**Innovative Techniques in *Autism Spectrum Disorder*: A Systematic Review**

**ABSTRACT**

With the growing number of studies, continuous advancements in learning practices have been introduced for children with autism. Whether it is therapeutics or technology-based, these advancements are embracing the autistic population and allowing autistic children to experience learning in ways that would not have been possible before, such as through virtual reality and interactive touch-screen devices. This is helping to bridge the gap between autistic and non-autistic learning experiences. To overcome limited social interaction, poor communication skills, negligible eye contact, isolation tendency, and developmental delays of autistic children. Numerous therapy-based techniques (speech, behavioural, art, etc.) and technology-based techniques (intervention programs and learning applications) were introduced. These techniques help autistic children practice social and communication skills in a safe, structured atmosphere. They also help to improve engagement time, language, and cognitive skills. With technology, autistic children can practice problem-solving and organisation in a more accessible and engaging way. This paper aims to study recent advancements and prior knowledge of autism to evaluate the findings of therapy and technology-based tools and techniques on the behaviour of children with autism disorder. It focuses on identifying the potential benefits of technology in providing a tailored, interactive learning experience to autistic children and will be beneficial for the parents and caregivers of children with ASD in selecting the appropriate technique for these children as per their requirements.

*Keywords:* *Autism Spectrum Disorder, Cognitive Ability, Technology-Based Techniques, Therapy-Based Techniques.*

**1. Introduction**

The American Psychiatric Association (APA) published the Diagnostic and Statistical Manual of Mental Disorders (DSM) and mentioned symptoms, diagnostic criteria, and available treatments for various disorders. The DSM-V acknowledges autism spectrum disorder as a discrete category and defines the severity levels in the context of behavioural skills and social communication. (Table 1.1) The stage of development and chronological age determine the severity of the disorder and are presented as a spectrum. At 12-24 months, the symptoms of ASD are noticeable. Due to severe developmental delays, these symptoms can be visible before 12 months and recognised after 24 months when symptoms are not prominent. The aetiology of autism spectrum disorder is unknown. In contrast, risk factors include environmental factors (i.e., low birth weight, prenatal exposure to valproic acid, and excessive parental age) and genetic or physiological factors (i.e., genetic mutations) (APA, 2013).

**Table 1. Developmental delays during the severity levels of ASD (APA, 2013).**

|  |  |  |
| --- | --- | --- |
| Level of severity | Social communication | Behavioural skills |
| Mild | * Able to speak entire sentences but poor at holding a conversation
* Difficult to initiate conversation in social gatherings
* Unusual response to the questions
 | * Less resistance to change
* Difficulty in organising routine chores
* Poor functioning but simple guidance can improve performance
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| Moderate | * Unable to communicate even with support
* Limited initiation of interaction socially
* Reduction in response rate in society
 | * Unable to adjust to change
* Frequent repetitive behavior occurs
* Impaired functioning due to repetitive behaviour

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|  Severe | * Limited word vocabulary
* Never initiate a conversation
* Respond to basic social approach
 | * Does not accept change and shows extreme resistance when change is forced
* Repetitive behaviour occurs consistently and hinders functioning
* Difficulty in performing any action
 |

**1.1 Technology-based techniques**

Technology-based techniques include ‘typically developing controls (TDC),’ which are monitored over the computer and record sudden facial features of the individual. It is designed to study the behavioural responses of individuals with an autism spectrum disorder. These responses were recorded based on various emotional and social contexts of autistic and non-autistic individuals. Each possible facial action was marked and characterised as ‘facial action units (FAU).’ These units were further statistically evaluated to generate quantitative data after comparing similar-aged individuals. The findings predict that the group of autistic children leads more FAU than the group of non-autistic children. Further interpretation of FAU highlights outspoken behaviour, contradictory reactions to pessimistic statements, and impaired expression imitation. Cost-effective prompting devices were introduced in 2019 to individuals with autism to study behavioural changes. (Goldsmith and LeBlanc, 2004). These prompts include:

**1.1.1 Mechanical prompts**

They include physical, motor, gestural, pictorial, and vocal prompts. These prompts are automated devices that require less human involvement and are developed to provide external stimuli for children with autism (MacDuff et al., 2001).

**1.1.2 Auditory prompts**

They are self-operating devices with recorded music and simple directions such as “concentrate,” “Do not stop,” etc. (Taber et al., (1999). Later, applying these prompts in the classroom helped reduce teacher-delivered prompts (Coyle & Cole, 2004).

