Journal of Advances and Scholarly Researches in Allied Education
Vol. 22, Issue No. 01, January-2025, ISSN 2230-7540

DOI: https://doi.org/10.29070/pq2vcq52

Evidence of the Relationship between Motor Skills & Cognitive Functioning

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Abstract: Motor skills are closely linked to cognitive functions such as attention, memory, and executive functioning. The findings highlight the need for integrating motor and cognitive training in educational and therapeutic settings for children with autism, potentially improving their long-term developmental outcomes. As a link between TDC and children with abnormal development, the co-occurrence of motor coordination issues and scholastic struggles in DCD children might be seen as a bridge Many developmental diseases share symptoms with cognitive impairments, lending credence to the idea that the two go hand in hand Each participant in the research had their baseline score determined using an evaluation tool called the Cognitive and Social Skill evaluation Test for Children with ASD.

Keywords: Evidence, Relationship, Motor Skills, Cognitive, Functioning

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INTRODUCTION

Motor decision-making tasks such as stimulus discrimination, response selection, and response programming rely on spatial working memory capacity and selective attention (Wang, 2013). In order to enhance children's and teenagers' cognitive abilities, it is feasible to study the routes and moderators of motor skills. Then, these moderators may be included into motor skills instruction methods, leading to gains in both motor skills and cognitive function.

This review aims to examine the routes, processes, and moderators of motor abilities that enhance cognition in children and adolescents by reviewing pertinent researchers have looked into the link between different physical skills and brain gains. This provides the groundwork for planned future research that will guide both academic pursuits and classroom instruction.

Eighty The Test of Gross Motor Development-2 (TGMD-2) showed that 8% of children with autism spectrum disorder (ASD) had delays in their gross motor skills. Studies of children aged 3–16 years old found that up to 80% of those children had overall motor skills problems. A more recent study looked at information from the Western Australia Register found that motor issues affected 35% of children diagnosed with ASD who were less than 6 years old, according to the Vineland Adaptive Behavior Scales. Previous research has also used the Mullen Scales for Early Learning (MSEL) to look at how children with ASD have progressed through developmental milestones.

In order to assist autistic students, succeed in school, teachers and therapists should focus on improving their fine motor abilities.1 They may enhance their motor skills for writing, sketching, and other fine motor

activities with occupational therapy treatments that target strengthening, coordinating, and dexterizing the hands. Their level of engagement, autonomy, and performance in the classroom may all be improved with these approaches

As a link between TDC and children with abnormal development, the co-occurrence of motor coordination issues and scholastic struggles in DCD children might be seen as a bridge. Because DCD is associated with deficits in both motor and cognitive functioning, understanding its origins may help us understand what the link is between these two domains

LITERATURE REVIEW

Marjorie H. Charlop et.al (2018) Some of the most prominent features of Autism spectrum disease (ASD) means having trouble interacting with other people play, both of which are addressed in this book.2 The importance of play as a setting for social relationships is discussed in the book, along with how its absence might worsen social impairments in the long run. In doing so, it draws attention to the many ways in which play influences development, including the cognitive, motor, social, and verbal parts of play. The parts talk about play and social skills treatments for kids with autism spectrum disorder that are based on good theory and study. Using different kinds of tools and including interactions with parents and friends, play activities are created to foster healthy social habits and support ongoing growth. The book offers personalized solutions that may be adjusted to match the needs of each kid.

Yeo Kee jiar et.al (2015) Limited Students with autism spectrum disorder (ASD) need to work on their social skills. have made it difficult for them to be included in IE classes. The researchers in this study set out to determine which areas of social skills were most commonly lacking among in inclusive education (IE) classes, students with autism spectrum disorder (ASD) are taught with other students. The hope is that this will help mainstream educators better meet the needs of these students and improve their academic performance. A total of thirty-four educators from three inclusive classrooms in the Malaysian state of Johor are part in this research.3 Based on the The TRIAD Social Skills Assessment (TSSA), which was made by the Vanderbilt Kennedy Centre, was used for this study. Students on the autism spectrum are tested on what they know and can do in three areas: behaviorally, cognitively, and emotionally. The instrument was modified to include a 41-item survey form. The results revealed that the majority of social skill deficiencies were located in the behavioral and emotional domains.

