Online Journal of Communication and Media Technologies, 2024, **14**(4), e202462
e-ISSN: 1986-3497

OPEN ACCESS

Research Article

The ways of communication for children with autism spectrum disorder

Galiya A. Abayeva [1*]
0000-0001-9784-5971

Anna I. Akhmetzyanova [2]
0000-0002-4962-0011

Laura A. Butabayeva [3]
0000-0002-3758-8624

Saltanat K. Abildina [4]
0000-0002-8324-8444

Akerke N. Umirbekova [1]
0000-0001-7964-7322

[1] Abai Kazakh National Pedagogical University, Almaty, KAZAKHSTAN
[2] Kazan (Volga region) Federal University, Kazan, RUSSIA
[3] National Academy of Education named after I. Altynsarin, Astana, KAZAKHSTAN
[4] Karaganda Buketov University, Karaganda, KAZAKHSTAN
[*] Corresponding author: abaeva70@bk.ru

Citation: Abayeva, G. A., Akhmetzyanova, A. I., Butabayeva, L. A., Abildina, S. K., & Umirbekova, A. N. (2024). The ways of communication for children with autism spectrum disorder. *Online Journal of Communication and Media Technologies, 14*(4), e202462. https://doi.org/10.30935/ojcmt/15611

ARTICLE INFO

Received: 29 Jul 2024
Accepted: 15 Oct 2024

ABSTRACT

Deficits in social cognition underlie many of the profound challenges individuals with autism spectrum disorder face interacting with and understanding others. This study aimed to evaluate abilities predicting behavioral, verbal, and emotional responses during simulated social scenarios in 42 autistic children. Additionally, communication patterns were analyzed across solitary, peer, and group settings. A multifaceted assessment battery including the "prognostic stories" technique, expert observational ratings, cultural congruence metrics, and activity mapping provided insights into participants' capacity forecasting actions, statements, and feelings in interpersonal situations. Results revealed marked variability across skill domains, with greatest impairments anticipating emotions. Communication quality and self-regulation strongly correlated with predictive accuracy. Cluster analysis indicated four distinct functional profiles ("proactive planners", "regulatory navigators", "quiet observers", and "balanced responders") highlighting heterogeneous strengths warranting support. Despite challenges inferring psychological states, personalized interventions targeting highly correlated skill deficits offer optimal social adaptation. Findings reiterate calls for balanced approaches recognizing autistic diversity while compassionately addressing barriers to inclusion. With acceptance and opportunity, individuals across the spectrum have much to contribute. Limitations include sample size and gender imbalance. Follow-up longitudinal tracking is warranted.

Keywords: autism spectrum disorder, social cognition, communication skills, prognostic methodology, executive functions

INTRODUCTION

Autism spectrum disorder (ASD) is a developmental disability characterized by challenges with social communication and interactions as well as restricted, repetitive patterns of behaviors, interests, or activities. According to the DSM-5, people with ASD tend to have deficits in social-emotional reciprocity, nonverbal

communication behaviors, and developing and maintaining relationships (American Psychiatric Association, 2013). For example, those with ASD may avoid eye contact, struggle to have back-and-forth conversations, or have difficulty making friends. The disorder also involves exhibiting restrictive, repetitive patterns of behavior such as repetitive speech or motor movements, hyper- or hypo-reactivity to sensory input, excessive adherence to routines, and intense focus on specific interests (Craig et al., 2016; Iversen & Lewis, 2021). The severity of ASD symptoms falls along the spectrum, with some individuals requiring more substantial support while others can function more independently. Research suggests that genetic factors, brain structure and connectivity differences, and environmental influences all likely contribute to the heterogeneous neurodevelopmental condition known as autism (Gillespie-Lynch et al., 2012; Ravi et al., 2023).

When the communication patterns of children with ASD are analyzed from the perspective of visual communication and design, it is seen that the use of visual cues plays an important role in social interactions. Visual support is recognized as an effective tool in improving communication skills and increasing social interactions of children with ASD (Knight et al., 2015). For example, picture communication systems, social stories and visual programs help children with ASD to understand their daily routines and grasp social expectations (Raubenheimer et al., 2024). Furthermore, advanced visual technologies such as virtual reality (VR) and augmented reality show promising results in improving the social skills of children with ASD (Almurashi et al., 2022; Mesa-Gresa et al., 2018). These visual tools attract the attention of children with ASD and enable them to perceive social cues more easily. For example, visual training programs designed for children with ASD who have difficulty in recognizing and interpreting facial expressions help them better understand emotional expressions in social interactions (Fridenson-Hayo et al., 2016).

A prominent theory related to the social communication challenges in ASD involves deficits in social cognition and the ability to mentalize or take others' perspectives. A comprehensive meta-analysis by Chung et al. (2014) synthesized hundreds of studies demonstrating poorer performance on theory of mind tasks among those with ASD compared to neurotypical controls. Children with ASD struggle to predict behavior based on someone else's different interpretation of events (Niu, 2022). Difficulties inferring others' thoughts, feelings, beliefs, and intentions likely underpins struggles engaging in social interaction (Cañigueral & Hamilton, 2019; Kilroy et al., 2019).

These mentalizing challenges may stem from neurological differences in networks linking cortical association areas to limbic emotional processing regions, causing weakened integration of cognitive and affective information necessary for social perception (Rudie et al., 2012). Some theories also propose those with ASD have detail-focused processing styles that restrict ability to construct the gestalt, contextually-bound narratives required in fluid social cognition (Happé & Frith, 2006). Central coherence difficulties could impede interpreting communicative intent, implicit social cues, or predicting expected responses (Keifer et al., 2020). In turn, such predictive impairment both stems from and amplifies the core social-communication deficits that characterize ASD. Enhancing mental flexibility through cognitive modeling and scaffolding may thus foster improved social forecasting abilities in autism (Gould et al., 2011; Pasqualotto et al., 2021).

A core area of impairment in ASD involves communication challenges, both verbal and nonverbal, that make social interaction difficult. Individuals with ASD frequently have delayed language acquisition or remain nonverbal, show echolalia and repetitive speech, interpret language very literally, and struggle with conversational pragmatics like turn-taking, topic maintenance, or adjusting communication for the listener (Vogindroukas et al., 2022). Impairments also exist in nonverbal domains, including recognizing and producing facial expressions, gestures, body language, and understanding prosody or tone of voice cues (Chaidi & Drigas, 2020; Grossman et al., 2013; Trevisan et al., 2018; Uljarevic & Hamilton, 2013).

Multiple studies have linked the communication deficits seen in ASD to struggles with social skills and functionality (Liu, 2023). Verbal ability strongly predicted performance on socialization tasks among high-functioning children with ASD (Kwok et al., 2015; Loukusa et al., 2018; Reindal et al., 2023). Gillespie-Lynch et al. (2012) demonstrated that nonverbal communication skill predicted the ability to establish rapport, cooperation, or intimacy during social interactions in adults with ASD. Research also indicates an association between early communication deficits and later social outcomes among ASD children (Ravi et al., 2023). Overall, both verbal and nonverbal communication pose challenges for individuals along the autism spectrum

and substantially contribute to difficulties navigating the social world. Interventions targeting communication and language development show potential, but more research is needed.

A core diagnostic feature of ASD involves exhibiting restricted, repetitive patterns of behavior, interests, or activities. These can include repetitive motor movements like hand flapping or rocking, insistence on routine and ritualized patterns, highly fixated interests, and distress with even small changes (Boyd et al., 2009; Demetriou et al., 2019; Iversen & Lewis, 2021). Research suggests that restricted and repetitive behaviors (RRBs) emerge early in development and persist over the lifespan for many with ASD, albeit sometimes less severely (Harrop et al., 2014).

However, RRBs may undermine social adaptation and peer relationships in several ways. According to Kinnear et al. (2016), the tendency towards repetitive conversations about special interests can overwhelm or bore potential social partners. Distress if routine is disrupted also limits flexibility during social activities (Leekam et al., 2011). Having very narrow or eccentric preoccupations can lead to social isolation or bullying as well (Sterzing et al., 2012). Some researchers have found that RRBs correlate to difficulties initiating friendships or poorer social skills in school settings even when accounting for other ASD deficits (Mazurek et al., 2012). Targeting and expanding fixated interests or coping strategies for change may thus hold promise for enhancing social connectivity. Although RRBs are central to ASD itself, unpacking how these behaviors intersect with already vulnerable social functioning remains important.

Executive functions like working memory, inhibitory control, and cognitive flexibility play an important role in complex social behaviors. However, a growing body of research suggests that individuals with ASD show executive dysfunction which may drive some of the characteristic social challenges of the condition (Craig et al., 2016; Demetriou et al., 2019). For example, multiple studies have demonstrated poorer performance on tasks of planning, set-shifting, and updating working memory representations in ASD groups compared to controls (Ozonoff et al., 2004). Such cognitive inflexibility underpins the difficulties with transitions, insistence on sameness, and struggles adapting language and behavior individuals with ASD often display (Memari et al., 2013).

