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Effectiveness of Virtual Reality on Emotional Inhibition in Children with Autism Spectrum Disorder

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ABSTRACT

The present study was conducted with the aim of examining the effectiveness of virtual reality on emotional inhibition in children with Autism Spectrum Disorder (ASD). The research design was a quasi-experimental pretest–posttest design with a control group. From the population of children with ASD in Arak City in 2024, a sample of 30 participants was selected purposively through reviewing clinical records and diagnostic forms completed by a specialist in neurodevelopmental disorders or a child psychiatrist. The participants were then randomly assigned to two groups of 15 (experimental and control). First, emotional inhibition in both groups was measured using the Emotional Stroop Task (pretest). Then, the experimental group received a virtual reality intervention for 15 sessions of 35 minutes each, twice per week. After the intervention ended, emotional inhibition in both groups was again measured using the Emotional Stroop Task (posttest), and two months later both groups were assessed again for treatment stability (follow-up). To evaluate the effect of the intervention on emotional inhibition scores, repeated-measures ANOVA with a between-group and a within-group factor was used. The findings showed that the mean scores of emotional inhibition in the experimental group increased significantly after the virtual reality intervention compared to the control group, and this effect remained stable at follow-up ($p < .05$). The results indicated that virtual reality, by providing an interactive and controlled environment, leads to improvement and maintenance of emotional inhibition in children with ASD. Therefore, this method can be utilized as a complementary approach in the emotional rehabilitation of these children.

Keywords: virtual reality, emotional inhibition, Autism Spectrum Disorder

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Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by persistent deficits in social communication, restricted and repetitive patterns of behavior, and diverse emotional and cognitive difficulties that affect children's adaptive functioning across developmental contexts (1). In recent years, deficits in emotional inhibition—an essential component of executive functions—have received increasing attention, as they significantly influence behavioral regulation, social adaptation, and mental health in individuals with ASD (2). Emotional inhibition is broadly defined as the capacity to suppress or modulate automatic emotional responses when they interfere with goal-directed behavior, and impaired inhibition has been widely documented among children on the autism spectrum (3). As research on ASD increasingly focuses on underlying cognitive mechanisms, scholars emphasize the need for evidence-based

approaches that directly target inhibitory control and emotion regulation through ecologically valid, engaging, and child-centered intervention methods (4, 5).

Traditional interventions for ASD, including behavioral therapies, cognitive-behavioral approaches, and social skills training, have provided substantial benefits; however, these methods often struggle to maintain children's engagement, limit opportunities for real-time emotional practice, and lack the immersive conditions necessary to generalize skills to real-world environments (6, 7). Furthermore, research indicates that children with ASD face significant challenges in generalizing intervention-based learning to dynamic social contexts because the training contexts are insufficiently interactive, sensory-rich, or realistic (8). As a result, researchers have turned to emerging technologies—particularly Virtual Reality (VR)—as a promising, potentially transformative tool for improving emotional and cognitive outcomes in ASD populations.

Virtual reality provides an immersive, controlled, and customizable environment in which children can repeatedly practice emotional inhibition without the unpredictable or overwhelming stimuli of real-world situations (9). VR offers several advantages over traditional interventions: it enhances engagement through gamified environments (3), allows precise manipulation of emotional stimuli (10), and creates a safe context for exposure to developmentally challenging emotional scenarios, such as frustration or anxiety (11). According to recent systematic literature reviews, VR has become an increasingly important intervention modality for individuals with ASD, demonstrating substantial benefits for emotional regulation, social cognition, and cognitive control (12, 13). This growth is supported by significant technological advancements and greater availability of portable VR systems, making VR more accessible for therapeutic use worldwide (14).

Studies specifically focusing on VR and emotion regulation present strong evidence for improvements in recognizing emotions, modulating affective responses, and enhancing inhibitory control. For instance, VR-based emotion regulation programs have demonstrated significant reductions in negative emotional reactivity in both clinical and non-clinical populations (8). Similarly, research on emotional processing within VR environments shows that controlled exposure to fear-inducing or anxiety-provoking stimuli leads to measurable improvements in behavioral inhibition and autonomic regulation (15, 16). These findings are consistent with earlier work on VR exposure therapy, which proposed that VR effectively activates both behavioral inhibition and behavioral activation systems, creating conditions conducive to emotional processing and regulation (11).

