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THE INTERCONNECTEDNESS OF COGNITIVE AND FORMATIVE SKILLS IN ELEMENTARY STUDENTS WITH SPECIFIC READING DISABILITIES: INSIGHTS FOR EARLY EDUCATION

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Abstract: *The current research aims to investigate the development of formative abilities in elementary school-aged children with specific reading disabilities and its relationship to reading efficiency. In this context, the analysis depicted poor performance in design tasks exhibited by SRD students compared to regular readers and GLD students. The researchers attribute these results to cognitive failures within the concerned mechanisms, including orientation, sequence, and organization of the Visual Analysis System. The findings indicate that these deficiencies affect not only visual representation but also reading and writing. More importantly, there were solid correlations between design abilities, perceptual-motor skills, and memory, pointing to the interrelationship between those skills. As a result, the findings recommend highly targeted interventions at an early stage of education and suggest the need to incorporate creative design-based activities into reading skill enhancement and support for students with special needs.*

Keywords: *Specific reading disabilities, formative ability, cognitive deficiencies, visual analysis system, perceptual-motor skills, early literacy education.*

Introduction

Reading and writing are essential competencies that enable communication and the transfer of knowledge in space and time, but these activities are very creative and pleasurable. Still, they become challenging and tiring for children, especially during the initial years of primary school. This transition is often influenced by factors ranging from biological elements such as mental potential and other cognitive abilities to environmental conditions within the schools. However, despite these challenges, it is still of paramount consideration for any school to teach children the basic skills of reading and writing necessary for communicating in this primarily written world. Proficiency in these skills constitutes the core of academic success and general development.

This research focuses on specific reading difficulties (SRD), defined as severe difficulties in using written language that is independent of intellectual, cultural, and emotional causes (Ellis, 2016). These difficulties impact various linguistic skills, including grapheme-phoneme correspondence, short-term memory, and the perception of order and sequence. Although specific reading difficulties have already been known for almost a century, new questions concerning their etiology, characteristics, and intervention methods continuously arise during this developing era, stressing the need for continuous research in this content area.

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The theoretical framework provided by the cognitive psychology approach holds complex insights into the reading process. To this end, a critical review of theoretical and research data on specific reading disabilities with an eye on possible cognitive causal factors is conducted within the parameters of Ellis's (2016) cognitive processing model for reading. Specific reading disabilities are mental and affect linguistic skills associated with written language use. It would also contain grapheme-phoneme correspondence, short-term memory, and perception of order and sequence–both of which are very crucial for reading proficiency.

Cognitive dimensions of children's drawing are considered in this research, particularly analyzing the processes of drafting and the skills required in producing integrated drafts. It is essential research to try to establish the differences between these two groups in terms of cognitive and developmental aspects, thus giving an insight into why students with SRD perform poorly compared to non-SRD students.

The research objectives driving the study are several. SRD children are compared to regular readers and GLD children to determine their construction skills. Such a comparison permits the identification of areas where children with SRD may have a deficit and their degree of difficulty. It also aims to investigate the relationship between reading ability and formative skills and determine whether reading difficulties can be linked to problems in other cognitive and motor tasks. In this respect, research into drafting procedures and the resulting skills necessary for integrated drafting production is hoped to create a picture of the cognitive dimensions involved in children's drawing.

In this work, the method includes detailed diagnostics of the following cognitive skills: short-term and working memory, design ability, perceptual-motor coordination, hierarchical representation, object connectivity, and visual realism with the design tasks "Draw a Person" and "Draw a Man Sitting on a Chair." Short-term memory tasks included recall of words, numbers, and shapes, and perceptual-motor skills were assessed in tasks contributing information about spatial orientation and visual-motor coordination. It follows from these observations, that such assessments should give a clear picture of the cognitive and developmental differences between SRD readers, regular readers, and students with GLD.

It is expected that this research finding on children with specific reading disabilities will bring out significant differences between them and those who are regular readers compared to students with general learning disabilities. It is expected that SRD will have poorer performance on tasks requiring cognitive and perceptual-motor skills, thus bringing deficits, regarding visual-spatial coding, sequencing, and processing. These findings will underscore the particular challenges faced by children with SRD and point out that specially designed interventions are essential to supporting their development.

In conclusion, the present research seeks an in-depth understanding of cognitive and formative skills development among students with specific reading disabilities attending elementary school. Relating these children to regular readers and children with general learning disabilities will seek to discover what makes SRD truly unique for children who experience it, along with how the ability to read proficiently relates to the development of formative skills. The results of the research consequently influence early literacy education by emphasizing the importance of targeted interventions and creative design-based activities in the process of reading skill development support and the provision of therapy to students with unique learning challenges.