The integrative nature of executive functions also supports fluid social information processing and self-regulation both areas of relative weakness for those with ASD. Scores on executive function tests significantly predicted the ability to recognize emotions and mental states during complex social interactions in high-functioning young adults with ASD (Jones et al., 2018). Difficulties exercising inhibitory control over thoughts, emotions, and behavior can also negatively impact social functioning and relationships (Rajendran & Mitchell, 2007). Thus, addressing underlying executive dysfunction through cognitive training or support strategies may offer an effective means of improving real-world social adaptation for individuals on the spectrum. While ASD itself stems from manifold causes, the intersection between executive functioning differences and social skill development remains an area deserving of further research.

Atypical sensory responding is increasingly recognized as a hallmark characteristic of ASD, incorporated as part of the diagnostic criteria in the DSM-5. Research suggests that between 45–95% of individuals with ASD exhibit heightened or reduced reactions to sensory stimuli across modalities (Baranek et al., 2006; Ben-Sasson et al., 2019). For example, children with ASD may cover their ears to filter loud sounds (auditory hypersensitivity), crave deep pressure touch (tactile hyposensitivity), gaze intensely at lights or spinning objects (visual hypersensitivity), or limit food preferences due to sensitivity towards certain tastes or textures (Tomchek & Dunn, 2007). These patterns likely result from differences in neural processing and connectivity between sensory cortical regions and association areas (Robertson & Simmons, 2013).

Crucially, atypical sensory responding often disrupts social communication and engagement in ASD. According to Hilton et al. (2010), sensory sensitivities predict the severity of social impairment above and beyond ASD symptomatology, highlighting the key interplay between the two domains. Both children and adults with heightened sensory reactivity exhibit greater difficulty orienting to social stimuli, communicating verbally in noisy environments, maintaining appropriate proximity in conversation, wearing uncomfortable clothing required in social situations, or conforming to unfamiliar cultural food preferences (Leekam et al., 2011). Finding ways to accommodate or treat atypical sensory processing in ASD may thus have significant positive impacts on social functioning and quality of life. Further research is warranted to elucidate the

complex associations between sensory perception, social deficits, communication differences, and restricted/repetitive behaviors in ASD (Boyd et al., 2009).

Research clearly demonstrates the critical importance of early intervention for improving social communication outcomes in young children with ASD. Evidence-based approaches include applied behavior analysis (ABA), naturalistic developmental behavioral interventions such as early start Denver model (ESDM), and targeted social skills curricula (Rogers et al., 2019). For example, Dawson et al. (2010) found marked gains in social orienting, attention, initiation, and other precursors following ESDM intervention initiated prior to age 30 months. Similarly, intake age strongly predicts progress in joint attention and play skills with ABA methods (Granpeesheh et al., 2009). Optimal intervention likely combines practices promoting skill generalization with family/community involvement (Siller et al., 2021; Stahmer et al., 2011).

The greatest treatment gains occur when intensive therapy begins early in life, capitalizing on neural plasticity and building upon emergent abilities (Bradshaw et al., 2015). Autism involves disruption of fundamental social learning mechanisms that typically unfold rapidly in the first years of life through interactive experiences. Early social deficits may thus cascade into broader and more severe future impairment (Puce & Bertenthal, 2015). However, research shows that addressing preverbal communication delays and attachment quality before age 3 facilitates significant "corrective" development – improving verbal skills, adaptive functioning, school readiness, and long-term prognosis (Koegel et al., 2014; Wan et al., 2013). Consequently, accelerated diagnosis through early screening paired with immediate, targeted intervention provides children with ASD the best opportunity to develop social communication abilities on track with typical peers. Ongoing support addressing emerging social demands and stressors nevertheless remains necessary across the lifespan.

Digital communication technologies show promise in improving the social interaction skills of children with ASD. These technologies, including VR, social robots and metaverse platforms, offer innovative ways to engage children with ASD in social learning environments. By providing structured, predictable and interactive experiences, these tools can help children with ASD develop important social skills. Asymmetric VR games, such as Share VR, have been developed to enhance empathy and perspective taking in children with ASD. These games include peer collaboration and cooperative tasks that help children understand others' behavioral intentions and improve their social communication abilities (Chen et al., 2022; Lee & Yang, 2024). Emphasizing the possible use of VR in the field of social skills training, empirical research from VR games has shown that children diagnosed with ASD can learn empathy by engaging in planned play activities (Lee & Yang, 2024). Using the natural connection between children with ASD and technology, including robots into therapy presents a very responsive and interesting learning environment (Annunziata et al., 2024).

Children diagnosed with ASD demonstrate a significant improvement in social skills based on thorough evaluations of information and communication technology (ICT)-based treatments like social robots and serious gaming. These technologies create a conducive and consistent setting that facilitates ongoing learning and the enhancement of social skills. The review highlights the translational potential of ICTs in educational and therapeutic settings, emphasizing their role in improving social cognition and emotional regulation (Scarcella et al., 2023). A metaverse-based program using platforms such as Roblox has been piloted to improve social skills in children with high-functioning ASD. The program demonstrated improved social functioning and reduced behavioral problems, showing a reduction in social responsiveness scale scores. Such interventions can be delivered at home and offer a flexible and accessible way to practice social interactions in a virtual environment (Lee et al., 2023). Although digital communication technologies present interesting approaches to help children with ASD develop their social interaction skills, it is important to take particular requirements and preferences of every kid into account. Maximizing the efficacy of these interventions depends on the integration of customized design concerns with caregivers (Hasan & Nene, 2024).

This study is to investigate, especially in relation to visual communication tools, the social interaction and communication skills of children with ASD. Our studies examine children with ASD's communication patterns in individual, peer, and group environments as well as their capacity to forecast behavioral, linguistic, and emotional reactions. Using a multifaceted assessment approach, we aim to comprehensively examine the social cognitive abilities and communication skills of children with ASD. This research aims to contribute to

the development of innovative digital interventions and visual communication strategies that can be used to improve the communication and social interaction skills of individuals with ASD. Our results are expected to guide the design of personalized, technology-assisted approaches for the education and therapy of children with ASD, thus providing new perspectives on the application of communication and media technologies in the field of autism.

METHODOLOGY

A robust range of assessments and observation tools were utilized to evaluate various dimensions of social cognition and communication among the autistic participants. A quantitative approach was adopted in the study. The study can be accepted within the scope of the relational screening model. Using this multidimensional assessment battery provides richer insights into participants' profiles and correlates compared to any single measure alone. Furthermore, the methodological triangulation of observational tools, performance metrics, and diagnostic criteria enhances validity and reliability in charting the heterogeneity inherent to the autism spectrum (Gillespie-Lynch et al., 2012).

Sample

The data comprises 42 preschool students. The ages of the students participating in the study range from 5 to 8 years old, with a mean age of 6.2 years and a standard deviation of 0.8. Students diagnosed with autism by authorized health institutions, according to school records from kindergartens in Kazan, Russia, and whose parents consented to their participation, were included in the study. Rather than selecting a sample, all eligible students were included. Data collection occurred during the students' free time or through activities designed by the researchers.

Data Collection Tool

Prognostic stories

The "prognostic stories" methodology was developed by staff of the department of psychology and pedagogy of special education, Institute of Psychology and Education of Kazan Federal University (Artemyeva & Akhmetzyanova, 2020). The research procedure is presented, as follows: initially, the child is asked to take a look at the image of a bear and then listen to the stories that happened with the hero. Albums with stories are presented in two versions – for girls and for boys. Each story is illustrated with two plot pictures. After explaining the pictures, the child is given a clean sheet of paper and is asked the question: "What do you think will happen next? Tell me what will happen next." If the child finds it difficult to answer on his own, he is asked some leading questions about what the heroes of the story will do, say, and how they will feel. If the child cannot give a verbal answer, he is shown two pictures depicting options for the development of story and is given instructions: "Look at these 2 pictures, think again, what will happen next? Show and tell us which one is more likely to happen." The methodology presents six situations covering areas of relationships that seem significant for the socialization of preschoolers in child-adult, child-parent, child-child situations of interaction and in different types of activities (free and organized). For their answers, children are given from 0 to 4 points in assessment of the structural components of forecasts: 4 points – independent answer, 3 points – answer with a hint (leading questions), 2 points – an answer with visual support, 1 point – non-verbal choice, and 0 point – no response. Thus, for their forecasts of emotions, children can score a maximum of 24 points and a minimum of 0 points. The methodology allows us to study the structural components of a child's forecast – prediction of actions, statements, and emotions (feelings) – as well as to interpret functional (regulatory, cognitive, and speech-communicative) characteristics of forecasts. Functional components are represented by nine indicators that allow to reveal attitudes toward prosocial/asocial behavior, optimistic/pessimistic, and active/passive attitudes in the respondents' forecasts. The methodology also allows to evaluate the variability, detailedness, and likeliness of forecasts and analyze the verbalization of forecast and the use of verbal means.