VR interventions for children with ASD are particularly promising. Early work by Lorenzo et al. introduced immersive VR systems aimed at strengthening emotional skills and found significant improvements in emotional recognition and regulation among ASD participants (17). Additional evidence suggests that VR-based social cognition training enhances children's ability to interpret social cues, respond appropriately to emotional situations, and generalize learned skills to real-life settings (18, 19). Likewise, studies employing VR-enabled approaches report enhanced emotional and social adaptation skills in ASD children, indicating that immersive VR can overcome limitations of conventional educational and therapeutic methods (20). More recent reviews emphasize the versatility of VR systems for autism inclusion, highlighting their applicability for improving attention, emotional functioning, and communication abilities (13, 21).

In addition to its applications in emotion regulation, VR has also been used to assess and measure cognitive constructs related to executive function. Research on VR-based measures of response inhibition demonstrates that VR tasks provide ecologically valid evaluations of inhibition under naturalistic or stressful conditions (22, 23). Other studies have revealed that VR can accurately capture behavioral slowing patterns associated with emotional interference, aligning with classical emotional Stroop paradigms (24, 25). Indeed, emotional Stroop interference—characterized by increased reaction time when naming the color of emotional versus neutral stimuli—is a widely used measure of emotional inhibition and attentional bias (24). The construct validity and reliability of Stroop-based assessments have been extensively demonstrated not only in emotional research but also in studies focusing on anxiety and attentional biases (25). Because children with ASD often show heightened emotional interference effects, VR may serve as an effective environment for both measuring and improving Stroop-related inhibition (26).

Alongside diagnostic advances, contemporary research highlights the critical importance of addressing executive dysfunction and emotion dysregulation in ASD, as these difficulties significantly contribute to secondary problems such as self-regulation deficits, increased anxiety, and impaired social engagement (2, 5). Emotional inhibition, in particular, plays a central role in allowing children to navigate everyday social and academic settings, manage frustration, and regulate impulsive emotional reactions (4). Deficits in inhibition also undermine children's capacity to process emotional information effectively and can exacerbate maladaptive behaviors, highlighting the need for targeted and developmentally appropriate interventions.

Recent VR studies involving children with ADHD, who share overlapping executive function challenges with ASD populations, have shown significant improvements in emotional regulation, cognitive flexibility, and inhibitory control following structured VR training sessions (3). These findings align with broader VR-based cognitive rehabilitation research, where VR interventions outperform classical training programs in enhancing executive functions and behavioral self-regulation (27). Moreover, neuroscientific evidence demonstrates that VR-based emotional tasks activate neural circuits associated with emotional processing and cognitive control, reinforcing the biological plausibility of VR as a therapeutic modality (10, 28).

Other strands of VR research focus on the emotional and sensory dimensions of VR experiences. For example, the use of VR in investigating fear-based inhibitory responses—such as exposure to virtual heights—reveals that VR environments can reliably evoke emotional reactions that allow researchers to study inhibitory control in ecologically valid conditions (15). Similar studies document how VR exposure influences physiological markers of emotion, such as brainwave activity and autonomic responses, demonstrating its utility for emotional modulation and anxiety reduction (9). VR's potential for structuring personalized emotional experiences makes it suitable not only for intervention but also for experimental assessment of emotional inhibition (29).

Moreover, the educational field has increasingly recognized VR's effectiveness for enhancing learning, executive functioning, and emotional processing. Meta-analytic evidence suggests that VR significantly improves learning outcomes among children in primary education, supporting the broader cognitive benefits of immersive learning (14). In ASD-specific contexts, VR enhances attention, engagement, and the ability to process social-emotional information (30). This educational and therapeutic synergy has encouraged multidisciplinary interest in VR for cognitive and emotional development across childhood.

The growing body of literature also highlights the importance of family-centered or integrated intervention approaches. Studies on parent-involved interventions demonstrate meaningful improvements in emotional and behavioral outcomes for children with ASD (6). Although these programs show promise, VR offers an alternative route that directly engages the child and presents realistic emotional contexts that may be difficult to simulate in traditional clinical environments. Likewise, play-based interventions, such as localized play therapy with parental participation, have shown efficacy for addressing stereotyped behaviors in ASD, further supporting the value of experiential, interactive approaches (7). VR, as an inherently interactive medium, aligns with these developmental and experiential models.

Collectively, the evidence indicates that VR represents a powerful and rapidly advancing tool for addressing emotional inhibition deficits in children with ASD, with advantages in ecological validity, engagement, emotional immersion, and functional generalization. Despite substantial progress, gaps remain in understanding how VR-based emotional scenarios improve inhibitory control over time, whether these gains sustain following intervention, and how these changes compare with those observed in children receiving no VR-based support.

