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Executive Functions and Their Effects on Learning Disabilities: A Review

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This review examines the relations among executive functions and specific learning disabilities. In Chapter I, the topic is formally introduced, and the research questions are addressed. In Chapter II, research addressing the relations among deficits in executive functions and specific learning disabilities that appears in the literature of education and of psychology will be reviewed (Learning Disabilities Association of Minnesota, n.d.; SMARTS, 2021). In Chapter III, the findings from the analysis are summarized, and the implications of these findings are described.

Introduction and Context

Executive functions allow students to self-direct and to self-regulate their learning and behavior (Zelazo et al., 2016). These functions are higher order cognitive processes including metacognition, volition, planning, purposeful action, and performance monitoring. Executive functioning affects most elements of a child's formal schooling. Deficits or dysfunction in executive functions are more common students identified as SLD than among their peers who do not have disabilities. Understanding the strengths and the deficits in executive functions for students who have specific learning disabilities is particularly important (Zelazo et al., 2016).

Context of the Review

The psychological construct of metacognition emerges from neurological descriptions of executive functions. Metacognition is higher order reflection and analysis of one's own thoughts and thinking. Flavell (1979) reported the seminal descriptions of metacognition. He defines metacognitive knowledge as consisting "…primarily of knowledge or beliefs about what factors or variables act and interact in what ways to affect the course and outcome of cognitive

enterprises. There are three major categories of these factors or variables–person, task, and strategy" (Flavell, 1979, p. 907). Deficits or difficulties arising in any of these areas adversely affect learning.

In addition to Flavell (1979), a number of other researchers contributed to early models of metacognition and of executive functions. Baddeley and Hitch (1974) and Baker and Brown (1984) are considered seminal works in the areas, and their findings also helped define instructional approaches and methods.

Metacognition and the relations among person, task, and strategy are widely accepted models in psychology and in education. Sternberg subsumes executive processes under analytic intelligence in his triarchic model of intelligence (Borkowski et al., 2009). Increasingly, researchers, e.g., Stahl et al. (2006), are addressing the roles of metacognition in instruction and are calling for assessments of executive functions in educational evaluations.

Statement of the Problem

This paper examines relations among learning disabilities and executive process dysfunction. The scope of the analysis is purposefully delimited to pupils and students in elementary schools. Three foci guide the review. First, prevalence and incidence data for learning disabilities arising from executive process dysfunction will be reviewed. Second, issues related to severity and to comorbidity will be discussed. Finally, interventions and remedial strategies for addressing dysfunction and deficits in executive processes will be compared and contrasted.

Rationale

A number of practical consequences and theoretical implications may arise from the results of this review. Classroom instruction may be improved by identifying and describing strategies improve working memory and cognitive flexibility for students who have learning disabilities. Behavior management and behavioral intervention systems may be enhanced by incorporating self-control and self-regulation models into the approaches. The relations among executive process dysfunction and other cognitive deficits may be better understood.

Discussion of Practical Consequences

The results of this review may have practical implications for an array of groups. Students, teachers, administrators, and I as the author may benefit directly. The review addresses the prevalence of executive process dysfunction in students with identified learning disabilities. Understanding that it is more common so have executive function disabilities tied to learning disabilities can lead to many changes in the school setting. This paper will help educators and administration of schools understand that some of our students that have identified learning disabilities might also need significant support in the areas of executive functioning. Executive function is a necessary part of learning and setting up students for successful learning.

Educators, parents, and administrators should gain understanding and come up with ideas to implement interventions or activities in the classroom or around the school building to support those students that need more individual support in the areas of executive functioning. This paper will provide insight to future and current teachers to understand and grow their depth of knowledge around learning disabilities and how executive functioning can part a role in a child's education together.

Chapter II: Review of the Literature

This review examines the relations among executive functions and specific learning disabilities. In Chapter I, the topic was formally introduced, and the research questions were addressed. In Chapter II, research addressing the relations among deficits in executive functions and specific learning disabilities that appears in the literature of education and of psychology is reviewed. In Chapter III, the findings from the analysis are summarized, and the implications of these findings are described.

Organization of the Literature

This review examines the relations among executive functions and specific learning disabilities. Specific themes for the review include prevalence of executive process dysfunction within the population of students identified with specific learning disabilities, how executive process dysfunction manifests in the context of specific learning disabilities, and classroom strategies for addressing behavioral and cognitive difficulties arising from executive process dysfunction. The scope of the review is purposefully delimited to pupils and students in elementary schools.

