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Evaluating and improving Perspective-Taking skill in pupils with ASD using an edugame: a case study

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Abstract: Several studies have shown that edugames can be considered an innovative educational tool to promote the acquisition of various skills, including academic, social, and motor skills. However, there is a notable lack of educational tools specifically designed to develop visuospatial perspective-taking (VPT), a key skill for STEM and socio-emotional competencies. The study aims to evaluate the effectiveness and reliability of the *Virtual Classroom* edugame as a tool for assessing VPT skills in children with Autism Spectrum Disorder (ASD). By analyzing data from a sample of 10 children the research explores the ability of *Virtual Classroom* to measure VPT accurately and reliably. It also examines performance differences among the children, aiming to identify cognitive strategies and insights into how the game can support educational interventions for students with ASD.

Keywords: Perspective-taking; Edugame; ASD; Social skills; Empathy

Introduction

Understanding and enhancing cognitive and social skills such as visuospatial perspective-taking (VPT) and empathy is a pivotal area of research, particularly in education, where inclusive tools and strategies are increasingly adopted to support diverse learners' needs, including those of pupils with Autism Spectrum Disorder (ASD). ASD is a complex neurodevelopmental condition characterized by persistent challenges in social communication and interaction, as well as restricted and repetitive behaviors, interests, or activities (APA, 2013). These core symptoms may vary in severity, affecting social and emotional development, and often lead to challenges in understanding others' thoughts and intentions. This has consequences for interpersonal relationships and empathic responsiveness (Peterson, 2014). In fact, among the key challenges faced by pupils with ASD, there is the development of Visual Perspective-Taking (PT), the ability to adopt and understand another person's point of view. VPT is a foundational skill for empathy, effective interpersonal relationships, and navigating complex social dynamics (Berthoz, & Thirioux, 2010; Bukowski, 2018; Caldwell et al., 2022; Erle, & Funk, 2022). As theorized by Alain Berthoz the mechanisms underlying visuospatial perspective-taking are also involved in empathy, suggesting that spatial cognition is integral to understanding others (Berthoz, &

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Thirioux, 2010; Berthoz, 2017). Empathy is critical for social relationships, as it enables individuals to infer others' opinions and positions. Additionally, empathy is fundamental to rational thinking, allowing one to examine facts and arguments from multiple perspectives. This mental operation involves a form of "mental rotation" relative to oneself, the environment, or an object, while maintaining a primary perspective of the surrounding context.

Research indicates that cognitive empathy, which encompasses perspective-taking, is positively correlated with rational thinking. A meta-analysis by Martingano et al. (2022) found that various types of cognitive empathy, including perspective-taking, are positively associated with self-reported rationality. Furthermore, perspective-taking, a component of empathy, is essential for effective social functioning. Davis (2017) reviewed evidence indicating that perspective-taking consistently relates to measures of relationship quality, such as global relationship satisfaction and reduced interpersonal hostility. These findings suggest that the ability to adopt others' viewpoints not only enhances social relationships but also supports rational analysis by enabling individuals to consider diverse perspectives.

Likewise, according to the neurophysiologist, Alain Berthoz, the spatial theory of empathy suggests that the ability to shift one's perspective spatially reflects the mental processes required to understand others' thoughts and feelings. To comprehend this ability, he suggests imagining the following situation: when individuals are asked to mentally reorient themselves relative to an object in a room, such as a chair, they employ different cognitive strategies. These strategies might involve continuously updating the spatial representation of the chair throughout their imagined movement or momentarily disregarding the chair's orientation and recalibrating mentally at the end of the task (Berthoz, 2011). This cognitive flexibility highlights the brain's capacity to use diverse approaches depending on the context, task, or cognitive state. This adaptability, characterized by redundancy in problem-solving strategies, is a hallmark of cognitive simplicity and resilience (Berthoz, 2011). The hippocampus plays a central role in these mechanisms of perspective shifts (Berthoz, 2011). Research on patients with hippocampal resections demonstrates the impact of this brain region on spatial perspective-taking. For instance, in one study, participants viewed a virtual room containing an avatar and a lamp. The avatar's gaze indicated the perspective from which the room would be viewed next. Healthy participants anticipated the new viewpoint, improving their performance. In contrast, individuals with hippocampal lesions struggled to predict the new perspective. Those with left-hemisphere lesions showed no understanding of what the avatar "saw", indicating the hippocampus's role in enabling accurate spatial reorientation and the anticipation of alternative viewpoints (Berthoz, 2011).