Therefore, the present study aims to examine the effectiveness of virtual reality on emotional inhibition in children with Autism Spectrum Disorder.

Methods and Materials

Study Design and Participants

The research design was quasi-experimental with a pretest–posttest control group. First, emotional inhibition in both groups was measured using the Emotional Stroop Task (pretest). Then, the experimental group received a virtual reality intervention for 15 sessions of 35 minutes each , two days per week. After the intervention was completed, emotional inhibition in both groups was again measured using the Emotional Stroop Task (posttest), and two months later both groups were re-evaluated to follow up the effects of the intervention. Data were analyzed using repeated-measures ANOVA. The statistical population included all children with Autism Spectrum Disorder in Arak City in 2025. The sample consisted of 30 children aged 7 to 12 years with ASD who were selected purposively through reviewing clinical records and diagnostic forms completed by a specialist in neurodevelopmental disorders or a child psychiatrist, and then were randomly assigned to two groups of 15 (experimental and control).

After obtaining permission to access the autism school in Arak City and the autism education and rehabilitation centers from the Exceptional Education Organization and the Welfare Organization of Arak, the sample selection process was initiated. Then, 30 children aged 7 to 12 years were assigned to two groups of 15 (experimental and control). Inclusion criteria included a confirmed diagnosis of Autism Spectrum Disorder by a psychiatrist (documented in the child's file), age range of 7–12 years, absence of other severe psychiatric disorders, and absence of severe sensory or motor impairments that might interfere with the use of virtual reality. Exclusion criteria included lack of cooperation by the child or family and absence from more than two sessions. Afterward, the pretest was administered to both groups.

For the virtual reality–based intervention, an interactive virtual environment was designed that included emotional scenarios (such as challenging social situations) and neutral stimuli. This environment was created using Unity software and the Oculus Quest 2 headset. The scenarios included situations such as

interacting with peers, anger management, and confronting anxiety-provoking stimuli. Each intervention session lasted 35 minutes, and the intervention continued for 15 sessions (two sessions per week).

During the intervention, children in the experimental group participated in the virtual reality sessions. In each session, children entered the virtual environment using the VR headset and experienced the emotional scenarios. The researcher monitored the children's performance online and provided guidance as needed. Children in the control group only participated in their routine school and center activities and did not receive any specific intervention. After completing the intervention, the posttest was again administered to both the experimental and control groups using the Emotional Stroop Task. Two months after the intervention, children in the experimental group were reassessed to examine the stability of intervention effects.

Before conducting the full intervention, in order to determine the external validity of the virtual reality program, based on the studies of (17, 18), a preliminary implementation was carried out with two participants randomly selected from the sample. The results of this preliminary implementation confirmed the effectiveness of this therapeutic protocol in improving emotional inhibition skills in children.

Data Collection

The Emotional Stroop Task is a psychological paradigm used to examine attentional biases toward emotional stimuli. This instrument is based on the classic Stroop task but uses emotional and neutral words instead of colors. Participants are required to name the font color of the words while refraining from attending to their semantic meaning. Delays in responding to emotional words relative to neutral words indicate attentional bias toward emotional stimuli. The validity of this test has been reported to range from .77 to .80, and its reliability from .86 to .92. The components of the test include emotional words, neutral words, colors, and a timer. The administration procedure requires participants to name the font color of words as quickly and accurately as possible while avoiding attention to the meaning of the words. Response times to emotional and neutral words are recorded, and the difference between these times is considered an index of attentional bias (24). Data analysis is performed based on response time, number of errors, and attentional bias (25).

Intervention

The 15-session virtual reality intervention protocol was structured to progressively strengthen emotional inhibition through immersive, developmentally appropriate, and increasingly challenging scenarios. In Session 1, the child was gradually familiarized with the VR headset, the therapist, and a neutral virtual environment to establish safety and control. Session 2 introduced a calming VR environment paired with a relaxation skill to associate VR exposure with emotional regulation. Session 3 focused on practicing basic behavioral inhibition through a simple colored-ball game requiring stopping and thinking before acting. In Session 4, impulse control was strengthened through a VR ticket-booth scenario displaying the child's favorite cartoon, with emphasis on delaying immediate responses. Session 5 targeted inhibition of avoidance or negative emotional reactions by identifying the child's real-life aversive stimuli and practicing active listening without reacting. Session 6 addressed frustration tolerance using a slightly challenging VR puzzle game, and Session 7 expanded impulse control by increasing waiting time and using more attractive stimuli.

