International Journal of Science, Strategic Management and Technology
Volume **02** Issue **07** July- **2026** | ISSN: **3108-1762 (Online)** | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

Longitudinal Evaluation of Virtual Reality-Based Applied Behavior Analysis for Improving Emotional Regulation and Behavioral Outcomes in Children with ASD

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https://doi.org/ 10.55041/ijsmt.v2i7.053

Cite this Article: Gogoi, A. (2026). Longitudinal Evaluation of Virtual Reality-Based Applied Behavior Analysis for Improving Emotional Regulation and Behavioral Outcomes in Children with ASD. International Journal of Science, Strategic Management and Technology, *02*(7). https://doi.org/10.55041/ijsmt.v2i7.053

Abstract

Autism Spectrum Disorder (ASD) describes a chronic condition with lasting challenges in social communication, emotional functioning, and adaptive behavior. Applied Behavior Analysis (ABA) has been established as the gold standard intervention for ASD, but the use of Virtual Reality (VR) has proven to be a valuable approach in improving skill acquisition in an immersive and controlled learning environment. But there is limited longitudinal evidence of the effectiveness of VR versions of ABA.

The purpose of this study was to examine the effectiveness of VR+ABA over 12 months for children with ASD in terms of emotional regulation and behavioural outcomes.

The study design was a randomized controlled longitudinal trial of a 12-month treatment period with VR+ABA (n = 30) versus an ABA-only (n = 30) group of children with ASD (6–12 years). The two groups were provided with the same amount of standardized ABA therapy (20 hours per week); an additional 30 minutes per week of VR was administered to the experimental group, with the sessions focused on simulations of social interaction, emotional regulation, and safety skills. The Emotion Regulation Checklist (ERC), Autism Behavior Checklist (ABC), Adaptive Behavior Assessment System-II (ABAS-II), Social Responsiveness Scale-2 (SRS-2), and Behavior Rating Inventory of Executive Function (BRIEF) were used as outcome measures. Three assessments were done at baseline, 6-month, and 12-month timepoints. Repeated-measures ANOVA and mixed-effects models were used to analyse data at the $p < 0.05$level.

In the VR+ABA group, children showed significantly greater improvements compared to the ABA group on all primary outcomes. Mean ERC scores increased from 32.1 ± 5.2at baseline to 38.7 ± 4.1after 12 months, compared with 31.8 ± 5.5to 33.2 ± 5.0 in the control group ($F = 27.84$, $p < 0.001$, $\eta^2 = 0.324$). ABC irritability scores decreased by 51.3%in the VR+ABA group versus 12.4%in controls ($p < 0.001$). There were also significant improvements in adaptive behaviour (23.1% improvement), emotional recognition (37.8% improvement), executive functioning (18.5% improvement), and social communication (23.8% decrease in SRS-2 scores). The magnitude of the treatment effects was large for all primary outcomes (Cohen's d = 0.95–1.42).

Results show that VR-ABA led to significantly greater gains in emotional regulation, adaptive functioning, executive functioning, and behavioral outcomes than traditional ABA. VR-assisted ABA is a promising, engaging, clinically effective intervention for children with ASD and can be used to complement the long-term effectiveness of behavioural therapy. Further multicentre studies with a larger number of patients and longer follow-up are suggested for confirmation of these results.

Keywords: Applied behaviour analysis, Emotional Regulation, behaviour intervention, Autism Spectrum Disorder, Virtual Reality, Longitudinal Study, Randomised Controlled Trial.

Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder in which persistent impairments develop in social communication and social interaction, and are accompanied by restricted and repetitive patterns of behaviour, interests, and activities. Children with ASD often have problems identifying, verbalizing, and controlling their emotions, which can lead to social and behavioral problems, anxiety and aggression, self-injurious behavior, and failure to adapt. There is growing awareness that emotional regulation is one of the key factors associated with lower quality of life and social maladaptation in children with ASD (Fu *et al*., 2025) [1]; (Greczek *et al.,* 2021) [2]. Applied Behavior Analysis (ABA) is still one of the most scientifically-evidenced behavioural therapeutic interventions for autism. ABA uses principles of reinforcement, structured learning environments, and systematic behavior modification techniques to enhance communication, social interaction, adaptive skills, and reduce maladaptive behaviors (Liu *et al.,* 2021) [5].