Method of expert assessment of a child's communicative behavior

The methodology developed by Veraksa (2010) is a structured approach to evaluating a child's communicative behavior through four key sections. It involves presenting children with images related to

specific areas and asking them to select the picture that represents the appropriate behavior. Each section is evaluated independently. The first section, understanding tasks in interaction situations, involves scenarios where children must understand and respond to tasks within various interaction contexts. The second section, understanding the emotional states of peers, requires children to identify emotions depicted in their peers' facial expressions and body language. In the third section, attitude towards an adult, children choose appropriate responses to scenarios involving interactions with adults, assessing their respect and communication skills. The fourth section, peer attitude, involves selecting responses that reflect appropriate behaviors in peer interactions, examining their social attitudes and competencies. This methodology is instrumental in assessing the communicative abilities of preschool-aged children and their understanding of various interaction scenarios, providing valuable insights for targeted interventions (Veraksa, 2010).

Communicative abilities

According to Shchetinina (2000), the "observational map for identifying communicative abilities in preschoolers," developed by Shchetinina and Nikiforova, is a comprehensive tool designed to assess the development of communicative abilities in children. This tool facilitates the detailed observation of a child's behavior across a variety of settings, including free play, structured activities, and during routine moments of the day (Shchetinina, 2000). The methodology involves a nuanced approach where the child's communicative skills are scrutinized based on specific criteria: organizational, perceptual, and operational abilities. By evaluating children in these diverse scenarios, this observational map offers a well-rounded perspective on their communicative development, highlighting strengths and areas for improvement in their ability to interact and express themselves effectively in different social and environmental contexts. This tool thus provides educators and researchers with valuable insights into the complex nature of communication skills development in early childhood.

Activity level

The methodology developed by Shchetinina and Abramova, known as the "activity manifestation map," was employed to study the manifestations of an active lifestyle in preschool-aged children (Shchetinina, 2000). This map was completed based on repeated observations of a child's behavior in various situations. The approach allowed for a comprehensive analysis of the child's engagement and activity levels, providing insights into how they interact with their environment, partake in physical activities, and respond to different social and solitary scenarios. The systematic observation and recording process enabled researchers and educators to track patterns and tendencies in the child's behavior, offering a detailed view of their active lifestyle. This methodology plays a crucial role in understanding the dynamics of early childhood development, particularly in assessing the influence of physical and social activities on overall growth and well-being.

Cultural Congruence

The research methodology developed by Bayanova and Mustafin, titled "Methodology for assessing preschoolers' adherence to rules in normative situations," facilitates the examination of how preschool-aged children conform to rules in standard settings (Bayanova & Mustafin, 2015). This approach specifically focuses on evaluating aspects that contribute to the cultural congruence of a preschool child. Key factors identified in this methodology include "obedience and meeting adults' expectations," "safety," "self-care and hygiene," and "self-control." By assessing these areas, the methodology provides a structured framework for understanding how young children respond to established norms and guidelines in various situations. It helps in determining their ability to follow instructions, maintain personal safety, perform basic self-care tasks, and regulate their own behavior. This comprehensive analysis is crucial for identifying the developmental stages of children in terms of their socialization and adaptation to societal expectations. Additionally, it offers valuable insights for educators and parents in guiding and supporting children's growth in these fundamental areas, thereby contributing to their overall social and personal development.

Data Analysis

Quantitative analytic approaches were employed to evaluate the multidimensional data collected through prognostic assessments, observational metrics, and diagnostic criteria. Descriptive statistics including means, medians, and standard deviations summarized performance patterns across key sub-dimensions related to

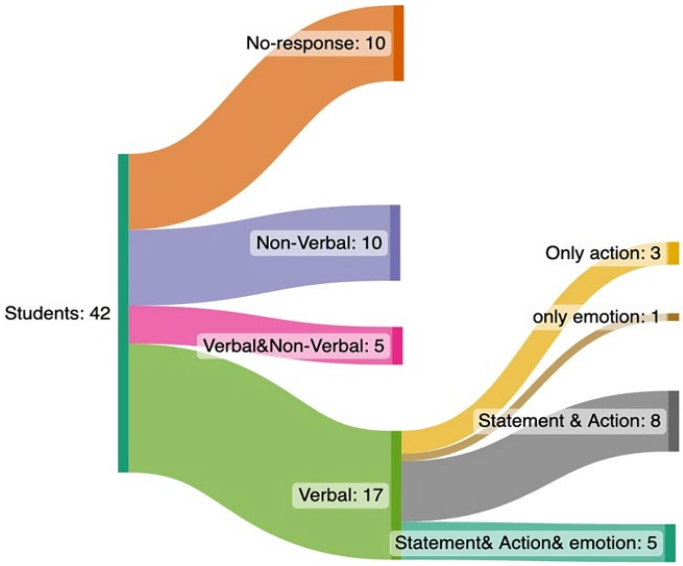

Figure 1. Classification of participant based on measurements (Source: Authors)

cognitive capacities, functional abilities, and engagement levels. This facilitated comparison of central tendencies and score variability within the sample. Additionally, correlational analyses using Kendall's tau and Bayesian inference systematically assessed relationships between social communication competence, forecasting accuracy, executive functioning, and real-world activity participation (Keifer et al., 2020; Pasqualotto et al., 2021). The resulting correlation coefficients and Bayes factors signified the strength and significance of associations between specific variable pairs. Furthermore, cluster analysis enabled classifying children into unique typological profiles based on multifaceted similarities in their measured capabilities and disability manifestations (Happé & Frith, 2006). This data-driven approach avoided assumptions of homogeneity within ASD. Classification distilled meaningful connections between strengths, weaknesses, and behavioral tendencies within the heterogeneous sample. All data underwent processing through the latest versions of JASP statistical software with significant levels set at 95% confidence intervals. Graphical visualization tools like Sankey plots and dual-axis charts depicted complex variable interactions for clear interpretation of results. For graphical visualization and cluster analysis, Tableau (2023) is used. Robust quantitative examination grounded conclusions in the objective performance patterns and relationships discerned across diverse analytical techniques (Rudie et al., 2012).

FINDINGS

The Sankey chart in **Figure 1** depicts the array of communication methods employed by 42 students, likely those with autism, as they interact with the "prognostic stories" assessment developed by the Kazan Federal University. This assessment measures the children's ability to predict outcomes in various social situations depicted in stories. A segment of the group, accounting for 10 students or approximately 24%, provided no response to the story prompts. This non-response could be indicative of a variety of factors, such as challenges with engagement, understanding, or simply a hesitance to express their predictions. Equally, 10 students communicated their predictions non-verbally. These children may have chosen to indicate their thoughts through gestures or other means without verbalizing, which highlights a preference or a necessity to rely on non-verbal modes of communication. There were 5 students who utilized both verbal and non-verbal communication. This dual approach suggests a level of versatility in their communicative abilities, as they were comfortable employing more than one method to convey their thoughts about the narratives presented to them.

The largest single category within the chart is verbal communication, with 17 students – roughly 40% of the participants – using spoken language to articulate their predictions. This suggests that a significant number of students were either capable of or preferred verbal communication for this particular task. A smaller group of 3 students conveyed their predictions solely through actions, such as pointing to one of the