Scope of the Review

The scope of reviews encompassed in the Saint Cloud State University Data Base. Searches included a title search that included Learning disabilities and Executive function, this result gave 33,209 results, after narrowing down the years, the data base yielded 97 suggested titles. A second search in the library data base advanced search titled Research on Executive function and learning disabilities gained 179 results. From review of some of the initial articles I also searched for Metacognition and Learning Disabilities and received 7,870 hits. For the final

part of my review, I searched articles and research for Interventions for executive functions and SLD and received 310 hits. Throughout the review of searches, the articles that had the most relevance in titles, and abstract that covered the essential topics for this paper.

Emergent Patterns Across the Studies

The initial review of studies reveals myriad patterns. First, several researchers completed foundational studies in the area. Baddeley and Hitch (1974) are most known for their work with working memory and how information is stored in our brain for retrieval. They demonstrate how executive functions can affect encoding and retrieval. Flavell (1979) conceptualized metacognition and drew attention to the roles of metacognition in initial learning and in mnemonic retrieval. Baker and Brown (1980) examine strategic control in reading. Because reading disabilities are the most common form of learning disabilities, their research informs models of dyslexia arising from executive process dysfunction. Second, executive process dysfunction is implicated in reading disabilities, in mathematical disabilities, and in combined forms (e.g., Locascio et al., 2010; Toll et al., 2011).

Presentation of the Individual Studies

The presentation of individual studies is organized thematically. First, studies that address potential relations among executive function difficulties and specific learning disabilities are addressed. Second, studies that address specific dysfunction in working memory and metacognition are reviewed. Finally, I review studies that help introduce interventions and data to show how it can benefit students with an executive dysfunction and learning disability.

Locascio et al. (2010): Executive Dysfunction and Reading

Executive dysfunction can decrease reading performance. Locascio et al. (2010) examined the effects of executive functions on reading comprehension. Deficits in reading comprehension impair academic achievement across the school settings (Locascio et al., 2010). Similarly, language and word recognition difficulties also attenuate school performance (Locascio et al., 2010). Denckla (1996) notes that executive functioning is central to the performance of students and is critical in remediation of skill deficits. Kibby and their colleagues (2004) report that deficits in working memory also adversely affect reading. Working memory is also an important part of reading (Kibby et al., 2004).

The main purpose for this study was to examine different executive functioning skills with students with a word recognition deficit, and a specific reading and comprehension deficit. The third group examined was typically same age children with neither of the deficits stated before. The aim was to examine how executive functions may show a pattern of dysfunction tied with reading dysfunctions. The participants included students the age of 10 to 14. Students were carefully selected and found to be either typically developing children, have a specific word recognitions deficit, or a specific comprehension deficit. Students with more severe disabilities were not included in this study as well as though hard of hearing or those cognitively below or above average.

Three groups that were given the same assessments. Using the subtests from the Wechsler batteries and the Delis-Kaplan Executive Function System (D-KEFS), three areas of executive functioning were assessed. Working memory was measured using Sentence Span, Digit Span Backward, and Spatial Span Backward from the Wechsler instruments. Planning and

D-KEFS. The last executive function area tested was the area of Response Inhibition, and this area was assessed using the conflicting Motor Reponses test and Contralateral Motor response Test.

The authors report that students who have reading disorders exhibited poor performance on the executive function tasks. Even students who did not have a learning disability but had difficulties with reading comprehension exhibited lesser performance in the area of executive functions. These results are consistent with previous studies. The authors recommend additional studies focusing on adolescent students.

Toll et al. (2010): Executive Functions and Disorders of Mathematics

Toll and colleagues (2011) studied executive functions as predictors of math learning disabilities. Although most learning disabilities involve literacy difficulties, mathematical learning disabilities are extant and are affected by difficulties in executive functions. The authors conducted a longitudinal study investigating whether executive function differences between typically achieving students in mathematics and those with a mathematical learning disabilities. The study was grounded in the theoretical model of Baddeley and Hitch (1974), but a longitudinal study of relations had not been conducted previously.

The authors conducted a repeated measures study on elementary school students. The participants were 227 children between the ages of 6 to 7 years. Three measures were collected over the course of one year and included the period of promotion to the next grade. Assessments were conducted in October of first grade, May of first grade, and then October of the second-grade year. Students who were persistently very low and persistently below average were identified as more at risk for a mathematical learning disability. The authors reached two

conclusions. First, screening students at an early age is a valuable form of prevention. Second, a working memory screening tool can identify students at risk for a math learning disability.

