Review

Using Technologies to Promote Adaptive Responding and Reduce Challenging Behaviors in Children with Autism Spectrum Disorder: A Selective Review

Anna Passaro [1], Antonio Zullo [2], Mariacarla Di Gioia [2], Mirella Dragone [1], Khalida Akbar [3, 4], Fabrizio Stasolla [1, *]

1. University Giustino Fortunato of Benevento, Benevento, BN 82100, Italy; E-Mails: a.passaro@unifortunato.eu; m.dragone@unifortunato.eu; f.stasolla@unifortunato.eu
2. Universitas Mercatorum of Rome, Roma, RM 00186, Italy; E-Mails: a.zullo3@unifortunato.eu; m.digioia@unifortunato.eu
3. North-West University, Potchefstroom, South Africa; E-Mail: academicresearch.press@gmail.com
4. MANCOSA, Research Doctorate, Durban, South Africa

*   **Correspondence:** Fabrizio Stasolla; E-Mail: f.stasolla@unifortunato.eu

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Abstract

The management and treatment of challenging behaviors in children diagnosed with Autism Spectrum Disorder (ASD) is a priority for caregivers, educators, and healthcare professionals. This selective review examined how different technologies were used to help manage challenging behaviors in children with autism, describing each technology's strengths, weaknesses, and applications. This paper aimed to provide accessible choices for caregivers, educators, and healthcare professionals, enabling them to make well-informed decisions on the most effective strategies for dealing with challenging behaviors in children diagnosed with ASD. The various technologies offered a wide range of tools and resources that could be used to provide practical solutions to overcome this issue. Overall, these technologies offered

versatile solutions tailored to the unique needs of children with ASD, enhancing their quality of life and promoting positive developmental outcomes.

Keywords
Autism; children; challenging behaviors; technologies

1. Introduction

Autism spectrum disorders (ASD) are characterized by two main features: a consistent challenge in engaging in reciprocal social communication and interaction and the presence of restricted and repetitive behavioral patterns, which are usually manifested in early childhood [1]. To diagnose ASD, clinicians evaluate the presence or absence of associated factors such as intellectual disability, language impairments, or any related medical or genetic conditions. The deficits may cause limitations in daily functioning in personal, familial, social, educational, and occupational areas [2]. Typically, these deficits are consistently present across different environments, although they might show some variability based on social, educational, or other contextual factors.

ASD is associated with morphological abnormalities and changes in brain functioning and is often accompanied by co-occurring psychiatric problems [3].

Children with ASD may exhibit challenging behaviors such as aggression, self-injury, and meltdowns, which can significantly impact their quality of life and the well-being of their families, leading to increased stress [4-7].

The prediction of lower caregiver mental wellbeing by heightened levels of emotional and behavioral difficulties in children is a significant aspect of understanding the broader impact of these challenges on family dynamics and mental health [8].

The demands of managing their child's behaviors and emotions can lead to increased stress, anxiety, and depressive symptoms in caregivers of children with elevated emotional and behavioral difficulties.

Specifically, persons with a diagnosis of ASD and severe spoken language development impairments may use challenging behaviors as a means of communication, showing a relationship between expressive language skills and some forms of problem behaviors [9].

These behaviors pose challenges for those providing direct care to children, such as teachers and behavioral therapists, as well as for parents seeking effective ways to manage such behaviors in daily life [10].

1.1 Challenging Behaviors

According to functional analysis, challenging behavior may have the following functions: (a) social reinforcement whenever it is exhibited to request attention by caregivers; (b) positive reinforcement whenever it is exhibited to receive a tangible item; (c) negative reinforcement whenever it is exhibited for escape, and (d) it is an automatic, reinforcement whenever it is exhibited irrespective of the conditions as mentioned above. The observation that challenging behaviors in children with ASD can be maintained by operant reinforcement, with differing sources of reinforcement, underscores the complexity of managing such behaviors [11].

This has important implications for interventions, as it indicates that strategies should focus on altering the internal reinforcement mechanisms rather than relying solely on social or external factors.

This finding highlights the need for personalized and comprehensive approaches to behavior management in children with ASD.

These behaviors, such as self-injury and aggression, carriage physical risks and impede the learning process, emphasizing the urgent need for intervention and support [12].

Stereotyped, repetitive, and self-stimulatory behaviors continue to receive the most attention in research on challenging behaviors, with interventions focusing on stimuli and reinforcement being frequently studied [13].

