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Title


The usefulness of virtual, augmented, and mixed reality technologies in the diagnosis and treatment of attention deficit hyperactivity disorder in children: an overview of relevant studies

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The usefulness of virtual, augmented, and mixed reality technologies in the diagnosis and treatment of attention deficit hyperactivity disorder in children: an overview of relevant studies

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Abstract

Background: Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental condition characterized by attention problems, excessive physical activity, and impulsivity. ADHD affects not only the patients but also their families. The development and use of technologies such as virtual reality (VR), augmented reality (AR), and mixed reality (MR) for ADHD has increased over recent years. However, little is known about their potential usefulness. This overview aimed to clarify the current knowledge about the use of these three innovative technologies for the diagnosis and treatment of children with ADHD.

Methods: This overview was conducted using the PubMed, Web of Science, and Scopus databases until January 24th, 2021. The following descriptive information was compiled from the identified studies: country, year of publication, sample size, study design, ADHD diagnosis methods, applied technology, hardware equipment, clinical target, and main findings.

Results: The initial database searches yielded 409 articles, but 103 were removed as duplicates. Eventually, 30 eligible studies remained for analysis, the majority of which were case-control ($n = 22$, 73%). Regarding the applied technology/hardware equipment, VR ($n = 27$; 90%), head-mounted displays ($n = 19$, 63%), VR-based continuous performance tests (VR-CPT) ($n = 21$, 70%) were most frequently used. Most studies ($n = 21$, 70%) used the DSM criteria for the diagnosis of childhood ADHD. They primarily evaluated the utility of these technologies in assessing ADHD symptoms ($n = 10$, 33%) and improving the ADHD diagnostic process ($n = 7$, 23%).

Conclusion: This comprehensive overview evaluated the studies on the use of VR, AR, and MR technologies for children with ADHD. These technologies seem to be promising tools for improving the diagnosis and management of ADHD in this population.

Keywords: Virtual reality, Augmented reality, Mixed reality, Attention deficit hyperactivity disorder

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- **Conclusion**

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Background:

ADHD

What if **ADHD**??

- ADHD as a **neurodevelopmental disorder** has a chronic and often impairing course



About ADHD:

- ADHD as a **neurodevelopmental disorder** has a chronic and often impairing course
- **Rates of ADHD** have been reported to be:
 - ✓ **7 to 8** percent in prepubertal (a recent meta-analysis calculated a pooled worldwide ADHD prevalence of 7.2% among children)
 - ✓ about **5** percent of youth including children and adolescents about **2.5-4** percent of adults
 - ✓ ADHD **is more prevalent in boys than in girls**, with the ratio ranging from **2: 1** to as high as **9: 1**

Diagnostic Criteria

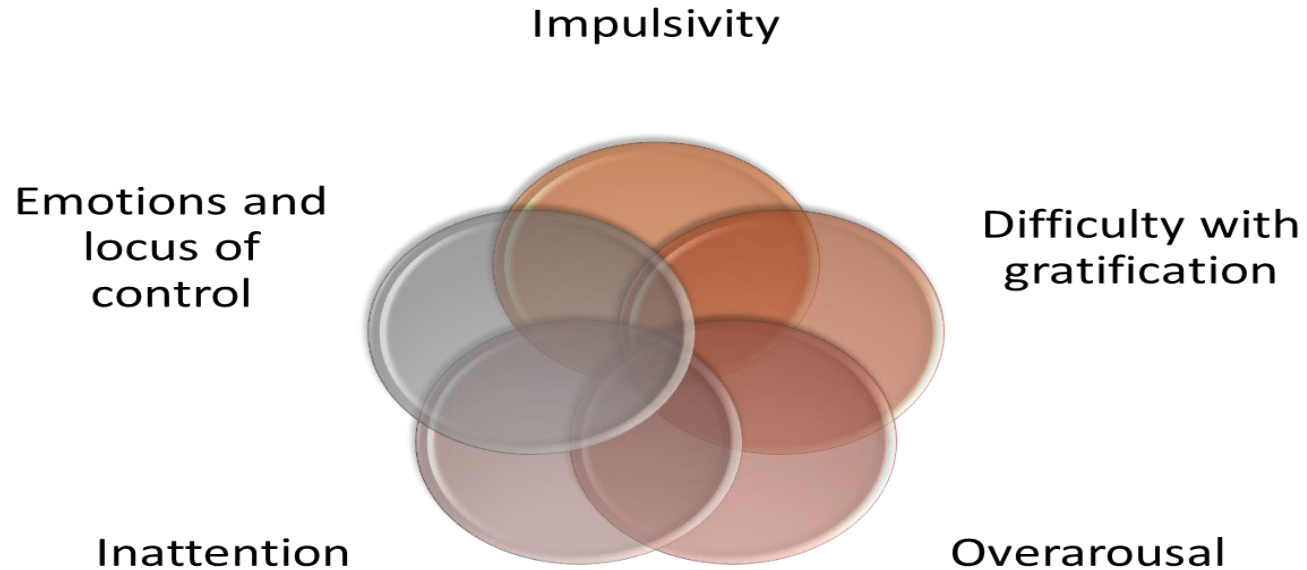
At least 6 symptoms in either/both list(s) present for ≥ 6 months