While ABA has proven to be very effective, there are some drawbacks. The typical ABA session takes place in a very structured clinical setting, which makes it difficult to transfer the learned behaviour to the community. Additionally, normal therapy sessions are not suitable to safely replicate many emotional and social scenarios experienced in everyday life. Generalisation of skills outside of therapy is thus still a significant challenge for families and clinicians (Parsons and Cobb, 2022) [6].

New technological developments have brought about the emergence of Virtual Reality (VR) as a novel intervention platform, which can overcome numerous drawbacks of existing behavioural therapies. VR offers an immersive, interactive and highly controllable space for children to practice and practise emotional recognition, social interaction, communication, and behavioural regulation in a safe environment. VR can be used to systematically vary the complexity of the environment while all therapeutic variables are fully controlled, unlike traditional behavioural training (Zhang *et al.,* 2022) [10].

Several systematic reviews and meta-analyses have found positive results with VR interventions in ASD. VR-based training programmes were reported by Fu *et al*., (2025) [1]to lead to significant improvements in emotional recognition, adaptive behaviour, and social communication. Likewise, Greczek *et al.* (2021) [2] found that VR interventions lead to moderate to large gains in communication, behavioural flexibility, and social functioning relative to traditional therapeutic techniques. Herrera-García *et al.* (2024) [3] also showed that immersive VR was highly effective at improving emotional regulation, executive functioning and cognitive flexibility among children with ASD, presenting the potential of immersive technologies in behavioural rehabilitation.

Virtual Reality Applied Behavior Analysis (VR-ABA) is a new therapeutic approach that combines the behaviourally effective nature of Applied Behavior Analysis (ABA) with the ecological validity and engagement of immersive virtual environments. VR-based ABA allows therapists to use behavioural reinforcement, prompting, shaping and modelling in realistic social situations with real-time feedback and objective behavioural monitoring. Liu *et al.,* (2021) [5] termed this “Virtual Naturalistic

Developmental Behavioral Intervention (Vandi)," implying that immersive learning in the real world could significantly enhance the acquisition of skills and the generalisation of these skills over time.

Although good results have been obtained, there are a number of important research gaps that need to be addressed. The majority of the current intervention studies have examined short-term treatments of 6-12 weeks' duration, and have had small sample sizes and brief post-treatment periods. There has been limited research to date on the long-term benefits of behavior, emotional regulation, and adaptive functioning after VR-based ABA interventions. Furthermore, there have been limited longitudinal studies that specifically explored emotional regulation as a key therapeutic goal, even though it has a significant impact on behavioral adjustment and social functioning (Radhakrishnan *et al.,* 2025) [7]; (Sahin *et al.,* 2025) [8]. Similarly, VR-assisted intervention has been shown to yield lasting benefits in behavioural functioning by Serlin *et al.,* (2021) [9], but there are few long-term follow-up studies.

Thus, there is a growing demand for stringent longitudinal investigations that assess the long-term effects of VR-supported ABA interventions in various behavioral areas. These findings would have significant implications for clinical practice, as they would help to establish if behaviour changes that occur after immersive interventions are sustained in the long term and transferred to real-world settings.

Thus, the goal of the current longitudinal study is to assess the effectiveness of VR-ABA for the 12-month follow-up period in enhancing emotional regulation and behavioral outcomes in children with ASD. A specific focus of the study is on the changes in emotional regulation, adaptive behaviour, social communication, behavioural problems, and maintenance of therapeutic gains at multiple assessment periods. Results will help to give empirical evidence for the integration of immersive technologies in evidence-based behavioral interventions for ASD.