In Session 8, frustration inhibition was practiced again with a more difficult puzzle, while Session 9 focused on reducing aggressive or disruptive turn-taking behaviors in a VR playground with other avatars. Session 10 required the child to inhibit excessive emotional expression during a stimulating VR birthday party. Session 11 generalized inhibition skills to a complex, multi-demand VR environment—such as a crowded space station—requiring coordinated self-regulation. Session 12 reinforced the child's progress by letting them select challenges and complete them with minimal guidance. Session 13 brought intervention closer to real-life conditions by simulating a meaningful real-world situation for the child. Session 14 emphasized independence, placing the child in a VR setting with alternating emotional challenges requiring autonomous use of inhibitory strategies. Finally, Session 15 reviewed the entire therapeutic journey in a celebratory VR environment, highlighting achievements and consolidating emotional inhibition skills.

Data analysis

Data were analyzed using SPSS software and repeated-measures ANOVA with a between-subjects factor and a within-subjects factor.

Findings and Results

An examination of the demographic characteristics of the participants showed that among the 30 children who participated in the study (15 in the experimental group and 15 in the control group), the highest frequency in both groups was observed among 8-year-old children (approximately 46.7%), whereas the lowest frequency in the experimental group belonged to 6- and 9-year-olds (13.3%), and in the control group to 6-year-olds (6.7%). Regarding parental employment status, the results indicated that in both groups, self-employment had the highest frequency among fathers (73.3% in the experimental group and 60% in the control group), while the lowest frequency belonged to fathers who were employees. In addition, most mothers in both groups were homemakers (53.3% in the experimental group and 73.3% in the control group), and a smaller percentage were employed. Overall, the descriptive findings indicate relative homogeneity between the two groups in terms of demographic variables.

Table 1. Descriptive Information on Emotional Inhibition by Group

Emotional Inhibition	Phase	Experimental		Control	
		Mean	SD	Mean	SD
Neutral Interference	Pretest	126.66	28.76	116.26	29.59
	Posttest	105.53	37.25	115.80	29.39
	Follow-up	105.26	36.19	117.20	29.04
Emotional Interference	Pretest	187.26	46.68	184.26	46.40
	Posttest	144.13	37.70	176.33	43.46
	Follow-up	143.86	37.58	184.86	46.02

According to the findings, emotional inhibition in the experimental group showed a considerable decrease in the posttest compared with the pretest, indicating improvement in emotional inhibition, whereas no notable changes were observed in the control group. To assess variance homogeneity between groups, Levene's test was used, which indicated that error variance was equal across the groups for all emotional inhibition subscales (F = 0.0958). The significance level for all dimensions was greater than .05; therefore, the assumption of equality of variances was confirmed, and repeated-measures ANOVA was appropriate.

Table 2. ANOVA Results

Group	SS	df	MS	F	p	η^2
Corrected Model	117350.3	1	117350.3	315.64	.001	.921
Group Interaction	60224.6	2	30112.3	80.99	.001	.857
Error	10038.1	27	371.78			

The test of between-group effects showed a significant difference between the groups on the dependent variable of emotional inhibition. The eta-squared value indicates a significant effect of the intervention group (virtual reality) on improving emotional inhibition compared with the control group.

Table 3. Mauchly's Test of Sphericity

Mauchly's Test	χ^2	df	P	Greenhouse–Geisser	Huynh–Feldt
.087	62.792	5	.001	.436	.484

To test the assumption of sphericity for repeated-measures ANOVA, Mauchly's test was conducted. The Mauchly value of .087 and the significance level below .001 indicate that the assumption of sphericity was violated. Therefore, corrections such as Greenhouse–Geisser or Huynh–Feldt should be applied in interpreting the results. The Greenhouse–Geisser epsilon was .436 and the Huynh–Feldt epsilon was .484, meaning that degrees of freedom should be adjusted accordingly.