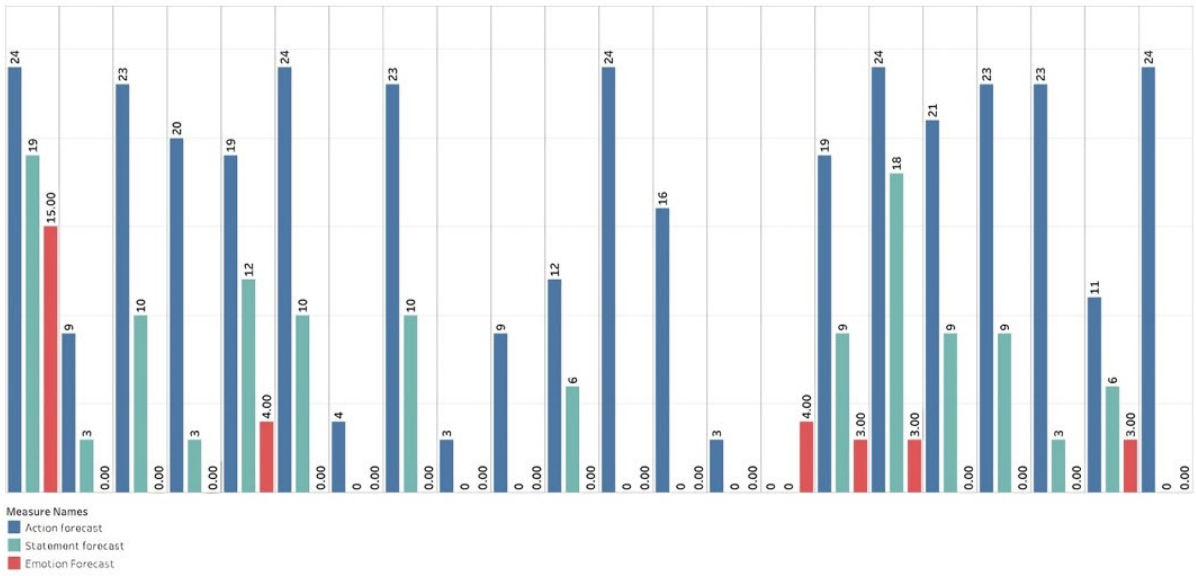

Figure 2. Distribution of participant responses across various measurements (Source: Authors)

visual options, which may indicate either a difficulty with or a strategic choice to avoid verbal or emotional expression. Interestingly, only one student expressed their prediction through emotional response alone. This mode of communication may encompass non-specific gestures or facial expressions that convey an emotional reaction rather than a clear predictive choice. Eight students combined verbal statements with actions to communicate their predictions. This integration of speech and physical gestures or choices implies a more interactive engagement with the storytelling process. Finally, 5 students demonstrated the most complex form of communication by integrating statements, actions, and emotional expressions. This multifaceted communication style reflects a sophisticated approach to expressing their thoughts and indicates a high level of cognitive and emotional integration.

In essence, the Sankey chart provides a visual breakdown of how the students communicated their understanding and predictions of the stories. The responses range from complete non-engagement to rich, multi-channel communication, illustrating the diverse spectrum of communicative abilities and preferences in the group. The chart serves as a tool to understand the varying degrees to which children with autism might engage with and respond to social and narrative prompts, shedding light on their unique ways of processing and anticipating social interactions.

The chart in **Figure 2** provides detailed individual scores for 22 students in three categories: action forecast, statement forecast, and emotion forecast, each with a maximum possible score of 24. These scores reflect the students' abilities to predict outcomes in the "prognostic stories" assessment. An analysis of the scores offers several insights:

Action forecast: Most students performed relatively well in predicting actions, with several students achieving the highest score of 24. This suggests a strong visual or situational understanding, as action prediction often involves interpreting immediate, concrete cues from the stories. However, a few students scored low or did not score at all in this category, which could point to difficulties in understanding cause and effect, or perhaps challenges in visual processing or attention.

Statement forecast: The scores in this category show more variability, with one student scoring as high as 19 and several others obtaining a score of 10 or above. However, many students scored low or did not score, indicating that predicting verbal outcomes is a more complex task for these students. This might be due to the abstract nature of language or a less developed understanding of social and conversational cues.

Emotion forecast: It is evident that this category was the most challenging for the students. The highest score is 15, with only one student reaching this mark. Many students did not score at all, and when scores were obtained, they were generally low. This underscores the complexity of emotional understanding and prediction, which requires interpreting nuanced expressions and perhaps inferring feelings from context, a known area of difficulty for many individuals on the autism spectrum.

Table 1. Descriptive statistics for functions, activity and sphere

Categories	Sub-dimension	Mean	Median	SD	Minimum	Maximum
Functions	Regulatory function	6.93	8	5.09	0	16
	Cognitive function	3.45	1	4.38	0	14
	Speech-communicative function	2.57	0	4.20	0	12
Activity type	Organized activities	6.69	6	6.08	0	21
	Free activities	6.29	4.5	5.97	0	18
Spheres	Child-parent sphere	4.86	4	4.26	0	13
	Child-adult area	4.48	4	4.23	0	13
	Child-to-child area	3.64	2	3.93	0	13

From the data, we can infer that the ability to forecast actions seems to be stronger overall than the ability to forecast statements or emotions. The latter two require a higher level of abstract thinking and social understanding, which are often challenging for individuals with autism. **Table 1** reveals that some students have strengths in certain areas but not others, highlighting the importance of personalized support and intervention. Additionally, the absence of scores in some areas for certain students may suggest a need for targeted help in developing specific social cognitive skills. This analysis can be instrumental in understanding each student's unique profile of social understanding and can guide educators and psychologists in tailoring their approaches to each child's needs. It also serves as a reminder of the diverse abilities within the autism spectrum, with each individual presenting a unique set of skills and challenges.

Table 1 presents a statistical summary of various cognitive and communicative functions and activities among a group of individuals, potentially students. Each function or activity area has a maximum score that participants could achieve, indicating the highest level of ability or engagement in that area. The variables assessed include regulatory function, cognitive function, speech-communicative ability, total scores in organized activities, total scores in free activity, and total scores within the child-parent, child-adult, and child-to-child spheres.

The regulatory function, with a maximum of 18 points, shows an average score (mean) of 6.93, a median of 8, and a standard deviation (SD) of 5.09. The spread from the minimum score of 0 to the maximum of 16 indicates considerable variability among participants. The relatively higher median compared to the mean suggests that more than half of the individuals scored above the average, yet the significant SD reflects a wide range of abilities in self-regulation. For the cognitive function, the mean score is markedly low at 3.45 out of a maximum of 24, with a median even lower at 1, and a standard deviation of 4.38. These figures suggest that the majority of the individuals scored on the lower end for cognitive tasks, indicating that this group may face challenges in this area. The speech-communicative function has a mean score of 2.57 out of a possible 12, with half of the individuals scoring zero, as indicated by the median. The standard deviation of 4.2 points to varied levels of communicative abilities, with some individuals possibly exhibiting strong skills while others may not be communicative through speech at all.

In organized activities, participants scored an average of 6.69 with a median of 6, out of a maximum score of 27. The standard deviation is 6.08, which again suggests a wide disparity in how participants engage in structured settings. Similarly, in free activities, the mean score is 6.29 with a median of 4.5, and the standard deviation is 5.97, indicating a range of engagement levels in unstructured settings, with some participants being quite active while others are less so.

The child-parent sphere shows a mean score of 4.86, median of 4, and a standard deviation of 4.26 out of a maximum of 18 points. These results suggest moderate engagement in activities involving parents, with a spread indicating some children engage more frequently or effectively than others. In the child-adult area, the mean score is 4.48 with a median of 4, indicating that interactions with adults are generally low among the group. The standard deviation of 4.23 points to a variation in the degree of these interactions. Finally, the child-to-child area has the lowest mean score of 3.64, with a median of 2, and a standard deviation of 3.93. This suggests that peer-to-peer interactions are particularly challenging for this group, with many scoring at the lower end of the scale.

Overall, **Table 1** indicates that the group assessed generally scores lower in the evaluated areas, with the greatest challenges observed in cognitive functions and peer interactions. The standard deviations are relatively high across all categories, reflecting a wide range of abilities and engagement levels. These statistics

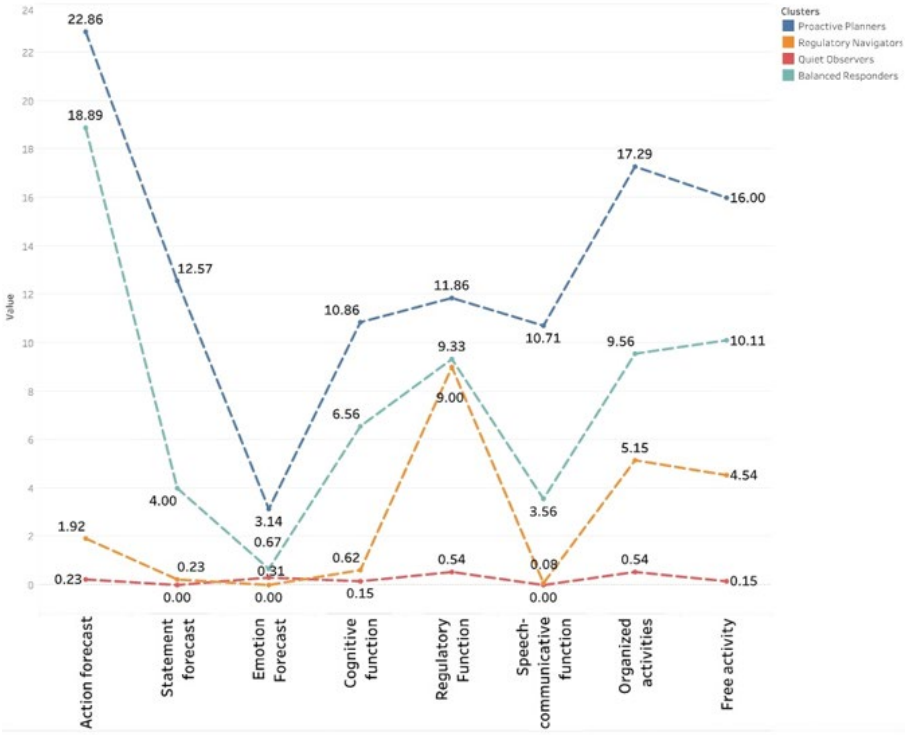

Figure 3. Average of variable based on clusters (Source: Authors)

could be critical for educators, therapists, and caregivers in understanding the group's needs and tailoring interventions to support their development in these functional areas.