Inattentive or hyperactive-impulsive symptoms were present before age 12 years.

DSM-V Child/Adolescent Criteria

Inattention	Hyperactivity/Impulsivity
Fails to give close attention to detail or makes mistakes	Fidgets or taps hands and feet, squirms in seat
Difficulty sustaining attention	Leaves seat in situations when remaining seated is expected
Does not listen when spoken to directly	Runs and climbs in inappropriate situations
Does not follow through on instructions and fails to finish schoolwork	Unable to play or engage in leisure activities quietly
Difficulty organizing tasks and activities	'On the go', acting as if 'driven by a motor'
Avoids, dislikes or is reluctant to engage in tasks that require sustained mental effort	Talks excessively
Loses things necessary for tasks or activities	Blurts out answers before a question has been completed
Easily distracted by extraneous stimuli	Has difficulty waiting their turn
Forgetful in daily activities	Interrupts or intrudes on others

Practical Definition



Types of ADHD Treatment

Medication-based

Stimulants

Non-stimulants

+

Antidepressants

Non-medication based

Behavior therapy

Psychotherapy

Social skill training

Support groups

Mango Clinic

mangoclinic.com

Types of ADHD treatment

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Background:
virtual, augmented, and mixed reality

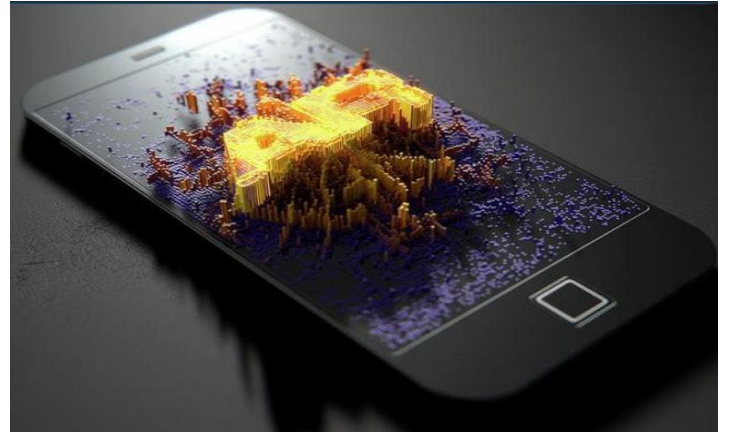
What is **Virtual reality**??

Virtual reality (VR) is a simulated experience that can be similar to or completely different from the real world.

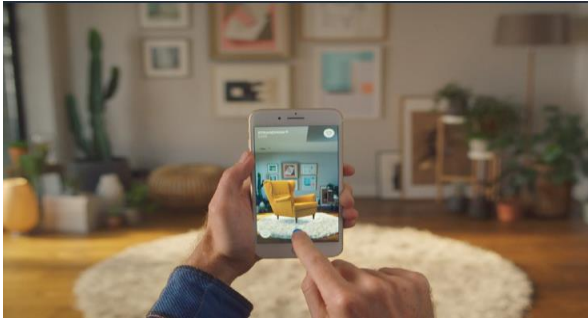


What is **Augmented reality**??

