Babes-Bolyai University
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OVERVIEW
Ph.D. THESIS
COGNITVE AND SOCIO-EMOTIONAL CORRELATION OF READING COMPREHENSION AND THE ROLE OF ALTERNATIVE INTERVENTIONS IN REMEDIATION OF READING AND COMPREHENSION DISABILITIES

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Introduction

Reading is a complex process, considered the basis for acquiring knowledge about the word and for living everyday life in an accessible environment (Xia, Gu, & Li, 2019). Also, reading is an effective tool for assuring lifelong learning (Milana, Webb, Holford, Waller, & Jarvis, 2018). All the above can be realized only if reading becomes a habit, a valuable free-time activity (Stahl, Flanigan, & McKenna, 2019, Martin-Chang, Kozak, Levesque, Calarco & Mar, 2021).

The prevalence for dyslexia has been estimated to 4-20% (Banfi *at al*., 2017; Knight, 2018), which is an extremely large number of affected people. Nevertheless, the percentage of people having difficulties during reading and comprehension is even higher. Statistical data

assumed that only 36% of fourth grade children read and comprehend at the expected level (Al Otaiba, Rouse, & Baker, 2018). The importance of the topic is given by the effect of the remedy program with involved research that can contribute to diminishing the functional analphabetism in elementary education.

Results on visual processing of information are contradictory. Some concluded that the development of these processes does not induce the change of reading quality (Rima, Kerbyson, Jones, & Schmid , 2020), while others think about these processes as unique predictors of reading ability (Liu, Liu, Pan, & Xu, 2018; Higuchi, Iwaki, & Uno, 2020).

Similarly, results are controversary for cognitive factors, which determine the academic performance. These factors represent the solid base for processing new information and for connecting this new information with own experience and knowledge (Neroni, Meijs, Gijselaers, Kirschner, & Groot, 2019).

The magnitude of cognitive disfunctions, the variety of theories, and the inconsistence of results determine one of the objectives of this dissertation, namely, to analyze the relation between cognitive processes and reading in dyslexic children. Our effort was inspired on previous research papers, which addressed the visuospatial processing and the role of visual working memory in reading. This represents a less studied topic then the phonological perspective in the scientific literature.

On the other hand, the cognitive symptoms affect the person's self-esteem and motivation, and the perceived differences are associated with socialization problems. Altogether, these favorize the emergence of secondary compartmental problems (Livingston, Siegel, & Ribary, 2018), or of different grades of self-isolation (Kollosche, Marcone, Knigge, Penteado, & Scovsmose, 2019).

The motivation for reading and reading comprehension (Soemer & Schiefele, 2018) are interrelated, and the quantity of reading has a mediating effect in this doubled relationship. Field research demonstrated that parents' expectance represents long-term predictors for their children's educational level (Loughlin-Presnal & Bierman, 2017). Another result (Marshik, Ashton, & Algina, 2017) evidenced that a positive relationship exists between the teachers' professional satisfaction and the students' intrinsic motivation.

The academic self-concept has a decisive role in cases of cognitive effort and perseverance (Locher, Becker, Schiefer, & Pfost, 2021). Low achiever students do not make any effort to learn, so the process of learning will not be completed successfully (Hier & Mahony, 2018).

Based on the above-mentioned results, the dissertation proposed the fallowing objective: to demonstrate the impact of motivational, behavioral, and environmental factors as predictors for reading comprehension. An additional research goal is to identify differences between groups based on comprehension level and gender.

The optimal cognitive load is to provide the reading activity with the sensation of flow (Thissen, Menninghaus, & Schlotz, 2018).

The cognitive load theory used in educational context for reducing overloading.

The multimedia learning is gaining ground but implies the use of modalities in alternate ways and rapid integration of the information, which can induce overload (Campen, Seger, & Ludo, 2018).

Grounded on this theory we create the adapted, personalized environment (Curum & Khedo, 2021), which is vital for the adequate support. This can assure all conditions in which children with special learning disabilities can develop (Farrell, 2017).

Work reported here will offer an answer to the questions related to the impact of cognitive load on the achievement and the differences between gender- and comprehension level-based groups.

Early intervention represents and efficient strategy for remediation of reading and comprehension problems (Miller, McCardle, & Connelly, 2018). Nonetheless, the success of remediation depends on parents' attitude, as well (Turek, 2020), particularly on their ability to be involved in teamwork with specialists (Adlof & Hogan, 2018). An adequate, personalized program can only be assured after knowing the students' abilities and involvement (McGeown , Bonsall, Andries, Howarth , & Wilkinson , 2020).

The Sindelar program focuses on students, offering them direct assistance. This is a cognitive development training program. Efficiency of this program was evaluated exclusively based on grade reports (Kiss & Zsoldos, 2004; 2008), or with the harmonization of cognitive structure (Chiş & Peter, 2012, Bendova & Karmanska, 2019, Sindelar, Aden, & Sindelar, 2018).

Co-repetition can offer immediate results, but though needing extended time, cognitive training can offer sustainable results. Therefore, our main objective was to confirm the hypothesis that harmonization of the cognitive architecture will develop reading, writing, and reading comprehension.

FIRST CHAPTER: THE PSYCHOLOGICAL CORRELATES OF READING

" Reading is important, if someone can read, then is capable of learning everything" (García & Lind, 2018)

"Speech determines humanity and reading determines civilization" (Santi & Reed, 2015).

Books belongs to everyone (Court, 2017), reading as a social practice is an integrated part

of everyday life. Reading affects the academic level, the quality of life, participation, and increases the number of choices (Luke, 2004).

1.1. Reading, as a complex cognitive process

Reading is composed of two factors: decoding (automatized in maxim four years) and comprehension, which develops continuously (Fritz, Hasse, & Rasanen, 2019). Identification of a written word is augmented with the proper fluency, optimum motivation, and several basic abilities (Burney, 2015). Culture, school, home environment, and different developmental programs affect the development of reading (Jones & Brown, 2011). Comprehension is one of the indispensable abilities acquired in school (Milana, Webb, Holford, Waller, & Jarvis, 2018).

The development of reading

In the model conceptualized by Linnea Ehri (2009) reading of words is an interaction between the printed text and the phonological representation, and this development has distinct stages. Morton's model of development (in Csépe, 2006) sustained that reading aloud can be accomplished in semantic or phonological manner.

Psychological models and theories of reading

According to Goodman's definition (Siew, Anderson, Moore, & Tang, 2019) reading is a selective process. Rumelhart (Zhang, 2018) proposed an interactive perspective. Identification of words in the incipient phase is a good predictor for later comprehension (Tong, McBride, Shu, & Ho, 2018). A simple view of reading sustains that the decoding accounts for 80% of comprehension (Leon & Escudero, 2017). The scheme theory (Anderson and Pearson) (in Cromley, Kunze, & Dane, 2021) emphasizes the role of interaction between new information and background information.

Cognitive aspects of reading

Comprehension and vocabulary

Proficiency of an individual's vocabulary is strongly associated with reading comprehension (Stahl, Flanigan, & McKenna, 2019).

Reading fluency

Reading fluency can be defined as the stage of reading where the accuracy and speed of reading is adequate (Katheb & Bar-Kotchva, 2016). Reading in mind does not impact the fluency of reading (Mather & Wendling, 2012). Fluency means that the number of words identified at a single glance is growing (Willingham, 2017). Identification of unfamiliar words implies different strategies (van Viersen, de Bree, Kalee, Kroesbergen, & de Jong, 2017).

Perception, memory, and other executive functions

Visual perception is correlated with reading (Kavale & Forness, 2000). Consciousness and the complying with rules demand resources from the working memory (Schiff & Levie, 2017).

The psychosocial dimension of reading

Development is a sociocultural process, and the specific characteristic of humans is the creation and usage of signs and symbols (Fleer & Oers, 2018). O'Donell (Arcidiacono & Aber, 2017) represents the cultural psychology.

The social learning theory explains how someone can develop himself/herself in a social context (Graham, 2017).

The motivational dimension of reading

The motivation is a basic factor for learning and development of reading. In a motivated child experiment, one discovers new tasks (Haywood & Lidz, 2007). Success depends on how others perceive the situation (Carpendale & Lewis, 2004).

1.2. Dyslexia and dysfunctions of reading

Specific learning disabilities (F81) are part of neurodevelopmental disabilities, in which the main symptom is the altered perception and processing of information (ApsyA, 2013). Specific limitations may occur, as learning or the executive functions, but much more severe difficulties may pop up, such disabilities in social abilities, or intelligence (ApsyA, 2016).

Theories and models of reading disabilities

Models of cognitive system deficits are focused on studies of linguistic systems, on memory, or attention. Once the way and the strategy of linking the ideas is disclosed to the reader, superior results will show up only in the learned situations (Willingham, 2017).

Cognitive dimensions of reading disabilities

In transparent languages the verbal comprehension and vocabulary are predictors of the written text comprehension (Florit, Roch, Dicataldo, & Levorato, 2020). In opaque languages decisive role in reading goes to morphological awareness (Görgen, De Simone, Schulte-Körne, & Moll, 2021). Orthography problems can show up even in the case of performant readers (Georgiou, Hirvonen, Manolitsis, & Nurmi, 2017). The reading process implies to decode the visual input and to code the information in concepts (Coates, Bernard, & Chung, 2019).

Rapid automatized naming is strongly connected with word reading skills over the first school years, but later this influence decreases (Gordon, Islam, & Wright, 2020).

Children with developmental dyslexia may have deficits in visual attention, which cause poor graphical processing of letters (Vidyasagar & Pammer, 2010; Higuchi, Iwaki, & Uno, 2020).

Beside the social, emotional, and social relational problems, children with reading disabilities have problems with executive function, automatization, attentional control, working

memory, vocabulary, reading comprehension, recalling, and spatiotemporal orientation (Cappelli, Noccetti, Arcara, & Bambini, 2018).

The psychosocial dimension of reading disabilities

Special reading difficulties are part of the invisible needs category, which combine various symptoms (Alexander-Passe, 2017). Such persons have problems in decoding, which affects text comprehension (Suárez-Coalla, Martínez-García, & Carnota, 2020; Romero, 2020), but the interpretation of the events hinders self-esteem (Petri & Govern, 2004; Mudrák, Zábrodská, & Takács, 2020).