These findings are directly relevant to ASD, where challenges in VPT often stem from atypical perceptual processing, such as a detail-focused cognitive style. This trait, characterized by heightened attention to specific details at the expense of global understanding, can interfere with tasks requiring flexible perspective shifts (Frith, 1989). Similarly, deficits in mentalizing, or "theory of mind" hinder the ability to infer others' mental states and intentions, posing barriers to social interactions (Baron-Cohen et al., 2001). However, these challenges are not universally shown by all pupils with ASD; furthermore, structured or rule-based tasks often reveal specific strengths in individuals with ASD, indicating the potential for targeted interventions (Pellicano, 2010).

In this context, video games and Digital Game-Based Learning (DGBL) emerge as promising alternatives for fostering PT and empathy. Gamified environments, through their immersive and interactive design, are particularly effective for engaging learners with ASD.

Numerous studies have demonstrated that edugames can be considered an innovative educational tool to promote the acquisition of various knowledge and skills, including academic, social, and motor abilities (Aiello et al., 2016; Ghanouni et al., 2021; Maliverni et al., 2017; Sibilio, 2017; Vallefuoco et al., 2022). For instance, Malinverni et al. (2017) demonstrated that tangible user interfaces could enhance enjoyment and social interaction among children with ASD, emphasizing the potential of game-based interventions for developing both cognitive and socio-emotional skills.

However, there is currently a lack of educational tools specifically designed to develop VPT, a fundamental skill for the development of various competencies, including STEM and socio-emotional skills (McCurdy et al., 2020; Viola, Zappalà, Sibilio, 2022). An exemplary tool in this domain is the game Schoolcam (Di Tore, Aiello, Sibilio, & Berthoz, 2020), developed to assess PT abilities. Based on user feedback and advances in technology, it has evolved into *Virtual Classroom*, which incorporates innovative features such as customizable avatars, tasks independent of social cues, and remote interaction capabilities. These updates align with findings suggesting that individualized, technology-enhanced tools are particularly effective for addressing the unique needs of children with ASD (Ghanouni et al., 2021). The immersive nature of virtual environments allows users to engage in controlled three-dimensional spaces where repeated practice and interaction with virtual elements foster VPT development. Virtual reality games simulating complex scenarios have been shown to enhance visuospatial perspective-taking by engaging relevant brain areas through progressive and calibrated tasks (Parsons et al., 2007).

Future research should focus on experimental studies to assess the long-term effectiveness of video games as educational and therapeutic tools. Key questions include whether training in virtual environments can generalize real-world applications and how factors such as cognitive functioning levels may influence outcomes. Emerging technologies like artificial intelligence and augmented reality could make gaming experiences even more personalized and engaging, revolutionizing not only autism intervention but also broader educational and therapeutic approaches to cognitive and social skill development.

This study seeks to evaluate the updated version of School Cam, the *Virtual Classroom,* for its effectiveness and reliability in assessing VPT among children with ASD. By analyzing data from a sample of 10 participants aged 7–14, the research investigates the tool's potential not only as an assessment mechanism but also as an educational resource for fostering VPT development. This work is embedded in a broader research framework exploring the integration of innovative educational technologies in inclusive learning environments, with the goal of enhancing cognitive and socio-emotional outcomes for students with ASD.

1. Visuospatial Perspective Taking skills and empathy in pupils with ASD

Visuospatial Perspective Taking) and empathy share a profound interconnection, particularly evident in their role in social cognition and interaction. Berthoz's spatial theory of empathy provides a valuable framework for understanding this relationship. He posits that empathy is not merely an emotional contagion or shared feeling but a

dynamic process requiring a shift in perspective - what he describes as a change in referential framework from egocentric to allocentric. This shift mirrors the cognitive transformations involved in VPT, where individuals mentally reposition themselves to perceive the world from another's viewpoint (Berthoz & Jorland, 2004) VPT enables individuals to perform mental spatial transformations, critical for understanding both physical and social environments. The temporoparietal junction, a key brain region implicated in perspective-taking, is also involved in processing empathy-related tasks, such as understanding others' emotions and intentions. This neural overlap underlines how VPT contributes to developing cognitive empathy, the ability to comprehend another's mental state without necessarily sharing their emotions (Decety, 2010 in Berthoz & Jorland, 2004). For pupils with ASD, deficits in VPT often correlate with challenges in empathy and Theory of Mind (ToM). These impairments hinder their ability to decode and predict others' intentions, posing significant barriers to effective social interaction. Berthoz (2007) emphasizes the necessity of a dynamic process in which individuals "create a virtual body" to simulate another's perspective. Such simulations allow for the integration of spatial, emotional, and cognitive cues, foundational for empathy and reciprocal social behaviors.