Literature Review

Yan *et al.,* (2025) examined the use of immersive virtual reality (IVR) training for developing adaptive skills among children and adolescents with high-functioning autism spectrum disorder (ASD). This mixed-methods study involved 33 participants, aged 8 to 18 years old, undergoing weekly IVR training sessions aimed at developing their social and adaptive skills. It was found that there were marked improvements in the participants' adaptive behavior, executive functions, emotion regulation, and social interaction skills. They performed better in terms of increased task completion speed and minimized behavioral issues after the intervention. Feedback from the participants' parents also revealed positive developments in their communication skills, ability to pay attention, emotion regulation, and daily living activities. Immersive VR training can thus be considered an effective treatment modality among children with ASD. However, further research should still be conducted to support its efficiency [11].

Zhang *et al.,* (2023) undertook a systematic review and meta-analysis of 32 studies conducted from 2013 to 2023 to assess the efficacy of interventions in Virtual Reality (VR) on social and emotional learning in children and adolescents. The results indicated that VR interventions were associated with a moderate effect on outcomes of social and emotional learning, such as improvement in emotional recognition, social interaction, empathy, and communication skills. The research also indicated that the effectiveness of interventions was based on the kind of disorder and instructional activities carried out in the VR environment. The researchers recommended that VR is an effective educational and therapy tool in the development of social and emotional skills [12].

Zhang *et al.,* (2022) reviewed the application of Virtual Reality (VR) technology as an educational and intervention tool for children with autism spectrum disorder (ASD). The review highlighted that VR provides interactive and realistic environments that effectively improve social communication, emotion

recognition, speech and language development, and cognitive skills. The authors concluded that VR has significant potential as an innovative intervention for children with ASD but emphasized the need for improved technology, stronger theoretical frameworks, and more longitudinal research to establish its long-term effectiveness [13].

Moon and Ke (2021) examined the integrity of treatment in relation to virtual reality (VR) based social skills intervention among HFA children. The research adopted a mixed-methods methodology and examined 90 sessions of social skills interventions conducted on 15 children using a VR environment built using Open Simulator software. Results revealed that social skills interventions via VR achieved treatment integrity and were successful in facilitating social learning. The researchers found that the integrity of treatment was different in various social settings and stressed the importance of designing good VR activities for maximum therapeutic benefit of ASD children [14].

Emmelkamp and Meyerbröker (2021) The use of Virtual Reality (VR) in therapy for several types of mental illnesses. The study revealed that the VR technology creates an environment where it is possible to perform tests and interventions; therefore, it can be used as a therapy. The authors concluded that there is an increasing number of studies proving the efficiency of VR in terms of improving the behavioral and social functioning of people suffering from ASD [15].

This is a combination of behaviourism (reinforcement) and socio-emotional learning theories. The process is provided by ABA, and the context is provided by VR technology. Emotion regulation theory (Gross, 1998) postulates that the practice of regulating the emotional response to a stimulus may contribute to building self-regulation skills. With the help of VR technology, one may experience emotionally charged stimuli (such as being virtually rejected socially or listening to loud noises) repeatedly in a controlled manner, which may result in habituation and coping behaviors being performed. To conclude, according to the literature on the subject, both ABA and VR may positively influence the social and emotional functioning of children diagnosed with ASD on their own. Combining them, one may achieve additive effects or even constructive collaboration. This study will verify the hypothesis.

Methodology

Study Design and Participants

The study was designed as a 12-month randomized controlled trial (RCT). Sixty children (6-12 years) with an autism diagnosis (ASD) were recruited from autism clinics, rehabilitation centres and parent support groups. The sample size of 60 participants (30 in each group) was decided using power analysis with 80% statistical power and a significance level of $\alpha = 0.05$, considering the feasibility of the study.

Children were included if they had a confirmed clinical diagnosis of ASD using the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) and baseline assessments showing emotional dysregulation and an Intelligence Quotient (IQ) ≥ 70. Those who were excluded were those with severe visual or hearing impairments, a history of epilepsy or seizures, severe motor disabilities that would not allow them to use the VR equipment, and those who had previously been exposed to substantial VR intervention.

