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Analysing the Effects of Attention Training Programs on Children with Learning Disabilities: A Comprehensive Review

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Abstract

Objective: This systematic Review examines the impact of interventions to train Attention of children with learning disabilities, focusing on their impact on improving Attention deficits. **Method:** A thorough literature search was conducted across platforms such as Google Scholar and PubMed. Studies aligning with the predefined inclusion criteria were selected, reviewed, and analyzed following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. **Results:** Out of 880 identified studies, 11 met the inclusion criteria, representing diverse methodologies and global interest in training Attention of children with learning disabilities. Both computerised and non-computerised interventions were found effective in improving various aspects of 'Attention', though limitations like small sample sizes and short training durations were noted. **Conclusions:** Targeted cognitive interventions show promise in improvement of Attention and academic outcomes for children with learning

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disabilities. However, methodological limitations call for rigorously designed, evidence-based programs. Forthcoming research should prioritize robust, longitudinal studies to enhance the reliability and applicability of findings**.**

Keywords: Attention, Retraining, Rehabilitation, Specific Learning Disabilities, Children

Introduction:

The term "Attention", a seemingly simple effortless process is the core construct for most of the higher-order cognitive operations and definitely an integral part of the entire learning process and quite complex in its entirety. It's combines many processes like decision-making, motor orienting and information processing via multiple sensory channels (Bornstein, 1990). Attention has been a topic of concern for both philosophers and psychologists. Before the establishment of psychology as a field, philosophers provided interesting views on Attention; for example, Vives believed in the close link between Attention and retention, Malebranche attributed Attention to the clarity of ideas, Leibniz referred to it as the determination of the soul denoting preference of one thing over another (Kim-Phuong, 2004). Attention has always been a controversial concern as some psychologists have tried to include broader mental phenomena like action planning, figure-ground, perceptual, and central processing in it as it cannot be studied in isolation. Hence, defining it can be difficult as there is a need to consider the different perspectives. While Titchner described it as a "state of sensory clearness with a margin and a focus" (Titchner, 1908), William James defined Attention as "the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of their essence. It implies withdrawal from some things to deal effectively with others and is a condition which has a real opposite in the confused, dazed, scatterbrained state which in French is called distraction" (James, 1890). According to Christopher Mole, Attention can be either mindful or unconscious (Mole, 2011).

The modern theories on Attention can be classified based on the different types of Attention. The theories on Attention first began to be proposed by the work of Donald Broadbent on selective Attention, which led to his filter theory according to which human Attention is in the

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form of bottleneck allowing only limited information to pass through based on its physical properties, while the rest is ignored or stored temporarily (Broadbent, 1958). Treisman proposed the theory of focussed Attention called 'Feature integration theory of Attention', according to which Attention needs to be directed in a serial order to different stimulus when they have more than one distinct feature which are needed to distinguish the objects displayed (Treisman et al.,1980).

Attention can be fractionated quite comprehensively into the following four sub-processes: (a) Attentional orientation (the simple direction of Attention to a particular stimulus); (b) selective (or focused) Attention (giving Attentional priority to one stimulus in favour of another); (c) divided Attention (dividing Attention between two or more different stimuli); and (d) sustained Attention (attending to one stimulus over an increasing time) (Coull,1998).

Posner & Boies have attempted to divide 'Attention' into three major elements i.e., "alertness", "selectivity", and "processing capacity" (Posner & Boies, 1971). Posner and Snyder's model of "cognitive control" emphasized its need for managing thoughts and emotions. They believed that cognitive control is necessary to guide behaviour in order to overcome automatic responses; Hence, emphasizing both the selective and inhibitory nature of the cognitive control (Posner & Snyder, 1975). Shallice's supervisory Attentional system model emphasized the mediation of inhibition required in controlling competing actions in order to choose one above the other (Shallice, 2002). Human Attention is seen as an interconnected neural network with three main functions: developing and maintaining the alert state, orienting to sensory input, and executive control (Fan & Posner,2004).

Mirsky's model of Attention divides Attention into four factors, i.e. focusing/executing, sustaining, stabilizing, encoding, and shifting (Mirsky,1999). This model of Attention does take on features of other cognitive processes like *shifting* which is an executive function. This model can be used to effectively explain the deficits in Attention and how it is manifested in a child with LD. The child with LD has difficulty in *focusing* his/her Attention on relevant instruction or information required to conduct the task given, in exclusion of other vying stimuli. Generally, the child with LD is not able to *sustain* Attention on some aspect of the task until

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completion. He/ she does not have the same amount of *stable* Attention at all times while performing the task from start to finish. Hence, Attention is most likely to vary from time to time hindering the task given. Finally, he/she has difficulty in *shifting* from one idea to another or from one aspect of the task to another to complete the task or move on to another.