Usually, the acquisition of VPT skills may follow a developmental progression. Level-1 VPT, emerging early, involves recognizing that others perceive objects differently based on their line of sight. Level-2 VPT, developing later, allows for understanding that two individuals can perceive the same object differently based on their spatial orientation (Flavell et al., 1981). While typically developing children acquire these abilities around the age of 5, children with ASD often struggle with these processes, impacting their ability to engage in both cognitive and affective perspective-taking (Frick, Möhring, & Newcombe, 2014). Berthoz's work also highlights the role of allocentric perspectives in fostering empathy. Allocentricity, or the ability to adopt another's viewpoint without losing one's primary perspective, is crucial for navigating complex social dynamics. This aligns with Decety's distinction between cognitive and affective empathy, where cognitive empathy involves perspective-taking mechanisms similar to those used in spatial transformations (Decety & Lamm, 2009).

Thus, interventions targeting VPT may significantly improve empathic abilities, particularly in controlled environments like virtual reality (VR), serious and edugames because they may provide immersive and engaging experiences where children with ASD may practice perspective-taking in a structured, low-pressure setting.

Furthermore, narrative-based video games emphasize role-playing and decision-making, enabling players to engage with characters' emotions and motivations. Such games encourage both Level-1 and Level-2 perspective-taking, fostering empathic understanding by simulating real-life social interactions. Additionally, incorporating VPT-focused strategies into educational curricula offers a dual benefit: enhancing both spatial reasoning and socio-emotional skills (Cerniglia et al., 2019). Activities such as collaborative spatial reasoning tasks and interactive games can help children with ASD develop the cognitive flexibility necessary for both VPT and empathy (Berthoz, 1997). Moreover, fostering these skills has broader educational implications for every child. Strong VPT abilities are linked to success in STEM disciplines, where spatial reasoning and the ability to visualize complex systems from multiple perspectives are crucial. This emphasizes the universal value of integrating spatial-emotional interventions into educational practices (Zhang et al., 2022).

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2. The educational potential of video games in developing social skills in children with ASD

In recent years, videogames have taken on an innovative role in the educational and didactic fields, attracting growing interest from researchers and education professionals. This shift reflects a significant transformation in the perception of interactive entertainment technologies, which have proven to be effective tools for fostering the development of social and cognitive skills in children with Special Educational Needs (SEN), particularly those with ASD (Lyu et al., 2024; Jiménez-Muñoz et al., 2022; Malinverni et al., 2017). The role of video games has transcended their traditional function as mere entertainment, thanks to their unique ability to create simulated environments and provide immediate feedback. These features make them highly valuable tools for enhancing specific skills (Quiroga Herranz et al., 2009), among which perspective taking stands out. This skill, broadly defined, refers to the distinctive ability to understand and adopt another person's point of view (Berthoz, 2015; Healey & Grossman, 2018). It is closely linked to the development of empathy (Healey & Grossman, 2018) and social skills, which are often impaired in individuals with autism spectrum disorder.