Ji et al. (2021): Event Based Prospective Memory and Learning Disabilities

The authors investigated relations among different forms of learning disabilities and perspective memory. For purposes of the study, perspective memory is operationally defined as the memory of expected behaviors such as appropriate time and situations. The researchers hypothesized that individuals with reading and math disabilities would have greater perspective memory deficits than typical students. The 1,102 students between the ages of 13 and 14 years participated in the study. The participants completed multiple executive function tasks to identify differential performance across subtypes of learning disabilities. The students with learning disabilities showed impairments in executive functions. The authors concluded that executive function can predict learning disabilities.

Mattison and Mayes (2012): Learning Disabilities, Executive Functions, and Psychopathology in Children With ADHD

The authors examined relations among learning disabilities, executive functions, and psychopathy in children diagnosed ADHD. Mattison and Mayes (2012) hypothesize a relation among executive function deficits and learning disabilities. To assess their hypothesis, the authors compared the executive function performance of children with learning disabilities with the performance of their peers who did not have a disability. All of the participants exhibited typical or above typical intelligence. Seventy-three percent of the participants were dually diagnosed with a learning disability and with ADHD. The assessments included evaluated a set of psychological tests, rating scales collected from teachers and parents, and a computerized continuous performance assessment of inattentiveness and impulsivity. Students with comorbid

ADHD and a learning disability exhibited "…lower-than-normal achievement and Neuropsychological scores and higher than normal psychopathology score was significant" (Mattison & Mayes, 2012). Scores in the areas of working memory and processing speed were significantly lower for students with learning disabilities. The group with identified learning disabilities also scored significantly lower on the neuropsychological measure of visual motor integration and the executive functioning composite. Participants with a learning disability also showed significant differences in all areas of the Weschler Individual Achievement Test. The findings further emphasize the importance of clinicians using the full WISC battery (or another IQ test with equivalent subtests) when working with children.

Schuchardt et al. (2008): Working Memory and Metacognition

The authors examined working memory and metacognition in children with specific learning disorders. Ninety-seven (97) students in second to fourth grade participated in the study. The instruments included the Kaufman intellectual test, standardized mathematical tests, and \standardized achievement tests. Students with learning disabilities exhibited working memory deficits associated with phonological tasks, visual spatial tasks, and central executive tasks. Students with mathematical learning disabilities showed specific deficits visual-spatial tasks. Results from this study confirmed that there is value in using comprehensive assessments when looking to measure cognitive memory deficits in children. Schuchardt et al., (2008) stated "The findings of this study replicated findings from numerous empirical studies that had reported phonological deficits in children with dyslexia along with specific greeting disorders that are exhibited from poor performance and tasks that test central executive functioning." (p. 12).

Jacob and Parkinson (2015): Interventions

Jacob and Parkinson (2015) critiqued the extant literature on school-based interventions for learning disabilities and executive function deficits. The results from many of the extant studies showed contradictory findings. For example, the authors report,

> Espy et al. (2004) found that inhibitory control was more highly correlated with emergent math skills than either working memory or shifting ability, whereas St. Clair-Thompson and Gathercole (2006) found that working memory was more strongly associated with mathematics achievement than was inhibition. Van der Ven, Kroesbergen, Boom, and Leseman (2011) found no significant association between either inhibition or shifting ability and mathematics achievement but found a strong relationship between working memory and achievement in mathematics.

Specific foci guided the overall analysis of executive function and achievement. First, the authors considered the association between executive function and achievement. Second, the authors considered these relations within the scope of specific academic disciplines. Finally, attribute variables, e.g., age, of the participants were considered. The principal constructs that were investigated included response inhibition, attention control, attention shifting, and working memory.

The authors identified 67 related studies in the literature, and 43 of the set specifically examined the relations among executive function and achievement. Of those studies, more than half were published after 2010. Most research looked at both reading and math. The researchers concluded that the association between executive functions and math achievement was more robust than the relation between executive function and reading. The same pattern held for relations among working memory and achievement. Researchers recorded unconditional correlations between executive function and achievement.