Most Attention models consist of four concepts: the speed with which any information is processed, the capacity and amount of incoming information that can be processed, controlling Attention and its allocation to various mental activities, and sustaining Attention over time (Sohlberg et al., 2022).

In recent years research on learning disabilities (LD) has a multidisciplinary approach. Learning disability is defined mainly inculcating inclusionary criteria like cognitive discrepancies, low academic achievements, and assessment of instructional responses (Fletcher et al, 2018). Most relevant definition with the view to plan intervention can be seen in the Barbara Bateman's definition of LD who through her transformative viewpoint stressed the importance of discrepancies in the educational potential of the child and the actual performance of the child notably not owing to mental retardation, educational, cultural or emotional deprivation or sensory loss, to be taken into consideration while diagnosing children with LD (Bateman, 1965).

When we consider the inclusionary viewpoint in defining LD, it is very evident that cognitive processes like Attention and working memory play a significant role in LD. (Rao et al.,2024) Recent neuroimaging studies have further clarified a reduced activation of the intra-parietal cortex which has been proven to have an active role in the process of Attention on mathematical tasks for children with mathematical difficulties. (Kucian et al., 2006). This further confirms the active role played by Attention in learning and how it affects children with LD. Research indicates impairments in alertness and executive control, but not in exogenous orientation are seen in children with Mathematical Learning Disabilities (Ashkenazi & Henik, 2010). One of the recent studies revealed that children with low arithmetic achievement scores find difficulty in counting owing to the incapacity to retain information for a long time in working memory, but it was also later deduced that it was most likely due to deficit Attentional capacity (Geary,

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D. C., Hoard, M. K., & Hamson, C. O, 1999). Visual Attention deficits have a possible link with reading disabilities, and training in Visual Attention span (VAS) can improve reading in dyslexic children. (Zoubrinetzky et al., 2019). The top-down Attentional network of the visual system is essential for reading, and any deficiencies in this area can result in developmental dyslexia. (Vidyasagar, 2019). Research involving preschool children demonstrated that different facets of attention, including visual focus and response speed, play a role in increasing the risk of encountering learning difficulties. (Commodari, 2012). There is a higher prevalence of dysgraphia in children with ADHD, hence; Attention does play a crucial role in writing (Mayes et al., 2017). Studies conducted recently show that in India, 1-19% school going children show signs of learning disabilities. (Kuriyan, Reddy& James, 2018). The proposed research is in line with the NEP goals and aims which stress on leaving no child behind and making new Indian Education system as child centric and inclusive as possible, at the same time aid in scaffolding children with learning disabilities. This study aims to highlight the importance of developing effective methods to enhance cognitive skills, such as attention, in children with learning disabilities, supporting their ability to learn, adapt, and achieve academic success.

Hence, the primary aim of this scoping Review is to find out the different tests used to measure Attention in children, different cognitive training techniques used to improve Attention in children with learning disabilities, their effectiveness, limitations and need for further research in this area.

Research Questions:

1. Is Training Attention in children with Learning Disabilities effective in improving their cognitive and Academic skills?

2. What tools or assessments are commonly utilized to evaluate attention in children with learning disabilities?

3. What are the different training techniques and programmes that can be used in training the Attention of children with learning disabilities and their effectiveness?

4. What is the scope for further research in finding effective strategies to train Attention of children with Learning Disabilities?

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Method:

The information about design, participants, methods of intervention etc were extracted as recommended by Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines with the help of a predetermined protocol in order to maintain consistency and rigor throughout the scoping Review.

Search Strategy:

For the bibliographical search, the electronic database scanned were Google Scholar and PubMed. This search took place between November and February 2024, without applying any filters related to date or year. The keywords used for the search included "Attention," "concentration," "retraining," "rehabilitation," "specific learning disabilities," "learning disabilities," and "children."

Eligibility Criteria:

This Review focused on studies that involved interventions targeting Attention in children (ages 5-12) with learning disabilities. Articles were excluded if they involved children with intellectual disabilities, autism, or those outside the 5-12 age range. Only studies in English language were selected. Inconclusiveness was another factor to discard the studies.