**1.1.3 Tactile prompts**

Earlier, classrooms required constant assistance, but prompting has reduced this requirement. They help to enhance social interactions (Shabani et al., 2002; Taylor & Levin, 1998) and seek regular assistance (Taylor et al., 2004).

**1.1.4 Video prompts**

These include concept-oriented videos for children with autism. They help to present concepts systematically and are easy to design. They are more effective than live models due to their eye-engaging qualities (Charlop-Christy et al., 2000)

**1.1.5 Computer-based intervention**

They are used to speculate and recognise emotions (Silver & Oakes, 2001; Liu et al., 2008), vocabulary enhancement (Moore & Calvert, 2000; Bosseler & Massaro, 2003), problem-solving skills (Bernhard-Opitz et al., 2001), vocal imitation (Bernhard-Optz et al., 1999), communication and reading skills (Heimann et al., 1995) and assessments performed through ICT (Sim et al., 2004).

**1.1.6 Virtual reality**

It is an unmasking therapy to eliminate irrational fears. It comprises a device that showcases an environment other than the natural world and helps individuals improve their response actions. (Max and Burke, 1997)

**1.1.7 Robotics**

Among children with autism, robots serve as toys to enhance social connectivity and communication through imitation (Boucenna et al., 2014; Andry et al., 2001; Bird, 2007) and joint interaction (Boucenna et al., 2014; Laurie et al., 2022). These robot toys are designed and constructed in a way that detects the presence of a human, and an individual should look into the eye. Hence, it improves eye contact (Diehl et al., 2012).

**1.1.8 Applications**

It is designed for children with autism to develop a positive social environment to achieve creative thinking (Tu et al., 2021), diverse expressions, and collaborative activities (Papadakis et al., 2017).

**1.2 Therapy- based techniques**

These techniques are designed to benefit autistic children through their challenges. It includes therapy sessions that help the child practice their developmental inadequacy and are performed under specialised personnel only (Ozsahin et al., 2021). Studies show that 13 of 30% of children with disorders suffer from behavioural problems (Horner et al., 2002). Autistic children are prone to these behavioural issues because they have restricted communication skills and impaired social interaction (Horner et al., 2002). Therapy-based techniques monitor these problems and work as a calming factor. It includes:

**1.2.1 Sensory Integration Therapy**

Abnormal behaviour in children with autism results in impaired sensory stimuli. Sessions in this therapy helped them develop the ability to change the stimulus, reduce abnormal behaviour, and improve learning (Lane et al., 2010). Therapy sessions include various physical activities to study stimulus-response (Dar et al., 2024; Lang et al., 2012).

**1.2.2 Art therapy**

This approach works as a healing agent for children with autism and provides them with a platform to express their emotions. It also helps to regulate their energy and enhance their engagement time. It works on healing from troublesome memories through symbolic communication (Malchiodi, 2002). Art therapy is beneficial for managing anxiety levels, frustration cycles, and social connectivity (Durrani, 2014).

**1.2.3 Speech therapy**

Children with autism avoid eye contact and are socially isolated, which leads to learning delays and an inability to imitate. Speech therapy sessions are conducted to facilitate healthy social interaction. These sessions consist of audio-visual information, which helps in eye fixation and facial recognition (Gepner et al., 2022). Customised games were also developed to facilitate speech and language delays to produce intelligible speech (Hoque et al., 2009).

**1.2.4 Parent Interaction Therapy**

It includes therapies built to coach parents to impart different ways to help children learn through their actions (Bagner & Eyberg, 2007; Agazzi et al., 2013). For instance, the developmental individual-differences relationship-based model (DIR) emphasises educating mothers to enhance developmental delays in children with autism (Aali et al., 2005; Greenspan & Wieder, 2005) and play therapy, in which adults allow their children to give orders and patiently follow them to develop joint interactions. It helps adults better understand the child’s world (Greenspan & Shanker, 2006), and adults teach children social behaviour and emotional regulation (Nee, 2013).

**1.2.5 Behavioural therapy**

This therapy includes cognitive behavioural therapy (Sharma et al., 2018; Wood et al., 2009) and social and behavioural therapy (Sharma et al., 2018). CBT is beneficial for autistic children to learn social, self-care, and cognitive skills (Ung et al., 2015). Moreover, social and behavioural therapy targets the functional development of children in which behavioural analysis is performed during the session to monitor the influence of external events on the child’s behaviour (Lai et al., 2014; Sharma et al., 2018).