Zuraida Ibrahim et.al (2017) Children on the autistic spectrum often struggle the most with a lack of social skills4. Therefore, it is crucial to intervene early on in order to foster social competency. Since social competence is a concept that depends on context, it is difficult to find an instrument that is appropriate for all of those contexts when trying to evaluate it. Considerations such as the following may be relevant to the context: the severity of the disease, the age group of children being assessed, the location of the assessment (home or school), the users of the instrument, and the definition of social skills competency construct. Cognitive, interpersonal, communicative, affective, and behavioral components of social competence were the focus of this research. These factors piqued our curiosity since they are the center of a larger study on children with ASD. As part of an effort to create a reliable instrument for a specific setting, this article offers a comprehensive analysis of current tools for gauging the social competence of kids who have autism spectrum disease.

Aikaterini Dolyka et.al (2024) The goal of this study is to find out if the "Power of Camp Inclusion" program helps kids with autism spectrum disorder (ASD) get along better with others while they are at camp. Participants in the program were caregivers who had undergone pedagogical training in disability concerns. People who took part were between the ages of 20 and 56 (mean age: 25.27), including 22 people with ASD ranging from 7 to 25 years old (mean age: 14.82). Helping out their involvement in the program, caregivers got in-vivo instruction on social skills.5 Some of the social skills that the Autism Social Skills Profile (ASSP) looked at were social exchange, social involvement, and damaging social behaviors. Everyone who took part also had semi-structured questions on top of ASSP. Information about people's backgrounds, how variables are correlated and how consistent they are with each other, and t-tests of groups and paired data were all part of the statistical study.

Hina Noor (2023) To examine social skill deficiency degree of children with ASD in Punjab and ICT. This research used a descriptive approach based on a survey methodology. Researchers drew their sample from the whole population of children with ASD who were enrolled in special education programs at ICT and Punjab institutions. John Constantino's (2005) We used the Social Responsiveness Scale (SRS-2) to find out how badly kids with ASD missed social skills in five areas: social awareness, social cognition, social speech, social drive, and lack of interest and repeat behavior.6 The data was gathered using a program that included statements in both Urdu and English, in both hard and soft versions (Google Forms and Excel).

DEVELOPMENTAL DISORDERS CO-MORBIDITY EVIDENCE

Many developmental diseases share symptoms with cognitive impairments, lending credence to the idea that the two go hand in hand. When at least two diseases manifest with symptoms that are similar to one another, this condition is known as comorbidity This section will focus on developmental diseases such as developmental dyslexia, ADHD, SLI, ASD, and DCD are all names for conditions that make it hard to pay attention or understand words. People who suffer from these conditions often struggle in areas such as motor skills, academic performance, and cognitive abilities. Problems with motor skills as well as intellectual abilities (reading, arithmetic, and science) will be discussed more extensively in the sections that follow. Nonetheless, we will examine three hypotheses that try to account for this observed comorbidity before introducing each developmental problem independently.

IDEAS ABOUT CO-MORBIDITY

The study and treatment of developmental disabilities has long been fraught with difficulty. The degree of overlap between different developmental issues makes it difficult to identify clear-cut limits for diagnostic criteria, which is a major cause for this. There are a number of competing ideas that attempt to explain the shared features of developmental disorders. Recent studies have shown that motor, academic, and cognitive impairments often occur together in youngsters, and this is the primary emphasis of the current investigation. The case of DCD and other developmental abnormalities that occur together is an intriguing one. According to the American Psychological Association a significant delay or failure in the maturation of motor coordination skills is the most common symptom of Down syndrome. It has also been suggested that sensory integration impairments contribute to motor issues. Children with Down syndrome seem to have issues in areas including learning, focus, and reading in addition to the primary motor symptoms.

In the 1970s and 1980s, the theory of Minimal Brain Dysfunction (MBD) provided support for a broader understanding of developmental difficulties. MBD argued that disorders like clumsiness, ADHD, and learning problems should all be put under a "general umbrella" of brain functions that aren't very specific issues. Many experts at the time argued that developmental delays were caused by smaller-scale brain dysfunctions, casting doubt on this notion. New ideas, such as the Automatization Deficit Hypothesis (ADH) and the Atypical Brain Development Hypothesis (ABD), have been proposed in an effort to reevaluate the MBD hypothesis in light of the high comorbidity rates among various developmental disorders.