Allsopp et al. (2010): Interventions and Technology

Technology and assistive technology have been proposed as interventions for our students with learning disabilities. Allsopp and their colleagues (2010) reviewed the literature in this area and concluded technology should be used as in an intervention in conjunction explicit and authentic instruction. Five anchors shared for differentiating tiered instruction were described: time, intensity, explicitness, strategic instruction, and opportunities to respond, and technology could be used to address each area. The authors concluded the effective integration of technology with mathematical problem solving and appropriate response to intervention could lead to effective mathematical practice and improvement of students with a mathematic leaning disability. The authors conclude that "Technology has great potential to provide greater access to relevant context within which to situate the big ideas in mathematics." A second consideration is "Technology must be closely integrated with the use of research-supported practices for students in the at-risk for identification of disabilities."

Todd et al. (2001): Planning, Self-regulation, and ADHD

Poor planning and self-regulation are difficult for students who have a learning disability and ADHD. The authors created a frontal lobe activity designed to increase planning, attention, simultaneous, and successive pass theory. They found that students could pass most of these pieces except for the planning portion of the tests, and they argued deficit in the planning area were remediable. Thus, if students being taught to better use planning strategies when engaged in academic tasks, they can improve their level of performance (Naglieri, 2005).

The authors developed intervention sessions to assist the children in understanding the need for the use of planning and employing effective strategies. The aim was that children could

strengthen their use of planning, self-reflection, verbalizing the methods employed, and self-evaluation. Guidelines for prompting were established following the method outlined by Naglieri and Pickering (2003). Students with cognitive average abilities showed little improvement from the intervention, but students with weaker cognitive abilities showed growth. Students in the experimental group had a great area of improvement from the intervention-based discussions. The most important finding was that students in the experimental group improved from the mean by 16.08 points from pre-intervention to post intervention. The effectiveness of this type of intervention was promising.

Diamond and Lee (2011): Interventions

Diamond and Lee (2011) investigated the use of a computer-based intervention for improving working memory. The participants in the study were children between the ages of 4 to 12 years. CogMed, created by Pearson, is a computerized system that develops the working memory of its users. The consumer proceeds through a series of tasks that progress in difficulty. Gains from this system are not immediate. However, after six months, the users exhibit improved working memory. The benefits of computer and non-computer games transferred to untrained measures of working memory (Diamond & Lee, 2011). However, the results are specific to the intervention. Participants trained on reasoning did not improve on speed, and participants trained on speed did not improve on reasoning relative to baseline.

Diamond and Lee (2011) also herald the use of aerobic exercise and physical activity for improving executive function. They argue, “Aerobic exercise robustly improves prefrontal cortex function and EFs, although most studies have involved adults and/or examined effects of a single bout of aerobic exercise, which may be transient, this conclusion has support in three studies of

sustained exercise in children" (Diamond & Lee, 2011). The authors also suggest that exercise can improve cognitive flexibility and creativity, in particular running can show significant more increase in those functions than other standard physical education. This was tested by taking sedentary 7- to 11-year-old and assigning 20 or 40 minutes of aerobic exercise a day. These activities were non-competition based and was meant to emphasize enjoyment. Of the three groups, participants receiving the highest level of aerobic exercise showed improvement on executive function and math when compared to their more sedentary peers. This was also true for working memory students who engaged in aerobic activity for 70 minutes a day showed more improvement in working memory that the controls in the group. Some evidence suggest that physical activity and music training can improve executive function. In an associated finding, Diamond and Lee (2011) promoted play activities as a means for fostering the development of executive functions. They argue for incorporating Vygotsky-type play elements as developed by Bodroya and Leong. The authors note "Vygotsky emphasized the importance of play in early development." (Diamond & Lee, 2011).

Li et al. (2020): Physical Activity as Intervention

Li and associates set forth to examine the effects of physical activity interventions on executive functions in children up to the age of seven. They set forth with a controlled group and experimental groups to examine executive function including meta-analysis. a second group was examined with modifying physical activity interventions from this study. The meta-analysis included 10 separate studies and incorporated over 716 participants.

The introduction went forth to explain the process and definition of executive functions this group of researchers identified executive functions as a higher order of cognitive processes

that could be divided into 3 subgroups including inhibition working memory and cognitive flexibility (Li et al., 2020). They also explained students or children with strong executive functioning skills tend to have better achievement health and quality of life in the future as where children with impaired executive functions often have related issues with behavioral and emotional problems. From the methods of meta-analysis researchers took into consideration studies that incorporated the criteria they were looking for including the participants of this study the intervention noted as physical activity and the outcomes of the executive function performance that included the street 3 subtypes listed above.