The motivational dimension of reading disabilities

Success is guaranteed in a complex task only by motivation, which assures perseverance and implication in the tasks to be solved (List, 2020). To improve achievement, self-regulated learning should be instructed to children with specific learning disabilities (Juntorn, Sriphetcharawut, & Munkhetvit, 2017). Whoever gains a positive self-concept as a reader, will have more books than those with negative self-concept (Segerer, Niklas, Suggate, & Schneider, 2020). A study (Forzani, et al., 2020) about curiosity affirms that intrinsic motivation is a key factor in education.

SECOND CHAPTER. THE RECIPROCAL RELATION BETWEEN THE COGNITIVE FUNCTIONS OF VISUAL PROCESSING AND READING DISABILITIES

Visualization is the ability to manipulate and transform images in new situations, based on spatial patterns (Duranovic, Dedeic, & Gavrić, 2015). Research (Bonifacci, 2004; Hein, Rolke, & Ulrich, 2006; Yang *at al*., 2013). This underlies the importance of visual abilities.

Cognitive processes in reading

According to Gabowitz *et al*. (2008) specific cognitive domains comprise attention and concentration, executive functions, learning and memory, visuospatial abilities, and psychomotor activities. The focus of attention gains an important role in comprehension (Khera, 2013). Visuospatial functions play a role in grapheme identification (von Karolyi, 2001).

Visual cognitive processes and reading disabilities

The precarious processing of letters/numbers is due to the deficit of visual attention, this plays a key role in developing reading deficits (Vidyasagar and Pammer, 2010). Executive functions will influence the way in which students will react to the intense interventions on their reading (Miciak, Cirino, Ahmed, Reid, & Vaughn, 2019).

Cognitive disfunctions in reading disabilities. Empirical results

From superior reading processes the most important one are the establishment of relations, conclusions, executive functions, and attention, which offer the possibility to focus on the important parts and the key concepts of the text (Kendeou, van den Broek, Helder, & Karlsson, 2014).

Meta-analyses of attitudes and efficiency of reading consider that the attitude is a predisposition, a result of repeatedly meeting of one thing or one person (Nootens *et al*., 2019).

In the learning process, cognitive competencies are indispensable. These competencies are the solid base for processing, storing, and recalling the information. The academic performance is determined by the formation of bridges between experiences and knowledge (Neroni, Meijs, Gijselaers, Kirschner, & Groot, 2019).

FIRST STUDY. META-ANALYSIS: EXPERIMENTAL PROOFS OF VISUAL MEMORY CAPACITY, VISUAL ATTENTION, AND FACTORS OF VISUAOSPATIAL

INFORMATION PROCESSING AS COGNITIVE MODERATORS OF READING DISABILITIES

Theoretical background: Relation between visuospatial information processing and reading disabilities

Reading difficulties are often associated with an extensive range of cognitive deficits as compared to control participants without dyslexia, chosen by chronological or by reading age. Results of different studies are heterogeneous about the cognitive domains or the severity grade. In consequences, the exact model and the magnitudes of cognitive disfunctions are unclear, so results are inconsistent and ambiguous.

Objectives and hypotheses

Objectives

The goal of this meta-analysis is to identify in the special literature studies that threat the role of visuospatial processing and capacity of working memory as considerations for elementary school age children with reading problems.

Objective of the meta-analysis is to identify in the literature studies, which treat the role of visuospatial processes and the accountability of working memory in causing reading difficulties of elementary school children. The main goal is to determine the intensity of relation between reading difficulties and cognitive deficits.

Methods and procedures

Procedures

In this study we focused on reading difficulties based on visual or visuospatial theory, and only with participants from elementary grade students.

Selection of the studies

Our search for studies and relevant research for this meta-analysis exploited the following databases: Web of Science, Psyinfo, Ebsco, ProQuest, PsyArticles, and ScienceDirect.

Key concepts (i.e., keywords used in the search) were the followings: visual perception, capacity of working memory, visual discrimination, visual differentiation, visual seriality, visuomotor coordination, visual attention, spatial orientation combined with concepts as reading disabilities, dyslexia, and poor reading.

Criteria for inclusion

Studies included in the present meta-analysis fulfill the following criteria: (1) published or available in English, (2) its participants are diagnosed dyslexic children from elementary grades without any other special needs, (3) they offer sufficient information about participants characteristics, methodological characteristics, and conceptualization of factors, and (4) are based on visuospatial theory of reading.

After the eligibility analysis in the qualitative synthesis were included 35 studies, while in the quantitative part 33 studies. The synthesis of selection process is illustrated in Figure 1.

Codification of the studies

Codification of the characteristics of the studies and participants

Characteristics of studies were codified directly.

Most studies presented more than one size effect, totally 377 were calculated.

Classification of cognitive domains

In the present meta-analysis we included as predictor factors the followings: visual perception, visual working memory, spatial proceeding, PIQ, cognitive speed, and visual attention.

Detailed description of the studies is summarized in Table 1.

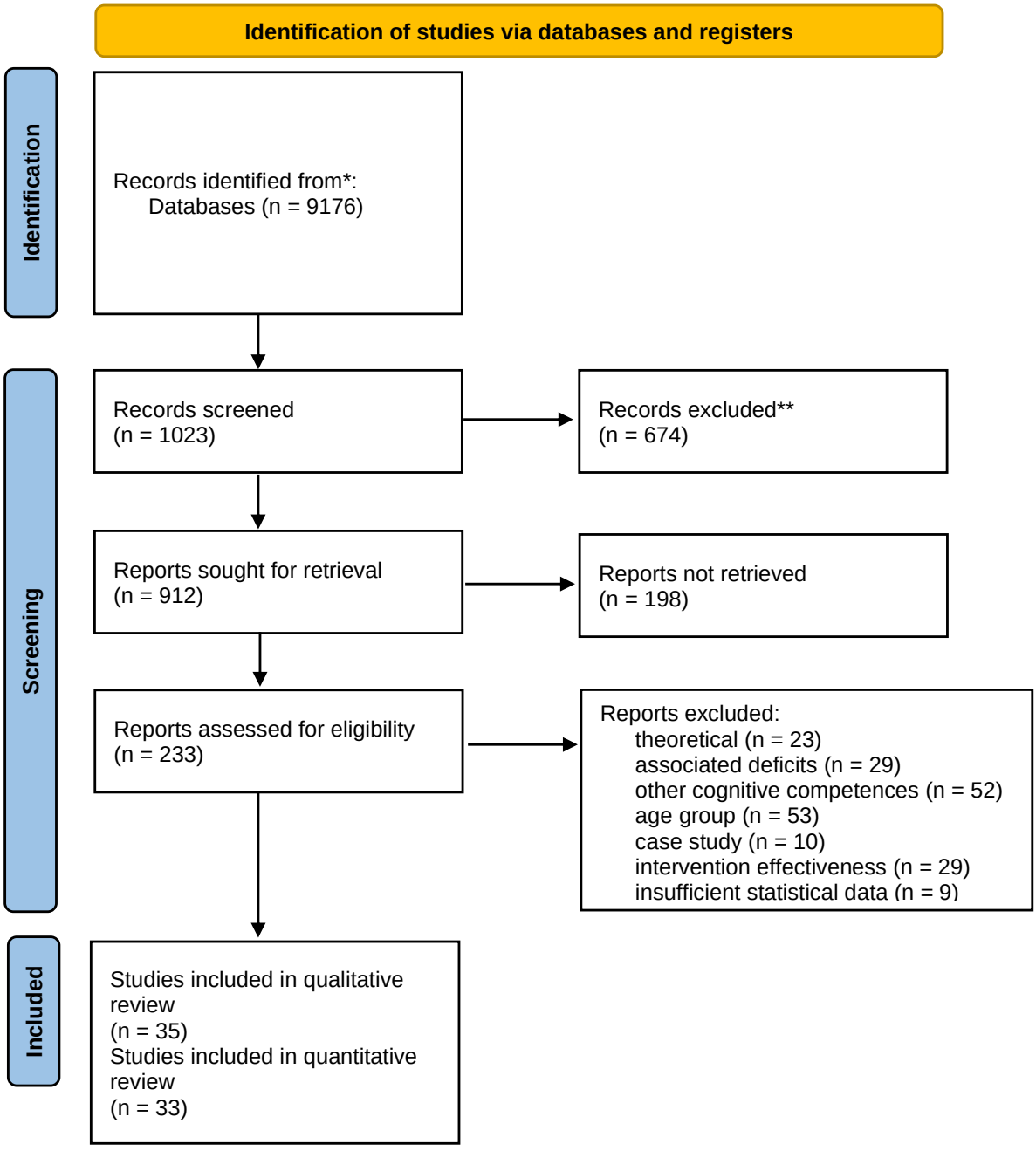

Figure 1. PRISMA Flow Diagram

Table 1. The Characteristics of the studies from the meta-analyses

name of the study	subgroups	nr. of participants	medium age	boy's percentage	tip of study	Predictors	criteria
Albano, 2016	dyslexic, neurotypical chronological age	46	10.41	49	CS	visual memory	read aloud
Alloway, 2010	dyslexic, neurotypical chronological age	98	5/10.11	51	CS, longitudinal	PIQ	read aloud, comprehension, spelling
Araujo, 2014	dyslexic, neurotypical chronological age	37	10	64.8	CS	cognitive speed	read aloud, reading speed
Bieger, 1978	dyslexic	22	8.5	50	CS	visual perception	read aloud
Bosse, 2007	dyslexic	68	11.6	64.7	CS	visual attention	read aloud
Campen, 2018	dyslexic, neurotypical chronological age	64	11.07	55	CS	visual memory	read aloud
Cho, 2011	dyslexic, neurotypical chronological age, neurotypical reading age	90	8.18	51.11	CS	visual memory, spatial processing, visual perception, cognitive speed	read aloud, spelling, reading speed
Chung, 2008	dyslexic, neurotypical chronological age, neurotypical reding age	78	8.7	unspecified	CS	visual perception cognitive speed	read aloud
Duranovic, 2015	dyslexic, neurotypical chronological age	80	10.01	47.5	CS	visual memory, spatial processing, visual perception	read aloud, comprehension, spelling
Emam, 2014	dyslexic, neurotypical chronological age	346	8.61	80.92	CS	visual perception	read aloud
Fernandez, 2017	dyslexic, neurotypical chronological age, neurotypical reading age	32	9.52	37.5	CS	visual perception, spatial processing cognitive speed	read aloud
Gang, 2002	dyslexic, neurotypical chronological age, neurotypical reading age	93	9.92	41	CS	visual memory	read aloud
Garcia, 2019	dyslexic, neurotypical chronological age	56	10.5	50	CS	visual memory	read aloud
Gathercol, 2006	dyslexic	46	9	71.73	CS	visual memory, PIQ, spatial processing	read aloud
Giorgetti, Lorusso, 2018	dyslexic, neurotypical chronological age, neurotypical reading age	60	10.6	50	CS	visual memory, spatial processing	read aloud
Gokula, 2019	dyslexic, neurotypical chronological age	53	9.7	62	CS	visual attention, visual memory	read aloud
Gopalan, 2020	dyslexic, neurotypical chronological age	100	12.73	41	CS	visual attention, spatial processing	read aloud