**1.2.6 Music therapy**

Sessions include music therapy improvements through singing or listening to songs. It helps individuals develop social interaction, self-confidence, and self-expression (Marquez-Garcia, 2022). In improvised music therapy, tuned and untuned music is played against the background of the child’s play, and the child is asked to follow the rhythm to practice turn-taking, imitation, and joint interaction (Crawford et al., 2017). Neuroimaging models work as catalysts for achieving the best results from music therapy for children with autism (Marquez-Garcia, 2022).

**1.2.7 Pharmacological therapy**

Treatment is performed through medications such as psychostimulants, antipsychotic drugs, antidepressants, inhibitors, NMDA receptors, and mood stabilisers (Sharma et al., 2018; Aman et al., 2008).

**2. METHODOLOGY**

**2.2.1 Research Design**

This study employs a comprehensive literature review and qualitative analysis to explore the advancements in therapy-based and technology-based intervention for children with autism. It involves an in-depth examination of existing studies, clinical trials and technological developments to assess their improvements in children with autism.

**2.2.2 Data Collection**

The data was collected through secondary sources like PubMed, ScienceDirect and Google Scholar. Additionally, reports from organisations, including the American Psychological Association (APA) and World Health Organisation (WHO), were gathered on ASD diagnosis and therapeutic interventions.

**2.2.3 Inclusion and Exclusion Criteria**

For the relevance and reliability of the study, the following inclusion and exclusion criteria were applied:

*Inclusion Criteria*

* Studies published in 2000 to 2024.
* Research focusing on technology and therapy-based intervention for children with ASD.

*Exclusion Criteria*

* Studies focusing on ASD in adults
* Non-peer-reviewed articles.
* Studies lacking empirical data

**2.2.4 Data Analysis**

A thematic analysis approach categorised findings into therapy-based and technology-based techniques. Comparative assessments were conducted to determine the success rates of each intervention, as well as key metrics such as social interaction, communication skills, and behavioural adaptation improvements. Statistical success rates from prior studies were used to evaluate the efficacy of different interventions, as shown in Table 2.

**3. RESULTS AND DISCUSSION**

Genetic disposition and genetic mutation can cause autism, and shared family variants play a vital role (Miles, 2011; Krumm, 2014). While there is no cure for ASD, various therapeutic and technological interventions have proven effective in improving the quality of life for children with ASD. Combining therapy and technology-based interventions offers promising outcomes, helping children develop life skills. Several therapy sessions have been used to support autistic children; these evidence-based therapies were designed to cater to various aspects of a child’s development. Among them, applied behaviour analysis (ABA) is a well-structured therapy that reinforces and discourages positive behaviour. It helps to enhance communication, social skills, and self-regulation and reduces problematic behaviours. Personalised sessions were preferable in this therapy for effective results, but they can be time-intensive and expensive. Speech and Language Therapy (SLT) improves verbal and non-verbal communication skills. It helps non-verbal children to use alternative communication methods (i.e., picture exchange and communication systems) (Alduais et al., 2023). It enhances social communication and interaction and improves comprehension and expressive language (Goldstein, 2002). Occupational Therapy (OT) emphasises developing fine and gross motor skills, sensory processing abilities, and daily living skills. It helps to enhance hand-eye coordination, sensory integration, motor skills, and independence in tasks related to daily routine. It also helps to reduce hypersensitivity or hyposensitivity to stimuli. Social Skills Training (SST) helps children with ASD develop appropriate social behaviour, such as making eye contact, taking turns in conversations (Saram et al., 2023), and understanding social cues. It helps to strengthen peer relations, understanding of emotions, body language, and social interactions. It helps reduce social anxiety and improves confidence.

Innovative technology-based interventions have been developed with the advancement in technology to support children with ASD. They, along with therapy sessions, help to cater to the requirements of children with autism. Augmentative and Alternative Communication (AAC) devices help to navigate children with non-verbal and minimal verbal communication. These devices include speech-generating devices (SGDs), enabling children to express their needs and emotions by developing speech over time. It benefits in reducing frustration and behavioural issues caused by communication barriers.