Selection of Relevant Records and Data Extraction:

At the outset, the titles and abstracts of all studies identified through the search strategies were meticulously Reviewed. When abstracts did not provide adequate information, the complete texts of the studies were examined to gather the required details. Studies that met the inclusion criteria were selected, and information such as the year, author, language, country of origin, journal, study type, instruments used, training methods, summary, objectives, sample, and intervention outcomes was meticulously recorded. Studies with inconclusive results were excluded.

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Results and Discussion:

Among the 880 studies identified using the specified keywords, 10 met the inclusion criteria and were included in this review. The analysis of the selection criteria used in this Review is presented in the table below:
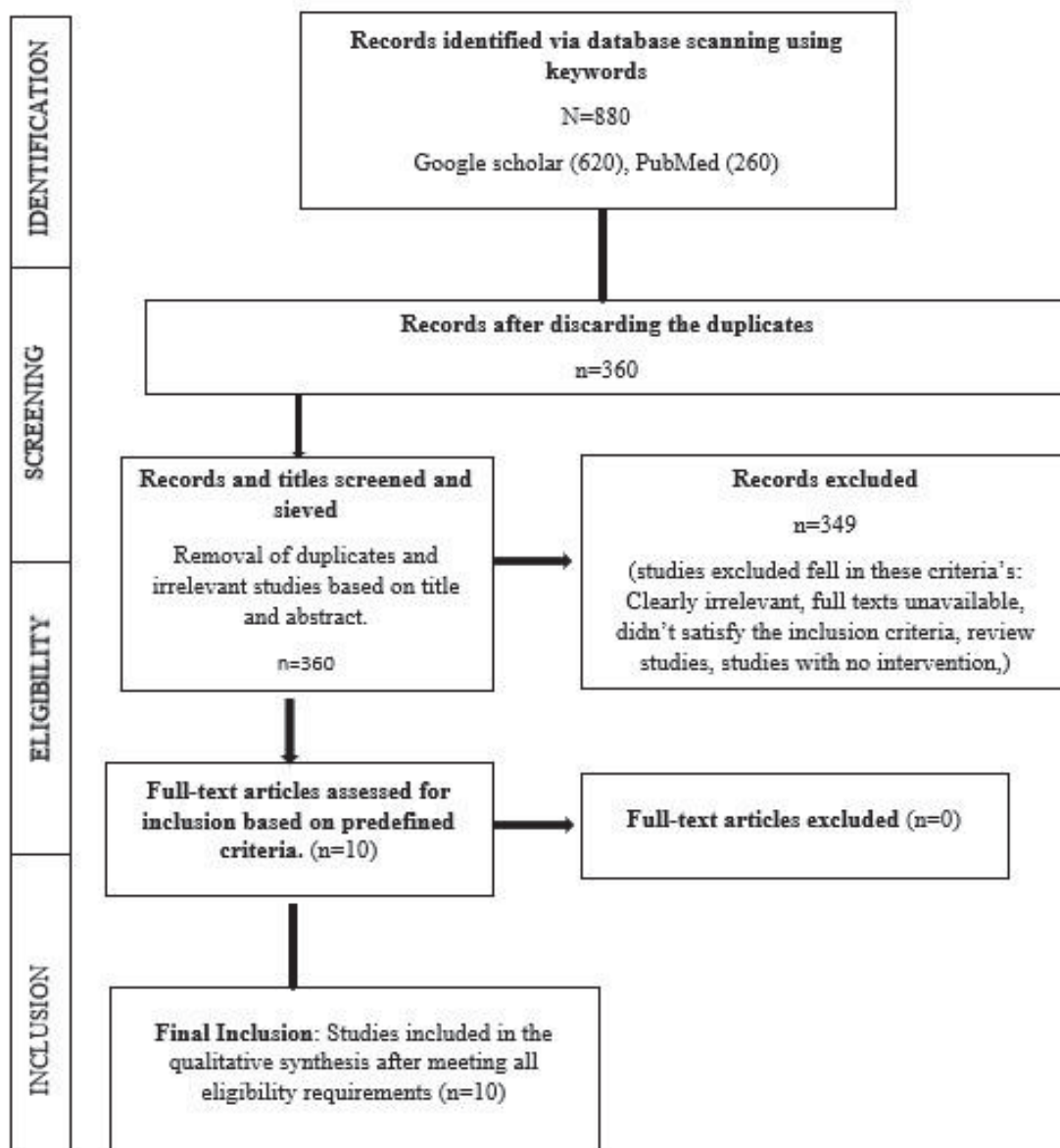