name of the study	subgroups	nr. of participants	medium age	boy's percentage	tip of study	Predictors	criteria
Helland and Asbjørnsen 2000	dyslexic, neurotypical chronological age	53	12.39	82	CS	visual perception, cognitive speed	read aloud
Hogan, 2011	dyslexic	194	8	58.24	longitudinal	visual perception, PIQ	read aloud comprehension
Hulme, 2007	neurotypical	127	8.11	48.03	CS	visual memory	read aloud
King, 2008	dyslexic, neurotypical chronological age, neurotypical reading age	69	10.1	85.5	CS	visual perception	read aloud, spelling
Langer, 2019	dyslexic, neurotypical chronological age	30	10.15	47	CS	visual perception	read aloud
Lazzaro, 2021	dyslexic, neurotypical chronological age, neurotypical reading age	48	11.94	56.25	CS	visual attention, spatial processing	read aloud
Leclercq, 2012	dyslexic, neurotypical chronological age, neurotypical reading age	45	9.34	42.22	CS	visual perception	read aloud
Li, 2021	dyslexic, neurotypical chronological age	60	10.7	53	CS	visual memory	read aloud
Liu, 2018	dyslexic, neurotypical chronological age	80	9.22	45	CS	visual attention, cognitive speed	read aloud
Mammarella, 2010	dyslexic, neurotypical chronological age	36	12	38.88	CS	visual perception, cognitive speed spatial processing, visual memory	read aloud
Marinus, 2010	dyslexic, neurotypical chronological age, neurotypical reading age	72	9.2	37.5	CS	visual perception	read aloud
Moura, 2014	dyslexic, neurotypical chronological age	100	9.81	69	CS	visual perception, PIQ, visual attention, cognitive speed, spatial processing	read aloud
Park, 2012	dyslexic, neurotypical chronological age	89	8.78	50.56	CS	visual memory visual perception	read aloud, spelling
Pereira, 2020	dyslexic, neurotypical chronological age	78	9.23	49	CS	visual attention, PIQ, visual memory	read aloud
Plaza, 2007	Dyslexic	75	7	37.33	longitudinal	visual perception, visual attention	read aloud, spelling
Wang, Chung, 2018	dyslexic, neurotypical chronological age	63	10.89	52	CS	visual memory, cognitive speed	read aloud

Research design

Our research will use the Comprehensive Metanalysis Calculator program for determining the magnitude of effect sizes. The variables of criteria are linked to reading: reading aloud, spelling, reading speed and comprehension.

Data processing

Steps of our data analysis are the followings: establishing the average for effect size, testing the hypothesis with meta-regression and analysis of the effect size for each moderator.

Results

Basic data and the used moderators are summarized in Table 1.

Analyses of heterogeneity

First stage was the analysis of heterogeneity Q (33) =1876.70, $p < 0.001$, $I^2 = 98.29$, and we used further the random effect model (Borenstein, Hedges, & Higgins, 2009).

The effect size for studies included in meta-analysis

To present the effect sizes was created the forest plot with the confidentiality interval of 95% (95CI).

Analyses for bias of publication

This analysis was made by calculating the indicator N (classic fail-safe N) of Rosenthal which shows that N= 1955, Z= 15.20, $p < 0.001$.

Moderator analysis – gender and age of the participants

Meta-regression analysis evidenced that male participants percentage is a significant positive predictor of size effect (B= 0.006, Z= 4.68, $p < 0.001$). The average age of male participants is also a significant positive predictor of size effect (B= 0.019, Z= 2.16, p= 0.030). These results are in line with the existent theories (Lei *at al*., 2011).

Moderator analysis – type of participants and design

There are no differences of effect size between the predictors, Q (5) = 7.98, p= 0.157.

Although there is no moderation effect, the visual memory is the most powerful factor with a significant, large effect size (D=0.86, p< .001). Attention (D=0.71, p< .001) and visual perception (D=0.75, p< .001) have medium effect size.

Results Q (3) = 18.58, p< .001 shows significant differences between the categories.

Comparative analysis of criteria: the effect of moderators on criteria

As we discuss 6 cognitive factors and 4 factors for reading, the number of studies in some cases shrinks to one single paper, which represents a considerable limitation of this meta-regression.

Visual memory has a significant but small size moderation effect Q (3) = 9.04, p> .001 for reading aloud (d=0.39, p< .001) and for spelling (d=0.2, p< .001).

In the case of cognitive speed, we found significant differences Q (2) = 14.30, p< .001 between categories. Spelling exerts a minute, insignificant effect size, while reading aloud has small, but significant effect size (d=0.28, p< .001). Finally, reading speed has a medium, significant effect size (d=0.52, p< .001).

Practical intelligence has no moderation effect, but one can detect a tendency for reading aloud with exceedingly small effect size (d=0.19, p< .001).

There are no significant differences between categories for visual attention Q (1) = 1.09, p> .001, but we can observe some tendencies for reading aloud (d=0.31, p< .001) with small effect size and for spelling (d=0.43, p< .001) with moderate effect size.

Visual perception has no moderation effect; nevertheless, for reading aloud it has a tendency for moderation effect with small effect size (d=0.32, p< .001) and the same applies for spelling (d=0.13, p< .001).

Spatial orientation has a moderation effect Q (2) = 11.31, p> .001, but it is not significant in reading comprehension and spelling, and has small effect size in reading aloud (d=0.2, p< .001)

and in reading speed (d=0.28, p< .001).

Comparative analysis of predictors: predictors of each criterion

For reading aloud, as a criterion factor, there are no significant differences Q (5) = 6.61, p> .001 between categories. Tendencies with small effect size can be observed in case of visual memory (d=0.32, p< .001), visual attention (d=0.31, p< .001), cognitive speed (d=0.28, p< .001), spatial orientation (d=0.2, p< .001), and practical intelligence (d=0.19, p< .001).

For spelling we find a moderation effect Q (5) = 16.02, p> .001. Visual attention has almost medium effect size (d=0.43, p< .001), but as there is only one study dealing with this topic, this result should be treated with caution. Significant, but small effect moderators are the visual memory (d=0.2, p< .001) and visual perception (d=0.13, p< .001).

In case of reading speed there are significant differences Q (5) = 8.22, p> .001. In this moderation cognitive speed has a medium (d=0.52, p< .001), while spatial orientation (d=0.28, p< .001) has a small effect size.

Discussion and conclusions of the study

The role and the impact of cognitive factors in reading was demonstrated in many previous studies, but none of them treated only one criterion and one predictor (Albano & Iacono, 2016; Campen, Seger, & Ludo, 2018; Chung *et al*., 2008; Emam & Kazem, 2014; Gang & Siegel, 2002; Garcia, Tomaino, & Cornoldi, 2019), or one predictor and some criteria (Alloway & Alloway, 2010; Araújo, Faísca, Bramão, Petersson, & Reis, 2014; Gathercole, Alloway, Willis, & Adams, 2006), or some predictors and one criterion (Bosse, Tainturier, & Valdois, 2007; Fernandes & Leite, 2017; Giorgetti & Lorusso, 2018; Wang & Chung, 2018).

In this study we proposed to define the role and impact of visual cognitive factors in reading, based on the theory of deficits in proceeding of visuospatial information (Duranovic,

Dedeic, & Gavrić, 2015; Swanson, Zheng, & Jerman, 2009). We evaluated this topic because previous research reported ambiguous results.

Summarizing disclosed results, we can conclude that the effect size is medium and significant in studies with dyslexic participants, while for other studies the effect size is still significant, but smaller.

Results partially supported the hypothesis that correlational studies with dyslexic participants have a greater impact than comparative studies.

Although we cannot state the existence of a moderation effect, the visual memory has a tendency with large size effect, the visual attention and the visual perception with moderate effect, spatial orientation and cognitive speed with small effect, and the smallest effect size is found for practical intelligence.

Meta-regression analysis evidenced that the percent of male participants represented a positive predictor for effect size. This finding was supported by the proportional prevalence of 4:1 for boys.

Results of meta-regression for every cognitive domain showed that the effect sizes are generally small. Only one medium effect size is present for cognitive speed as a predictor for reading speed. This confirms the third hypothesis.

Reading comprehension has no significant predictor, but this may originate from the reduced number of studies for this category. Practical intelligence has no moderation effect, so the fourth hypothesis is not confirmed. Spatial orientation is a moderator with small effect size for reading aloud and for reading speed, so the fifth hypothesis is confirmed. Visual attention is a good moderator for spelling with almost medium effect size (but this result should be treated with

caution, because we have found one single study), the practical intelligence, the visual memory and visual perception are present with small effect size as moderators.

Meta-analysis results sustain the differences in cognitive structure of dyslexics compared with neurotypical children, even when the control group is chosen by reading age.

Limits and future directions of the research

A limit is the relatively substantial number of studies that had to be excluded based on the chosen inclusion criteria.

The main themes and questions remain open and as a future direction we can formulate the research of all influences, all comorbidities, and all other factors based not only on visuospatial, but also on phonological theory.

CHAPTER THREE. THE ROLE OF MOTIVATIONAL, BEHAVIORAL, AND ENVIRONMENTAL FACTORS IN READING COMPREHENSION

In the social model, discrimination appears as a social barrier. In this context dyslexia is a social limit and not a personal problem. In Colin's model (Macdonald, 2009) the meta-psychological items are particularly important: how the person one perceives his/her one problems and what experiences he/she has related to them.