The recognition of challenging behaviors as a significant characteristic of ASD underscores the necessity for targeted interventions and support, especially within unique school settings [14].

1.2 Technologies for Managing Challenging Behaviors in ASD

Among assistive technologies, microswitches are a basic form of electronic device enabling persons with multiple and severe to profound disabilities to have independent access to preferred stimuli. Microswitch-cluster technology pursues the dual goal of promoting an adaptive response and simultaneously reducing a challenging behavior [15-18].

Microswitch technology emerges as a predominant intervention that helps promote self-determination. Similarly, cognitive behavioral therapy and art, music, or illustrated stories also positively affect managing such behaviors [11, 12].

Recent research has focused on employing wearable physiological sensors and related algorithms to identify and forecast occurrences of problematic behaviors [14, 15]. These advancements hold promise in offering an immediate understanding of the internal emotional fluctuations among persons with ASD, as well as in anticipating the manifestation of challenging behaviors.

Applied Behavior Analysis (ABA) and assistive technologies emphasize the importance of well-designed technologies to support learning and improve functional skills for persons with ASD [19-23]. Utilizing technology for self-management interventions is highly effective for persons with ASD [24]. It enables personalized strategies, enhances independence, and fosters greater autonomy in daily life.

2. Method

2.1 Search Strategy

This review considered the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (*PRISMA*) [25]. A search was conducted in the Scopus database by merging "autism"; "technology"; "children"; and "challenging behavior" as keywords.

2.2 Inclusion Criteria

1) Documents publication date of last decade (2012-2024); 2) Papers written in English; 3) Empirical research (i.e., an evidence-based rehabilitative program was implanted) on the use of

technologies to address challenging behaviors in children with ASD; 4) Participants were recruited across the lifespan (i.e., no range of age was considered).

2.3 Exclusion Criteria

1) Review and conference papers; 2) Studies not relevant to the aim of this review.

2.4 Screening for Inclusion

We screened empirical contributions having at least one participant with ASD. Furthermore, a cognitive-behavioral rehabilitative program was implemented to reduce challenging behavior. Finally, an adaptive behavior was first promoted.

2.5 Data Extraction

Forty-nine relevant records were collected, and six studies were extracted according to the following criteria.

The flowchart of the studies analyzed in this review is according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [25]. Figure 1 summarizes the review process.
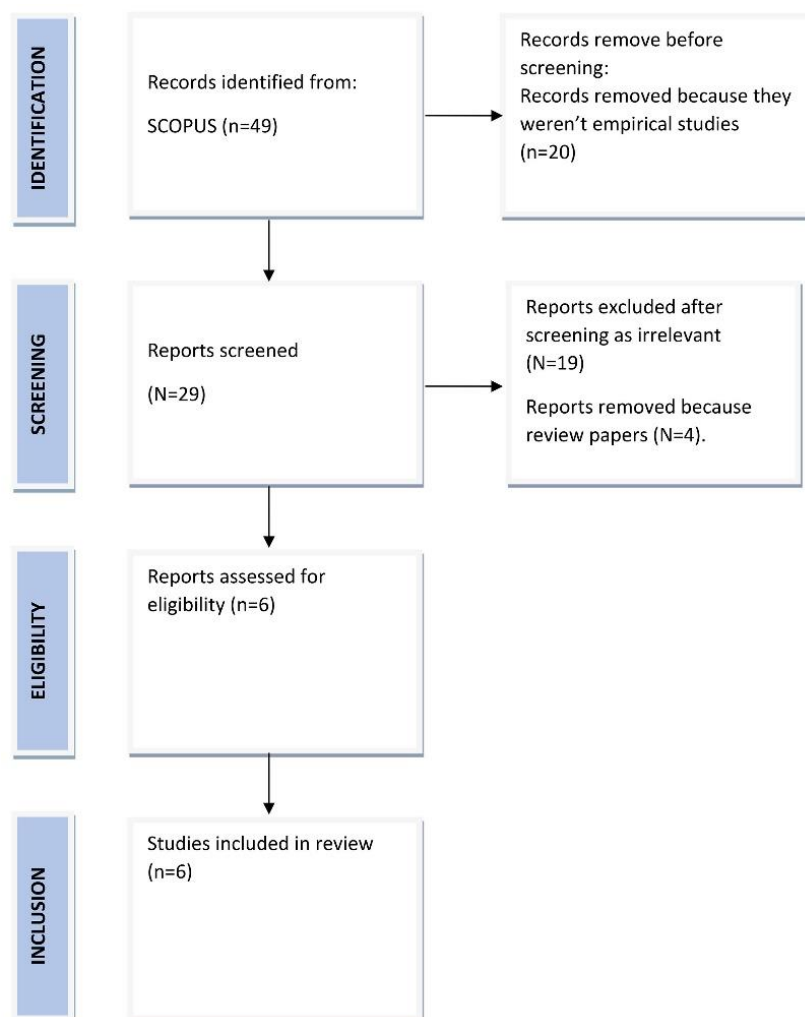

Figure 1 Flow chart of the reviewed studies.