Cluster Analysis

According to the cluster analysis results in **Figure 3**, 4 different clusters were obtained. The students in this cluster were named considering their measurement averages. Children in the 'proactive planners' group exhibit a strong inclination towards action and organization according to other children. They are characterized by high mean values in action forecast (22.86) and organized activities (17.27), reflecting their proactive approach and structured behavior. Additionally, this group also shows considerable involvement in statement forecast (12.57), emotions forecast (3.14), and various functions like regulatory (11.86), cognitive (10.86), and speech-communicative (10.71), indicating a well-rounded profile with competencies spanning emotional, cognitive, and communicative aspects.

The 'regulatory navigators' stand out for their moderate involvement in regulatory functions (9.00), amidst otherwise low mean values in areas like action forecast (1.92), statement forecast (0.23), and other functions. This pattern suggests a group more focused on control and self-regulation, demonstrating a particular strength in managing their interactions and responses in a measured way.

The 'quiet observers' are distinguished by their minimal engagement across all variables, with very low means in areas like action forecast (0.23), emotions forecast (0.31), and organized activities (0.54). This group's profile suggests a tendency towards a more reserved or observant approach, possibly indicating a preference for passive interaction or a reflective nature in their environment.

Lastly, the 'balanced responders' show a well-distributed engagement across the measured variables. With higher engagement in action forecast (18.89) and moderate participation in organized activities (9.56), this group exhibits a balanced approach. They also maintain moderate levels in other areas like statement forecast (4.00), emotions forecast (0.67), and cognitive function (6.56), suggesting a capability to adapt and respond effectively to varying situations.

Each of these groups represents a unique set of strengths and tendencies among autistic children, illustrating the diverse ways in which they interact with and perceive their surroundings. These clusters offer insightful perspectives on the varied abilities and preferences within the autism spectrum.

Table 2. Correlation coefficient and Bayesian factor

Variables		C	Structural characteristics of the forecast			Functional characteristics of the forecast			Activity type	
			AF	SF	EF	RF	CF	SCF	OA	FA
Method of expert assessment of a child communicative behavior	Understanding tasks in IS	KT	0.366	0.45594	0.3797	0.2836	0.4287	0.3485	0.4013	0.3782
		BF_{10}	58.016	1,315.753	89.363	6.034	475.181	34.235	182.501	85.196
	Understanding the ES of peers	KT	−0.1206	0.07221	0.248	0.0309	−0.032	−0.0548	0.045	0.0156
		BF_{10}	0.37	0.249	2.707	0.208	0.209	0.227	0.218	0.202
	Attitude towards an adult	KT	−0.0613	0.06626	−0.1682	0.1593	−0.0509	−0.0503	0.1095	0.1021
		BF_{10}	0.234	0.241	0.663	0.586	0.223	0.222	0.332	0.311
	Peer attitude	KT	0.1503	0.14957	−0.0413	0.0562	0.1754	0.0946	0.1089	0.1484
		BF_{10}	0.521	0.516	0.215	0.229	0.737	0.292	0.33	0.508
Communicative abilities	Communication quality	KT	0.3691	0.3101	0.3157	0.2625	0.4074	0.4123	0.4028	0.3472
		BF_{10}	63.83	11.737	13.602	3.701	224.494	265.679	192.06	32.954
	Communication skills	KT	0.6284	0.49264	0.3037	0.2716	0.64	0.5142	0.4846	0.4526
		BF_{10}	3,410,000	5,708.663	9.929	4.553	6,300,000	14,250.975	4,100.906	1,159.512
Activity level		KT	0.1578	0.16064	0.029	0.3176	0.1507	0.1004	0.2433	0.2389
		BF_{10}	0.574	0.597	0.207	14.338	0.523	0.306	2.453	2.242
Cultural congruence	Obedience	KT	0.2521	0.135	−0.0832	0.2781	0.1822	0.2074	0.2225	0.3176
		BF_{10}	2.953	0.433	0.268	5.288	0.816	1.238	1.629	14.336
	Safety	KT	−0.0568	0.00673	0.034	0.1252	−0.0332	0.032	0.037	0.1017
		BF_{10}	0.229	0.2	0.21	0.389	0.209	0.209	0.212	0.31
	Self-control	KT	0.3787	0.31608	0.1049	0.2462	0.3639	0.3972	0.3692	0.3341
		BF_{10}	86.614	13.751	0.319	2.607	54.347	158.763	64.185	22.546
	Self-service	KT	0.4702	0.34539	0.2339	0.331	0.4984	0.3847	0.4283	0.4262
		BF_{10}	2,292.333	31.225	2.031	20.693	7,262.216	104.95	469.925	435.328

Note. IS: Interaction situations; ES: Emotional states; C: Coefficient; KT: Kendall's tau; AF: Action forecast; SF: Statement forecast; EF: Emotions forecast; RF: Regulatory function; CF: Cognitive function; SCF: Speech-communicative function; OA: Organized activities; FA: Free activities.

Correlations

Table 2 presents a Bayesian analysis of various behavioral and communicative variables and their association with different types of forecasts and functions. Kendall's tau values and Bayes Factors (BF_{10}) are used to determine the strength and significance of these associations.

For "understanding tasks in interaction situations," there is a strong positive Kendall's tau correlation with action forecast, statement forecast, and emotions forecast, with very high Bayes factors, especially for action forecast. This indicates a strong and statistically significant association, suggesting that those who are better at understanding tasks in interaction situations tend to predict actions, statements, and emotions more accurately. The variable "understanding the emotional states of peers" shows a slight negative correlation with the action forecast and a small positive correlation with emotions forecast. However, the associated Bayes factors are relatively low, indicating weaker evidence for these associations. "Attitude towards an adult" has a small negative correlation with emotions forecast but a small positive correlation with Statement forecast. The Bayes factors, while not very high, suggest that there is some evidence for these associations, with a moderate level of confidence.

"Peer attitude" shows a small positive correlation with both action forecast and emotions forecast, with Bayes factors indicating moderate evidence for a relationship, especially in predicting actions in peer-related contexts. "Communication quality" and "communication skills" both show strong positive correlations across all types of forecasts and functions. The extremely high Bayes factors for communication skills, in particular, suggest very strong evidence for a significant association with the ability to predict actions, statements, and emotions.

"Activity level" is positively correlated with emotions forecast, with a substantial Bayes factor, indicating a significant relationship between higher activity levels and the ability to predict emotions accurately.

"Obedience" shows a moderate positive correlation with emotions forecast, with a Bayes factor providing reasonable evidence for this association. "self-control" and "self-service" both show strong positive correlations with most forecasts and functions, especially for regulatory function and speech-communicative function. The associated Bayes factors are very high, indicating strong evidence for these correlations.

In conclusion, **Table 2** suggests that variables such as communication skills, self-control, and understanding tasks in interactional situations have strong and significant correlations with the ability to

forecast actions, statements, and emotions. The evidence is particularly compelling for communication skills, indicating that they may play a crucial role in social cognition and predictive abilities. Variables with negative correlations or low Bayes factors suggest weaker or less consistent associations. Overall, these results could be incredibly insightful for developing targeted interventions to enhance predictive abilities in social situations.

DISCUSSION

The current study aimed to assess predictive abilities and communication patterns among children with ASD. The findings highlight significant variability in the sample's capacity to forecast actions, verbal statements, and emotions during social interactions depicted in prognostic stories. These results support past research indicating mentalizing and communication deficits in ASD that disrupt social cognition and forecasting (Chung et al., 2014; Kwok et al., 2015).

In line with prior studies, participants showed the greatest facility predicting actions, followed by difficulties forecasting statements and notable challenges anticipating emotions (Pasqualotto et al., 2021). The concrete, situational nature of behavior outcomes likely enables stronger visual-spatial processing strengths frequently observed in ASD profiles (Happé & Frith, 2006). However, higher-order inference about psychological states and expected social responses relies on integration of cognitive and affective information – precisely the area of weakness hypothesized in autism social cognition (Rudie et al., 2012).