Current research converges on the idea that videogames may represent a valid support for learning and the development of social skills (Granic et al., 2014; Parsons, 2015; Walsh et al., 2024), in particular, thanks to the simulation of social scenarios and the possibility of providing real-time feedback. However, some divergences and critical issues remain within the literature. Parsons and colleagues (2015) highlight that those videogames designed to encourage perspective-taking, such as the Block Challenge, have shown promising results in improving social skills in children with ASD. Researchers, however, underline how the effectiveness of such tools strictly depends on the structure of the proposed scenarios, the ability to promote mutual interactions and the role of qualified facilitators, such as teachers and educators, in line with the principles of a learner-centered design. In accordance with that, Walsh and colleagues (2024) emphasize the potential of videogames as tools for the development of social skills in children with ASD but highlight some problems. According to Walsh, technologically advanced games can promote the development of cognitive flexibility and the expression of personal identity; however, their study highlights a limited participation of people with autism in the design process. For this reason, Walsh proposes a more inclusive approach, which actively involves people with autism in the definition of design needs, to create more relevant and representative interventions. Carneiro and colleagues (2024) also highlight the potential of serious games as tools for improving social skills in children with ASD. Their studies show that these games, designed with specific educational objectives, can positively influence abilities such as emotion recognition, joint attention, and gaze processing. Despite the promising results, the authors emphasize the need for further studies with rigorous methodological designs to broaden the applicability of serious games to different ASD subgroups, considering variations in age and severity of the disorder. Furthermore, they underline how the intrinsic interest of children with ASD in technologies can be leveraged to create personalized and engaging interventions that cater to individual needs. Other studies have observed that excessive or repetitive use

of video games can lead to maladaptive behaviors, such as the exclusion of other meaningful activities, including outdoor play or social interactions. For some children, heightened sensory sensitivity can make certain visual or auditory content particularly distressing, while for others, interest in specific games can result in repetitive usage patterns that limit the diversification of experiences. Although video games may foster social interactions in multiplayer settings, many children with ASD prefer to use them in solitary ways, reducing potential opportunities for social development (Stiller & Mößle, 2018).

Consequently, this work fits into a research field in which the use of innovative technologies is one of the most promising frontiers for inclusive education. Exploring the educational potential of videogames in promoting the development of perspective taking in children with autism spectrum disorder not only aims to fill a significant gap in the scientific literature, but also provides practical indications for the design of inclusive teaching tools. The goal of promoting social skills through devices that are both engaging and customizable to the needs of each student represents an essential priority to fully enhance individual potential.

3. Methodology

3.1. Design

This exploratory study examined the use of a video game to measure VPT abilities in ASD children. The use of Virtual Class to measure the ability of VPT has two advantages. Virtual Class is an adaptation of an older version that differs in the class organization and students' number that was tested on children without Special Educational Needs (Beatini et al., 2024). In particular the number of students was reduced from 6 to 5 to have a central reference and a more symmetrical class, and the conformation of the class was changed from curved to linear to have different references during the game and not only the other children's heads.

3.2. Population

We recruited 10 participants aged 7-12 years who were recruited from the Behavioral Center San Luca in Battipaglia located in Salerno (Campania, Italy). The participants were a group of children with ASD (n = 10). The inclusion criteria for children with ASD were as follows:

- aged 7 to 12 years with atypical development,
- capacity to understand digital tasks,
- a diagnosis of ASD leading to special education.

These children attended mainstream schools, where their chronological age aligned with their developmental age. Since recruitment was in a behavioral center, we cannot provide clinical characteristics of the pupils with ASD (severity of autism, IQ scores). We only provide information regarding education level and common language at school. Anyone of the children involved had an intellectual disability, and one child only had language delay.

The study received approval from the local ethics committee and written informed consent was obtained from the parents.

3.3. Tools and data analysis

The experimental paradigm that we used was Virtual Class, developed by the reasearch group of professor Maurizio Sibilio, Stefano Di Tore, Paola Aiello, Alain Berthoz (Di Tore et al., 2020). The Virtual Class paradigm is a tool created to explore spatial cognition in children. It was developed at the University of Salerno in collaboration with the College of France (Professor Alain Berthoz and Dr. Mohamed Zaoui). The game consists of two phases (approximate duration: 30 minutes):

- a practice phase,
- a test phase.