3. Literature Review

Table 1 summarizes the reviewed studies.

Table 1 Studies summary.

Authors	Participants	Aims	Outcomes
Ledbetter-Cho et al. [26]	Five male students with ASD	Assessed the impact of a video schedule intervention used by teachers on the academic performance and untargeted challenging behaviors of young students with ASD.	The intervention proved effective in enhancing participants' academic performance, and a reduction in challenging behaviors and stereotypy was noted among participants after the intervention was introduced.
Palermo et al. [27]	Twenty educational teams of students with ASD	Protocol for an innovative preliminary study evaluating a mobile digital mental health application: KeepCalm app.	The results are being processed.
Gkiolnta et al. [28]	Two eight-year-old school children: one boy with typical developmental and one girl with ASD	Utilizing educational robotics in school settings to enhance the social and communication skills of primary school children with ASD.	Although displayed repetitive and stereotyped behaviors throughout the educational sessions, there was also a noted decrease in her challenging behavior.
Stasolla et al. [29]	Six participants with ASD and Intellectual Disabilities (ID)	Improved the adaptive behavior to promote more functional and socially appropriate behaviors while mitigating self-injurious or disruptive actions.	The results indicated that all participants experienced an enhancement in their performance.
Rosenbloom et al. [30]	One male student	Enhancing positive social behaviors and reducing problematic behaviors among students with ASD in academic environments.	There was an immediate improvement in on-task behavior and a reduction in disruptive behaviors each time I-Connect was introduced.
Tentori et al. [31]	School clinic in Tijuana: approximately 60 students with autism	Discussed their deployment process and illustrated that their bright environment is user-friendly and beneficial, supports continuous empirical measurement and iterative development, and provides various educational	The results demonstrate that collective experiences are pivotal in adopting bright spaces, facilitating both the utilization of technology and the development of new processes.

and therapeutic advantages
for children with ASD.

To effectively address challenging behaviors in individuals with ASD, it is essential to develop and implement innovative interventions that use appropriate strategies and tools.

Ledbetter-Cho et al. [26] investigated to what extent teachers, through a video-schedule intervention, affected academic abilities and other challenging behaviors not explicitly targeted in young students with ASD. During the baseline sessions, students rarely, if ever, completed the steps correctly for the targeted academic skills.

Following the introduction of the intervention, every student promptly increased the number of steps they completed on their own and correctly answered most of the worksheet problems, indicating a functional relationship between the intervention and student performance. Additionally, there was proof that some participants could apply their knowledge to fresh academic challenges and various teaching environments.

They found that the video-schedule intervention was significantly effective as it lifted participants' academic performance while reducing challenging behaviors and stereotypy levels in the participants after the introduction of the intervention.

Palermo et al. [27] proposed a KeepCalm app to identify and manage challenging behaviors exhibited by children diagnosed with ASD. The app combines physiological stress monitoring to detect internal stress in children with real-time intervention suggestions. These interventions are tailored to each child, reminding teachers of individualized emotion regulation strategies and offering in-app resources on evidence-based approaches for parents and educators. Additionally, the app evaluates the effectiveness of different methods for each child based on physiological stress reduction data, teacher feedback on strategy efficacy, and behavioral data. The authors will publish the results of the trial in 2025.

Gkiolnta et al. [28] investigated whether implementing educational robotics within the school environment could enhance the social and communication abilities of a primary school student diagnosed with ASD, potentially decreasing challenging behaviors. The authors developed and carried out educational exercises using the "Codey Rocky" robot, which was created explicitly for primary school children to learn coding and programming. Before and after the intervention, assessments revealed an overall increase in the first two areas evaluated (social and communication skills) and a decrease in most challenging behaviors.