Communication quality and skill robustly predicted forecasting performance, aligning with literature linking communication deficits to real-world social competence (Gillespie-Lynch et al., 2012). Nuanced pragmatic language use scaffolds the narrative cohesion and mental flexibility many with ASD struggle to construct independently (Keifer et al., 2020). Targeted early communication interventions demonstrate improved social adaptation over time for children on the spectrum (Siller et al., 2021; Wan et al., 2013) – gains potentially stemming from enhanced predictive capacities.

The cluster analysis revealed unique autistic profiles, reminding us that a singular skill weakness does not define an individual. For example, the "quiet observers" challenge warrants support to safely expand engagement, while the "proactive planners" strength in organizing actions could scaffold new learning. Focused coaching to broaden fixated interests shows promise (Sterzing et al., 2012), much like leveraging detail-oriented autistic processing to improve central coherence (Happé & Frith, 2006).

The correlations revealed intriguing associations between several key variables and predictive abilities among the autistic participants. Most notably, communication quality and skills showed significant positive correlations with forecasting actions, statements, and emotions. The strength of these relationships aligns with research highlighting communication challenges as a core impairment in ASD that substantially impacts social functioning (Liu, 2023; Vogindroukas et al., 2022). It suggests that strong verbal and nonverbal communication scaffold the development of predictive social cognition. Additionally, self-control demonstrated strong correlations with performance across prognostic scenarios. This finding echoes existing evidence that executive functioning differences in ASD, including inhibitory control, underpin rigid behavior and difficulties adapting language and responses during dynamic social interactions (Rajendran & Mitchell, 2007). Interventions targeting improved self-regulation may therefore mitigate social challenges rooted in these pervasive deficits. Furthermore, the data revealed that lower understanding of peer emotional states accompanied poorer emotion forecasting, reiterating that reading others' internal states supports anticipating responses and reactions (Niu, 2022). Analyzing variable relationships provides guidance for practitioners seeking to bolster social adaptation through enhanced prediction abilities. Tailoring support to strengths while addressing highly correlated areas of weakness yield optimal outcomes among autistic youth.

The results of our study emphasize the variety in social interaction and communication abilities of children with ASD. Particularly, we found that the capacity to predict social events was correlated with communication quality and self-regulation skills. These findings imply that digital communication technology could help kids with ASD to develop their social interaction skills. For example, the four different functional profiles we identified ('proactive planners', 'regulatory navigators', 'silent observers', 'balanced responders') could provide a basis for the development of digital interventions customized to the unique needs of each group. As noted in the study by Chen et al. (2022), asymmetric VR games may be effective in improving empathy and

perspective-taking skills in children with ASD. Such technologies may be particularly useful for children who have difficulty with emotional predictions. Furthermore, our findings emphasize the importance of communication quality. In this regard, Lee and Yang (2024) studies shown that planned play activities in VR games can help children diagnosed with ASD develop empathy. Such digital tools can be developed and used in a way that supports the high correlation between anticipatory capacity and communication quality noted in our research.

However, the effectiveness of interventions depends on their adaptation to the individual needs and preferences of each child. The comprehensive evaluation by Scarcella et al. (2023) showed that ICT-based interventions, such as social robots and serious games, led to significant improvements in the social skills of children with ASD. These technologies foster a suitable and consistent surroundings for ongoing education and social skill development. Moreover, a metaverse-based program using Roblox piloted by Lee et al. (2023) demonstrated improvement in social functioning and a drop in behavioral difficulties among children with high-functioning ASD. Such interventions are important in that they can be implemented at home and offer a flexible and accessible way to practice social interactions in a virtual environment. However, as Hasan & Nene (2024) highlight, to maximize the effectiveness of these interventions, customized design considerations need to be integrated with caregivers. This approach is particularly important for children with the different functional profiles identified in our study (e.g., 'proactive planners' and 'regulatory navigators') and suggests that digital intervention strategies specific to each profile should be developed.

In conclusion, predictive social cognition relies inherently on flexible information integration and communication. While prognosis methodology offers insights into functioning, personalized interventions tailored to individual needs and strengths provide the greatest opportunity for growth. Supporting autistic self-understanding also facilitates identity development and self-advocacy essential for lifelong wellbeing (Gillespie-Lynch et al., 2012). Moving forward, emphasis must remain on enabling social inclusion and agency for all across the diverse spectrum.

CONCLUSION

The present work offers significant contributions to the understanding of the prediction abilities and functional characteristics of children with autism who participate in social forecasting activities. The results present complex difficulties in predicting behavioral, verbal, and emotional reactions in social interactions, highlighting characteristic social-cognitive variations that interfere with actual functioning for individuals with ASD. It shows that effective communication skills and social-emotional competencies are strongly linked to the ability to accurately predict others' behaviors, words and emotions in interpersonal interactions. This suggests that developing communication-oriented skills may help individuals to make more successful predictions in social settings and thus communicate more effectively.

However, the heterogeneity across skill domains and cluster analysis underscore equally diverse strengths that warrant nurturing. Attuning interventions to individual needs while addressing highly correlated weaknesses in communication, executive functions and understanding peer emotions offers the greatest support. Early, intensive behavioral approaches capitalizing on neuroplasticity provide a promising avenue, with caregiver coaching in natural settings proving optimal for generalization (Stahmer et al., 2011). Targeted assistive technologies supporting self-regulation and social understanding also show increasing utility.

Certain limitations provide direction for future research. The small sample size of autistic children assessed restricts result generalization to the broader spectrum. Follow-up with longitudinal data across developmental stages could track evolving trajectories. Finally, incorporating multiple observational and diagnostic measures would strengthen conclusions by mitigating inherent subjectivity in the applied rating scales.

In closing, this research highlights the necessity of balanced, personalized approaches that empower autistic self-understanding while providing appropriate scaffolding to expand social access and connectivity. When met with acceptance and opportunity, individuals across the diverse spectrum have much to contribute.

Author contributions: Conceptualization: GAA, AIA, SKA; Data curation: AIA; Formal analysis: GAA, LAB; Methodology: GAA, AIA, LAB; Supervision: AIA; Writing – original draft: LAB, SKA, ANU; Writing – review & editing: GAA, LAB, SKA, ANU. All authors approved the final version of the article.

Funding: This article was supported by the Ministry of Science and Higher Education of the Republic of Kazakhstan BR21882231 «Conceptual model of ensuring inclusion and accessibility in Kazakhstani secondary education system» (2023-2025 y.).

Ethics declaration: The authors declared that this study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Kazan Federal University (KFU21/0202071). In order to conduct the study, the necessary permissions were obtained from the parents of the students through the school administration. Consent was obtained from the parents for both participation in the study and publication of the data obtained for scientific purposes. During the research process, the confidentiality of the identity information of the participants and their parents was observed and no records that could reveal their identities were kept.

Declaration of interest: The authors declare no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

REFERENCES

Almurashi, H., Bouaziz, R., Alharthi, W., Al-Sarem, M., Hadwan, M., & Kammoun, S. (2022). Augmented reality, serious games and picture exchange communication system for people with ASD: Systematic literature review and future directions. *Sensors, 22*(3), Article 1250. https://doi.org/10.3390/s22031250

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders*. American Psychiatric Association. https://doi.org/10.1176/appi.books.9780890425596

Annunziata, S., Santos, L., Caglio, A., Geminiani, A., Brazzoli, E., Piazza, E., Olivieri, I., Pedrocchi, A., & Cavallini, A. (2024). Interactive mirrOring games wIth sOCial rObot (IOGIOCO): A pilot study on the use of intransitive gestures in a sample of Italian preschool children with autism spectrum disorder. *Frontiers in Psychiatry, 15*. https://doi.org/10.3389/fpsyt.2024.1356331

Artemyeva, T. V., & Akhmetzyanova, A. I. (2020). *Diagnostika strukturno-funktsional'nykh kharakteristik prognozirovaniya u detey: metodicheskoye rukovodstvo* [Diagnostics of structural and functional characteristics of prognosis in children: A methodological guide]. https://dspace.kpfu.ru/xmlui/bitstream/handle/net/160081/Posobie_Akhmetzyanova_A.I.__Artemeva.pdf?sequence=1

Baranek, G. T., David, F. J., Poe, M. D., Stone, W. L., & Watson, L. R. (2006). Sensory experiences questionnaire: Discriminating sensory features in young children with autism, developmental delays, and typical development. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 47*(6), 591–601. https://doi.org/10.1111/j.1469-7610.2005.01546.x

