings, they identified four main themes pertaining to communication preferences for autistic individuals: Not the Phone, Written Communication, Masking versus Autistic Communication, and Avoiding Communication (2021). Within these possible explanatory variables, Written Communication was featured with the subsects of Thinking Time, Sensory Aspects, and Structured Communication whereas Avoiding Communication featured Anxiety and Supported Communication as subgroups (Harold and Sedgewick, 2021). Moreover, Not the Phone was established as a nonpreferred modality due to issues in processing speed tied to auditory filtering. Ultimately, the study stressed the importance of individuals' with ASC need to engage socially from a familiar sensory environment via their preferred communication mode, which lessened their anxiety and allowed them to 'stay calmer and concentrate more' on the interaction as compared to an unfamiliar and sensory saturated environment (Harold and Sedgewick, 2021).

Identifying digital social engagement as a preference by members of the autistic community is important to help accommodate individuals in a variety of settings. In addition, drawing a connection between preferred communication mode and sensory processing issues is also vital in better understanding the needs of this community. Sensitivity to sensory stimuli, such as adverse reactions to specific sounds, textures, lights, and smells (American Psychiatric Association, 2022; Marco et al., 2011) can extend beyond this symptomatic domain, and even reflect sensory behaviors such as sensory seeking (needing or avoiding pressure), movement sensitivity, and low energy as detailed on the Sensory Short Profile (Dunn, 1999). Both children and adults with ASC have been found to have higher rates of sensory processing issues ranging from integration to hyper/hyposensitivity when compared to neurotypical peers (Tomchek and Dunn, 2007; Marco et al., 2011), with over 96% of children with ASD reported to have hyper and hypo-sensitivities in multiple domains that can endure through adulthood (Crane et al., 2009; Leekam et al., 2007).

A 2020 study by Crasta et. al investigated sensory behaviors between neurotypical children, children with ASC, and children with SPD aged 6-11 years old (M = 7.83; SD = 1.26). Crasta et al. recruited a sample of 69 children in total, with 24 with a confirmed medical diagnosis of ASC with no parent-reported comorbid conditions (19 males, five females; mean age 8.24 years, SD = 1.39), a sample of 21 children with SPD (15 males, six females; mean age 7.54 years, SD = 1.42) who were undergoing therapy for sensory processing issues and lacked a diagnosis of other comorbid conditions such as autism or ADHD, and a control group of 24 neurotypical children (17 males, seven females; mean age 7.67 years, SD = 0.86) who had no known physical, neurological, or behavior disorders and had not previously received any therapy services as reported by the parents (2020). The Short Sensory Profile (SSP) was administered to participants' caregivers to report on their child and responses were scored on a 5-point Likert scale, with higher scores indicating better functional and adaptive behaviors in seven select domains: auditory filtering, low energy/weak, under-responsive/seeks sensation, sensitivity to movement, tactile, taste/smell, and visual/auditory as well as giving a total score (Crasta et al., 2020; Dunn, 1999). Furthermore, Figure 2 depicts the calculated mean by group—ASC, neurotypical, and SPD—of the parent reported scores in the seven SSP domains. Higher means designate better functional and adaptive behaviors in that domain (Dunn, 1999). Error bars of the standard deviation (SD) indicate dispersion of the data from mean; a 95% confidence interval was used (Crasta et al.).