With results from this study identifying 10 different studies, it noted that they were recorded and conducted in different areas of the world three of which included the United States the sample sizes also ranged from 26 to 189 the duration also resulted from four weeks to 16 weeks long. The frequency of these studies really depended as well; the duration could be from 15 to 60 minutes and from one time a week to 10 times a week. The conclusion of this intervention shared that physical activity plus cognitive interventions have a positive effect on multiple domains of executive functioning and children up to the age of 7. As a result, researchers included suggestions to parents and educators would be to incorporate and pay attention to physical activity and provide more opportunities to increase their physical activity levels due to their findings of physical activity having a positive effect on executive functions.

Benzing et al. (2019): A Classroom Intervention

Benzing et al.(2019***)*** and his associates set forth to examine the relationship between executive function and academic achievement in the form of classroom-based interventions. the aim of this study was to examine if customized school intervention could improve core executive

functions in school aged children. the sample size for this study included 118 students from 10 to 12 years old. Researchers conducted two separate 6-week studies that included cognitive games or controlled regular school lessons. To begin this study students were given a pre and post assessment on the days of interventions being completed the assessments were computer based and children were seated in separate spaces apart from one another.

The training program noted by Benzing et al. (2019) and his associates lasted 6 weeks, each week students would have two 30-minute interventions at the teacher's discretion. They were given opportunities to play four different games each game increased in difficulty as the intervention went on.

The results from these interventions over the course of 6 weeks included in shifting and updating there was a significant improvement in the cognitive games group compared to the control. In the area of inhibition, it was shared no significant differences were found. However, it was concluded the results from their findings showed improvement for a specific executive function they titled updating and shifting. they also shared no significant correlations were found when it came to participants age and gender (Benzing et al., 2019).

Chapter III: Summary and Implications of the Findings

Although the studies reported some contradictory findings, several principal conclusions emerged from this review. First, the relation between executive dysfunction with students and subtypes of specific learning disabilities was robust. Students with specific learning disabilities are more likely to show lower performance in the areas of executive functioning (Locascio et al., 2010). Students with mathematic learning disabilities consistently exhibit more difficulty with tasks associated with working memory. Although not all forms of learning disabilities arise from executive function deficits, executive dysfunction contributes to learning disabilities and exacerbates the effects.

Interventions may benefit students with executive dysfunction, and these adaptations and accommodations can across all the tiers of RTI. The five anchors shared for differentiating tiered instruction are time, intensity, explicitness, strategic instruction, and opportunities to respond. Some of the unique approaches included educational computerize games and aerobic exercises. Physical activity and music can improve executive function. I also found it intriguing the amount of information and articles that included interventions for Executive function to include physical activity and movement in the classroom. It was eye opening that from the article included that was based on classroom intervention. Shared that the method for intervention was a game-based intervention that incorporated memory and shifting.

Implications

Although myriad interventions for improving the executive functions of students were promulgated, the degree to which such interventions can be implemented in the classroom is a continuing question. Based on my experience, teachers are already required to track and to

record an increasing set of behaviors in their classrooms. Not only do they have to teach the academic content, but teachers must also instruct students about social emotional emotions, mental health, and wellbeing. The studies I reviewed lacked a focus on individual needs. The strategies discussed may be helpful, but individual needs make a consistent type-treatment interaction unlikely. The efficacy of the interventions is also likely to vary across educational environments. However, I believe some of the interventions designed to improve memory and attention can be incorporate into the classroom. Combining these interventions with a fun environment and movement throughout the day, students can experience meaningful learning. I also feel that computerized educational apps and games can help students improve their academic outcomes. The studies I have seen do not support ample amounts of screen time for students in the younger grades. Executive functions are essential for learning and promotes student well-being. I think executive function strategies should be more heavily used in all three tiers of RTI.

Further Research

A number of questions require additional research and study. First, strategies for making these opportunities accessible for all students must be discovered. Within the scope of this issue, the use of games and of computer applications requires further research. Second, the validity of assessments of executive functions needs to be further evaluated. Many of the extant instruments show contradictory findings. Finally, procedures for ensuring the fidelity of implementing interventions must be developed. This also ensures advocacy that allows for school-based interventions to be used in a complementary manner at home.

Other theoretical issues also need to be resolved. First, is the relation between learning disabilities and executive dysfunction constant across all levels of the severity of the disability? Second, are specific subtypes of executive function-based learning disabilities extant? Many of the articles focused not only students who had a specific learning disability but also included a comorbid diagnosis of ADHD. Finally, the relations among how executive functions and other health disabilities needs to be investigated.

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