Figure 1: Identification of Target Records via Databases

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Overview of Included Studies:

The narrative synthesis furnished to demonstrate the effectiveness of Attention training interventions to enhance Attention in children identified with learning disabilities revealed the wide variations in the scope of the Review as it encompassed 10 studies (see table 1) selected worldwide from countries like Spain, Mexico, Brazil, China, Italy, India, Cuba and three from Iran. These studies denote the world-wide interest in Attention studies as numerous studies done over the years have established its importance in teaching and learning process, more so in the case of children with learning disabilities. This also adds to the generalizability of the studies as they are representative of more diverse population.

The studies varied in the study design. Some of the study designs used were experimental trials, randomized controlled trials and interventional designs representative of the diversity in interventions used and their effectiveness invariably adding to the robustness of Review.

Table 1 Features of the Studies Included in this Review:

Studies (authors, year)	Language in which the article is published and Country of Origin	Name of the Journal	Objective of the study	Type of study	Sample
Garcia-Redondo et al. (2019)	English Spain	International Journal of Environmental Research and Public Health	To evaluate whether serious games have an effect on Attention of children with learning disabilities	Experimental	N=44(age range of 6-16 years with specific learning disabilities Experimental group E=24 Control group C=20
Flores-Gallegos et al. (2022)	English Mexico	International Journal of child-computer interaction	To explore the various impacts of virtual reality training programs on visual Attention and motor skills in children with reading disabilities.	Experimental	N=11(7 boys and 4 girls age range of 6.9-10.9 years with specific reading disability Experimental group E=6 (girl-1, boys - 5) Control group C=5(girls -3and boys-2)

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Farias et al. (2017)	English Brazil	Neuropsychiatric disease and treatment	To observe the behavioural and academic improvements of children with learning disabilities after Attention-memory training.	Pretest-post-test experimental design	N=27(8-12 yrs of age both boys and girls) Unmedicated n=8 Medicated n=19
Zhao et al. (2019)	English China	Scientific Reports	To examine the enhancement of sentence reading in Chinese children with developmental dyslexia through training focused on visual Attention span.	Experimental design	N=47(girls from 4th - 6th grades) 5groups of participants including Trained group with dyslexia and Visual Attention span (VAS) deficits=10 Untrained group with dyslexia and VAS=10 Trained group with dyslexia without VAS=10 Untrained group with dyslexia without VAS=10 Age matched normal readers=14
Barahmand (2008)	English Iran	Research Journal of Biological Sciences	To examine the impact of Attention and memory training on improving arithmetic skills in children with arithmetic disabilities.	Pre- test post-test experimental design	N=44(grades 2 to 5; boys=28, girls=16) Experimental group= 14 boys and 8 girls Control group=14 boys and 8 girls
Safari et al. (2023)	English Iran	Journal of learning disabilities	To study whether a Direct Attention training program (DAT) has an effect on Attention of children with learning disabilities.	Pre-test post-test follow up semi - experimental design	N=30 boys
Guarnera et al. (2014)	English Italy	Europe's journal of psychology	To assess the impact of Attention training on children with arithmetic learning disabilities.	Test-treatment-retest quasi-experimental design	N=14 (6 males, 8 females with mean age 9years 5 months,)

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Bose et al. (2018)	English India	Indian Journal of clinical Psychology	To examine the potential impact of cognitive retraining on enhancing attention in children with learning disabilities.	Pre-post treatment design	N=10 (age group 8 to 13 years)
Narimani et al. (2022)	English Iran	Journal of learning disabilities	To investigate whether cognitive rehabilitation improves Attention and working memory in children with learning disabilities	Experimental design	N=40 (7 to 12 years with learning disabilities Experimental group n=20 Control group n=20
Pérez-Puelles et al. (2022)	English Cuba	Educar	To determine the effectiveness of training sustained Attention in children with high risk for learning disorders with videogames.	Experimental design	N=32 (grades 2nd -6th grade with high risk for learning disorders

Characteristics of Tests used to Measure and Interventions:

The training techniques and interventions used in these studies varied in their methodology and approach. Some of the techniques used were "serious games", "virtual reality training programs", "computerised cognitive techniques", "Visual Attention span based training" (VAS), "direct Attention training (DAT)", standardised Neuropsychological tasks like "trail making test", "simple arithmetic problems", "Attention with discrimination with sounds" , "letter cancellation tasks", "number cancellation tasks", "counting", "figure matching", "Alphabetizer", "letter number scanning technique", "shape matching" , "random paced problems", "contingent random letters", "pattern construction", "random dot to dot pictures", "mazes and category sorting" and "ARAM (Attention and memory rehabilitation) cognitive rehabilitation program". In conclusion it can be noticed that mainly two types of intervention techniques were used -computerised and non-computerised techniques. The various techniques used emphasise the different aspects of Attention effecting the child with learning disabilities.

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A detailed analysis of the techniques used for measuring and training Attention in children with learning disabilities is given in the table 2 below:

Table 2: Features of the Instruments and Training used in the Studies:

Authors	Instruments used to measure the Attention	Training techniques to train Attention number of sessions	Overview of the intervention and results
Garcia-Redondo et al. (2019)	D2 Attention test	2 games -Boogies academy and cuibrain developed based on Tree of Intelligence using Gardner's multiple intelligence theory. A training program consisting of 28 sessions (two ten-minute sessions per week) was carried out.	The results indicated an increase in Attentional variables post intervention.
Flores-Gallegos et al. (2022)	For visual Attention- ENI-2 Test of variable of Attention (TOVA)- selective visual Attention and inhibition	2 different games of virtual reality using an Oculus headset i.e. Beat Saber and GrafoTami. The experimental group participated in an intensive 30-session program, which included 15 minutes of Beat Saber and 15 minutes of GrafoTami training. Meanwhile, the control group, initially placed on a waiting list, received the same TAMI training as the experimental group after the post-test phase.	The result of this study indicates that there is a positive effect statistically on motor balance, motor coordination, and visual Attention and a positive qualitative effect on reading ability and self-perception with TAMI training on children with RLD (reading learning disability).
Farias et al. (2017)	D2 Attention test for visual sustained Attention	The computerized cognitive training (CCT) program focused on developing several key skills, including attention, conceptual and memory abilities, visual-motor coordination, and logical reasoning. The training encompassed 50 distinct programs with 36 cognitive exercises and was carried out over 24 weekly sessions across three months.	The results concluded an improvement in both the medicated and non-medicated group during the post -test assessment. Hence, it was concluded that CCT was beneficial for the children to improve their cognitive skills like Attention.
Zhao et al. (2019)	Visual 1 Back test to identify VAS (Visual Attention span) deficits	VAS-based training tasks included – 1) length estimation task 2) visual search and digit cancelling tasks 3)visual tracking tasks Over four weeks, 10 training sessions were held, each lasting about 30 minutes and scheduled two to three times per week. The study included two groups of dyslexic children—one group with visual Attention span	The results indicated that visual training on children with dyslexia only improved VAS skills in individuals having VAS impairment. Training led to enhanced accuracy in silent sentence reading. A notable correlation was observed between enhancement in VAS function due to training and overall reading

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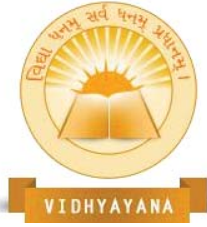
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		(VAS) issues and another with normal VAS function. These children received the training. Meanwhile, two other groups—untrained dyslexic children and normal readers of the same age—participated in free activities.	performance. Hence, the results show that reading skills of children with dyslexia can be improved using VAS-related training.
Barahmand (2008)	Raven's progressive matrices	Neuropsychological tasks – trail making test for visual Attention only part A is used for training administered in three forms- with numbers 1-20, 1-25 and 1-30. The sample divided into two groups -only group 1 received both content based and cognitive training sessions. The cognitive training was 15 sessions of individualised practice ie. 260 min sessions per weeks in neuropsychological tasks including trail making, digit symbol and memory tasks.	The results indicated that both content based and cognitive training is required for improvement of arithmetic performance in children with arithmetic disabilities.
Safari et al. (2023)	Stroop test	Direct Attention training program targeting dimensions of Attention, including sustained, selective and shifting Attention. The direct Attention training was given to the experimental group in 12 sessions of 45 minutes.	The findings indicated that direct Attention training positively influenced various aspects of Attention during the post-test phase, with these improvements persisting into the follow-up phase.
Guarnera et al. (2014)	A computerized task battery (Attenzione e Concentrazione; Di Nuovo, 2000) consists of seven subtests, which assess various cognitive abilities: simple reaction time, speed and precision, auditory and visual recognition, digit span, divided attention, the colour-word interference task, and attentive shifting	A four-week training was given to the experimental group for 30 minutes each day, 4-6 days a week. For each training session the seven tasks included in the Attenzionee Concentrazione (Di Nuovo, 2000) battery were presented and their performance was noted.	The results showed that the experimental group improved more than the control group.