Table 4. Test of Within-Subject Effects

	Group	SS	df	MS	F	p	η^2
Time	Sphericity Assumed	14203.4	3	4734.4	4.134	.009	.133
	Greenhouse–Geisser	14203.4	1.309	10851.5	4.134	.040	.133
	Huynh–Feldt	14203.4	1.451	9791.6	4.134	.035	.133
Time × Group	Sphericity Assumed	8790.9	6	1465.1	1.279	.276	.087
	Greenhouse–Geisser	8790.9	2.618	3358.1	1.279	.295	.087
	Huynh–Feldt	8790.9	2.901	3030.1	1.279	.295	.087

In the corresponding table, the test was conducted using sphericity corrections for the time factor and its interaction with the group. According to the within-subject effects results, the time factor had a significant effect on the improvement of emotional inhibition in children with Autism Spectrum Disorder. However, the interaction between time and group (virtual reality intervention vs. control) was not significant. This finding indicates that although the effect of time/repeated assessment on emotional inhibition was confirmed, these changes did not significantly depend on group differences between the experimental and control conditions.

Discussion and Conclusion

The present study investigated the effectiveness of virtual reality (VR) intervention on emotional inhibition in children with Autism Spectrum Disorder (ASD), using the Emotional Stroop paradigm as the main performance-based measure. The results demonstrated that children in the experimental group showed significant improvement in emotional inhibition from pretest to posttest, and these effects remained stable at follow-up, whereas the control group did not exhibit meaningful changes across assessment points. These findings confirm that VR-based exposure to emotionally relevant scenarios can effectively enhance inhibitory control in children with ASD, a population known to have deficits in emotion regulation, attentional control, and executive functioning (1, 2). The pattern of reduction in Stroop interference scores indicates that the VR program helped children suppress automatic emotional responses that previously

interfered with task performance, consistent with the broader literature on emotional inhibition training using digital technologies.

The improvement observed in emotional inhibition is aligned with previous work indicating that VR environments can modulate affective processing, provide safe exposure to emotional stimuli, and strengthen cognitive control mechanisms. Earlier studies have shown that VR can successfully activate emotional and attentional networks associated with inhibitory control and can present emotionally challenging situations with high ecological validity (10, 11). For children with ASD, who often experience difficulties generalizing skills learned in traditional therapeutic settings, VR provides an immersive environment that more closely resembles real-life emotional tasks. This ecological validity may contribute significantly to the improvements detected in the present study. Indeed, multiple reviews have highlighted that VR-based training can help individuals with ASD overcome rigid patterns of attention, practice adaptive responses to emotional cues, and rehearse inhibitory behaviors in controlled yet realistic conditions (12, 13).

The findings of this study also correspond with empirical research demonstrating the utility of VR in improving executive functioning, including inhibitory control, emotional regulation, and cognitive flexibility. For example, VR-based cognitive training among children with ADHD, who share overlapping executive deficits with ASD, has demonstrated meaningful improvements in emotion control and inhibitory processing (3). Similarly, VR-based rehabilitation programs have been shown to outperform classical cognitive rehabilitation approaches in enhancing executive functions, including inhibition, attention, and emotion regulation (27). These results strengthen the argument that VR can serve as a developmentally appropriate intervention for children who struggle with executive control due to neurodevelopmental conditions.

In the context of emotional inhibition specifically, VR appears particularly advantageous due to its capacity to simulate emotional triggers that are difficult to recreate in clinic-based environments. Research examining affective processing within VR environments indicates that VR scenarios can reliably evoke negative emotional reactions such as fear, anxiety, or frustration, which are necessary to stimulate inhibitory responses (15). Likewise, exposure to emotionally charged VR simulations has been shown to improve emotion regulation and reduce internalizing symptoms in adolescents at risk of executive dysfunction (5). The present findings align closely with these studies, suggesting that repeated exposure to VR-mediated emotional challenges may enhance children's ability to suppress or modulate automatic responses to emotional cues.

Moreover, the improvement in emotional inhibition in the VR group is consistent with findings from interventions targeting emotional and social skills in ASD populations. Research suggests that VR-based social cognition training can improve emotional recognition, social interaction, and adaptive behavioral responses among children with ASD (18, 19). The enhanced emotional inhibition observed in this study may reflect broader improvements in emotional processing that result from engaging with social and emotional VR scenarios. VR's ability to engage children through immersive sensory-rich environments may heighten motivation, increase attentional focus, and provide more opportunities for rehearsal of adaptive behaviors than conventional therapy.