MOTOR SKILLS AND COGNITIVE FUNCTIONING: THE EVIDENCE BETWEEN THE TWO

The ability of motor skill training to enhance cognitive functioning, as measured by improved performance on reading and mathematics, is one of the primary concerns of this study. Numerous research has shown a correlation between motor abilities and other forms of academic found that there are strong positive relationships between motor scores at four years old and academic performance at eight years old, regardless of whether the children were born healthy or premature. The significance of integrating motor or physical activity therapies into the school day to improve motor and learning performance was further highlighted by a recent quantitative evaluation conducted in the USA. Theoretically, there seems to be sufficient reason to evaluate motor capabilities alongside cognitive or academic abilities

CAUSAL MODELLING APPROACH

The three-level model that incorporates biology, cognition, and behavior is proposed by the Causal Modeling framework to explain co-morbidities. Any degree of interaction between the model and the environment is possible since environmental factors may be included at both the biological and cognitive levels. According to this theory of causation, mental illness develops when several biological and cognitive.

Because doctors often have trouble distinguishing between primary and secondary symptoms, as well as detecting the comorbidity of various symptoms, the framework is crucial for reaching a diagnosis. The presence of a single causal chain may confirm the notion of a diagnostic item, according to the causal modeling paradigm. Since this same chain of causation may be used to explain several developmental problems, it can also explain the current comorbidities. Cognitive differences might cause distinct behavioral patterns or, in the case of developmental problems, co-occurring symptoms.

A youngster with dyslexia may also struggle with motor coordination, while another youngster with the same diagnosis may not have any such issues. Changes in cognitive processes leading to significant behavioral differences are the root cause of this variability, as proposed by the causal modeling method. Therefore, instead of relying just on biology to explain human growth, this new model incorporates cognition into the "equation.". Morton states on page 39 of his 2004 publication that "observed behavioral abnormalities are caused by abnormalities at the cognitive level; these in turn have biological precursors." The following is a simplified version of the model that offered for this strategy:

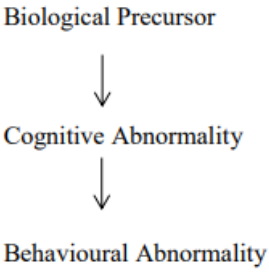

Figure 1 Basic Framework of Causal Modelling Approach

This model proposes that viruses and brain abnormalities are the biological level elements that may alter the expression of behaviors. Variables at the cognitive level include autistic children's possible absence of theory of mind. Lastly, a low intelligence quotient (IQ) is an expression of the behavioral level, which is the result of the two elements discussed before Thus, cognitive impairments might have biological roots and subsequently generate reported behavioral abnormalities.

It is clear that more clarity is required on the involvement of the environment in the model; currently, we do not have any data on the exact extent to which different environmental factors might alter the level of behavior. To be more precise, there should be more clarity on the criteria that should inform this choice, even while The model suggests that outside factors, like the social context, could "fit" into the structure on either the biological or cognitive level. The idea that developmental problems can only be adequately explained by the causal modeling framework if they have a solid biological foundation, is another intriguing aspect.

This may help shed light on why kids with the same diseases have different symptoms. Since the causal modeling paradigm clarifies the co-morbidities between motor and intellectual impairments, it has had a significant impact on the present investigation. Further evidence of the link between physical skills and intellectual or thinking skills challenges is provided by developmental disorders that display both, as will be explored in the sections that follow. Consequently, the present thesis benefits from evidence-based research that examines this link and provides a framework for explaining these commonalities. It makes sense to create an intervention that may help children as it has been proposed that changes in the cognitive level can change the behavioral results, and these changes can include changes in the surroundings as well.

DEVELOPMENTAL DYSLEXIA

Clumsiness, trouble with sequencing and ordering, poor short-term verbal memory, and speech and language impairments are among other symptoms that may be present Disorders in phonological processing have been proposed as the primary etiology of dyslexia. According to research referenced in Fawcett and Nicolson and Ramus, there is strong evidence of motor skill deficiencies as well as phonological problems. These include difficulties with postural stability, bead threading, and throwing or catching activities. Also, according to observational evaluations, children who are dyslexic tend to have slower development on a range of motor activities that deal with stability, coordination, and speed. Results also show that motor abilities are one area where children with dyslexia struggle. In a study conducted by Fawcett & Nicolson for instance, it was discovered that dyslexic children performed much worse on bead-threading than

controls of the same reading age.