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Bose et al. (2018)	Children's Colour Trial Test (Llorente et al., 2003)	The Attention training involved modified versions of several tasks, including letter cancellation, Alphabetizer, shape and figure matching, sound discrimination, number cancellation, basic arithmetic, counting, letter-number scanning, random-paced problems, contingent random letters, pattern construction, dot-to-dot pictures, mazes, and category sorting. The sessions were conducted three times per week, lasting 30 to 40 minutes each, over a span of 10 to 12 weeks. Participants also engaged in homework activities. Among the total of 20 to 25 sessions, 10 were conducted in a group setting, while the rest were held individually.	The results prove that the Attention improves with training in children with learning disabilities as the time required to complete the task and the number of errors made reduced significantly after the Attention training.
Narimani et al. (2022)	Continuous performance test. N- back working memory test.	ARAM (Attention and memory rehabilitation) cognitive rehabilitation program. The training program was given only to the experimental group for 10 sessions (45 minutes duration) while no interventions were conducted on the control group.	The results indicated that children who received both content based and cognitive training improved better than the other group which received only content-based training. Since the Attention scores were higher in post - test than pre -test of the experimental group, hence; ARAM cognitive rehabilitation program improves Attention of children with learning disabilities.
Pérez-Puelles et al. (2022)	Continuous performance task to assess sustained Attention	Computerised commercial games for sustained Attention. A 30-minute session, twice weekly for 12 weeks was conducted.	The results indicated an improvement in sustained Attention in post- test which was indicated by reduced reaction time.

Educational video games have demonstrated potential as an effective tool for training children with learning disabilities, particularly in improving their ability to regulate and automate cognitive functions like attention. (Garcia-Redondo et al., 2019; Flores-Gallegos et al., 2022). These studies were grounded in the hypothesis that children with learning disabilities experience Attention impairments and that Attention training leads to improvements in their academic skills through transfer effects. Evidence supporting this comes from five studies

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(Barahmand, 2008; Flores-Gallegos et al., 2022; Farias et al., 2017; Guarnera et al., 2014; Zhao et al., 2019).

The studies differed in the rate of effectiveness of the techniques used for intervention. The different Attention training interventions targeted varied aspects of Attention like visual Attention, inhibition, sustained Attention, visual Attention span, Attention with discrimination, focussed Attention, divided Attention and shifting.

The majority of Attention training techniques operate on the principle that efficiency improves through repeated practice of specific cognitive tasks (Tamm et al., 2013). However, these studies varied in the duration and frequency of the training sessions.

Although these studies demonstrate that the Attention training techniques are quite effective, before any conclusions can be drawn there are several fundamental limitations regarding the design of Attention training programs that need to be addressed. Most of the studies lacked blinding which increased the risk of bias. Most of the studies had small sample sizes often leading to overestimated effects. Only 1 had a follow-up design which underscored the far transfer of the targeted intervention (Safari et al.,2023). The studies also displayed other limitations like shorter training periods, lack of clarity in the interventions used, and failure to consider other variables effecting Attention like the physical conditions of the participants, emotions, interest level, sleep quality etc.

These limitations emphasise the need to improve the study design and methodology in future research.

These findings highlight the potential effectiveness of the targeted interventions. Hence, further research is required in developing both computerised and non-computerised interventions techniques for Attention training of children with learning disabilities.

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Limitations:

This article focussed on articles published in English only. The databases other than Google scholar and PubMed were not scanned for the Review. Only free articles were studied. Hence, paid articles were not scanned for the Review.

Conclusion:

Attention has always been an integral part of the teaching and learning process. Hence, Attention studies have always shown that improvement in Attention is positively correlated to learning which is even more true for children with learning disabilities. (Zhao et al., 2019; Barahmand, 2008). The Review paved the way to understand the different training techniques that could be used to train Attention of children with learning disabilities and their efficacy.

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