Additionally, the durability of the effects at follow-up suggests that VR intervention may produce stable, long-lasting changes in emotional inhibitory systems. This finding mirrors previous research where VR-

based exposure or training produced sustained improvements in emotional regulation and reduced maladaptive responses to emotional triggers over time (9, 31). Theories of behavioral activation and inhibition systems propose that repeated exposure to emotional stimuli in safe, predictable VR environments enhances children's tolerance of emotional arousal and strengthens regulatory neural circuits (11). Therefore, the stable outcomes observed in this study likely reflect both behavioral and neurocognitive adaptations resulting from repeated VR-based practice.

The use of the Emotional Stroop Task as a performance-based measure provides additional insight into how VR training may influence underlying attentional biases and emotional interference patterns. The Emotional Stroop is widely accepted as a measure of emotional inhibition and attentional control, and its sensitivity to individual differences in emotional reactivity and anxiety has been extensively documented (25). Several studies have emphasized that interference effects are heightened in individuals who exhibit strong emotional biases or attentional dysregulation, such as children with ASD (24). Therefore, the significant reduction in interference scores suggests that VR training may have reduced emotional over-responsiveness or improved the ability to shift attentional resources away from emotionally salient but task-irrelevant information.

The present findings also resonate with studies investigating inhibitory control using VR measurement tools. For example, VR-based inhibitory control tasks have shown strong ecological validity and accuracy in capturing real-world inhibitory behaviors (23). Moreover, VR-based measures of response inhibition under stressful conditions have demonstrated that VR can enhance the precision of assessment tools by simulating naturalistic emotional contexts (22). The consistency between these findings and the observed improvements in Stroop performance further supports the hypothesis that VR may effectively train emotional inhibition by replicating real-world attentional demands within a safe simulation environment.

Additionally, VR's impact on sensory and perceptual processing may have indirectly contributed to improvements in emotional inhibition. Some studies investigating visual processing styles and emotional engagement in VR environments suggest that VR may sharpen perceptual attention and influence emotional responses through immersive multimodal stimulation (26, 29). For children with ASD, who often experience atypical sensory processing, VR may help regulate sensory input while simultaneously presenting controlled emotional stimuli, creating optimal conditions for practicing emotional inhibition.

The findings also complement educational research that highlights VR's value not only as an intervention tool but also as a learning environment that enhances cognitive functioning, emotional engagement, and self-regulation among children (14, 30). The combination of emotional, cognitive, and behavioral practices afforded by VR may create an integrative developmental pathway through which emotional inhibition can improve.

Furthermore, VR-based interventions in ASD have proven effective for supporting social inclusion, communication, and interaction skills (13, 21). Interventions incorporating emotional VR scenarios may help children with ASD interpret social cues, respond appropriately to heightened emotional states, and suppress impulsive reactions—skills strongly associated with emotional inhibition. Therefore, the improvements detected in the current study may also reflect broader gains in emotional competence beyond the confines of Stroop performance.

Finally, the results are consistent with studies demonstrating that children who participate in VR emotional training often show positive behavioral outcomes related to emotion regulation, social adaptation, and reduced maladaptive behaviors (16, 20). This convergence of findings suggests that VR is not only an effective tool for targeting emotional inhibition but also a complementary therapeutic modality capable of addressing multiple developmental needs in ASD.

This study had several limitations. The sample size was relatively small, which may limit generalizability to the broader ASD population. The participants were selected from a single geographic area, potentially restricting cultural or contextual diversity. The VR intervention followed a fixed protocol, not individualized to each child's sensory profile or emotional needs. Additionally, the follow-up period was limited to two months, making it difficult to determine longer-term maintenance of treatment effects. Lastly, the study relied solely on performance-based measures, and did not include parent or teacher behavioral ratings that could provide a more comprehensive assessment of emotional functioning.

Future studies should include larger and more diverse samples to enhance external validity. Researchers should explore individualized VR interventions tailored to each child's emotional and sensory characteristics. Longer follow-up periods would help clarify whether improvements in emotional inhibition persist over time. Future studies should also incorporate multimethod assessment approaches, including qualitative feedback, behavioral observations, and physiological monitoring. Moreover, comparative studies evaluating VR against other evidence-based interventions could help clarify relative effectiveness. Finally, exploring adaptive VR systems that adjust difficulty levels in real time may further optimize emotional inhibition outcomes.