Attention Deficit Hyperactivity condition (ADHD) is the next condition we will talk about in the part on developing disorders. Kids who have attention deficit hyperactivity disorder (ADHD) often have trouble with fine motor skills, which new studies show are likely related to a motor deficiency rather than hyperactivity (Pitcher, Piek & Hay, 2003). On top of that, reading difficulties are typical among youngsters with ADHD and DCD. Given the same cognitive, motor, and academic challenges between ADHD and DCD, it is imperative to examine their connection.

HYPERACTIVITY DISORDER WITH ATTENTION DEFICIT

A lot of recklessness, restlessness, and not paying attention are signs of attention deficit hyperactivity disorder manifests in childhood7. Attention deficit hyperactivity disorder (ADHD) kids have a lot of trouble in school and with other things. with reading and spelling, among other issues in addition, elementary school students who behave erratically in class but have not been officially ADHD stands for attention deficit hyperactivity disease also tend to struggle academically, Results from research tracking 4,148 children throughout four, five, six, and seven years old showed the aforementioned connections.

According to clinical investigations, motor coordination issues are present in 30% to 50% of children with ADHD Mood, behavior, learning, motor control, communication, and anxiety problems are among those that share symptoms with The National Institute for Health and Clinical Excellence (NICE) says that a person has attention deficit hyperactivity disorder (ADHD). A lot is still unknown about the link between ADHD and motor coordination issues, even though there is a lot of evidence that the two conditions often occur together. Furthermore, it would be beneficial for researchers to examine this correlation while accounting for attention in all of the tests, since attention deficits may be a contributing element to children's poor performance on motor and cognitive activities.

In the part that follows, we will talk about the shared symptoms that children with DCD and ADHD have, specifically the symptoms that children with DCD show with ADHD.

DEVELOPMENTAL COORDINATION DISORDER

Problems with motor coordination in some youngsters cannot be attributed to a common medical issue, as indicated before. The children in question have been described using a wide variety of terminology over the years, such as clumsiness, apraxia, developmental dyspraxia, and many more .The current popular term can be "developmental coordination disorder," which is called a "marked impairment in the development of motor coordination, which cannot be attributed to a general medical condition or mental retardation" . According to the DSM-IV-TR (2000), kids with DCD have trouble coordinating their big and little motor skills, as well as with moving around, being agile, having good hand-eye coordination, and doing hard tasks. The movement disabilities make it harder for the child to do well in school and in normal life; this is another requirement for the diagnosis. Children with DCD are different and have a lot of motor coordination issues, which is something that has to be recognized.

Further research with 45 Greek children of the same age found that, in comparison to their non-DCD peers, DCD children scored worse on tests of Static and dynamic balance, planning, and writing code at the same

time. According to, this study also looks at the motor part of math (i.e., planning how to do sums) and the last two variables were linked to reading and math ability.

Gubbay, Ellis, Walton & Court, and Smyth has also shown a correlation between DCD diagnoses and poor academic achievement in reading and mathematics. According to the ABD theory, which was previously discussed, DCD and other diseases may be seen as trends of problems that point to a deeper problem deficiency. There is evidence linking DCD to ASD, Asperger Syndrome, and Attention eficit/Hyperactivity Disorder. Diagnosis should be approached with care because of the strong associations between these conditions. It is important to carefully analyze the overlapping nature of the symptoms as well.

"Deficits in Attention Motor Control and Perception" (DAMP) offers an additional intriguing viewpoint to the existing studies linking motor coordination issues with difficulties with attention and intellectual abilities. DAMP was an effort by researchers to classify children with symptoms of both DCD and ADHD into a single group. Problems with areas like attention, motor control, learning, language, and perception might have their roots in underlying neurodevelopmental issues, according to DAMP Between 65 and 80 percent of children with a DAMP diagnosis also exhibited learning disabilities in reading, mathematics, and language, according to studies conducted on children aged 10 to 13.

As a link between TDC and children with abnormal development, the co-occurrence of motor coordination issues and scholastic struggles in DCD children might be seen as a bridge. Because DCD is associated with deficits in both motor and cognitive functioning, understanding its origins may shed light on the nature of the connection between these two domains.