Methodology

The research uses an exhaustive research methodology designed to examine cognitive and formative skill development in elementary students with specific reading disabilities compared to regular readers and GLD students. The methodology will be tightly held to guarantee the validity, reliability, and replicability of findings adhering to rigorous scientific experimentation standards.

Sample Selection and Participant Demographics

The sample consisted of 80 children from elementary school aged between 7 and 9 years: 30 SRD, 30 regular readers, and 20 GLD. This age range was chosen given the critical periods of development in cognitive skills and literacy. The participants were selected using a multistage procedure where the first

stage was teacher referral and a series of diagnostic tests to confirm the presence or absence of SRD as based on the Diagnostic and Statistical Manual for Mental Disorders, 5th Edition (DSM V) (American Psychiatric Association 2013).

The SRD participant inclusion criteria required considerably lower reading achievement than their age, amount and quality of schooling, and intellectual ability, but with no evidence that vision, hearing, or neurological disorders could be a primary cause. The regular readers were matched on age, sex, and intellectual ability. Still, they demonstrated average reading skills, whereas the GLD group showed general learning difficulties, which were not confined to reading only (Archibald & Gathercole 2012). Socio-economic status was controlled because children were chosen from similar socio-economic backgrounds to limit extra variability.

Assessment tools and procedures

Throughout this phase, the research drew upon special diagnostic tools which were utilized for weeks concerning reading proficiency, general cognitive abilities, and formative skills. Since there are no standardized diagnostic tools in Greek, the researchers approached reading proficiency through a personalized test battery in this context. The test battery consisted of a measure of reading speed, accuracy, and comprehension that was formulated and standardized by a pilot study with 30 children who attended each grade level (Arnheim 1956).

Reading Assessments

Reading assessments were conducted where the children read out aloud grade-appropriate passages, which were then followed by comprehension questions. Speed was timed and errors analyzed, all in an attempt to show trends of mistakes, finally helping to rule out the sole cause of comprehension mistakes: decoding issues. Benchmarks of reading speeds were formed during the pilot study to allow comparison between SRD, GLD groups, and regular readers as a baseline.

Cognitive Assessments

Performance tasks for cognitive abilities included measurement for short-term memory, working memory, and visual-spatial processing. The assessments conducted for this involved:

i. Verbal memory tasks: immediate repetition of those words, such as monosyllabic and two-syllable words, that test phonological memory.

ii. Numerical Memory Tasks: This involves the recall in a forward and backward order of single-digit sequences to quantify the working memory capacity.

iii. Visual-Spatial Tasks: Shapes, their orientation, and positions contribute to the understanding of visuospatial deficits in SRD students.

Formative skill assessments

Formative skills were assessed by the design tasks requiring drawing and copying complex geometric patterns. Tasks such as “Draw a Person” and “Draw a Man Sitting on a Chair” were performed to estimate visual spatial encoding and hierarchical representation as described by Freeman, 1980. These tasks provided information regarding planning and organizing abilities at work while drawing with pencil and paper, which is how Piaget (1952) ranks children’s cognitive development stages.

Testing environment and procedures

All the tests were conducted in quiet, distraction-free school settings to establish a consistent atmosphere. Each child was tested individually, with sessions recorded to enable detailed error analysis, as well as, to ensure accuracy in data collection. Extensive training was provided to teachers and researchers executing the tests to undertake assessments adhering to standardized procedures for all sorts of tests (Cortiella & Horowitz 2014).

Data Analysis

The analysis of the data focused on comparing the performance of SRD students to that of regular readers and GLD students using statistical methods. Primary ANOVA analyses were run to determine any significant difference across groups; these are supported by post-hoc tests examining specific group differences. A correlational analysis was implemented about reading proficiency versus cognitive abilities and formative skills.

Ethical Considerations

Ethical approval for this research was sought from the appropriate educational and research ethics committees. Consent was obtained from the parents or guardians through informed consent. In addition, assent was sought from the children themselves based on confidentiality and anonymity grounds. Good practice consisted of properly storing data with only appropriately authorized persons having access to it for proceedings, according to Fargas-Malet et al. (2010. This would then be a relatively solid and comprehensive research methodology for gaining an in-depth understanding of the cognitive and formative skill development of SRD children. It uses many validated assessment tools so that, through stringent data analysis techniques, this research adds valuable input into the literature on the particular challenges among SRD students with a view toward targeted educational interventions. The methodology is so meticulously designed and implemented that it ensures the reliability and validity of the findings, thus paving the way for future research and improved educational practices.

Results

The research has compared cognitive, design, and perceptual-motor features in children with specific reading disabilities (SRD), regular readers (RR), and general learning disabilities (GLD). It takes explicitly into account the short-term and working memory processes, features in design ability, and perceptual-motor coordination as the children use verbal, arithmetic, and virtual-symbolic systems.