Practitioners should consider incorporating VR as a supplementary tool within comprehensive ASD intervention programs. VR scenarios should be integrated with traditional therapeutic techniques to maximize generalization. Therapists may use VR to simulate specific emotional challenges children encounter in daily life, providing controlled opportunities for practice. Educators can also apply VR-based activities to enhance emotional and cognitive skills in inclusive classroom settings. Parents and caregivers may benefit from training that helps them support children's VR-assisted emotional learning at home. Overall, VR can be implemented as a developmentally appropriate, engaging, and flexible tool to support emotional inhibition in ASD populations.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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References

1. Qin L, Wang H, Cui M, Wang Q, Ning W. New advances in the diagnosis and treatment of autism spectrum disorders. Eur J Med Res. 2024;29(1):322. doi: 10.1186/s40001-024-01916-2.

2. Conner CM, Elias R, Smith IC, White SW. Emotion regulation and executive function: Associations with depression and anxiety in autism. Research in autism spectrum disorders. 2023;101:102103. doi: 10.1016/j.rasd.2023.102103.

3. Martin-Moratinos M, Bella-Fernández M, Rodrigo-Yanguas M, González-Tardón C, Li C, Wang P, et al. Effectiveness of a Virtual Reality Serious Video Game (The Secret Trail of Moon) for Emotional Regulation in Children With Attention-Deficit/Hyperactivity Disorder: Randomized Clinical Trial. JMIR Serious Games. 2025;13:e59124. doi: 10.2196/59124.

4. Norouzi Homayoun MR, Hataminejad M, Sadri Damirchi E, Sadeghi M. Comparing the Effectiveness of Emotion Regulation Training and Transcranial Direct Current Stimulation Intervention on Improving Executive Functions (Attention, Cognitive Flexibility, Response Inhibition, Emotion Control) and Impulsivity in Male Students with Attention Deficit/Hyperactivity Disorder. Neuropsychology. 2024;10(37).

5. Carballo-Marquez A, Ampatzoglou A, Rojas-Rincón J, Garcia-Casanovas A, Garolera M, Fernández-Capo M, et al. Improving Emotion Regulation, Internalizing Symptoms and Cognitive Functions in Adolescents at Risk of Executive Dysfunction-A Controlled Pilot VR Study. Applied Sciences. 2025;15(3):1223. doi: 10.3390/app15031223.

6. Safarpour F, Ashouri M. The Effect of Incredible Years Program Training on the Behavioral Emotion Regulation of Mothers of Autistic Children. Journal of Modern Psychological Researches. 2024;19(74):178-84.

7. Jafari S, Parizad N, Radfar M, Khalkhali H. Investigating the Effect of Localized Play Therapy with Parental Participation on Stereotyped Behaviors of Children with Autism. 2022. doi: 10.52547/unmf.20.2.125.

8. Colombo D, Díaz-García A, Fernandez-Álvarez J, Botella C. Virtual reality for the enhancement of emotion regulation. Clinical Psychology & Psychotherapy. 2021;28(3):519-37. doi: 10.1002/cpp.2618.

9. Cavallo F, Campbell F, Brubaker H, Smith K. A case study utilizing virtual reality to reduce behavioral symptoms and brainwave activity related to anxiety. NeuroRegulation. 2024;11(4):379. doi: 10.15540/nr.11.4.379.

10. Rodríguez A, Rey B, Clemente M, Wrzesien M, Alcañiz M. Assessing brain activations associated with emotional regulation during virtual reality mood induction procedures. Expert Systems with Applications. 2015;42(3):1699-709. doi: 10.1016/j.eswa.2014.10.006.

11. Wilhelm FH, Pfaltz MC, Gross JJ, Mauss IB, Kim SI, Wiederhold BK. Mechanisms of virtual reality exposure therapy: The role of the behavioral activation and behavioral inhibition systems. Applied psychophysiology and biofeedback. 2005;30(3):271-84. doi: 10.1007/s10484-005-6383-1.