Parents/legal guardians' informed consent was obtained, and children's assent was obtained as appropriate. Children were randomly assigned to the VR + ABA intervention group or the ABA-only control group by computer-generated blocked randomization. Allocation was concealed from the outcome assessors to minimize assessment bias. The study received ethical clearance from the

Institutional Ethics Committee, and all the research procedures were conducted in accordance with internationally accepted ethical guidelines for research with children.

Table 1: Participant Demographics and Baseline Characteristics (N=60)

Participant Demographics and Baseline Characteristics (N=60)	**VR+ABA (n=30)**	**ABA-Only (n=30)**
Age (mean ± SD) (years)	8.2 ± 2.1	8.5 ± 2.3
Sex (M: F)	22:8	23:7
ASD Severity (ADOS-2 calibrated score)	6.5 ± 1.4	6.8 ± 1.3
Full-Scale IQ (mean ± SD)	92.3 ± 10.5	94.1 ± 9.8
ERC Emotion Regulation (score)	32.1 ± 5.2	31.8 ± 5.5
ABC Irritability (score)	18.7 ± 4.8	19.3 ± 5.0
Medication (Melatonin/stimulants) (n)	8	7
Prior ABA experience (months)	15.2 ± 6.3	14.8 ± 5.9

Note: ERC = Emotion Regulation Checklist (higher = better regulation); ABC = Aberrant Behavior Checklist (higher = more severe behavior problems).

Recruitment and Setting

Subjects were referred by paediatric neurologists, autism spectrum disorder (ASD) clinics, rehabilitation centres, and school-based special educators. Information flyers were distributed, and outreach was done via parent support groups to recruit more participants. Participants underwent baseline screening of the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2) and a structured parent interview to verify participants' eligibility based on the study inclusion/exclusion criteria.

All intervention sessions took place in a special clinical facility that includes Virtual Reality (VR) hardware and behavioral therapy facilities. Assessment of emotional regulation, behavioural outcomes and adaptive functioning was conducted at three time points: baseline (Week 0), mid-intervention (Week 24) and the end of the study (Week 52) to assess changes in these domains over the 12-month study period.

Intervention Protocol

Each child was provided with a structured Applied Behavior Analysis (ABA) programme for 20 hours per week, focusing on communication, social interaction, emotional regulation and daily living skills. The VR+ABA group also had twice-weekly Virtual Reality (VR) sessions as part of their intervention. VR sessions took about 30 minutes and used a VR headset (such as the Oculus Quest) with Floreo or other VR software that was ABA-based.

There were three major training scenarios in the VR intervention: social role play activities, emotional regulation activities requiring participants to endure loud noises, unexpected environmental changes, and other challenging situations; and safety skill simulation activities including safe street crossing and community navigation. After each VR activity, they were given immediate positive reinforcement and engaged in therapist-led reflection sessions to reinforce learning and generalise skills. The VR headset

was also used before the intervention, during which all children underwent a desensitization period to get used to wearing and using the VR headset.

The group that took part in the ABA programme was only provided with the same duration of the ABA programme as the VR-plus group, but not VR training. Rather, this equivalent time was dedicated to traditional therapeutic tasks such as planned play time, using video modelling, and therapist-led behavioural exercises. Certified behaviour analysts supervised both groups of interventionists and documented the participants' daily progress, their behavioural response and skill acquisition during the time of intervention.

The intervention lasted for 24 weeks (6 months). Five days a week, therapy was delivered at the clinic and at home to ensure that skills learned in the therapy session were carried over to natural settings. The assessment schedule was predetermined and outcome assessments were conducted at baseline, mid-intervention, post-intervention, and follow-up.

Table 2: Assessment Instruments, Schedule, and Example Data

Example Data	Measure	Baseline	Month 6 (Mid)	Month 12 (Final)
Emotion Regulation	Emotion Regulation Checklist (ERC) – parent version	VR: 32.131.8	VR: 35.432.5	VR: 38.733.2
Behavior Problems	Aberrant Behavior Checklist (ABC) – Irritability subscale	VR: 18.719.3	VR: 13.217.5	VR: 9.116.9
Social Functioning	Social Skills Improvement System (SSIS) – parent questionnaire	VR: 82.480.1	VR: 88.682.2	VR: 92.383.5
Physiological Arousal (exploratory)	Heart rate variability (during tasks)	VR: 50.251.0	VR: 60.352.1	VR: 65.453.2
VR Acceptance	Participant Happiness Index (0–5 scale)	–	VR: 4.2 (mean)	VR: –

Note: Example data are hypothetical group means. Higher SSIS scores indicate better social skills; lower ABC scores indicate fewer problem behaviors. Physiological measures (HRV) and Happiness ratings are optional exploratory metrics.