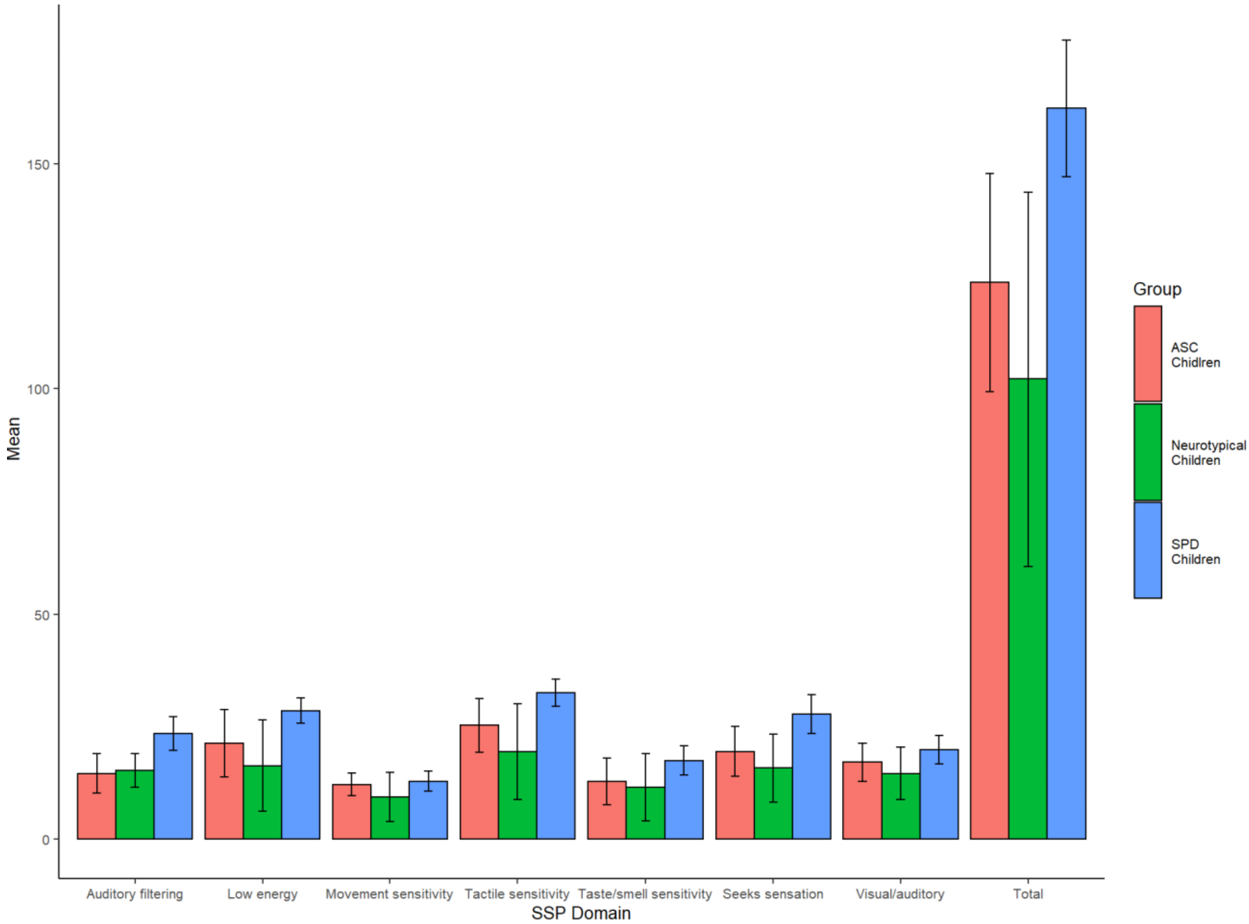

Figure 2. Sensory Processing Differences Between Children with ASC, SPD, and Neurotypical Peers (Crasta et al., 2020)

These findings indicate that children with SPD and ASC experience significantly greater sensory processing challenges than neurotypical children their age, with specific challenges in the categories of auditory filtering, under-responsive/seeks sensation, low energy/weakness, and taste/smell sensitivity (Crasta et al., 2020) and is aligned with current research. Furthermore, there was a discriminate difference between children with SPD and ASC in terms of the impact of the sensory issues, with children with SPD being more impacted in their typical functioning (Crasta et al., 2020). The significant differences in functional and adaptive behaviors associated with sensory processing challenges is consistent with the canonical literature when comparing the autistic community and neurotypicals. The identification of differences in the ASC and SPD communities brings greater understanding to the extent of challenges these two populations face when it comes to sensory processing issues and reconciliation of social approach, setting, and general population understanding of the challenges of sensory sensitivity must be addressed in order to increase comfort of social engagement both in education and industry.

Furthermore, even before the widespread adoption of virtual reality, research indicated that introverts and individuals with ASC favored virtual environments over traditional face-to-face interactions. Amichai-Hamburger, Wainapel, and Fox (2002) conducted a study comparing the use of internet chat between two different populations. Their findings revealed that introverted and "neurotic" individuals identified their "real me" in virtual interactions, while extroverted and "non-neurotic" participants felt their true selves were best expressed through conventional, face-to-face communication and social interaction. Recent studies have further supported the idea that using avatars in virtual reality can help alleviate anxiety across various populations. While participants from all demographics reported feeling comfortable engaging with avatars in immersive social environments, introverts, individuals with social anxiety disorders, PTSD, and ASC were found to be more effective in engaging within social virtual reality settings than in person (Vianez, Marques, and Simões de Almeida, 2022; Suh and Ahn, 2022).

XR Interventions

Recent advancements in technology, such as the use of avatars in virtual reality and even robots, have demonstrated promising results in enhancing engagement among individuals with ASC. Studies have shown that people with ASC often experience higher levels of task and social engagement when interacting with robots compared to human interactions (Kumazaki et al., 2020). Virtual reality has been shown to foster numerous positive outcomes in various aspects of learning. Salzman, Dede, Loftin, and Chen (1999), for example, developed a model that explains how virtual reality can enhance conceptual learning and influence the learning process and outcomes. This concept is supported by research suggesting that virtual environments can stimulate learning and comprehension by creating a strong connection between symbolic and experiential information (Bowman, Hodges, Allison, and Wineman, 1998, p.121). A consistent positive relationship has been observed between the use of immersive technology and various aspects of learning, such as increased motivation (Cheung et al. 2013; Jacobson et al. 2005; Sharma, Agada & Ruffin 2013; Brownridge 2020), time-on-task (Huang et al. 2010; Johnson et al. 1998), enhanced enjoyment of learning (Apostolellis & Bowman, 2014; Ferracane, Pezzatini & Del Bimbo, 2014), deeper understanding, and long-term retention (Huang et al. 2010; Rizzo et al., 2006; Hussein & Nätterdal, 2015).