Early intervention research to lower the risk of not doing well in school and having bad mental development is urgently needed, according to all the studies listed in this section. Though the present intervention only focused on TDC, many children who may have DCD or another developmental problem may not get a diagnosis until much later in life. For both the children who may be diagnosed later in life and those who are at risk for the many risk factors mentioned previously, the MSI for the Early Years plays an important preventive function. 8Two further developmental diseases that have been linked to motor issues are autism spectrum disorder and Specific Language Impairment will be talked about in the following section.

AUTISTIC SPECTRUM DISORDER & SPECIFIC LANGUAGE IMPAIRMENT

According to research, the typical symptoms experienced by kids with ASD and DCD start when they are very young. continue throughout the child's formative years. suggested that children with autism may have delayed communication development due to motor deficits, particularly problems with motor gestures. We can learn a lot about how to make these problems less prevalent in the future if we dig further into the typical symptoms conducted a meta-analysis that looked at the correlation between ASD and motor coordination.

They discovered an effect size of 1.20, which means that a lot of kids with ASD had trouble with motor coordination. Furthermore, difficulties with motor coordination seem to be prevalent across diagnosis, suggesting that they may be a significant feature of ASD. The impact of additional moderating factors (such as the several subgroups with ASD) and the condition's inherent heterogeneity have sparked a protracted

discussion over motor impairments in children with ASD. Children with ASD had a smaller movement repertoire and worse coordination, according to the aforementioned meta-analysis that compared them to normally developing controls. According to this meta-analysis of 51 research, these symptoms should be regarded as core symptoms since they seem to be prevalent.

The American Psychological Association says that a person is labelled with a specific language impairment if their language skills fall below the predicted age level, even while their non-linguistic abilities are within the expected age range. Researchers used a tapping task in their investigation. When children with SLI were asked to touch a tally counter as quickly as possible with their thumbs, the findings showed that their motor skills were compromised. Further evidence pointed to shared hereditary factors between motor and speech deficits. The second research that came after it also connected language with a motor skill challenge. "The study suggests that motor problems can be part of the phenotype of heritable speech and language disorder" suggesting that the study's conclusions are like the ones found in the study by Wolff et al. on juvenile dyslexia.

There is no denying the correlation between motor deficits and ASD and SLI. In contrast, according to the ideas presented of the causal modeling theory, various illnesses might have distinct causes, even when they exhibit similar behavioral symptoms. Consider the possibility that a kid with SLI and a dyslexic youngster have certain symptoms but really have distinct cognitive deficits. It is important to differentiate between the aetiology, neurobiology, cognitive processes, and observable behaviors when evaluating various developmental diseases. Here we see two more developmental disorders associated with motor issues and cognitive impairments. This discovery further strengthens the association between motor and cognitive development and gives a good reason to investigate it further.

It is important to note that the developmental issues mentioned below have diverse profiles when it comes to the spectrum of challenges and the intensity that people encounter.

PHYSICAL ACTIVITY & ACADEMIC PERFORMANCE EVIDENCE

A lot of study has been done to look into and record the correlation between exercise and cognitive performance, and some of these studies have shown highly encouraging outcomes. Before we get into the data from various research, how exactly do we need to define physical activity? As described by the World Health Organization (WHO), "physical activity is any movement of the body made by skeletal muscles that requires energy and expenditure."

In the first research, 1,538 students from seven different public elementary schools were included Examining the potential impact of a health-related physical education program on standardized test results was the primary motivation for the research. The research divided participants into three groups: those who received instruction from SPARK curriculum experts, those who received instruction from classroom instructors, and a control group that maintained their previous programing. The schools were divided into two groups for the intervention.

The second piece of writing was a meta-analysis of fourteen research that looked at how exercise affected academic achievement The data and findings from these investigations were compiled from the publication of While this assessment may lend credence to the idea that exercise may have some immediate benefits

(such enhanced focus), it does not rule out the need for more research into the potential long-term consequences on academic performance. In keeping with this trend, recent research was able to determine that physical activity (PE) had positive impacts on motor skills and academic success that lasted for nine years.