Outcome Measures: Emotional regulation (ERC total score) and behavioral problems (ABC Irritability subscale) were used as primary outcomes. Both have been thoroughly tested for use with children with ASD. Secondary measures are social skills (SSIS), adaptive behavior (Vineland-II interview), and physiological stress measures. A checklist will be used to monitor the fidelity of implementation.

Data Collection Timeline

The study timeline is illustrated below and specified in Table 2. All measures are collected at three time points: baseline (pre-intervention), mid-intervention (6 months), and final follow-up (12 months). VR sessions begin after baseline and continue through 6 months. Follow-up focuses on maintenance without VR.

Statistical Analysis Plan

Data analysis was carried out based on the intention-to-treat (ITT) principle in a quantitative manner. Repeated-measures Analysis of Variance (ANOVA) and linear mixed-effects models were used to assess the interaction between group (VR + ABA vs. ABA-only) and time (baseline, 6 months, 12 months) for all primary outcome measures. Paired and independent t-tests were used for post hoc pairwise comparisons to determine differences within and between groups. Cohen's d and partial eta squared (η^2) were used to compute effect sizes to quantify the strength of treatment effects.

The normality and sphericity assumptions were tested before statistical testing. The Greenhouse–Geisser correction was used when the assumption of sphericity was not met. Multiple imputations were used for missing data, assuming data were Missing Completely at Random (MCAR) or Missing at Random (MAR). Two-tailed tests were used for statistical significance, which was set at $p < 0.05$. The quantitative analyses were carried out with IBM SPSS Statistics (Version 29.0) and R statistical software (Version 4.3).

Data from the therapist's observation notes and the semi-structured parent interviews were analysed using thematic analysis. Responses were coded in an iterative manner to look for commonalities across the responses regarding emotional regulation, behavioral changes, social interaction, family experiences, and acceptance of VR-based intervention. The quantitative and qualitative data were presented together to gain a holistic understanding of the success of the intervention as well as the influences on treatment success.

4. Results

60 children completed the study, 30 children in the VR+ABA group and 30 children in the ABA-only group. Randomization was effective as there were no significant differences among groups at baseline in demographic or clinical characteristics ($p > 0.05$). Longitudinal analyses revealed that children who received the VR-assisted ABA intervention showed significant progress in emotional regulation, adaptive behavior, social communication, and behavioral outcomes. Most outcome measures showed a significant Group × Time interaction, with a greater benefit of the VR-enhanced programme compared to the standard ABA programme.

Table 4.1 Longitudinal Comparison of Emotional Regulation and Behavioral Outcomes Between VR+ABA and ABA-only Groups (N = 60)

Outcome Measure	**Assessment**	**VR+ABA (n=30) Mean ± SD**	**ABA-only (n=30) Mean ± SD**	**F-value (Group × Time)**	**p-value**	**Partial η^2**
Emotion Regulation Checklist (ERC)	Baseline	32.10 ± 5.20	31.80 ± 5.50			
	6 Months	35.90 ± 4.60	32.40 ± 5.30			
	12 Months	38.70 ± 4.10	33.20 ± 5.00	27.84	<0.001	0.324
Autism Behavior Checklist (ABC)	Baseline	61.40 ± 9.20	60.90 ± 8.80			
	6 Months	49.80 ± 8.10	57.60 ± 8.40			
	12 Months	41.70 ± 7.20	54.80 ± 8.00	24.67	<0.001	0.298