The prediction role of motivational, social, and behavioral factors in comprehension: Comparative analyses between neurotypical and reading disabled group

Research which sets as its objective to identify the etiological factors must also consider the explicative stage for biological and for environmental factors. Basic coding activities facilitate the later decoding, and semantic activities develop the linguistic abilities and reading comprehension (Hulme & Snowling, 2013).

Motivational factors of reading

Matthew's effect (Clark & Zoysa, 2011) can be seen also related to reading: if reading becomes a pleasant activity, the attitude toward it will be positive. Therefore, the child will read frequently, so he/she develops into an even more competent reader (Orellana, Melo, Baldwin, Julio, & Pezoa, 2020).

To most children with reading difficulties a decisive role has the perceived obstacle in completing the task (Guthrie, Klauda & Ho, 2013).

Resent research results shows that intrinsic reading motivation determines leisure reading and the reading amount. (Martin-Chang, Kozak, Levesque, Calarco, & Mar, 2021)

Social factors of reading

Based on Epstein's model (Dockett, Griebel, & Perry, 2017) parents assure the home environment, keep communication with the educational institution, and facilitate the at home learning.

SECOND STUDY. THE PREDICTIVE VALUE OF THE MOTIVATIONAL, BEHAVIORAL, AND ENVIRONMENTAL FACTORS IN READING COMPREHENSION FOR THIRD AND FOUR GRADE STUDENTS

Theoretical background

This study focuses on the predictive value of motivation in reading comprehension. Beside basic needs of elementary grade students, one should provide them support for learning and reading. In this period self-esteem establishment is particularly important. Family assures stability and protection with developing social cognition facilitates to form friendships (Strassen Berger, 2009).

In the learning process a key role goes to the deep understanding of readings, which can be developed through self-regulated learning with the cooperation of peers and learning from peer's feedback (Vrieling-Teunter, Stijnen, & Bastiaens, 2021).

Objectives and hypotheses

Objectives

Theoretical objectives: In the present work, we evaluate research factors that affect the academic achievement of persons with reading difficulties in comparison with neurotypical children. The study aims to answer the question to what extent motivational, behavioral, and environmental factors can be predictors of reading comprehension? We are also looking for differences between the two groups.

Practical objectives of the research are the followings: obtaining information about these factors, clarification of differences, and offering an extended framework, which makes possible the interventions from a holistic perspective.

Methodological objectives are to gather information on the applicability of results obtained in one cultural-linguistic context. Another objective is on the validity of the reading motivation questionnaire for Hungarian-speaking three and four graders in Transylvania, Romania.

Hypotheses

1. Reading motivation, comorbidity with behavioral problems, time spent in community, parents' academic level, quality time spent with family are significant predictors of reading comprehension.
2. There are important differences between the neurotypical and the group with reading comprehension problems. Gender of the participants have an effect on these differences.

2.1. There are notable differences in self-concept of reading, but not in the value of the reading activity.

2.2. Teachers consider that children with reading difficulties have a worse behavior compared to the neurotypical peers, although the self-evaluations of the two groups do not differ substantially.

2.3. Parents of children with learning disabilities provide much more activities to their children then those who raise neurotypical children.

Methods and procedures

Participants

The number of participants was established with the G*power program. Effect sizes were calculated or converted with Pychometrica program (Lenhard & Lenhard, 2016).

Instruments

Reading comprehension

Reading comprehension was assessed with the standardized reading and comprehension test for Hungarian speaking children (Szebenyiné Nagy, 1999).

Reading motivation

Reading motivation was assessed with a popular questionnaire based on expectancy and value theory of motivation (Malloy, Marinak, Gambrell, & Mazzoni, 2013). The Reading Survey Instrument (Gambrell, Palmer, Codling, & Mazzoni, 1996) has two subscales: one for value of activity of reading and another for self-concept as a reader.

Behavioral problems

Behavioral problems were assessed with self-reported and teacher form Child Behavior Checklist (CBCL) (Achenbach, 1991). We used the Hungarian version (Gádoros, 1996) of this test.

Parental resources

This questionnaire contains beside the demographical data, information about the daily routines and the leisure time activities of the child.

Procedure

After the partnership agreement with the school inspector and the school director gave his/her support, the teachers and parents of the children signed an informed agreement for participation.

Research design

The correlational design was chosen, predictors were the motivation for reading, the comorbidity of behavior problems, the time spent in community, the academic level of parents, and parental resources, and as the dependent dichotomous variable: the level of reading comprehension.

In the second part of the research, we used the between group design.

Data analysis

In the first phase of data analysis, we verified all necessary conditions for performing the proposed analysis. To confirm the first hypothesis, we used binominal logistical regression analysis and for the second hypothesis two-way ANOVA.

Results

Predictors of reading comprehension

ROC curve area is equivalent with the concordance of probabilities. In the present case the area is .963 (95% CI .941 to .984) which in Hosmer (2000) view is an excellent discrimination.

It was derived by for children with reading comprehension problems by the stepway binominal logistic regression used for determination of effect of waited academic level, of social programs, of parents' academic level, of reading motivation, of parental resources, and the behavior problems.

The binominal logistic regression model is statistically significant: $\chi^2(6) = 119.45$, $p < .0005$. The model explains from 32% (Cox & Snell R^2) to 72% (Nagelkerke R^2). The accuracy precent is 93.8%.

Behavior problems were not a predictor for comprehension problems. Parental resources area positive predictors (B=.239), but odd ratio showed that in fact this has no effect on predicting of comprehension problems. Motivation for reading and the parents academic level function as protective factors with small effect size. The expected academic level and the participation in social activities are predictors with a large effect size.

Between groups differences: neurotypical and reading disabled boys and girl participants

For confirmation of the second hypothesis, we used two-way Anova.

Self-concept as a reader

For variable self-concept as a reader, we found significant values for interaction between comprehension problems and gender F (1, 302) = 6.18, p=.013, partial η^2 =.02, d=.3 with small effect size.

In neurotypical group the average for boys is 25.56±.28, and for girls is 25.62±.24. The paired comparison evidenced that the score for self-concept of reading is .062 (CI from -.662 to .785) points higher for girls compared to the boys F (1,302) =.28, p=.867, partial η^2 =.0001, but this difference is not statistically significant.

The average values for boys without problems are 25.26±.28, and for those with comprehension problems are 20.26±.78. From paired comparison it can be showed that the value is 5.29 (CI from 3.65 to 6.92) higher for boys without problems F (1,302) = 40.569, p< .0001 partial η^2 =.11, d=.7 and the effect size is almost large.

In the girls' group the average value in neurotypical group is 25.62±.24, and for the group of girls with reading comprehension problems is 23.45±.91. If one compares the two groups, the score of neurotypical girls is 2.16 (CI from .311 to 4.02) point higher than the girls with comprehension problems F (1.302) = 5.27, p=.02, partial η^2 =.017, d=.26, this difference has a small effect size, and it is statistically significant.

Reading value

For interaction between the level of comprehension and gender we did not find significant values, F (1, 302) =.267, p=.605, partial η^2 =.001.

Significant differences were revealed for the main effect of reading comprehension problems F (1, 302) =7.46 p=.007 η^2 =.024 and for gender F (1, 302) =6.82, p=.009 partial η^2 =.022, d=.3 with small effect size.

Evaluation of behavior by the teacher

There are no significant differences of main effect for comprehension problems F (1, 302) =.73, p=.787 η^2 =.000. There are significant, medium size effect differences of main effect for gender F (1, 302) = 23.47, p< .001, partial η^2 =.07, d=.54. There were no significant main effect differences identified for reading comprehension, but for gender it was evidenced a medium size effect and significant difference.

Average value for the neurotypical boys is 23.13±1.54 and for girls is 14.25±1.30. For children without problems boys scored 8.88 (CI from 4.9 to 12,86) point higher from teachers for behavior as compared with girls F (1, 302) =19.32, p< ,001, partial η^2 =.06, d=0.5. This is a medium size effect difference.

Self-evaluation of behavior

We did not find any main effect differences for either comprehension: F (1, 302) =7.19 p=.397 η^2 =.002, or for gender F (1, 302) =0.01, p=.922 partial η^2 =.001.

Parental resources

For parental resources were not found significant values for interaction between gender and comprehension F (1, 302) =2.717, p=.1, partial η^2 =.009. Neither for main effect for comprehension F (1, 302) = 1.785 p=.183 η^2 =.006 or for gender F (1, 302) =.434, p=.511 partial η^2 =.001.

From paired comparisons in the group of girls only, we found significant differences. Average value for the girls without problems was 41.98±.38, while for girls with comprehension problems was 45.00±1.46. The value for parental resources is 3.08 (CI from .31 to 6,00) points higher for girls belonging to reading comprehension problems group F (1, 302) = 3.954, p=.048, partial η^2 =.013, d=0.2, with small effect size. In the boys' group F(1, 302)= .056, p=.813, partial η^2 =.001, there is no statistically significant differences.

Discussions and conclusions of the study

The hierarchical binominal logistical regression analysis clarified the effects of predictors (motivation of reading, academic level of parents, parental resources, expected academic level of children, time spent in social programs, and comorbidity with behavioral problems) on reading comprehension. Linearity of relationship was established with Box-Tidwell procedure. Significant outliers were not found. The generated models are statistically significant.

The first model explains 18% and the last one 72%. The accuracy percentage is 93.8%. The comorbidity with behavior problems is not a predictor for reading comprehension problems, while parental resources is a predictor, but with so minute effect size that we can conclude that in fact it is not a predictor for these problems.

Reading motivation and the parents' academic levels are predictors with small effect size. The expected academic level and participation in social programs are predictors with large size effect. When a child is motivated for reading, he/she is not likely to encounter comprehension problems. Similar research concluded the same (Schaffner, Schiefele, & Ulferts, 2013; Katzir, Leseaux, & Kim, 2009; Bozack & Salvaggio, 2013; Torbeyns, Lehtinen, & Elen, 2015; Cartwright, Marshall, & Wray, 2016; Hier & Mahony, 2018).