Bayanova, L. F., & Mustafin, T. R. (2015). Metodika issledovaniya sootvetstviya doshkol'nika pravilam normativnoy situatsii [The methodology of the study of the preschooler's compliance with the rules of the normative situation]. *Philology and Culture*, *3*(41), 325–332. https://cyberleninka.ru/article/n/metodika-issledovaniya-sootvetstviya-doshkolnika-pravilam-normativnoy-situatsii

Ben-Sasson, A., Gal, E., Fluss, R., Katz-Zetler, N., & Cermak, S. A. (2019). Update of a meta-analysis of sensory symptoms in ASD: A new decade of research. *Journal of Autism and Developmental Disorders, 49*(12), 4974–4996. https://doi.org/10.1007/s10803-019-04180-0

Boyd, B. A., McBee, M., Holtzclaw, T., Baranek, G. T., & Bodfish, J. W. (2009). Relationships among repetitive behaviors, sensory features, and executive functions in high functioning autism. *Research in Autism Spectrum Disorders, 3*(4), 959–966. https://doi.org/10.1016/j.rasd.2009.05.003

Bradshaw, J., Steiner, A. M., Gengoux, G., & Koegel, L. K. (2015). Feasibility and effectiveness of very early intervention for infants at-risk for autism spectrum disorder: A systematic review. *Journal of Autism and Developmental Disorders, 45*(3), 778–794. https://doi.org/10.1007/s10803-014-2235-2

Cañigueral, R., & Hamilton, A. F. D. C. (2019). The role of eye gaze during natural social interactions in typical and autistic people. *Frontiers in Psychology, 10*. https://doi.org/10.3389/fpsyg.2019.00560

Chaidi, I., & Drigas, A. (2020). Autism, expression, and understanding of emotions: Literature review. *International Journal of Online and Biomedical Engineering, 16*(2), 94–111. https://doi.org/10.3991/ijoe.v16i02.11991

Chen, J., Hu, J., Zhang, K., Zeng, X., Ma, Y., Lu, W., Zhang, K., & Wang, G. (2022). Virtual reality enhances the social skills of children with autism spectrum disorder: A review. *Interactive Learning Environments, 32*(5), 2321–2342. https://doi.org/10.1080/10494820.2022.2146139

Chung, Y. S., Barch, D., & Strube, M. (2014). A meta-analysis of mentalizing impairments in adults with schizophrenia and autism spectrum disorder. *Schizophrenia Bulletin, 40*(3), 602–616. https://doi.org/10.1093/schbul/sbt048

Craig, F., Margari, F., Legrottaglie, A. R., Palumbi, R., de Giambattista, C., & Margari, L. (2016). A review of executive function deficits in autism spectrum disorder and attention-deficit/hyperactivity disorder. *Neuropsychiatric Disease and Treatment, 12*, 1191–1202. https://doi.org/10.2147/NDT.S104620

Demetriou, E. A., DeMayo, M. M., & Guastella, A. J. (2019). Executive function in autism spectrum disorder: history, theoretical models, empirical findings, and potential as an endophenotype. *Frontiers in Psychiatry, 10*. https://doi.org/10.3389/fpsyt.2019.00753

Fridenson-Hayo, S., Berggren, S., Lassalle, A., Tal, S., Pigat, D., Bölte, S., Baron-Cohen, S., & Golan, O. (2016). Basic and complex emotion recognition in children with autism: Cross-cultural findings. *Molecular Autism, 7*(1). https://doi.org/10.1186/s13229-016-0113-9

Gillespie-Lynch, K., Sepeta, L., Wang, Y., Marshall, S., Gomez, L., Sigman, M., & Hutman, T. (2012). Early childhood predictors of the social competence of adults with autism. *Journal of Autism and Developmental Disorders, 42*(2), 161–174. https://doi.org/10.1007/s10803-011-1222-0

Gould, E., Tarbox, J., O'Hora, D., Noone, S., & Bergstrom, R. (2011). Teaching children with autism a basic component skill of perspective-taking. *Behavioral Interventions, 26*(1), 50–66. https://doi.org/10.1002/bin.320

Granpeesheh, D., Dixon, D. R., Tarbox, J., Kaplan, A. M., & Wilke, A. E. (2009). The effects of age and treatment intensity on behavioral intervention outcomes for children with autism spectrum disorders. *Research in Autism Spectrum Disorders, 3*(4), 1014–1022. https://doi.org/10.1016/j.rasd.2009.06.007

Grossman, R. B., Edelson, L. R., & Tager-Flusberg, H. (2013). Emotional facial and vocal expressions during story retelling by children and adolescents with high-functioning autism. *Journal of Speech, Language, and Hearing Research, 56*(3), 1035–1044. https://doi.org/10.1044/1092-4388(2012/12-0067)

Happé, F., & Frith, U. (2006). The weak coherence account: Detail-focused cognitive style in autism spectrum disorders. In *Journal of Autism and Developmental Disorders, 36*(1), 5–25. https://doi.org/10.1007/s10803-005-0039-0

Harrop, C., McConachie, H., Emsley, R., Leadbitter, K., & Green, J. (2014). Restricted and repetitive behaviors in autism spectrum disorders and typical development: Cross-sectional and longitudinal comparisons. *Journal of Autism and Developmental Disorders, 44*(5), 1207–1219. https://doi.org/10.1007/s10803-013-1986-5

Hasan, N., & Nene, M. J. (2024). Determinants of technological interventions for children with autism–A systematic review. *Journal of Educational Computing Research, 62*(1), 250–289. https://doi.org/10.1177/07356331231200701

Hilton, C. L., Harper, J. D., Kueker, R. H., Lang, A. R., Abbacchi, A. M., Todorov, A., & Lavesser, P. D. (2010). Sensory responsiveness as a predictor of social severity in children with high functioning autism spectrum disorders. *Journal of Autism and Developmental Disorders, 40*(8), 937–945. https://doi.org/10.1007/s10803-010-0944-8

Iversen, R. K., & Lewis, C. (2021). Executive function skills are linked to restricted and repetitive behaviors: Three correlational meta analyses. *Autism Research, 14*(6), 1163–1185. https://doi.org/10.1002/aur.2468

Jones, C. R. G., Simonoff, E., Baird, G., Pickles, A., Marsden, A. J. S., Tregay, J., Happé, F., & Charman, T. (2018). The association between theory of mind, executive function, and the symptoms of autism spectrum disorder. *Autism Research, 11*(1), 95–109. https://doi.org/10.1002/aur.1873

Keifer, C. M., Mikami, A. Y., Morris, J. P., Libsack, E. J., & Lerner, M. D. (2020). Prediction of social behavior in autism spectrum disorders: Explicit versus implicit social cognition. *Autism, 24*(7), 1758–1772. https://doi.org/10.1177/1362361320922058

Kilroy, E., Aziz-Zadeh, L., & Cermak, S. (2019). Ayres theories of autism and sensory integration revisited: What contemporary neuroscience has to say. In *Brain Sciences, 9*(3). https://doi.org/10.3390/brainsci9030068

Kinnear, S. H., Link, B. G., Ballan, M. S., & Fischbach, R. L. (2016). Understanding the experience of stigma for parents of children with autism spectrum disorder and the role stigma plays in families' lives. *Journal of Autism and Developmental Disorders, 46*(3), 942–953. https://doi.org/10.1007/s10803-015-2637-9

Knight, V., Sartini, E., & Spriggs, A. D. (2015). Evaluating visual activity schedules as evidence-based practice for individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 45*(1), 157–178. https://doi.org/10.1007/s10803-014-2201-z

Koegel, L. K., Koegel, R. L., Ashbaugh, K., & Bradshaw, J. (2014). The importance of early identification and intervention for children with or at risk for autism spectrum disorders. *International Journal of Speech-Language Pathology, 16*(1), 50–56. https://doi.org/10.3109/17549507.2013.861511

Kwok, E. Y. L., Brown, H. M., Smyth, R. E., & Oram Cardy, J. (2015). Meta-analysis of receptive and expressive language skills in autism spectrum disorder. *Research in Autism Spectrum Disorders, 9*, 202–222. https://doi.org/10.1016/j.rasd.2014.10.008

Lee, I.-J., & Yang, W.-C. (2024). Enhancing perspective-taking and empathy in children with autism spectrum disorder through asymmetric VR games and peer collaboration. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2024.2351174

Lee, J. H., Lee, T. S., Yoo, S. Y., Lee, S. W., Jang, J. H., Choi, Y. J., & Park, Y. R. (2023). Metaverse-based social skills training programme for children with autism spectrum disorder to improve social interaction ability: An open-label, single-centre, randomised controlled pilot trial. *eClinicalMedicine, 61*, Article 102072. https://doi.org/10.1016/j.eclinm.2023.102072