Cognitive Factors: Short-Term and Working Memory Short-Term Memory Performance

All the symbolic systems under consideration showed significant short-term memory performance differences. For numerical tasks, SRD children performed worse compared to other children using the RR and GLD systems. In particular, the straight-line recall of single-digit numbers revealed significantly poorer performance for SRD children (mean = 3.60, 3.63, 3.71) compared to RRs (mean = 6.42, 6.74, 6.80) and GLD children (mean = 5.76, 6.63, 6.02). This is consistent with findings from Ornstein et al. (2013) and Chang et al. (2019), which both emphasize the challenges SRD students have with basic arithmetic recall.

Working Memory Deficits

Reversed-digit recall tasks that placed demands on working memory also showed the deficit of the SRD students. Their mean scores of 2.60, 2.46, and 3.13 were significantly lower than those of both the RRs with 5.29, 5.77, and 6.13, practically equal to those of the GLD students with 3.73, 5.16, and 6.11. In this sense, such tasks that place students in a position to initialize components to handle controls are complex for SRD students to handle.

Verbal memory performance

The researchers found that in verbal tasks, the scores for the repetitive monosyllable and two-syllable meaningless words tasks were significantly impaired in the SRDs. They scored very low: mean = 2.45, 2.38, 3.31 for monosyllables and mean = 4.42, 4.38, 4.93 for meaningless words, against a much superior performance by NRRs, who scored mean = 5.82, 6.24, 6.96 for monosyllables and mean = 4.10, 4.41, 5. This supports the notion that SRD students have tremendous problems with phonological processing, as also noted by Gupta and Sharma (2017).

Human Contact

Overall System Performance

Results indicated that the SRD students always performed much worse than the RRs and GLD in all design tasks. For instance, the talk about the human figure drawing test revealed that students whose belongings registered means of 9.82, 22.33, and a value of 25.58 were less compared to RRs and GLD with corresponding means of 42.26, 53.83, and 64.80, and 33.89, 43.77, and 39.25, respectively.

Specific design work

In tasks demanding the representation of spatial relationships and structural links, SRD students performed very poorly. For example, their score was meager (mean = 2.26, 2.92, 2.19) on the task of drawing a mug with a concealed handle, compared to RRs' performance (mean = 3.64, 3.69, 3.95) and that of GLD students (mean = 3.42, 3.30, 3.46). It is possible that this indicates a profound deficit in orientation, direction, and sequence handling of visual information, and that confirms our initial hypothesis.

Complex spatial tasks

Even with more complex tasks, such as the ability to draw a multi-colored cube, SRD children faced another day of terrible debt. In this regard, the performance of SRD children (mean = 0.48, 0.63, 0.92) did not compare favorably to that of either the RRs (mean = 2.82, 3.27, 3.58) or the GLD children (mean = 2.42, 2.91, 2.78). This signals a more fundamental problem.

Perceptual-Motor Coordination

Orientation and coordination

The research revealed that perceptual-motor tasks that involved spatial orientation and coordination showed large discrepancies. SRD students performed the worst in activities that required precise spatial representation and sequencing, an example of which is the Rey-Osterrieth complex figure. Their scores (mean = 2.00, 2.99, 2.49) were much below those of RRs, with a mean of 3.60, 3.86, 3.98, and GLD students with means of 3.17, 3.44, and 3.43. This showed major inadequacies in these areas, as reported by Pick (2012).

Developmental Trajectories

The trajectory analysis showed that while the groups improved with age, the reaction to improvement was significantly slower for the SRD students compared to the controls. This was an observation based on development being found to be two years behind the peers of cognitive function for tasks involving complex cognitive processes among people classified as SRD (Low et al., 2019). An interaction between group and age for working memory tasks is described at the next level of cognitive processing.

Correlation Analyses

These immediately reveal high correlations between reading ability and performance in cognitive and design tasks. The most highly correlated with reading ability was spatial relationships, at 0.87, with direction and orientation yielding 0.77 and sequencing with 0.74. These results underline that cognitive skills, design skills, and perceptual-motor skills are very much interrelated. The results of this research confirm earlier reports that children with specific reading disabilities demonstrate fewer cognitive, design, and perceptual-motor skills compared to their counterparts. The deficits were pervasive across verbal, arithmetic, and virtual symbolic systems, as well as exceptionally sharp in tasks requiring complex visual-spatial processing and working memory. These findings recommend that perspectives be directed to target such diversified difficulties in intervention measures and focus on developing crucial skills amongst the SRD students.