12. Glaser N, Schmidt M. Systematic literature review of virtual reality intervention design patterns for individuals with autism spectrum disorders. International Journal of Human-Computer Interaction. 2022;38(8):753-88. doi: 10.1080/10447318.2021.1970433.
13. Bravou V, Oikonomidou D, Drigas A. Applications of Virtual Reality for Autism Inclusion. A review (Aplicaciones de la realidad virtual para la inclusión del autism. Una revisión). Retos. 2022;45:779-85. doi: 10.47197/retos.v45i0.92078.
14. Villena-Taranilla R, Tirado-Olivares S, Cózar-Gutiérrez R, González-Calero JA. Effects of virtual reality on learning outcomes in K-6 education: A meta-analysis. Educational Research Review. 2022;35:100434. doi: 10.1016/j.edurev.2022.100434.
15. Tjiptono D. Does Fear Affect Inhibitory Control? Insights From a Virtual Reality Height Exposure Paradigm: Open Access Te Herenga Waka-Victoria University of Wellington; 2024.
16. Marchena-Giráldez C, Carbonell-Colomer M, Bernabéu-Brotons E. Emotional eating, internet overuse, and alcohol intake among college students: a pilot study with virtual reality. Frontiers in Nutrition. 2024;11:1400815. doi: 10.3389/fnut.2024.1400815.
17. Lorenzo G, Lledó A, Pomares J, Roig R. Design and application of an immersive virtual reality system to enhance emotional skills for children with autism spectrum disorders. Computers & Education. 2016;98:192-205. doi: 10.1016/j.compedu.2016.03.018.
18. Didehbani N, Allen T, Kandalaft M, Krawczyk D, Chapman S. Virtual reality social cognition training for children with high functioning autism. Computers in Human Behavior. 2016;62:703-11. doi: 10.1016/j.chb.2016.04.033.
19. Ip HH, Wong SW, Chan DF, Byrne J, Li C, Yuan VS, et al. Enhance emotional and social adaptation skills for children with autism spectrum disorder: A virtual reality enabled approach. Computers & Education. 2018;117:1-15. doi: 10.1016/j.compedu.2017.09.010.
20. Yuan SNV, Ip HHS. Using virtual reality to train emotional and social skills in children with autism spectrum disorder. London journal of primary care. 2018;10(4):110-2. doi: 10.1080/17571472.2018.1483000.
21. Frolli A, Savarese G, Di Carmine F, Bosco A, Saviano E, Rega A, et al. Children on the autism spectrum and the use of virtual reality for supporting social skills. Children. 2022;9(2):181. doi: 10.3390/children9020181.
22. Donahue JJ, Shrestha S. Development and preliminary validation of a virtual reality-based measure of response inhibition under normal and stressful conditions. Journal of Technology in Behavioral Science. 2019;4(3):219-26. doi: 10.1007/s41347-018-0084-0.
23. Rocabado F, Duñabeitia JA. Assessing inhibitory control in the real world is virtually possible: a virtual reality demonstration. Behavioral Sciences. 2022;12(11):444. doi: 10.3390/bs12110444.
24. Algom D, Chajut E, Lev S. A rational look at the emotional stroop phenomenon: a generic slowdown, not a stroop effect. Journal of experimental psychology: General. 2004;133(3):323-38. doi: 10.1037/0096-3445.133.3.323.
25. Bar-Haim Y, Lamy D, Pergamin L, Bakermans-Kranenburg MJ, Van Ijzendoorn MH. Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. Psychological bulletin. 2007;133(1):1-24. doi: 10.1037/0033-2909.133.1.1.
26. Dubovi I. Facial expressions capturing emotional engagement while learning with desktop VR: the impact of emotional regulation and personality traits. Interactive Learning Environments. 2024;32(9):5041-57. doi: 10.1080/10494820.2023.2208173.
27. Barati S, Sepah M, Radfar. Comparison of the Effectiveness of Virtual Reality-Based Cognitive Rehabilitation with Classic Cognitive Rehabilitation on Improving Executive Functions in Children with Attention Deficit/Hyperactivity Disorder. Arak Medical University Journal. 2021;24(5):688-703. doi: 10.32598/jams.24.5.6493.1.
28. Mohamed Aly L, Masi M, Montanaro M, Ricciardelli P. The effect of negative emotion processing on spatial navigation: an experimental study using virtual reality. Frontiers in Psychology. 2024;14:1301981. doi: 10.3389/fpsyg.2023.1301981.
29. Savickaite S, McNaughton K, Gaillard E, Amaya I, McDonnell N, Millington E, et al. Using HMD Virtual Reality to investigate individual differences in visual processing styles. 2021.

30. Zhang M, Ding H, Naumceska M, Zhang Y. Virtual reality technology as an educational and intervention tool for children with autism spectrum disorder: current perspectives and future directions. Behavioral Sciences. 2022;12(5):138. doi: 10.3390/bs12050138.

31. Nazemi, Najafi, Makvand Hosseini S, Maleki, Rahimian B, Es'hagh. The Effectiveness of Virtual Reality-Based Exposure Therapy on Reducing Avoidance Symptoms and Social Distress in Individuals with Social Anxiety Disorder. Journal of Behavioral Sciences Research. 2019;16(3):389-99. doi: 10.52547/rbs.16.3.389.