Thirdly, this part will give the results of a research that looked at the correlation between students' levels of how fit they were and how well they did in third and fifth grade. What the point of this research was to expand upon previous work that sought to understand "the relationship between physical fitness (aerobic exercise) and academic achievement". Two hundred and fifty-nine students from grades three and five made up the sample. Mathematical and reading proficiency, aerobic capacity, body composition, and muscular fitness were among the measures used to evaluate the children. ratings were linked to greater total fitness. Even after accounting for factors including age, sex, and poverty index, there was a favorable correlation between children's physical and cognitive scores These findings show that the availability of physical education opportunities in elementary school significantly predicts later success in school, particularly in reading and mathematics.

A LOT OF PHYSICAL ACTIVITY, GETTING FIT, CONTROLLING YOUR MOTOR SKILLS, AND LEARNING NEW ONES.

Physical fitness, motor control, motor skill development, and physical exercise are all concepts that need clarification at this juncture. There is a propensity for some of the words to be used interchangeably, even if they are meant to denote distinct ideas. Programs designed to encourage physical exercise often have as their primary goal the enhancement of motor skill development and control. As a result, research on the benefits of exercise and motor skill development is often conducted in tandem. To be more precise, most people mistakenly believe that physical activity and exercise and health are the same thing set of behaviors. Expenditure of energy is the result of muscular contractions, which is what we mean when we talk about physical activity (WHO). Throughout life, people may and do differ in terms of how active they are. Conversely, physical The American College of Sports Medicine (2013) says that fitness is "a set of attributes that people have or achieve that relate to the ability to do physical activity."

The purpose of providing both meanings is to make these concepts more understandable, which should make it easier to draw conclusions from various studies conducted in this field. Being able to tell the difference between studies that use these words and focus on looking into the link between fitness and physical exercise that lead to health or academic advantages is particularly helpful. We shall define motor control and motor skill development before we talk about the physical and motor differences.

MOTOR SKILLS & READING-MATHS PERFORMANCE RESEARCH EVIDENCE

To better understand which cognitive capabilities are impacted, researchers have been more targeted in their studies of the link between how well you do motor skills and its consequences on many cognitive abilities.

The correlation between pre-kindergarten motor abilities and first-grade reading and arithmetic proficiency was investigated in 2006 American research by Son and Meisels. Twelve thousand five hundred and

eighty-three kids made up the ECLS-K cohort, a nationwide dataset from the Early Childhood Longitudinal Study The children were distributed equally between the sexes, with a mean age of 65 months. Coordination of the eyes and hands, balance, and jumping were among the fine and gross motor abilities evaluated. One There was better proof from correlational data, which showed that visual-motor skills were linked to cognitive success (r =.40 for reading and r =.48 for mathematics) than gross motor skills.

The second set of findings included reading and math-specific four-stage hierarchical regressions. Spring first grade reading success is significantly predicted by motor skills and early reading, according to regressions. In addition, there is a strong correlation between visual motor abilities, early arithmetic scores, and subsequent math performance. Reading and arithmetic proficiency may be impacted by routes other than phonics, according to the aforementioned research. These pathways may include visual or spatial thinking. The findings also corroborate the concept put out by the dynamic systems approach, which states that a young child's emerging abilities in the areas of motor, reading, and mathematics are interrelated.

Examples of research showing a connection between motor skills and cognitive. A new A meta-analysis has shown that reading and math are two results in school that, in a hierarchical fashion, generate among the biggest impact sizes during a physical activity intervention, with effects on motor abilities. Research on the potential direct or indirect correlations between various motor skills and other cognitive abilities is therefore very beneficial for the future. Its potential to pave the way for innovative pedagogical approaches that target motor correlates as a means to improve students' academic performance is one such advantage. More than that, it will provide a firmer foundation for future TDC screening tools and treatment programs.9

A number of variables are thought to impact both TDC and children with abnormal development, beyond particular developmental diseases that impact a child's cognitive and motor development. We will talk about these considerations in the following section, but they were major ones in choosing TDC for this study.

CONCLUSION

Each participant in the research had their baseline score determined using an evaluation tool called the Cognitive and Social Skill evaluation Test for Children with ASD. So, it was determined that all the kids had problems with social and cognitive abilities in different areas Problems with motor coordination in some youngsters cannot be attributed to a common medical issue, as indicated before. The children in question have been described using a wide variety of terminology over the years, such as clumsiness, apraxia, developmental dyspraxia, and many more Motor decision-making tasks such as stimulus discrimination, response selection, and response programming rely on spatial working memory capacity and selective attention. In order to enhance children's and teenagers' cognitive abilities.

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