Leekam, S. R., Prior, M. R., & Uljarevic, M. (2011). Restricted and repetitive behaviors in autism spectrum disorders: A review of research in the last decade. *Psychological Bulletin, 137*(4), 562–593. https://doi.org/10.1037/a0023341

Liu, X. (2023). The social interaction deficits in autism spectrum disorder and relevant interventions. *Lecture Notes in Education Psychology and Public Media, 3*(1), 174–179. https://doi.org/10.54254/2753-7048/3/2022500

Loukusa, S., Mäkinen, L., Kuusikko-Gauffin, S., Ebeling, H., & Leinonen, E. (2018). Assessing social-pragmatic inferencing skills in children with autism spectrum disorder. *Journal of Communication Disorders, 73*, 91–105. https://doi.org/10.1016/j.jcomdis.2018.01.006

Mazurek, M. O., Shattuck, P. T., Wagner, M., & Cooper, B. P. (2012). Prevalence and correlates of screen-based media use among youths with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 42*(8), 1757–1767. https://doi.org/10.1007/s10803-011-1413-8

Memari, A. H., Ziaee, V., Shayestehfar, M., Ghanouni, P., Mansournia, M. A., & Moshayedi, P. (2013). Cognitive flexibility impairments in children with autism spectrum disorders: Links to age, gender and child outcomes. *Research in Developmental Disabilities, 34*(10), 3218–3225. https://doi.org/10.1016/j.ridd.2013.06.033

Mesa-Gresa, P., Gil-Gómez, H., Lozano-Quilis, J. A., & Gil-Gómez, J. A. (2018). Effectiveness of virtual reality for children and adolescents with autism spectrum disorder: An evidence-based systematic review. *Sensors 18*(8), 2486. https://doi.org/10.3390/s18082486

Niu, K. (2022). Autism spectrum disorder as a disorder of prediction in sensorimotor processing. *Journal of Education, Humanities and Social Sciences, 5*, 320–326. https://doi.org/10.54097/ehss.v5i.2927

Ozonoff, S., Cook, I., Coon, H., Dawson, G., Joseph, R. M., Klin, A., Mcmahon, W. M., Minshew, N., Munson, J. A., Pennington, B. F., Rogers, S. J., Spence, M. A., Tager-Flusberg, H., Volkmar, F. R., & Wrathall, D. (2004). Performance on Cambridge neuropsychological test automated battery subtests sensitive to frontal lobe function in people with autistic disorder: Evidence from the collaborative programs of excellence in autism network. *Journal of Autism and Developmental Disorders, 34*(2), 139–150. https://doi.org/10.1023/B:JADD.0000022605.81989.cc

Pasqualotto, A., Mazzoni, N., Bentenuto, A., Mulè, A., Benso, F., & Venuti, P. (2021). Effects of cognitive training programs on executive function in children and adolescents with autism spectrum disorder: A systematic review. *Brain Sciences, 11*(10), Article 1280. https://doi.org/10.3390/brainsci11101280

Puce, A., & Bertenthal, B. I. (Eds.). (2015). *The many faces of social attention: Behavioral and neural measures*. Springer. https://doi.org/10.1007/978-3-319-21368-2

Rajendran, G., & Mitchell, P. (2007). Cognitive theories of autism. *Developmental Review, 27*(2), 224–260. https://doi.org/10.1016/j.dr.2007.02.001

Raubenheimer, M., Geertsema, S., Le Roux, M., & Graham, M. A. (2024). The influence of vestibular input on the responses of children with autism spectrum disorder using picture exchange communication to request. *Journal of Occupational Therapy, Schools, & Early Intervention, 17*(2), 313–330. https://doi.org/10.1080/19411243.2023.2177238

Ravi, S., Bradshaw, A., Abdi, H., Meera, S. S., Parish-Morris, J., Yankowitz, L., Paterson, S., Dager, S. R., Burrows, C. A., Chappell, C., St.John, T., Estes, A. M., Piven, J., & Swanson, M. R. (2023). Corrigendum: Are early social communication skills a harbinger for language development in infants later diagnosed autistic?–A longitudinal study using a standardized social communication assessment. *Frontiers in Communication, 8*. https://doi.org/10.3389/fcomm.2023.1120237

Reindal, L., Nærland, T., Weidle, B., Lydersen, S., Andreassen, O. A., & Sund, A. M. (2023). Structural and pragmatic language impairments in children evaluated for autism spectrum disorder (ASD). *Journal of Autism and Developmental Disorders, 53*(2), 701–719. https://doi.org/10.1007/s10803-020-04853-1

Robertson, A. E., & Simmons, D. R. (2013). The relationship between sensory sensitivity and autistic traits in the general population. *Journal of Autism and Developmental Disorders, 43*(4), 775–784. https://doi.org/10.1007/s10803-012-1608-7

Rogers, S. J., Estes, A., Lord, C., Munson, J., Rocha, M., Winter, J., Greenson, J., Colombi, C., Dawson, G., Vismara, L. A., Sugar, C. A., Hellemann, G., Whelan, F., & Talbott, M. (2019). A multisite randomized controlled two-phase trial of the early start Denver model compared to treatment as usual. *Journal of the American Academy of Child & Adolescent Psychiatry, 58*(9), 853–865. https://doi.org/10.1016/j.jaac.2019.01.004

Rudie, J. D., Hernandez, L. M., Brown, J. A., Beck-Pancer, D., Colich, N. L., Gorrindo, P., Thompson, P. M., Geschwind, D. H., Bookheimer, S. Y., Levitt, P., & Dapretto, M. (2012). Autism-associated promoter variant in MET impacts functional and structural brain networks. *Neuron, 75*(5), 904–915. https://doi.org/10.1016/j.neuron.2012.07.010

Scarcella, I., Marino, F., Failla, C., Doria, G., Chilà, P., Minutoli, R., Vetrano, N., Vagni, D., Pignolo, L., Di Cara, M., Settimo, C., Quartarone, A., Cerasa, A., & Pioggia, G. (2023). Information and communication technologies-based interventions for children with autism spectrum conditions: A systematic review of randomized control trials from a positive technology perspective. *Frontiers in Psychiatry, 14*. https://doi.org/10.3389/fpsyt.2023.1212522

Shchetinina, A. M. (2000). Diagnostika sotsial'nogo razvitiya rebenka: Uchebno-metodicheskoye posobiye [Diagnostics of the child's social development: A teaching aid]. *Veliky Novgorod: NovSU named after Yaroslav the Wise, 88*.

Siller, M., Morgan, L., Wedderburn, Q., Fuhrmeister, S., & Rudrabhatla, A. (2021). Inclusive early childhood education for children with and without autism: Progress, barriers, and future directions. *Frontiers in Psychiatry, 12*. https://doi.org/10.3389/fpsyt.2021.754648

Stahmer, A. C., Akshoomoff, N., & Cunningham, A. B. (2011). Inclusion for toddlers with autism spectrum disorders: The first ten years of a community program. *Autism, 15*(5), 625–641. https://doi.org/10.1177/1362361310392253

Sterzing, P. R., Shattuck, P. T., Narendorf, S. C., Wagner, M., & Cooper, B. P. (2012). Bullying involvement and autism spectrum disorders: Prevalence and correlates of bullying involvement among adolescents with an autism spectrum disorder. *Archives of Pediatrics and Adolescent Medicine, 166*(11), 1058–1064. https://doi.org/10.1001/archpediatrics.2012.790

Tomchek, S. D., & Dunn, W. (2007). Sensory processing in children with and without autism: A comparative study using the short sensory profile. *The American Journal of Occupational Therapy, 61*(2), 190–200. https://doi.org/10.5014/ajot.61.2.190

Trevisan, D. A., Hoskyn, M., & Birmingham, E. (2018). Facial expression production in autism: A meta-analysis. *Autism Research, 11*(12), 1586–1601. https://doi.org/10.1002/aur.2037

Uljarevic, M., & Hamilton, A. (2013). Recognition of emotions in autism: A formal meta-analysis. *Journal of Autism and Developmental Disorders, 43*(7), 1517–1526. https://doi.org/10.1007/s10803-012-1695-5

Vogindroukas, I., Stankova, M., Chelas, E. N., & Proedrou, A. (2022). Language and speech characteristics in autism. *Neuropsychiatric Disease and Treatment, 18*, 2367–2377. https://doi.org/10.2147/NDT.S331987

Wan, M. W., Green, J., Elsabbagh, M., Johnson, M., Charman, T., Plummer, F., Baron-Cohen, S., Bedford, R., Bolton, P., Chandler, S., Fernandes, J., Garwood, H., Gliga, T., Tucker, L., Pasco, G., & Volein, A. (2013). Quality of interaction between at-risk infants and caregiver at 12-15 months is associated with 3-year autism outcome. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 54*(7), 763–771. https://doi.org/10.1111/jcpp.12032