Stasolla et al. [29] extended the use of microswitch-cluster technology to six children with severe to profound developmental disabilities and autism spectrum disorders. This intervention program aimed to improve adaptive behavior by training the children to insert three objects into three containers within 3 seconds and simultaneously reduce challenging behaviors, specifically hand and object mouthing. This approach aimed to promote more functional and socially appropriate behaviors while mitigating self-injurious or disruptive actions. By focusing on both increasing adaptive skills and decreasing maladaptive behaviors, the intervention sought to provide a more comprehensive and balanced strategy for improving these children's quality of life and developmental outcomes.

Rosenbloom et al. [30] implemented an intervention to improve prosocial behaviors and reduce disruptive behaviors in educational settings in students with ASD through I-Connect. This SM application offers customizable prompts, recording, and data monitoring. This study used an ABAB

experimental design to evaluate the relationship between implementing the I-Connect SM intervention and its impact on increasing on-task behavior and decreasing disruptive behavior in an elementary student with ASD in a general education classroom. Results showed an immediate increase in on-task behavior and a decrease in disruptive behavior with each introduction of I-Connect. The study discusses implications for practice and future research.

Tentori et al. [31] have been creating and testing pervasive technology to support various aspects of therapy for children with autism. Their innovations include augmented reality to enhance cognitive functions, ambient displays to promote positive behaviors, and exergames to aid motor development. These technologies have been implemented in a school clinic where 15 physiologist-teachers work with around 60 children with autism. The ongoing effort demonstrates how intelligent environments can significantly improve therapeutic practices.

4. Discussion

The selective review presented promising findings regarding the management of challenging behaviors in children with ASD, taking into account different facets of the interventions and their consequences for daily life.

In addition to solving behavioral problems, implemented strategies can improve engagement and decrease interruptions to foster a positive learning environment. A decrease in stressful and anxious behaviors leads to improved cognitive functioning or increased classroom participation, which can contribute to improved academic achievement [26].

After the technology intervention, participants' challenging behaviors and stereotypies decreased significantly. This is an important finding because it shows that the intervention was successful in addressing the core symptoms of ASD, which can be very disruptive and hinder socialization and learning. Reducing stereotypical behaviors allows the intervention to encourage more flexible approaches to self-control or offer substitutes for disruptive behaviors that still meet the exact needs [28, 29].

The increase in on-task behavior and the reduction in disruptive behaviors with each use of I-Connect highlight its effectiveness in fostering a positive learning environment [30]. The consistent improvements demonstrate the intervention's reliability and strength in managing behavioral issues in educational settings. These results suggest that I-Connect is valuable for enhancing school student behavior.

This highlights the potential of digital tools in behavior management, perhaps through instantaneous feedback, regimented schedules, or captivating stimuli that draw children in and lessen their chances of acting out [32-34].

The positive impact of technology-based interventions like I-Connect and the role of collective experiences in adopting innovative spaces provide valuable insights for future research and practice [30, 31]. These findings contribute to a growing body of evidence supporting tailored, context-aware, and technology-enhanced strategies for managing ASD in educational settings.

These technologies also create a more welcoming and encouraging learning environment by strengthening cognitive abilities, addressing challenging behaviors, and encouraging improved social communication and academic achievement [35].

5. Conclusion

Practical strategies and tools mediated by technologies and tailored to the specific needs of persons with ASD can facilitate better management of challenging behaviors and promote positive outcomes.

Therefore, there is a critical need for ongoing research and development of innovative interventions with technologies that incorporate evidence-based practices to support persons with ASD and their families in managing their challenging behaviors.

One significant limitation of this study is the small sample size in studies testing technologies for managing challenging behaviors. Due to this limitation, future research should aim to conduct experiments with larger sample sizes. Second, this is not a systematic review. Third, with considered only challenging behaviors. Aggressive, disruptive, and self-injurious were not included. We searched only in Scopus, which is regarded as the largest literature database.

Accordingly, future studies should highlight the potential of Extended Reality (XR) and Virtual Reality (VR) technologies in managing challenging behaviors in ASD [36, 37]. This approach will ensure the replicability of the results and provide more robust evidence for the effectiveness of these technologies in the population with ASD. By addressing this limitation, we can further understand these interventions' broader applicability and potential benefits for individuals with ASD.

Author Contributions

AP conceived and drafted the paper. AZ, MDG, MD, and KA Revised the manuscript. FS Edited and supervised the all process. All the authors made a substantial contribution and approved the final version of the manuscript.

Competing Interests

The authors have declared that no competing interests exist.

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