Research findings showed that not only the parent's academic level (Tighe, Wagner, & Schatschneider, 2015) but also their occupation and income (Winne & Nesbit, 2010) correlates with their children's academic performance. Results are in line with Voelk (2012) findings, which support that acceptance and positive feedback generate a positive attitude for the preferred activities of this environment. The role played by parents' expectance was demonstrated only for neurotypical children (Loughlin-Presnal & Bierman, 2017). Our results evidenced that this decisive role is present also for children with reading comprehension problems. Hence, our results

contradict the findings (Karasinski & Anderson, 2017) that consider the behavior problems negative predictors for reading comprehension problems.

This paper assessed the factors that influences the academic achievement of children with reading comprehension problems compared with neurotypical children, and we researched the differences between these two groups for a clearer picture.

For variable self-concept as a reader, we revealed significant values for interaction between gender and level of comprehension. Differences based on gender are present only in the group with problems, girls have a better self-concept as compared with boys. When we compared the boys' groups, we found big differences between the two groups. In the girls' group we also found significant differences, but with modest size effect.

If reading is a pleasant activity, then there is a positive attitude toward it; the person will read frequently, and by this will practice reading, so the her/his competence will develop (Neroni, Meijs, Gijselaers, Kirschner, & Groot, 2019), the lexical representation will be enriched and the background knowledge will be extended (McLachlan & Arrow, 2017). Self-concept as a reader is an indispensable factor in academic achievement.

Usually, girls' self-concept for linguistic activities is more positive as compared with boys (Pesu, Viljaranta, & Aunola, 2016). With age, gender differences get accentuated (Xia, Gu, & Li, 2019).

For value of reading, we found significant differences between the groups of neurotypical boys and girls; typically, girls considered reading a valuable activity (Bozack & Salvaggio, 2013; Schaffner, Schiefele, & Ulferts, 2013; Cartwright, Marshall, & Wray, 2016; Katzir, Leseaux, & Kim, 2009).

Based on the theory of expectances and values (Pfeiffer, 2018) the persons' needs, and the ability that assure success for valuable activities, reading will become a repetitive habit (Cho, Marjadi, Langendyk, & Hu, 2017).

Regardless of reading problems, teachers considered boys' behavior more problematic than that of girls, although the self-evaluation of behavior did not show these differences.

Parental resources prevail for girls with comprehension problems compared to girls without these problems. In another paired comparisons no differences were found.

Limits and further directions of the research

In our study we tried to avoid the appearance of secondary behavior problems, hence restraining the participants' age to the third and fourth grade can be considered as a limitation of this research. Based on the results of the study intervention programs can be developed, which focus on parents and communities. Such programs are already widespread in the USA.

CHAPTER FOUR. THE INFLUENCE OF COGNITIVE LOAD ON THE ACADEMIC ACHIEVEMENT

Cognitive structure is the coherent and unitary base for hypothesis of instruction and data collection. It is a useful tool for conceptualization of the design for instruction. The basic theory refers to cognitive load (Sweller, Ayres, & Kalyuga, 2011).

The structure of information is essential in altered information processing characteristics for children with reading problems. Should instructions ignore this, then the cognitive load increases and the learning process becomes difficult (Kormos, Košak Babuder, & Pižorn, 2019).

Theory of cognitive load

The subtitle refers to a theory of instruction (Sweller, Ayres, & Kalyuga, 2011). We based our research on this theory, which led to a change in the hypothesis on working memory capacity.

The reason was that we observed that when the cognitive effort is high, the capacity decreases. Performance and cognitive load are the two faces of the same coin (Mavilidi & Zhong, 2019).

Types of cognitive load

Cognitive load has three types or components (Sweller, Ayres, & Kalyuga, 2011).

Intrinsic cognitive load refers to the basic structure of information (Todd, 2010), while extraneous cognitive load is about educational design (Lovett & Greenhouse, 2000; Hughes, Costley, & Lange, 2021). Germane cognitive load is releasing the working memory, as it assures automatization for processing and construction of schemes (Todd, 2010). The subjective cognitive load depends on motivation (Willingham, 2017). A complex, challenging task implies a deeper involvement of the person, so that his/her mental effort is higher, but the subjective cognitive load is optimal (Minkley, Xu, & Krell, 2021).

Implications of cognitive load

Experiments (Liu, Inhoff, & Li, 2020) evidenced that the change of direction of reading did not influence the comprehension. The attentional deficit disturbs the information processing and it limits the capacity of working memory. Attention is a complex process, with a series of subprocesses (Vereșezan, 2017); it refers to the person's ability to selectively respond to one stimulus and ignore all others, as unimportant.

Recent observations (Snell, Cauchi, Grainger, & Lété, 2020) allowed to predict that attention has a larger visual area than a single word, but for those with problems this area remain narrow even in the later stage of development, in this way the cognitive load increase exponentially.

Satisfaction questionnaires revealed the positive role of social media (ElSayed, Caeiro-Rodríguez, Mikic-Fonte, & Llamas-Nistal, 2021), which decreases the cognitive load. The

asynchrony of different modalities of information processing speed does not change with interventions; it causes decoding difficulties (Menashe, 2018) and a cognitive overload of persons with learning disabilities. The level of cognitive load is influenced by the feedbacks rather than by abilities (Redifer, Bae, & Zhao, 2021).

Intervention based on cognitive load theory

Classic interventions for reading development are time-consuming methods (30-60 hours for neurotypical children and 80-100 hours for learning disabled). In the digital word the cognitive load decreases, the efficiency is high (Jamshidifarsani, Garbaya, Lim, Blazevi, & Ritchie, 2019).

THIRD STUDY. THE ROLE OF THE COGNITIVE LOAD IN SOLVING LOGIC PROBLEMS AND READING COMPREHENSION OF CHILDREN FROM THIRD AND FOURTH GRADE

Theoretical background

This study is focused on the role of cognitive load in problem solving and in reading comprehension for students attending third and fourth grade. The cognitive load theory is a set of universal principles of efficient learning. Some forms of cognitive load are beneficial, while others cause the waste of mental resources. The three forms of cognitive load are simultaneously present, and if the tasks are complex (intrinsic load) and the contained design elements imply the distributive attention and memory (extraneous load), the benefic germane load will have a small area to action, although this should be maximized in the learning process (Clark, Nguyen, & Sweller, 2006).

Metacognitive benefits compensate the negative effects of cognitive load, although for extraneous load the outcome remains intact, but participants complain because of the lack of extra cognitive effort (Beege, Nebel, Schneider, & Rey, 2020). Usage of the same modality in the

primary and secondary tasks causes cognitive overload, supplementary influences can be detected if one manipulates the frequency or temporal structure of the secondary task (Bijarsari, 2021).

Five strategies can be applied for reducing the cognitive load and for monitoring the learning process: multimedia utilization principle (complete the text based on imagines and visualization), utilization of distributive attention and spatial contingencies, the redundancy effect and the principle of coherence implying the deletion of unessential information. The signal principle is used for evidencing the important information and, last but not least, by applying transitory information effect and the principle of segmentation facilitate the rhythm of learning (Castro-Alonso, de Koning, Fiorella, & Paas, 2021).

Diminishing with efficient instructions the cognitive load will optimize the effort and achievement.

Objectives and hypothesis

Objectives

Theoretical objectives: The study is focused on the factors, which affect the academic achievement of persons with reading difficulties compared to the neurotypical persons. We searched answers for question in which the amount of cognitive load influences the achievement, and we are searching for the differences between groups based on level of comprehension and gender.

Practical objectives are to obtain information about these factors, the clarification of the differences, and offering a large framework for holistic interventions.

Methodological objectives refer to the assessment of different types of cognitive load of Hungarian speaking students in third and fourth elementary grades, in Transylvania.

Hypothesis

The cognitive load in students' performance shows significant differences. Performance depends not only on reading comprehension level, but also on the gender of students.

Methods and procedures

Participants

Number of participants was established with G*power program. Used a small to medium effect size (f) and the power of study of 0.8, the number was priori estimated to 309. After data collection we obtained 342 complete series.

Instruments

Reading comprehension

We used the standardized test for reading and comprehension for Hungarian speaking children (Szebenyiné Nagy, 1999).

Cognitive load

For conceptualization of these instruments, we were inspired by Wernaart's (2012) paper.

Reading tasks

We chose two Hungarian folk tales of the same length. The comprehension equivalency was tested on two classes of five grade level (N=63). The second text contained the dual task for cognitive load.

Verbal logic tasks

We designed two simple logic puzzles (5*5) and two complex logic puzzles (4*4*3).

Sudoku

The logic puzzle was followed by Sudoku's tasks, four simple 4*4 and four of them were complex 6*6.

Procedure

After the main agreement with the school inspector and the agreement of school directors every teacher and parent signed an informed agreement for participation.

Research design

Between group design was used. Independent variables were the level of comprehension and gender. The dependent variables were the performance on different kind of cognitive load tasks.

Data processing

To confirm the hypothesis, we ruled two-way Anova test.

Results

For two-way Anova is verified when data satisfied the conditions for running this probe. Results are presented separately for every sub-hypothesis.

Verbal logics

We detected significant values for interaction between comprehension and gender F (1, 342) = 9.16, p<.0001, partial η^2 =.052, d=.48with medium size effect.

We evidenced significant differences of main effect for comprehension F (2, 342) = 10.03 p < .0001, η^2 =.056, d=0.48 with moderate effect size. For gender we did not find differences of main effect F (2, 342) = 1.07 p=.301.

The main effect for comprehension showed significant differences for both groups. For boys' group F (1, 336) =12.68 p<.001, d=.54 with medium effect size, and for girls' group F (1, 336) =7.03 p<.001, d=.4 with small effect size.

Paired comparisons evidenced that in the boys' group significant differences were present when compared to the group with comprehension problem and with the two other groups. Between

the neurotypical and talented boys the differences were not significant. Average values for boys with comprehension problems were 5.86 ±.331, for group without problems 7.57±.194, and for that talented group 8.07±.36. From paired comparisons we found that the value of verbal logics for the group with problems had a score of 1.7 (CI from 0.784 to 2.63) points smaller compared to the neurotypical group, and of 2.2 (CI from 1.03 to 3.38) points smaller compared to the talented group.