The utilization of virtual reality (VR) as a treatment for autism spectrum condition (ASC) has been extensively explored in various studies (Strickland, Marcus, Mesibov, and Hogan, 1996; Strickland, 1997; Parsons and Mitchell, 2002; Goodwin, 2008; Ehrlich and Miller, 2009; Mesa-Gresa, Gil-Gómez, Lozano-Quilis, and Gil-Gómez, 2018; Yuan and Ip, 2018; Ghanouni, Jarus, Zwicker, Lucyshyn, Mow, and Ledingham, 2019). Bellani, Fornasari, Chittaro, and Brambilla (2011), for instance, highlighted the growing prevalence of ASC and reviewed the potential of virtual reality as an intervention strategy (La Salvia and Tansella 2009; Faras et al., 2010; Pillay, Duncan, and de Vries, 2022). The authors outlined the "core deficits" in three domains for those with ASC: social interaction, communication, and repetitive behaviors. They then advocated for the development of intervention strategies to support individuals with ASC, their caregivers, and educators. The primary advantage of VR is its capacity to provide a safe virtual environment (VE) that enables simulations to be repeated and adapted for learning purposes. A VE can eliminate competing stimuli from traditional social and environmental contexts, offer the ability to manipulate time during the interaction process, and ultimately allow users to learn through engaging in seemingly playful experiences (Vera et al., 2007). By harnessing the power of virtual reality, tailored interventions can be created to address the unique challenges faced by individuals with ASC, thereby fostering their development and supporting their caregivers and educators.

The capacity of VR to create controlled environments for practicing various social interactions has been noted for its potential benefits for both introverts and those with ASC in learning diverse social skills. For example, Lorenzo, Lledó, Pomares, and Roig (2016) shared the outcomes of a study that focused on designing and applying an immersive virtual reality system aimed at enhancing and training the emotional skills of students with ASC. The study targeted primary school students aged 7-12 with a confirmed ASC diagnosis. The virtual learning environment developed encouraged students to engage with different social situations visually. Computer vision technology was employed to assess the emotional states of the participants. The researchers pursued two objectives: to align emotional states with social situations and to evaluate whether a child's behavior was suitable for the represented social situation. The findings revealed a notable improvement in emotional competencies when compared to similar systems that predated VR technology.

Further studies have explored the potential of virtual learning environments as tools for habituating children with ASC. Researchers have been particularly interested in approaches that teach children appropriate behavior in various social situations and help them better comprehend standard social conventions (Mitchell, Parsons, and Leonard, 2007; Herrera et al., 2008). One study used a virtual café as a learning environment to teach social skills, resulting in participants improving the speed and execution of specific social tasks. Another example replicated a virtual supermarket, where participants engaged in different scenarios to better understand the functional, physical, and symbolic uses of particular objects. The performance of participants was assessed, revealing an increase in their ability to transfer the skills acquired during the simulation to real-life exchanges. Other studies have investigated the use of Collaborative Virtual Environments (CVEs) to enable simultaneous participation of multiple users. Typically, the patient and their therapist would inhabit the environment, communicating through avatars. CVEs have shown promise in helping participants better recognize emotions (Moore et al., 2005), as well as promoting social interaction and regulating emotions to understand others' feelings (Cheng & Ye, 2009). Additional research has utilized VR-based learning environments like OpenSimulator to support social-oriented role-play, gaming, and design (Ke et al., 2020).

Along with CVEs, other studies provide ample evidence supporting the use of immersive environments to improve skills such as identifying others' emotions and enhancing social performance. For instance, VR has also found applications in preparing for job interviews. Artificial intelligence interviewing platforms, such as HireVue, Big Interview, and Humanly.io, are increasingly employed by companies to screen candidates for specific positions. These platforms analyze multiple data sources and use AI-powered video interview software and natural language processing (NLP) to search for key terms in resumes. However, the behaviors that the AI has been trained to identify (e.g., body language, eye contact, confidence in word choice, and limited use of filler words and sounds) may disadvantage those with ASC. Although the previously mentioned examples assist with the cues that could help in such interviews, studies have also explored how VR is specifically used for this purpose. Smith et al. (2014) examined the potential use and effectiveness of virtual reality job interview training (VR-JIT) in a single-blind study. The VR-JIT in question was developed by SIMmersion LLC (http://www.jobinterviewtraining.net), with the guidance of academic and vocational experts to ensure the training simulation would be both appropriate and effective.