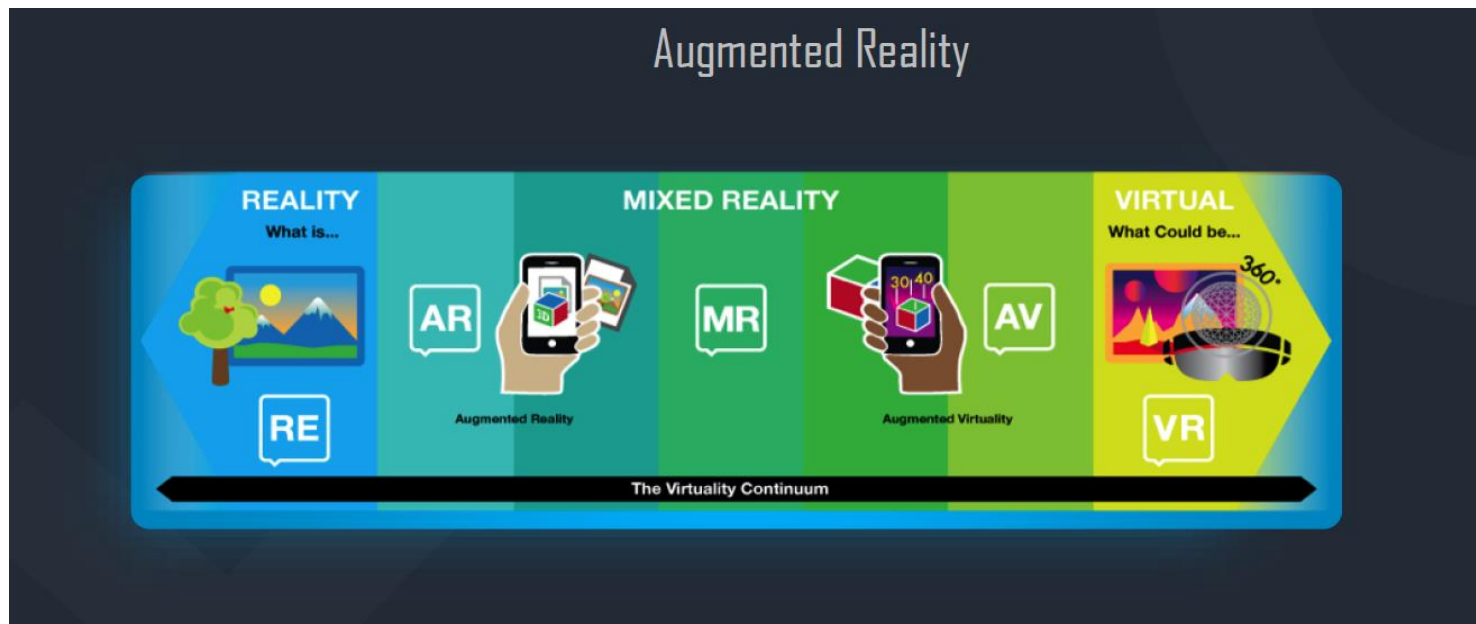
Augmented reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.



Example for Augmented reality



What's the Difference???



Materials and methods:

- ✓ searched relevant articles on ADHD published until January 24th, 2021, and available on PubMed , Web of Science, and Scopus.
- ✓ keywords, including VR; AR; MR; ADHD
- ✓ Inclusion & Exclusion criteria : PICO guideline
- ✓ The inclusion criteria were being written in English
- ✓ were excluded full text, and if they were reviews, abstracts, notes, protocols, letters, or editorials

Table 1 Key Search Terms

PICO	Key Search Term
Population	(attention deficit hyperactivity disorder) OR (ADHD)
Intervention	(virtual reality) OR (augmented reality) OR (mixed reality)
Comparison	Based on the inclusion and exclusion criteria
Outcome	Based on the inclusion and exclusion criteria

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Results:

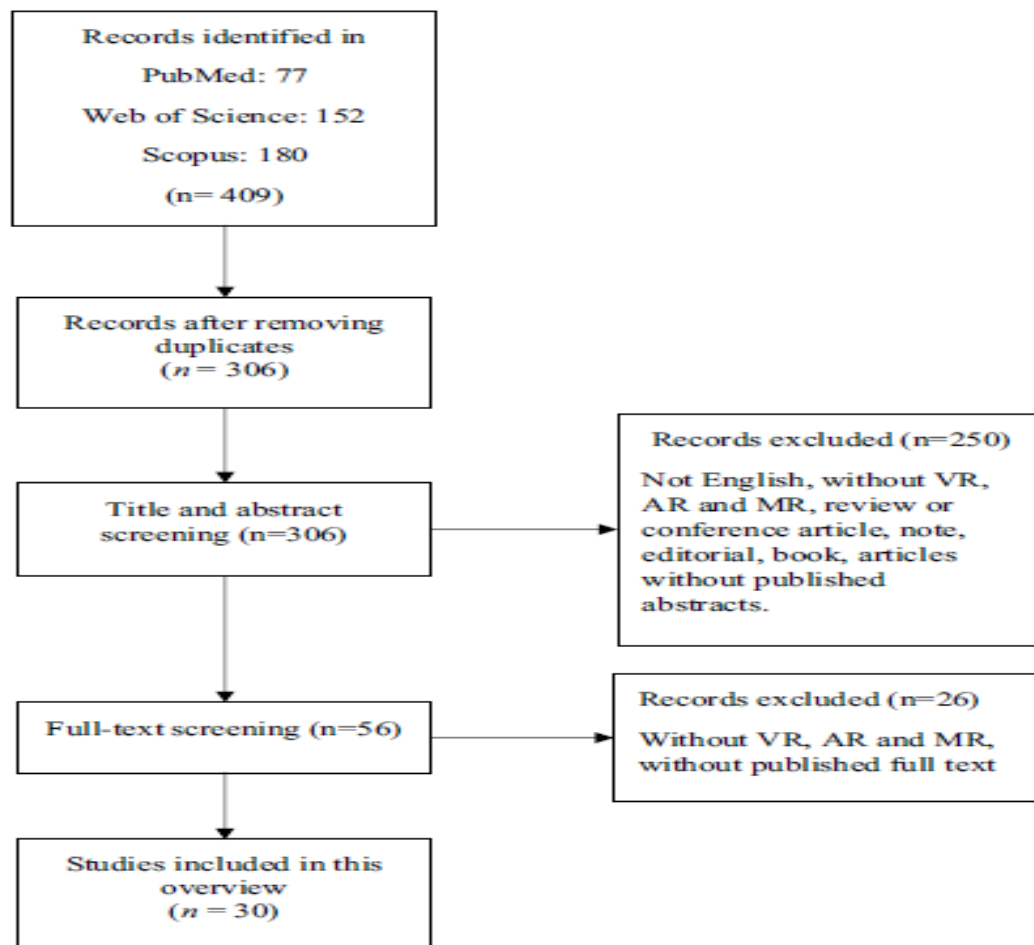


Fig. 1 Flow Chart of Data Collection and Analysis

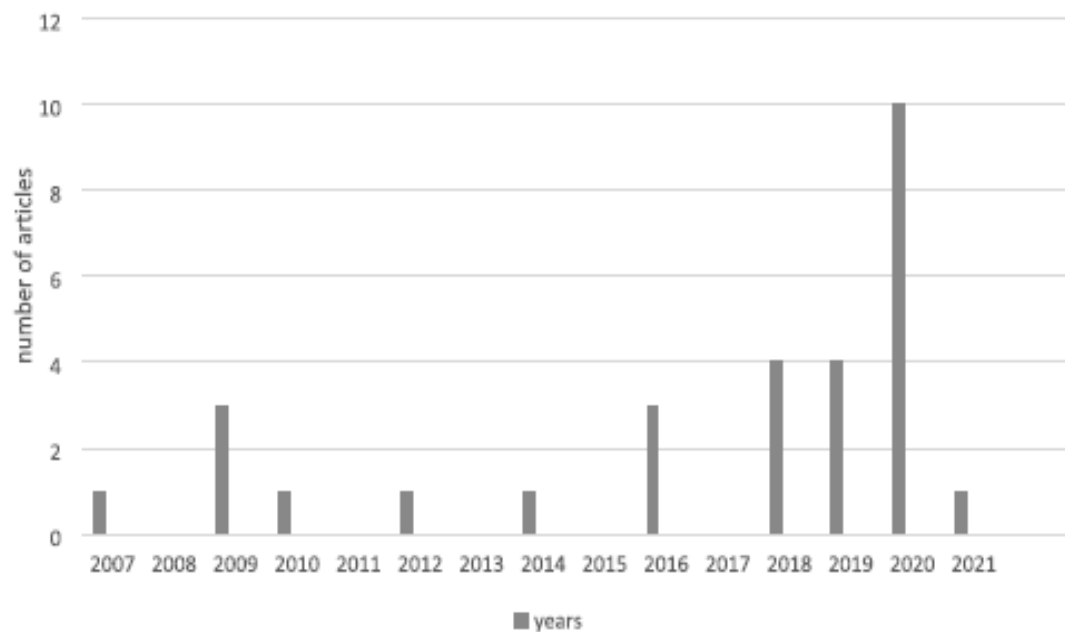


Fig. 2 Year of Publication

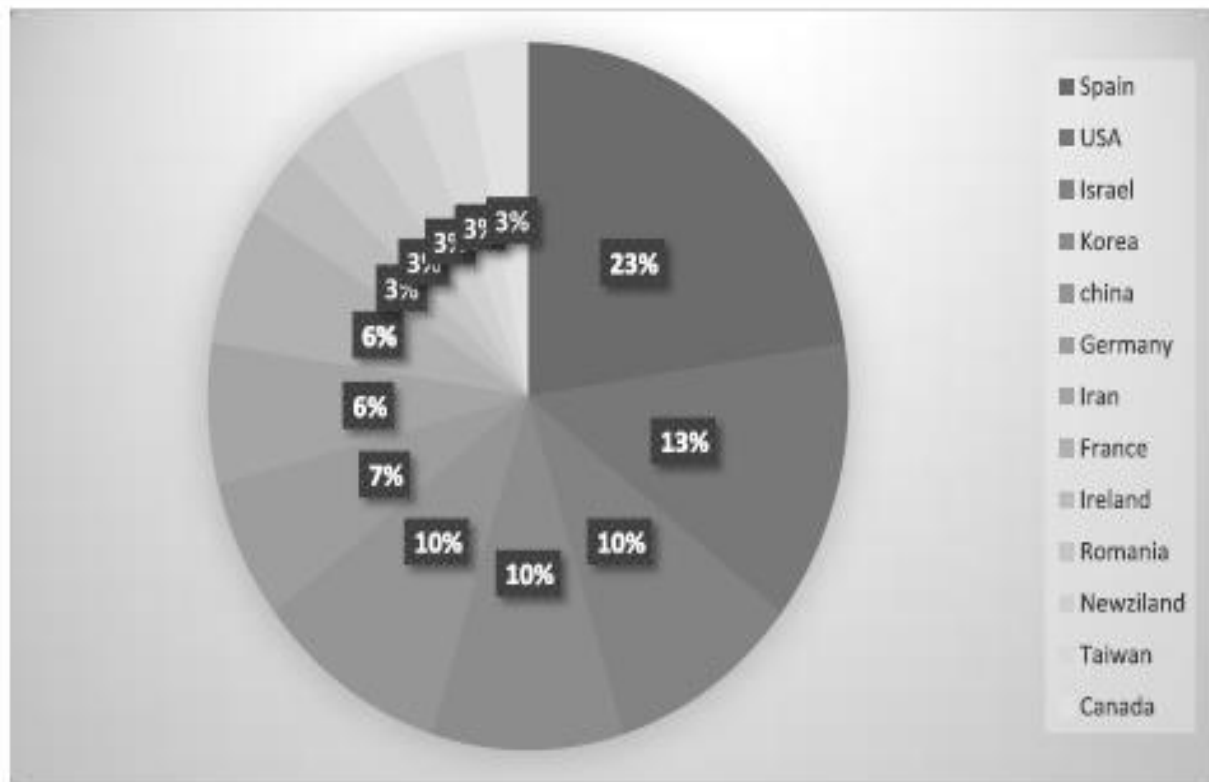


Fig. 3 Frequency of Articles by Country

Table 2 VR, AR, and MR Used for Children with ADHD

Reference	Number of Participants, Age, Sex,	Study Design	ADHD Diagnosis Methods	Clinical Target	Hardware technology, type of technology	Significant Findings
Adams et al. 2009, USA [49]	35 (8–14) y/o, (35 M)	Case, Control Experimental (children with ADHD; n = 19) Comparison (Control: n = 16)	-licensed mental health professionals or pediatric physicians -parent confirmation	Diagnosis of ADHD	Elumens dome system, head-tracking sensor/ VRC_CPT	VRC_CPT has an overall better ADHD classification rate than standard CPT (89% versus 69%).
Arces et al., 2016, Spain [50]	n = 117 (5–16) y/o (90 M, 27 F)	Case, Control Experimental (inattentive ADHD: n = 28) I/H ADHD: n = 29 ADHD combined: n = 