In the groups of girls, we found a different scenario. Significant differences were only present upon comparing neurotypical and talented groups. Average value for the group without problems is 6.77±.17**4**, and for those talented is 8.13±.326. From paired comparison we found out a score 1.36 (CI from 0.47 to 2.25) higher for talented girls.

Reading comprehension

We found significant values for interaction between gender and comprehension F (1, 342) = 7.89, p<.0001, partial η^2 =.045, d=.4, with small effect size.

We unveiled significant differences for main effect of comprehension F (2, 342) =18.74 p < .0001, η^2 =.1, d=0.6 with moderate effect size. For gender no main effect differences F (2, 342) =1.45 p=.229 were identified.

The main effect for comprehension showed significant differences in the groups of boys F (1,336) =17.87 p<.001, d=.65 with medium effect size, and in the groups of girls F (1,336) =9.38 p<.001, d=.47 with small to medium effect size.

Verbal logics – easy tasks

We found significant values for interaction between gender and comprehension F (1, 342) = 5.87, p<.0001, partial η^2 =.034 d=.38 with small effect size. The main effect for comprehension showed significant differences F (2, 342) =7.89 p < .0001, η^2 =.045, d=0.45 with small to moderate effect size. For gender we did not find main effect differences F (2, 342) =0.18 p=.892.

The main effect for comprehension showed significant differences in the group of boys F (1,336) = 18.04 p<.001, d=.43 with small to medium effect size and in the group of girls F (1,336) = 6,17 p=.002, d=.38 with small effect size.

Verbal logics – hard tasks

We found significant values for interaction between gender and comprehension F (1, 342) = 6.59, p=.0002, partial η^2 =.038, d=.39 with small effect size. The main effect for comprehension showed significant differences F (2, 342) =6.64 p < .0001, η^2 =.038, d=0.39 with small effect size. For gender no differences were found F (2, 342) =1.81 p=.179. The main effect for comprehension showed significant differences in the boys' groups F (1,336) =8.5 p<,001, d=.44 with small to medium effect size and in girls' groups F (1,336) =5.12 p<,006, d=.35 with small effect size.

Low extraneous load

We found significant values for interaction between gender and comprehension F (1, 342) =6.59, p=.0002, partial η^2 =.038, d=.39 with small effect size.

The main effect for comprehension showed significant differences, F (2, 342) =11.3 p < .0001, η^2 =.063, d=0.51 with moderate effect size. No differences were revealed for gender F (2, 342) = 3.08 p=.08.

The main effect for comprehension showed significant differences in both groups. For boys F (1,336) =9.66 p<.001, d=.54, and for girls F (1,336) =9.007 p<.001, d=.51, both with medium size effect.

High extraneous load

We found significant values for interaction between gender and comprehension, F (1, 342) = 5.3, p=.005, partial η^2 =.031, d=.35 with small effect size. For comprehension we detected significant differences of main effect, F (2, 342) =14.11, p < .0001, η^2 =.078, d=0.58 with moderate effect size, and for gender F (2, 342) =4.46 p=.035 η^2 =.013, d=0.22 with small effect size.

The main effect for comprehension showed significant differences for boys' groups F (1,336) =11.94 p<.001, d=.53 with medium effect size and for girls' groups F (1,336) =.05 p<.001, d=.43 with small to medium effect size.

Low intrinsic load

For interaction between gender and comprehension we did not find any significant differences F (1, 342) = 1.11, p=.328. We found, however, significant differences of main effect for comprehension F (2, 342) =5.33 p =.005, η^2 =.031, d=0.35 with small effect size. For gender we did not notice differences of main effect F (2, 342) =3.11 p=.076. In paired comparisons we did not find any differences based on gender. The main effect for comprehension showed significant differences in group of boys F (1,336) =3.95 p=.02, d=.3 with small effect size, and for girls there were no significant differences F (1,336) =2.66 p=.071.

High intrinsic load

We found significant values for interaction between gender and comprehension, F (1, 342) = 9.12, p< .0001, partial η^2 =.038, d=.46 with small to medium effect size. Also, significant differences were assessed for the main effect for comprehension F (2, 342) =7.02, p = .0001, η^2 =.04, d=0.4 with small effect size. For gender no differences were noted for the main effect F (2, 342) =2.56 p=.110.

The main effect for comprehension showed significant differences in both groups with small to medium effect size. For boys F (1,336) =8.44 p<.001, d=.44 and for girls F (1,336) =8.46 p<.001, d=.44

Sudoku with letters

We found significant values for interaction between gender and comprehension F (1, 342) = 3.05, p=.048, partial η^2 =.018, d=.27 with small effect size. We revealed important differences of main effect for comprehension F (2, 342) =4.56 p =.011, η^2 =.026, d=0.32 with small effect

size. For gender we did not find main effect differences F (2, 342) =2.05 p=.153. For comprehension significant differences were shown only in the group of girls F (1,336) = 6.74, p=.001, d=.4 with small effect size.

Sudoku with forms

We found significant values for interaction between gender and comprehension F (1, 342) = 3.48, p=.032, partial η^2 =.02, d=.28 with small effect size. We revealed significant differences of main effect for comprehension F (2, 342) =9.8, p < .0001, η^2 =.055, d=0.48 with small to medium effect size and for gender F (2, 342) =5.05 p=.025, η^2 =.015, d=0.24 with small effect size. The main effect of comprehension showed significant differences with small to medium effect size in boys' group F (1,336) = 8.27 p<,001, d=.44 and a small effect size for girls F (1,336) =5.38, p=.005, d=.35.

Discussions and conclusions of the study

The main objective of this study is to evidence the role of distinct types of cognitive load in the achievements of separate groups of children (based on comprehension level and gender). We searched for differences between groups, excluding age differences. Participants were chosen from third and fourth grade elementary school students, because at this age the learning strategies are not yet so consolidated to compensate the effects of cognitive load.

Two-way Anova is the appropriate statistical test for studying differences between groups. We verified for each variable and group whether the test can be performed; there were no significant outliers, and the scale residuals for every subgroup showed a normal distribution. For every variable, the assumption of homogeneity was demonstrated with the Levene probe.

We found significant values for the interaction between gender and comprehension for the verbal logic variable, with medium effect size. The main effect of comprehension is also significant. In paired comparisons gender differences were present only for children with problem

and the neurotypical group, with small effect size. In the group without problems boys' achievement was better, but in the problem group girls' scores were higher. Boys with problems remained behind, and this could not be demonstrated in girls' group. The working memory load could be diminished if the linguistic abilities were superior, and in this case, girls have direct access to the linguistic resources, which could explain the demonstrated differences (Miller, McCardle, & Connelly, 2018).

Easy verbal logic tasks had low intrinsic cognitive load, as opposed to complex tasks, which are characterized by high intrinsic load. Evidenced patterns remained the same, but with small size effect.

Classical stereotypes of differences between boys and girls sustain that the girls are more competent in linguistic tasks, while boys are better in mathematics problem solving (Pesu, Viljaranta, & Aunola, 2016). Obtained results support this stereotype. Children with elevated level of comprehension have good performance regardless the cognitive load, and the most vulnerable group comprise the boys with reading comprehension problems. Therefore, the context facilitating program elaborated by Lee and Kalyuga (2011) may be efficient to the boys' group.

For comprehension ability, the interaction effect between comprehension and gender played a medium effect size. In the neurotypical group, boys performed better, which appears to be in contradiction with the stereotypy about verbal abilities (Xia, Gu, & Li, 2019), but this is sustainable in the problem group. In the boys' groups, the problematic group had the lowest scores. By contrast, in the girls' groups one could evidence differences only when the problem or the neurotypical group were compared to the talented ones. Here we uncovered the mediation role of motivation (Hier & Mahony, 2018), but it was not evaluated in the present dissertation.

For low extraneous cognitive load, we found a significant but small effect size for interactions between gender and comprehension. As the main effect for comprehension, differences were moderate effect size. Paired comparisons showed differences with small effect size only between the neurotypical and problem group, with small effect size. Gender differences showed a similar pattern with the precedent findings; in the neurotypical group boys performed better, while in the problem group the girls prevailed. Boys with comprehension problem had the lowest performance, and in the girls' groups there are differences only in comparisons with the talented group.

We found equivalent results for complex extraneous load. Gender differences appear only in the group of children with reading comprehension problems and have small effect size. As the main effect, comprehension showed significant moderate effect size differences.

Effect of distributive attention (Elliot *et al.*, 2018) were not observed in the current work. Reading in mind (Takahashi & Tanaka, 2011) of a text is a risk factor for all groups, because it necesites greater cognitive resources then reading aloud. The clasic condition of multitasking appear in tasks with high extraneous cognitive load. This should affect the achievement, but one experiment (Cho, Altarriba, & Popiel, 2015) showed that it does not always appear.

Results obtained on the intrinsic cognitive load showed dependence on the level of load. If the task has no cognitive load, differences based on comprehension are small and are significant only for boys, and in groups based on gender there are no differences. When the task has a high load, we assessed significant differences for the interaction between the comprehension and gender, with small to medium effect size.

In the problem group, girls were significantly better achiever than boys. In the group without problems this reversed. The main effect for comprehension is present in both groups, with

moderate effect size. These differences could be explained by the deficit of attention mobilization or by the deficit of automation (Gabay, Schiff, & Vakil, 2012), so the overload of working memory is much clearer for participants with reading comprehension problems (Elliot, Kettler, Beddow, & Kurz, 2018).

Connected to the task of sudoku with letters, we reveal significant values for gender and comprehension interaction, with small effect size. Gender differences appear only in the gifted group. In the girls' group differences are corelated with the level of comprehension, and the best performance was obtained by the gifted group.

In the tasks of sudoku with forms, we identified significant values for interaction between comprehension and gender, with small effect size. The main effect for comprehension has a small effect size. Differences based on gender are significant only in the group with comprehension problems and with small effect size. Boys with comprehension problems had the worst performance compared with the two other groups. In girls' groups significant differences were present only when comparing to the talented and without problems groups.

The hypothesis is partially confirmed. Results evidenced that not only the problem group needed specific attention for designing instructions through cognitive load theory, but also girls with a medium comprehension level.

Limits and further directions of research

The used instruments were not standardized, and the tasks were unfamiliar for children except the reading task.

Based on obtained results, we should try an intervention based on diminishing the cognitive load in school.