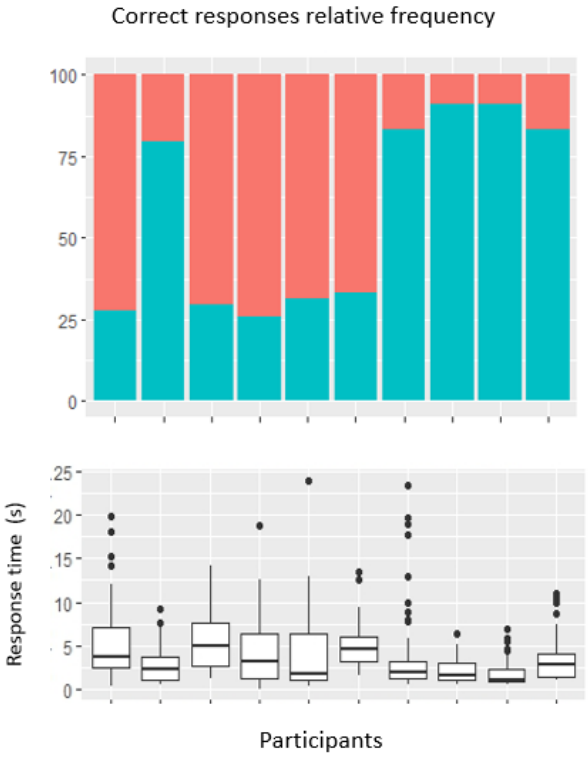
The test phase consists of 9 trials, and each last 30 seconds. Each experiment was conducted with the accompanying adult (parent, teacher, school assistant, or caregiver, as appropriate) and with a staff from the department. The participant was seated, and looked at a tablet displaying two images of the same classroom. The first view was from a camera placed at the back of the classroom, showing 5 student avatars arranged in a line facing the teacher at the front of the class. This provided a general view of the classroom as seen by someone standing at the back of the classroom. The second image was a first-person perspective of one of the 5 children looking at the teacher. The subject is instructed to identify which of the five children sees the teacher from this point of view. For each trial, the images are shown for 30 seconds. The children had no time limits on the answer period to minimize anxiety. The experimenter recorded the response and the response time of the child.
We also developed a feedback questionnaire for children to understand the types of strategies they employed while playing the game to answer the questions. Some of the questions were “Did you like the game?”, “Did you find the game funny? Or not? ” “Did you find more difficult the buttons sequences or the children sequences? ”

3.4. Correct responses’ relative frequency analysis and time response in ASD sample

Statistical analyses were conducted using R software, version 4.2.3.

In order to highlight potential differences in scores and task completion times during gameplay, for each participant, the relative frequency (measured by the proportion of correct responses) and the average response time were calculated. However, individual results in children with ASD highlight potential variations in both the frequency and speed of responses, providing insights into how these groups differ in terms of cognitive processing and task performance.

Figure 1. Relative frequencies of correct responses and time responses.



The results indicate that within the ASD group, two distinct profiles may be identified based on correct answers and response times: one group of high-performing ASD children, who perform at a level comparable to typical children of the same age, and another group with significantly lower performance and a high error rate. This suggests that different spatial comprehension strategies may be employed by these two groups.

Through the feedback the children gave to express which strategie they used to accomplish to the different tasks, we observed interesting patterns in their preferences. Some children indicated that they preferred situations involving red buttons, likely because these provided clear, tangible prompts or cues. On the other hand, other children expressed a preference for situations involving other children, possibly due to the social interaction and preferences. These insights provide valuable information about how different stimuli and contexts can influence children's engagement and decision-making strategies during the game.

4. Conclusion

This study emphasizes the significant potential of innovative digital tools, such as the *Virtual Classroom*, in addressing the unique challenges faced by children with ASD in developing VPT skill. By revealing distinct cognitive profiles within the ASD population, the findings highlight the necessity for tailored and adaptive educational

interventions. The identification of high-performing and low-performing subgroups reinforces the importance of individualized approaches that accommodate varying needs and abilities. Moreover, these differences suggest that not all children with ASD experience the same level of difficulty in spatial tasks, confirming the existence of heterogeneous cognitive profiles (Craig et al., 2017).

The literature review and findings further underscore the transformative potential of video games in inclusive education, particularly their ability to enhance both social and cognitive skills. These tools, with their immersive and interactive designs, create an engaging and stress-free learning environment that enables children with ASD to practice and refine complex abilities like perspective-taking. Beyond their immediate applications, these video games offer a strong argument for their integration into comprehensive educational frameworks. By supporting the development of spatial reasoning and socio-emotional competencies, they hold promises not only for children with ASD but also for a broader range of learners, contributing to more inclusive and effective educational practices.

Future research should aim to validate these findings by investigating their applicability to broader populations, comparing outcomes with control groups, and assessing the long-term impacts of such interventions. In particular, futures investigations will aim to examine whether the *Virtual Classroom* may effectively enhance perspective-taking (PT) skills within the ASD sample and also a detailed examination will be conducted to explore the developmental trajectory of perspective-taking abilities in children with ASD aged 7 to 12 years.

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