Virtual Reality (VR) and Augmented Reality (AR) help generate environments to practice social communication, behaviour modelling, and exposure therapy. It helps children to experience real-life social situations in a controlled setting and to overcome social anxiety from new or overwhelming environments. It helps to improve engagement and motivation for learning. Robotic systems provide interactive learning experiences for children with autism through a humanised robot, which helps to enhance social engagement and interaction. It provides consistent and predictable responses, comforting children with ASD, and helps them learn facial expressions, gestures, and emotions. Mobile applications, such as Proloquo2Go, Autism Speaks Visual Support, and Otsimo were also designed to enhance cognitive, behavioural, and communication skills. They provide personalised and engaging learning experiences with independent learning and skill building. It allows parents and therapists to track progress (Zang et al., 2019).

Every child is born with their abilities and challenges. Hence, they require personal assistance and monitoring while using these techniques. Techniques should be child-centric and built on naturalistic conditions. (Klin et al., 2002). Therapy and technology-based techniques have a greater than 50% success rate (Table 1.2) and should be recommended per the child's requirements. Psychiatrists can also suggest more than one technique for the holistic development of autistic children.

**Table 2. The success rate of therapy and technology-based techniques.**

|  |  |  |  |
| --- | --- | --- | --- |
| S.no | Challenges of children with autism | Technology-based techniques | Therapy-based techniques |
| 1. | Social communication (verbal and nonverbal) and Social interaction | Robotics 86.6% (Szymona et al., 2021); tactile prompting 90% (Cengher et al., 2015); Computer-based intervention 94.6% (Hosseini et al., 2022); application | Speech therapy 70% (Brignell et al., 2018), Parent’s interaction therapy 90% (Harrington et al., 2023), music therapy 95% (Geretsegger et al., 2014)  |
| 2. | Emotional and social reciprocity | Computer-based intervention 94.6% (Hosseini et al., 2022), virtual reality 70% (Mesa-Gresa et al., 2018) | Art therapy 73% (Schweizer et al., 2022) |
| 3. | Poor eye contact and lack of facial expression and gestures | Mechanical prompts 90%, video prompts 90%, auditory prompts 90%, tactile prompting 90% (Cengher et al., 2015), Robotics 86.6% (Szymona et al., 2021) | Speech therapy 70% (Brignell et al., 2018), Music therapy 95% (Geretsegger et al., 2014) |
| 4. | Repetitive and restricted patterns of behaviour | auditory prompts 90% (Cengher et al., 2015) | Sensory integration therapy 80% (Karim & Mohammed, 2015), Behavioural therapy 90% (Lovaas, 1987; Smith, 2013) |
| 5. | Hyperactivity | auditory prompts 90% (Cengher et al., 2015) | Pharmacological therapy 90% (Doyle & McDougle, 2012) |

The synergy of traditional therapies and advanced technology-based interventions offers a comprehensive approach to ASD through personalised learning (technology facilitates customisation in therapy sessions based on the child’s requirements), improved engagement (children with ASD respond positively to interactive games and learning environments), remote accessibility (teletherapy and digital tools for remote therapy), and data-driven insights (progress tracking through AI-powered tools). The integration of traditional therapy and technology-based interventions has significantly improved outcomes for children with autism. While traditional therapies remain the foundation of ASD treatment, technology enhances their effectiveness by providing interactive, personalised and engaging support. Continued research, affordability, and accessibility will be the key in ensuring that children with ASD can benefit from these advancements.

**4. CONCLUSION**

Children with autism spectrum disorder construct an isolation zone around themselves, which causes language delays and negligible social interaction. As a result, it becomes more difficult for the child to reach developmental milestones and carry out daily tasks. Several children on the autism spectrum find it difficult to perform daily life activities. However, some individuals can perform these daily activities with great precision. Autistic children are uncomfortable changing their environment since learning new methods can distract them, and they cannot adapt well to changing settings. Moreover, some children find it interesting to learn new things and develop an excessive interest in them later in their lives. Regular therapy sessions for a child with autism are recommended to practice skills so that the child will remember them for a long time. Each child should be considered individually. Therefore, therapy sessions must be tailored to meet each child's needs. In the case of a child with autism, both therapy and technology-based techniques improved their behaviour. Continuous trial and error methods should be recommended to familiarise the child with the task and visualise further progress. Including technology in therapy-based techniques can help autistic children explore their environment and learn new skills.

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**CONFLICT OF INTEREST**

The authors listed above certify that they have no affiliations with or involvement in any organisation or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

SciSpace (version 1.4.12) <https://typeset.io/> was utilised to enhance the conclusions drawn by entering the input prompt- “Autism Spectrum Disorder”

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