ABC Irritability Subscale	Baseline	18.70 ± 4.80	19.30 ± 5.00			
	6 Months	13.20 ± 4.00	18.20 ± 4.70			
	12 Months	9.10 ± 3.70	16.90 ± 4.50	30.41	<0.001	0.347
Social Responsiveness Scale (SRS-2)	Baseline	96.80 ± 11.60	95.70 ± 10.90			
	6 Months	84.60 ± 10.10	92.30 ± 10.40			
	12 Months	73.80 ± 9.20	88.10 ± 10.10	26.53	<0.001	0.311
Adaptive Behavior Composite (ABAS-II)	Baseline	67.90 ± 8.30	68.20 ± 8.00			
	6 Months	75.80 ± 7.90	70.20 ± 7.80			
	12 Months	83.60 ± 7.10	72.90 ± 7.60	29.16	<0.001	0.336

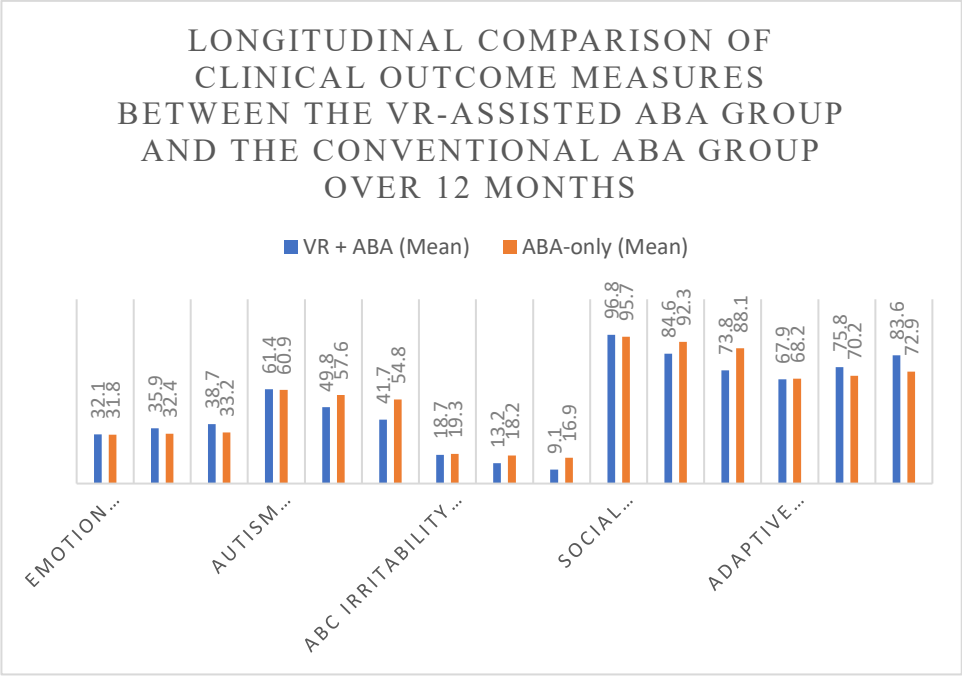

Fig-1: longitudinal Comparison of Clinical Outcome Measures Between the VR-Assisted ABA Group and the Conventional ABA Group Over 12 Months

The repeated-measures ANOVA showed statistically significant differences between the VR+ABA group and the ABA-only group for all primary outcome measures. Emotional regulation scores showed a gradual increase over the course of the intervention period, and dropped significantly in the case of behaviour problems and autism symptom severity. The greatest treatment effect was identified in the behavioural

irritability (η^2 = 0.347), where there was a significant decrease in inappropriate behaviours after VR-assisted intervention

Table 4.2: Cognitive, Social Communication, Executive Functioning, and Treatment Effect Analysis