CHAPTER FIVE. COGNITIVE TRAINING FOR REMEDIATION OF READING AND COMPREHENSION PROBLEMS

Treating and remediation of reading and comprehension problems is a continuous challenge for the educational system. The variability of the class can be valorized only in inclusive settings. In this context, we can change the multiple etiological processes of the state (Plows & Whitburn, 2017).

Sindelar (2010) identified nine cognitive abilities as possible causal factors for learning disabilities. If just one of them is not properly functionable, the child should find energy and time-consuming compensatory strategies. In this way, children could achieve well in elementary grades, but when the expectations become higher, the compensatory system fails, and specific symptoms show up.

Evidence-based interventions for correction of reading and comprehension problems

Education is a fundamental right of human beings. Instead of excluding people, we must assure support, which is attainable only with educational reforms (Kollosche, Marcone, Knigge, Penteado, & Scovsmose, 2019). The alternative cognitive developmental programs have the following elements (Tzuriel, 2014): direct learning, instructions, observations and dialog, application, multimedia programs, and role playing. Evidence-based programs for reading are multisensorial. Thorton, Jones, and Toohey (Nourbakhsh, Mansor, & Madon, 2013) elaborated a program based on visual processing and oral prompts.

FORTH STUDY. THE APLICABILITY OF SINDELAR'S COGNITIVE TRAINING FOR REMEDIATION OF DYSLEXIC STUDENTS READING AND WRITING WITH PERSONALIZED DEVELOPMENTAL PROGRAM

Theoretical background

The child-centered developmental programs can be co-repetition, direct assistance, instruction of strategies, or complex support programs (Zeng, Ju, & Hord, 2018).

Sindelar's method (Zsoldos, 2002) is a form of cognitive development or a cognitive training, assuring the systematic reconstruction of little developed abilities, and indirectly, improving academic achievement. Brigitte Sindelar's learning theory (Sedlak & Sindelar, 2005) combines models and research directions as the cognitive psychology, namely, Piaget, Neisser (1974) and Affolter's (1994) theories. The cognitive development is focused on the important domains of information processing: attention, perception, spatial orientation, memory, intermodal coding, and seriality (Zsoldos, 1999).

Actual intervention takes only 10 minutes daily. In a meeting we focus exclusively on one single cognitive ability. Development of this ability is based on simple exercises, which assure from the beginning success and motivation for more complex tasks. Because of the interdependence of cognitive abilities, the series of exercises guarantee global modification (Rourke, 2005).

As children with learning disabilities frequently are confronted with own incompetence and are considered persons with low IQ, it their motivational and emotional rehabilitation is extremely important. One should calculate the relations, self-regulation, learning competence, the physical and psychical well-being. Every case should be treated from holistic perspective (Fogler & Phelps, 2018).

Objectives and hypothesis

Objectives

The study is centered on the cognitive factors which influence the academic achievement of children with comprehension and reading problems. We seek answers for questions as how the harmonization of cognitive structure affects positively school performance.

Practical objectives were the indirect influence on children's achievement.

Methodological objective consisted in the investigation of how efficient the personalized intervention program was.

Hypothesis

Harmonization of cognitive structure will positively impact the reading, writing, and comprehension abilities, the distractibility of attention will diminish, the number of reading errors will reduce, the fluency will be optimized, and the written sentences will be longer and more complex, number of spelling errors will decrease, and reading comprehension will develop.

Methods and procedures

Participants

Selected were 10 children from third and fourth elementary grades, diagnosed with learning disabilities. Based on the Sindelar assessment tool, all subjects presented a disharmonic profile.

Instruments

For the evaluation of the cognitive profile and the establishment of the intervention program we used the Sindelar assessment tool for school age children. For evaluating the dependent variables, we used texts, chosen by each child. Assessment is based on the standardized tests for reading and writing in Hungarian language, from the handbook of evaluations used by speech therapists (Juhász, 1999).

Research design

Multiple baseline design (Barlow & Hazes, 1979) was applied. This kind of design permitted the individualization of assessment (Horner, Swaminathan, Sugai, & Smolkowski, 2012). Dependent variables were distractibility, reading and spelling errors, number of read or written words, and reading comprehension.

Procedure

The first step was to determine eligibility. Based on Sindelar's assessment tool the focused behaviors were chosen. After a stable baseline was determined, we proceeded to intervention and post-test. After a few weeks the phase of follow up closed the procedure.

Data processing

Because of the single case design, we used in data analysis the nonparametric Man-Whitney probe (as the number of measurements were unequal in the studied phases) and visual analysis, which was specific for this design.

Results

Intervention results were presented separately for each participant of the study. Because of equivalent results in this overview, we present only the development of student H.

The curve of development is displayed in Figure 1, which accounts for four dependent variables: distractibility, number of errors in reading and spelling, and reading comprehension. Distractibility and the number of errors tend to diminish, and the reading comprehension is growing mostly over the last phase of intervention. This result was expected because at the end we worked with letters, numbers, and words.

Mann-Whitney probe was performed between every phase for each dependent variable.

The first studied variable was the distractibility. In the first phase of intervention Md=5.5 was smaller than at the baseline Md=6, but this difference was not significant U ($N_{baseline}$=5, $N_{phase\ 1\ of\ intervention}$ =6) =7.5, z=-1.76, p=.077. In the second phase of intervention, the scores were lower Md=5, but still not significant U ($N_{phase\ 1\ of\ intervention}$=6, $N_{phase\ 2\ of\ intervention}$ =12) =22.5, z=-1.52, p=.126. Only in the third phase of intervention Md=4 one could detect significant change U ($N_{phase\ 2\ of\ intervention}$ =12, $N_{phase\ 3\ of\ intervention}$ =20)=15.5, z=-4.23, p<.001. This has been maintained over the next stage (Md=1) U ($N_{phase\ 3\ of\ intervention}$ =20, $N_{phase\ of\ posttest}$ =5)=1.5, z=-3.41, p=.001, and continued in the follow-up phase (Md=0), U($N_{phase\ of\ posttest}$ =5, $N_{phase\ of\ follow\text{-}up}$=5)=0 z=-2.88, p=.004. Results indicated that distractibility of the student disappeared completely.

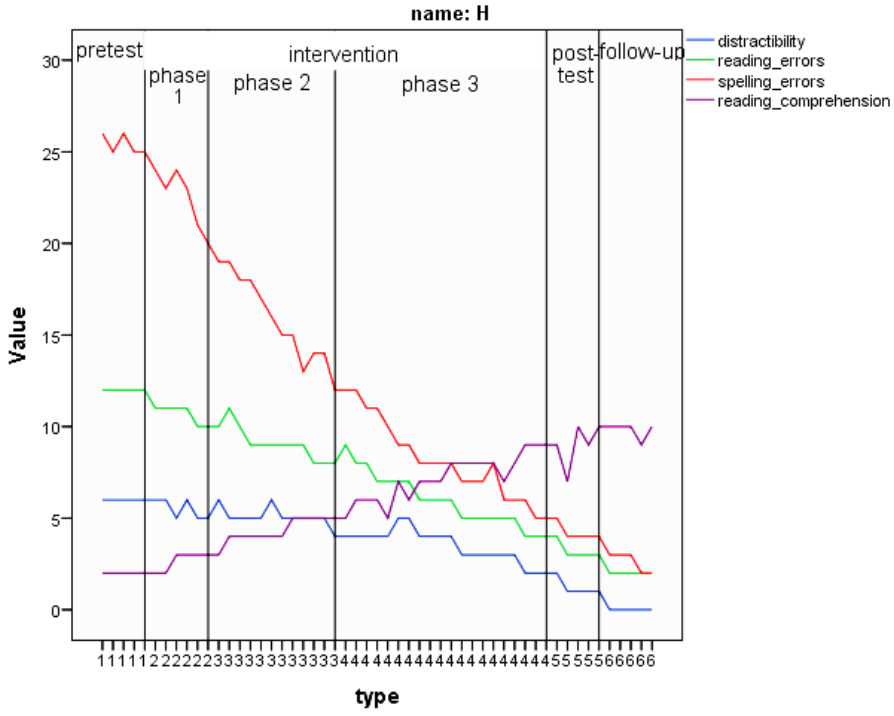

Figure 1. Development curve of student H: distractibility, reading and spelling errors, and reading comprehension

Student H did not have too many reading errors (Md=12) in the phase of establishing the baseline for it. In the first stage of intervention (Md=11) we recorded a significant development of the students, confirmed by Mann-Whitney test U ($N_{baseline}$=5, $N_{phase\ 1\ of\ intervention}$=6) =0, z=-2.95, p=.003. In the next phases the errors did not disappear, but they decrease constantly and

significantly. In phase 2 of the intervention with Md=9 the difference was significant relative to the previous phase U ($N_{\text{phase 1 of intervention}}$ =6, $N_{\text{phase 2 of intervention}}$ =12) =6, z=-2.91, p=.004. The positive change continued in the last phase (Md=6), as well: U ($N_{\text{phase 2 of intervention}}$ =12, $N_{\text{phase 3 of intervention}}$ =20) =9, z=-4.37, p<.001. Between the last phase and post-test (Md=3) the differences were still significant U ($N_{\text{phase 3 of intervention}}$ =20, $N_{\text{phase of posttest}}$ =5) =1.5, z=-3.34, p=.001. The substantial development continued in the follow-up phase (Md=2), U ($N_{\text{phase of posttest}}$ =5, $N_{\text{phase of follow-up}}$=5) =0, z=-2.88, p=.004.

Number of spelling errors decreased, but there were some persistent errors present even in the follow-up phase. There was a significant difference between the baseline (Md=25) and first phase of intervention (Md=23) U (N_{baseline}=5, $N_{\text{phase 1 of intervention}}$ =6) =0, z=-2.78, p=.005. Between the first and second (Md=15,5) phase there was a meaningful difference U ($N_{\text{phase 1 of intervention}}$ =6, $N_{\text{phase 2 of intervention}}$=12) =0, z=-3.38, p=.001. Compared with the third phase (Md=8) there still was a significant difference U ($N_{\text{phase 2 of intervention}}$ =12, $N_{\text{phase 3 of intervention}}$ =20) =1, z=-4.64, p<.001. The development continued in the post-test phase (Md=4) U ($N_{\text{phase 3 of intervention}}$ =20, $N_{\text{phase of posttest}}$ =5) =1, z=-3.35, p=.001, as well as in the follow-up (Md=3) phase U ($N_{\text{phase of posttest}}$ =5, $N_{\text{phase of follow-up}}$=5) =0, z=-2.73, p=.006.