Alignment to Mitigate Symptoms with XR in the Metaverse

The four symptomatic areas associated with ASC can be supported with XR considering various studies related to individuals who may benefit from improving their social interaction skills.

1. **Comfort in indirect social situations:** Research has shown that active learning strategies in postsecondary education, such as intensive peer-to-peer interactions in group-based activities, do not disadvantage introverted students (Flanagan and Addy, 2019). Both introverts and extroverts can adapt their behaviors to meet different contexts and requirements within cooperative learning environments (Jacobs, 2014). XR can provide a comfortable, indirect social setting where individuals with ASC can engage in social situations without feeling overwhelmed.
2. **Preference for digital communications:** Studies have found no significant difference between introverts and extroverts regarding preferences for teaching methods (Murphy et al., 2017). However, a notable difference was observed in preferences for engaging in discussions with fellow students and speaking up during lectures. XR offers a digital communication platform where individuals with ASC can comfortably interact with others, catering to their preferences for digital communication over face-to-face interactions.
3. **Sensory sensitivity:** XR can be customized to accommodate individuals with sensory sensitivities by adjusting elements such as light, sound, and smell to create an environment more suitable for those with ASC. This allows users to engage in immersive experiences without being overwhelmed by sensory stimuli, promoting better learning outcomes and improved social interactions.
4. **Preference for avatar-based communication:** Research has demonstrated the effectiveness of avatar-based communication in reducing anxiety and enhancing social interactions for individuals with ASC (Vianez, Marques, and Simões de Almeida, 2022; Suh and Ahn, 2022). XR allows users to communicate via avatars, reducing the need for masking and making social interactions more accessible and enjoyable

for those with ASC.

The psychological benefits of social virtual reality (VR) have been demonstrated for various populations. For instance, Barreda-Ángeles and Hartmann (2022) studied the relationships between participants' activities and feelings of presence during the pandemic, as well as the psychological benefits related to enjoyment, self-expansion, and relatedness. Results confirmed that spatial presence predicted these three outcomes, while social presence predicted relatedness and enjoyment, but not self-expansion.

Presence and immersion provided by VR are crucial for creating safe and comfortable virtual social environments for populations such as introverts and those with ASC (Coban, Bolat, and Goksu, 2022). Introverts typically prefer minimally stimulating environments and need additional time alone to regulate (Blevins, Stackhouse, and Dionne, 2022; Terry, 2022). Similar reactions to external stimuli can be observed in the ASC population, who may experience symptoms such as poor eye contact, repetitive actions or words, inappropriate social interaction, and sensitivity to texture and stimuli, including auditory and photosensitivity (Hayashi et al., 2022).

The metaverse offers significant benefits to these groups, with virtual environments for collaboration and meetings like Spatial, Horizons Workroom, Meetin VR, Rumii, and Engage featuring low-key settings with low lighting, minimal music or noise, and customizable sound options. Users can also choose any avatar or digitally embodied version of themselves to present to others. Previously, VR tools were used to help individuals with ASC and social anxiety disorders adapt to the pre-pandemic world's conditions and expectations. However, these tools can now be repurposed to enable these individuals to thrive in the metaverse. By leveraging the immersive and customizable nature of VR and the metaverse, people with ASC and introverts can experience increased comfort and improved social interactions, ultimately leading to better overall well-being and personal growth.

Conclusion

The metaverse and virtual reality (VR) technologies are transforming the landscape of social interaction, presenting unparalleled opportunities for introverted individuals and those with autism spectrum conditions (ASC) to engage with others and develop essential social skills. These technologies, which were initially aimed at helping these individuals adapt to the pre-pandemic world, are now being repurposed to empower them to thrive within the expanding virtual realm. HMDs and virtual environments offers highly customizable and immersive experiences that cater to the specific needs and preferences of introverts and those with ASC, enabling them to experience social interactions in a comfortable and safe space. By embracing the metaverse and VR technologies, we can create inclusive and supportive environments where individuals with diverse social and emotional needs can flourish.

Furthermore, the use of VR and the metaverse for educational and therapeutic purposes can significantly enhance the learning outcomes and social competencies of introverts and those with ASC, as they can engage in meaningful social experiences without the limitations and barriers often encountered in traditional settings. As the metaverse continues to evolve, it is crucial for developers, educators, and therapists to collaborate and ensure that these virtual environments remain inclusive and accessible. By doing so, we can harness the full potential of VR and the metaverse to foster personal growth, social interaction, and overall well-being for all, regardless of their social disposition or neurological background. In a rapidly changing world, the metaverse and VR technologies hold the promise of bridging gaps and connecting people in ways never before possible, ultimately contributing to a more inclusive and understanding society.

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