32) Comparison (control: 28)	-DSM-5	Diagnosis of ADHD	HMD equipped with motion sensors and headphones/VRC_CPT	VRC_CPT classified 67% of control and 57% of ADHD combined participants correctly; standard CPT classified 60% of control and 50% of ADHD combined participants correctly.
Arces et al., 2018, Spain [51]	n = 88 (6–16) y/o (66 M, 22 F)	Case, Control Experimental (children with ADHD: n = 50) Comparison (Control n = 38)	-DSM-5	Diagnosis of ADHD	3D virtual glasses/ VRC_CPT	Omission errors on VRC_CPT had a classification rate of 66% for the control group and 89% for the ADHD group.
Arces et al., 2020, Spain [52]	n = 150 (5–16) y/o (114 M, 36 F)	Cross-sectional children with ADHD: n = 150	-DSM-5	Assessment of ADHD symptoms	(3D) glasses equipped with motion sensors and headphones/VRC_CPT	EDAH ADHD observation Inattention subscale predicts VRC_CPT omission errors with 89% accuracy, commission errors with 89% accuracy, and response time with 74% accuracy.
Arpaia et al., 2020, Italy [45]	n = 4 (6–8) y/o	Case Study Children with ADHD	Not identified	Concentration	AR/Glasses, Acquisition Unit, Processing Unit, Robot/AR, Robot	Controlling a robot in an AR environment enhanced attentional performance to 89% accuracy.
Boulac et al., 2012, France [53]	n = 36 (7–10) y/o (36 M)	Case, Control Experimental (children with ADHD: n = 20) Comparison (Control: n = 16)	-DSM-IV -Interviews with children and parents -The Conners' Parent Rating Scale (CPRS)	Assessment of ADHD symptoms	HMD/ VRC_CPT	VRC_CPT is a reliable method to assess the ability to sustain attention over time. VRC_CPT variables correlate with standard CPT (CPT-III) measures.
Boulac et al., 2018, France [44]	n = 51, (7–11) y/o (41 M, 10 F) RCT	Randomized Control Trial Experimental (children with ADHD: n = 16) Comparison (methylphenidate group: n = 16, psychotherapy group: n = 16)	-DSM-IV -Interviews with children and parents	Concentration	HMD/ VRC_CPT	The VR cognitive remediation program reduces distractibility.