Discussion

Several limitations must be drawn out while drawing valuable insights from this study. First, the sample size was relatively small. Besides, it had geographical limitations; therefore, generalization is not very applicable. Future studies should test these findings in more extensive and diverse populations. The study was focused on 7-9-year-old children, which is quite a narrow age range and hence not representative enough to explain the entire developmental trajectory of SRD students. Longitudinal studies with participants of a greater age span will be critical in setting the proper understanding of how cognitive and design abilities may change over time.

Moreover, reliance on specific tasks to measure cognitive skills, design skills, and perceptual-motor skills may not explain the summation of each of these abilities. The assessment is more enriched with a variety of tasks and measures to understand the deficits based on SRD students holistically. Finally, although correlations between reading abilities and cognitive skills were determined in this study, causal relationships were not established. Experimental studies are called to establish causal relationships between these variables.

Several key areas should address the results of this study in future research, however. First, while a small, homogeneous sample was sufficient for the initial research, increasing sample size and diversity is most important for generalizing the findings. There should be an increased representation of students from different socio-economic backgrounds and regions, presenting more variety in facing challenges that SRD students commonly encounter. In addition, if one added a longitudinal design at this point,

researchers could follow up on the development of cognitive, design, and perceptual-motor skills in children over time, thus gaining a deeper understanding of the progress and possible interventions against reading disabilities.

Further research should be conducted on the neural mechanisms underlying these deficits. Neuroimaging studies could thus provide information about which brain structures and functions might underlie the cognitive and visuospatial difficulties seen in SRD students. The neural basis of these deficits may, therefore, underpin more efficient and targeted interventions.

Another area of future critical research should relate to intervention studies. It would be of probable assistance in improving their reading if specific educational programs for students with SRD were designed and tested to enhance cognitive, design, and perceptual-motor skills. These intervention strategies will have to be based on evidence-based practices, addressing clearly any challenges the study identifies as peculiar to such children.

Future research should investigate how technology can support SRD students in various ways. This may involve pragmatic digital tools and applications, along with other interactive opportunities that enable students to practice reading and other cognitive skills. In this respect, therefore, studies into the effectiveness of these tools within educational settings would be beneficial.

The last is interdisciplinary research involving educators, psychologists, neuroscientists, and technologists. Through such interdisciplinary collaborative efforts, comprehensive intervention programs for SRD can be realized in several aspects with the multimodal approach needed to address the multifaceted reading disability. This will help combine expertise from different specializations to generate holistic and more potent strategies for supporting SRD students.

This work brings out in clear terms how a relevant majority of children with specific reading disabilities manifest significant cognitive, design, and perceptual-motor deficits. The findings here further emphasize the importance of focused interventions and further research in facing such challenges. Expanding the scope of future research will provide additional insights into improving educational outcomes for SRD students through interdisciplinary approaches. Many of these deficits need to be addressed in trying to ensure that every possible attention is accorded toward the level of development of reading and writing, which will be supportive of the realization of lifelong learning and academic success.

Conclusion

This research investigated the cognitive, design, and perceptual-motor skills of children with specific reading disabilities compared to regular readers and those with general learning disabilities. The findings revealed pervasive, significant deficits in cognitive abilities–in particular, short-term and working memory–along with design and perceptual-motor coordination in SRD students. These deficiencies cut across verbal, arithmetic, and virtual symbolic systems and are most striking in tasks requiring complex visual-spatial processing and working memory.

Cognitive and memory deficiencies

Research showed that SRD students are facing problems regarding short-term and working memory tasks. When compared to RRs and students with GLD, their results in terms of recalling a single-digit number and words, both meaningful and meaningless, were poor. It helps focus on the difficulties faced by SRD students in phonological processing and recall, which are very important for reading and writing skills. These findings have rightly placed phonological and working memory deficits at the core of reading disability in children, as identified through previous research (Swanson, Zheng, & Jerman 2009; Gupta & Sharma 2017).

Designing and Visual-Spatial Challenges

Students with SRD demonstrated substantial challenges in designing tasks requiring visual-spatial coding and coordination. Drawing, for example, functions like human figures or three-dimensional objects, were inferior as compared to their peers. Indeed, these tasks demand complex cognitive and motor skills related to planning, sequencing, and spatial integration–areas behind the performance of students with SRD. This sustains the hypothesis that visual-spatial deficits are a critical component of reading

disabilities since these are significant skills underlying the decoding and comprehension mechanisms of written language.

Perceptual-Motor Coordination

This current research confirms that students with learning difficulties show perceptual-motor coordination defects. It primarily emerged in tasks requiring spatial orientation, like the Rey-Osterrieth complex figure. Defects in the accurate representation and coordination of spatial relationships negatively affect reading development since they are connected with a student's perception and processing of written text. The results indicated findings from previous studies that pointed out perceptual-motor skill performance as affecting reading skills.

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