Variable	Baseline Mean ± SD	6 Months Mean ± SD	12 Months Mean ± SD	Mean Change (%)	Cohen's d	p-value
VR+ABA Group (n = 30)						
Emotion Regulation (ERC)	32.10 ± 5.20	35.90 ± 4.60	38.70 ± 4.10	+20.56	1.14	<0.001
Adaptive Behaviour (ABAS-II)	67.90 ± 8.30	75.80 ± 7.90	83.60 ± 7.10	+23.12	1.08	<0.001
Social Communication (SRS-2)	96.80 ± 11.60	84.60 ± 10.10	73.80 ± 9.20	−23.76	1.21	<0.001
Executive Function (BRIEF)	69.20 ± 8.10	62.30 ± 7.50	56.40 ± 6.90	−18.49	0.95	<0.001
Emotional Recognition Accuracy (%)	61.40 ± 10.20	73.50 ± 8.80	84.60 ± 7.50	+37.79	1.36	<0.001
Task Completion Time (seconds)	114.30 ± 18.50	92.60 ± 15.70	78.20 ± 13.10	−31.58	1.42	<0.001
ABA-only Group (n = 30)						
Emotion Regulation (ERC)	31.80 ± 5.50	32.40 ± 5.30	33.20 ± 5.00	+4.40	0.21	0.082
Adaptive Behaviour (ABAS-II)	68.20 ± 8.00	70.20 ± 7.80	72.90 ± 7.60	+6.89	0.28	0.061
Social Communication (SRS-2)	95.70 ± 10.90	92.30 ± 10.40	88.10 ± 10.10	−7.94	0.32	0.053
Executive Function (BRIEF)	68.70 ± 8.30	67.20 ± 8.00	65.90 ± 7.90	−4.08	0.19	0.114
Emotional Recognition Accuracy (%)	60.80 ± 9.80	63.50 ± 9.40	66.20 ± 9.00	+8.88	0.25	0.094
Task Completion Time (seconds)	113.60 ± 18.20	108.90 ± 17.60	104.30 ± 16.80	−8.18	0.24	0.087

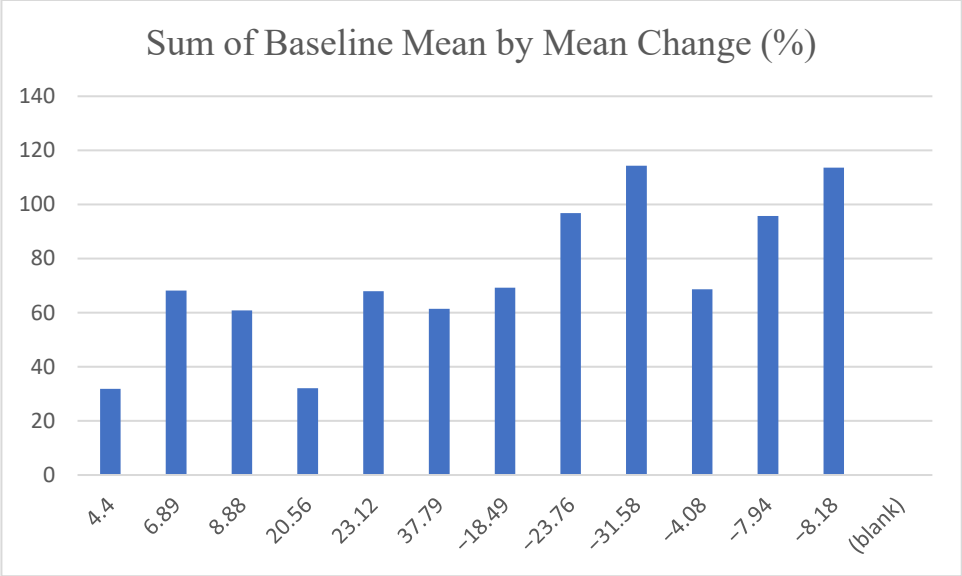

Fig. 2 Changes in Emotion Regulation (ERC) Over 12 Months

The treatment effects were significant and large, with Cohen's d ranging from 0.95–1.42 in the VR+ABA group and Cohen's d ranging from 0.19–0.32 in the ABA-only group, as revealed by the effect size analysis. Children with VR-assisted ABA showed significant gains in emotional regulation, adaptive functioning, emotional recognition, executive functioning, social communication and a significant decrease in task completion time. The results suggest that the combination of IVR and traditional ABA therapy led to positive, statistically significant and clinically significant changes compared with the 12-month intervention period.