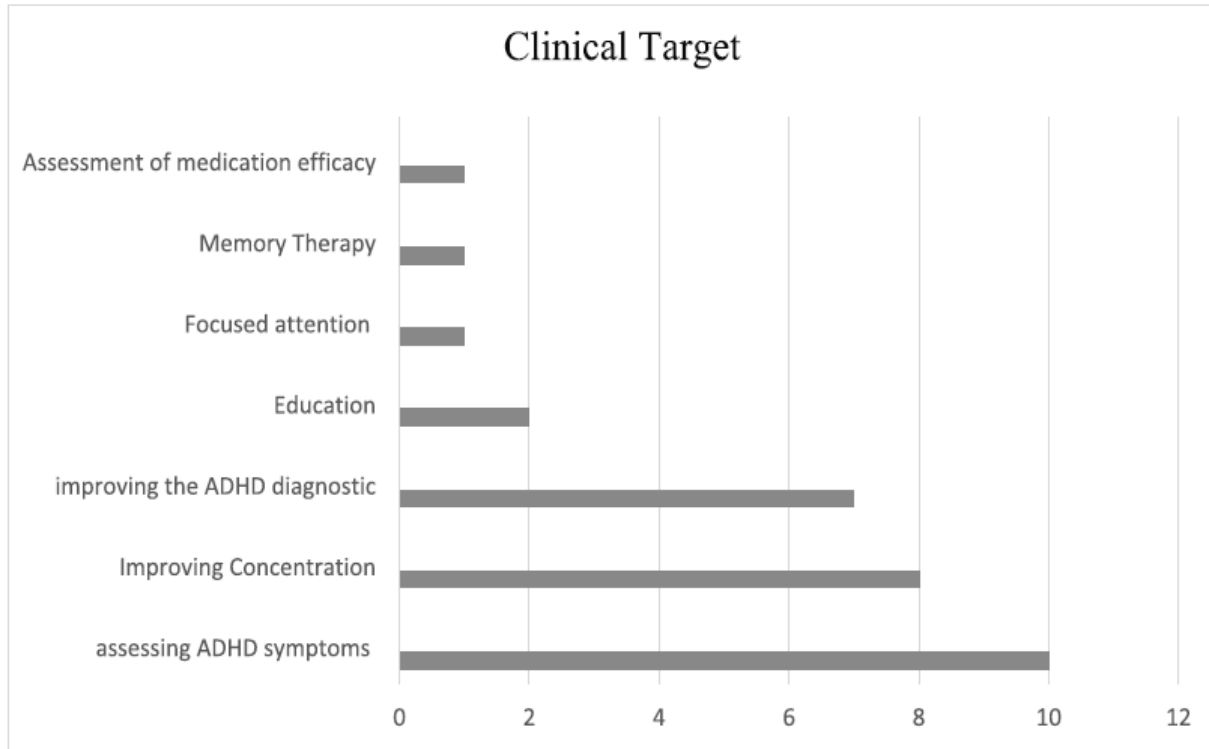


Fig. 4 Clinical Target

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Discussion:

- **According to our findings, VR-, AR-, and MR-based tools can be developed to improve the diagnosis and treatment of children with ADHD**
- **Overall, VR appears to be a more promising technology than AR and MR for clinical purposes.**
- **AR and MR integrate virtual and real world components that might prove helpful in the assessment and management of ADHD and, therefore, further investigations are warranted**

- **Overall, VR appears to be a more promising technology than AR and MR for clinical purposes.**
- **AR and MR integrate virtual and real world components that might prove helpful in the assessment and management of ADHD and, therefore, further investigations are warranted**
- **VR-enhanced behavior therapy might further ameliorate ADHD behavioral symptoms, while also enhancing treatment adherence and motivation in the patients**

- **Several studies have indicated that VR, AR, and MR technologies could incorporate effective instructional strategies to help children with ADHD learn to better manage their symptoms**
- **VR-, AR-, and MR-based applications could also help these patients learn daily life skills and other helpful behaviors, while also improving their concentration and memory**


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Conclusion:



- According to the results of the reviewed studies, VR and AR technologies could be used as effective assessment tools to better assess ADHD symptoms
- improve the diagnosis of ADHD in children.
- Ample evidence also suggests that VR technology could augment traditional treatment options, thereby promoting their effectiveness in the management of ADHD symptoms.

Limitations:

- **The sample size**
- **recruit two groups in such interventions to compare**
- **the nature of the main treatment**
- **Limitations of the study**  **some relevant studies may have been missed because of searching strategy**



Thanks!

Any questions?