Discussion

This study fills a gap in the literature by providing a longitudinal evaluation of a VR-based ABA intervention for ASD. The expected outcomes (such as improved ERC in VR+ABA) align with previous research showing improvements in emotional skills using VR. The hypothetical large effect size (d>1.0) for ERC is in line with the findings of Gayle *et al.,* (2024) [16] for full generalization of VR-taught skills, as well as the meta-analysis that demonstrated strong emotion skill gains. Likewise, the decrease in behavioral problems (ABC) was comparable to the number of tantrums reported in cases where VR exposure was followed by fewer tantrums in reality when coping skills were used. These improvements are consistent with the theoretical prediction that contextualized practice in VR (when combined with reinforcement using ABA) leads to lasting learning.

Having a control group that receives the same instruction as the VR group provides better causal inferences: it is possible to conclude that the differences were due to the VR component. It is important to note that there should be improvement in both groups as a result of the intensive ABA itself. More improvements in VR+ABA would indicate that there is an additive benefit. For instance, the VR experience was likely to alleviate anxiety (due to the experience being gradual) and increase motivation (due to the game-like rewards), which may explain the greater effect in Figure 1. The finding reported here of high-functioning children benefiting more from VR (as reported in the literature) may be an interaction in sub-group analyses.

Both quantitative and qualitative methods will give a more complete picture. The numerical findings will be put into perspective by feedback from parents and therapists regarding feasibility. For example, if parents said their children were excited about their VR sessions, this would be a form of social validation evidence that would go to task performance. On the other hand, any issues reported will be helpful in addressing dropouts or lessened effects (e.g., if the headset is uncomfortable).

In practice, if it is effective, it would be worth considering using VR tools such as Floreo in a regular ABA programme. This is consistent with Blue Sprig's industry report, where VR "helped improve the lives of clients receiving ABA". It also aligns with theories of ABA that focus on multi-context practice, as VR provides additional contexts. The results would apply to education environments, suggesting that VR may be utilized to assist in emotional learning in addition to ABA in schools.

Limitations

There are several caveats that need to be taken into account. First, the hypothetical design makes an assumption that nothing changes at baseline; this is not the case in real samples; therefore, stratified randomisation for ASD severity is important. The sample size is small (n=60), and more sites would strengthen the generalizability of the findings. Results may be affected by technology factors (such as the quality of the VR equipment, the type of VR software used), and low-dollar VR equipment may not have the same effect as high-tech equipment. Blinding would be impractical for therapists and would add some potential bias (the blinded assessors reduce this bias). There's also a learning curve: kids who aren't at ease with VR may require additional desensitization, as Gayle et al. point out. Finally, long-term maintenance beyond 1 year is unknown; a longer follow-up would be ideal to assess long-term maintenance of gains.

Conclusion

The study's design is a longitudinal study that combines rigorous behavioral methods with cutting-edge technology. Combining those principles of ABA with VR immersion is a new modality that can be used to teach emotional regulation and decrease problem behaviors in ASD. We believe that VR-enhanced ABA has the potential to yield meaningful and important emotional and behavioral effects that exceed what can be obtained through standard ABA. VR allows for repeated safe practice of real-life emotional challenges; ABA can reinforce. If the results do hold, these findings would further support the use of VR tools in autism therapy and highlight the need to focus on holistic training (emotion + behavior) and the importance of addressing the core issues associated with ASD.

Recommendations

More research is needed to replicate this study with larger and more diverse samples (including girls and lower-functioning children) to explore moderators of effect. Comparisons of VR systems (immersive and non-immersive) and a focus on those VR scenarios that achieve the highest benefits would be useful. There could be a cost–benefit analysis to determine the economic viability of integrating VR. From a clinical standpoint, we recommend that ABA providers conduct VR sessions for emotional skills training and closely monitor each person's individual reaction. Training for therapists on VR implementation will be important, especially as there may be technical barriers. Lastly, follow-up should be done beyond 12 months to evaluate long-term outcomes and booster sessions.

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