Comprehension developed significantly. During the establishment of baseline, H could offer only two correct answers on reading comprehension questions, but in the follow-up phase he could answer all questions correctly. The difference between the baseline (Md=2) and first stage of intervention (Md=3) was significant U (N_{baseline}=5, $N_{\text{phase 1 of intervention}}$ =6) =5, z=-2.18, p=.029. It was the same, however, within phase one and two (Md=4), U ($N_{\text{phase 1 of intervention}}$ =6, $N_{\text{phase 2 of intervention}}$ =12) =2, z=-3.31 p=.001. Also, the constant development was underlined by the results of the next phase (Md=7) with U ($N_{\text{phase 2 of intervention}}$ =12, $N_{\text{phase 3 of intervention}}$ =20) =5, z=-4.54,

p<.001. Even during the post-test (Md=9) the level of comprehension was growing U ($N_{\text{phase 3 of intervention}}$ =20, $N_{\text{phase of posttest}}$ =5) =14.5, z=-2.46, p=.014. Compared to the follow-up phase (Md=10) results were not significant U ($N_{\text{phase of posttest}}$ =5, $N_{\text{phase of follow-up}}$=5) =7, z=-1.31, p=.31, but the qualitative results showed that H could answer all the questions.

Visual analysis referred to the number of reading or written words, as shown in Figure 2. The number of words read during the 5 minutes interval increased visibly compared to written words. In the phase of follow-up, we noticed a moment of emotional load, when the student's achievement suddenly decreased.

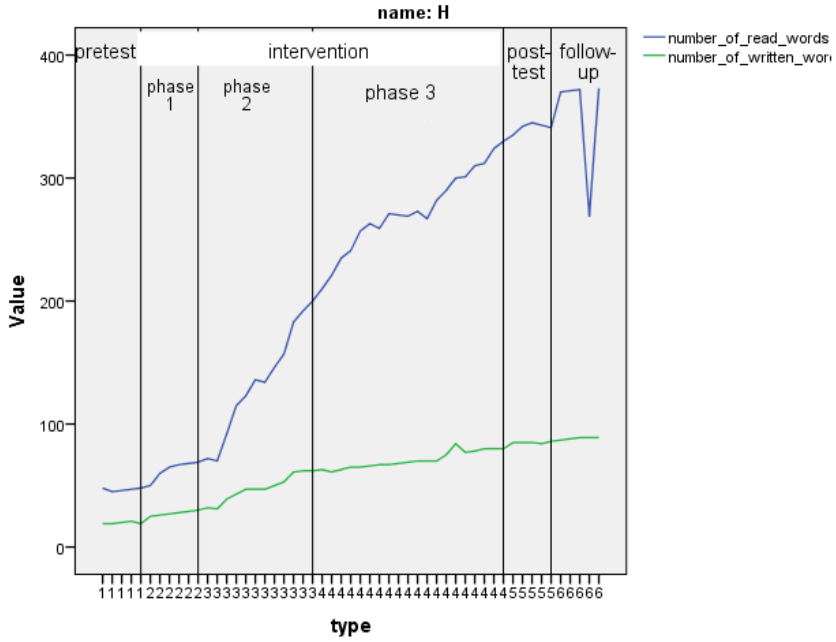

Figure 2. Developmental curve of H, number of words read and written

The number of read words continuously increased. Differences between baseline (Md=47) and the first phase of intervention (Md=66) were significant U (N_{baseline}=5, $N_{\text{phase 1 of intervention}}$ =6) =0, z=-2.74, p=.006. Considerable differences remained present in the next stages of measurements. Between the second phase of intervention (Md=135) in comparison with the first phase, U ($N_{\text{phase 1 of intervention}}$ =6, $N_{\text{phase 2 of intervention}}$ =12) =0, z=-3.37, p=.001. Between the third phase (Md=270.5) compared with the previous phase U ($N_{\text{phase 2 of intervention}}$ =12, $N_{\text{phase 3 of intervention}}$

=20) =0, z=-4.67 p<.001. When compared with the post-test phase (Md=342) results remained significant U ($N_{\text{phase 3 of intervention}}$ =20, $N_{\text{phase of posttest}}$ =5) =0, z=-3.39, p=.001. Compared to the fallow up phase (Md=371), values showed an increasing tendency, but the differences were not significant U ($N_{\text{phase of posttest}}$ =5, $N_{\text{phase of follow-up}}$=5) =5, z=-1.56, p=.117.

During the baseline assessment the number of written words was low. Student H phrased sentences that contained one or two words. The difference between baseline (Md=19) and first phase of intervention (Md=27,5) showed a significant change U (N_{baseline}=5, $N_{\text{phase 1 of intervention}}$ =6) =0, z=-2.76, p=.006. This was maintained in the next phase (Md=47) U ($N_{\text{phase 1 of intervention}}$ =6, $N_{\text{phase 2 of intervention}}$ =12) =0, z=-3.38, p=.001. Written words number increased considerably (Md=69,5) U ($N_{\text{phase 2 of intervention}}$ =12, $N_{\text{phase 3 of intervention}}$ =20) =2.5, z=-4.58, p<.001. A continuous positive change could be observed by the post-test (Md=85), compared with the previous phase U ($N_{\text{phase 3 of intervention}}$ =20, $N_{\text{phase of posttest}}$ =5) =0.5, z=-3.37, p=.001. In the follow-up (Md=89) phase significant differences were present U ($N_{\text{phase of posttest}}$ =5, $N_{\text{phase of follow-up}}$=5) =0, z=-2.67, p=.008.

Discussions and conclusions of the study

For this intervention it was necessary to use single subject design, because disharmonies causing the deficits are unique for each participant. This result should be explained by the multiple cognitive theory of reading (Parrila & McQuarrie, 2014). All children presented significant development on all studied variables. The Sindelar-program in the first stage of intervention consolidated the perceptual-motor base. For children included in our research, the program began with visual and/or auditive discrimination, respectively, where some of them needed the development of spatial orientation. Based on the previous results we expected the development of reading speed (Ralph, Seli, Cheng, Solman, & Smilek, 2014).

Limits and further directions of research

Possibilities for generalizing obtained results are limited, because of the single case design. Participants were chosen by convenience, they attended classes, where it was accepted to perform intervention. Another limitation is that children attended school during the intervention. The used assessment instruments were conceived as analogies with those with standardization.

CHAPTER SIX. GENERAL CONCLUSIONS AND DISCUSSIONS

The general objective of this dissertation is to study the reading and reading comprehension ability. During the elaboration of the topic, we have taken into consideration the cognitive, socioemotional, motivational, behavioral, and environmental factors. As the differences between the neurotypical and reading problems groups is not clear, and literature disclose ambiguous results with this respect, our work is focused on clarifying the differences and the remediation of reading and comprehension problems.

Besides the theoretical background, our work contains four studies.

(1) The first study is the meta-analysis, which aims the experimental proof of the role of visual working memory, visual attention, and the visuospatial information processing factors in reading disabilities.

(2) In the second study, two parts are strongly interrelated. (2.1) Its first part studied the predictive value of motivational, behavioral, and environmental factors for reading comprehension, whereas its second part (2.2) identified the differences between the 4 groups based on comprehension and gender.

(3) The third study continued the demonstration of intergroup differences in comprehension, verbal- and nonverbal logic tasks with cognitive load.

(4) The last study is a single subject experiment with dyslexic participants. The main objective was the offer of a cognitive developmental program for development of attention, fluency, and quality of reading and writing and, finally, the development of reading comprehension.

Previous results are heterogenic as they consider the cognitive domains or the severity level. In this research different kinds of combinations of predictor and criterion factors were considered, as follow: one criterion and one predictor (Campen, Seger, & Ludo, 2018; Garcia, Tomaino, & Cornoldi, 2019); one criterion and several predictors (Fernandes & Leite, 2017; Giorgetti & Lorusso, 2018; Wang & Chung, 2018); and several criteria with one predictor (Alloway & Alloway, 2010; Araújo, Faísca, Bramão, Petersson, & Reis, 2014). The first study is a meta-analysis based on the visuospatial information proceedings deficits theory (Duranovic, Dedeic, & Gavrić, 2015).

Results evidenced medium effect size for studies with exclusively dyslexic participants. For comparative studies the size effect was still significant, but with small effect size. The male gender is a positive predictor for dyslexia. Visual processing is an independent predictor of reading disabilities (Cho & Ji, 2011). Results of the present metanalysis confirmed this hypothesis.

Meta-regression results for each cognitive domain showed mostly small effect sizes. One single moderate effect size was capture in the case of cognitive speed as predictor for reading speed. Visual attention was the best predictor for spelling, with almost medium size effect, in line with previous findings (Anderson, Moore, & Tang, 2019; Morgan, 2017). Spatial orientation has a decisive role in learning to read (White, Boynton, & Yeatman, 2019). Results confirm that it is a moderator for reading aloud and for reading speed. Differences between the cognitive architecture of neurotypical and reading disabled was sustained even when the control group was chosen based on reading age. Efficient remediation of reading is based on cognitive predictors,

such as cognitive trainings, focused on factors as visual memory, visual attention, and perception, according to Sindelar method, presented in fourth study.

The second study's main objectives were the research of links between reading comprehension problems and reading motivation, academic level of parents, parental resources, the children's expected highest academic level, time spent in social programs, and the comorbidity with behavior problems.

Results were in line with the similar literature findings (Schaffner, Schiefele, & Ulferts, 2013; Katzir, Leseaux, & Kim, 2009; Bozack & Salvaggio, 2013; Torbeyns, Lehtinen, & Elen, 2015; Cartwright, Marshall, & Wray, 2016; Hier & Mahony, 2018). Reading motivation explained 18% of reading comprehension problems. The general prediction model had an explicative value of 72%. Results on the parents' academic level (Tighe, Wagner, & Schatschneider, 2015) and the role of social context (Voelkl, 2012) were confirmed by us, but the behavior problems as negative predictor (Karasinski & Anderson, 2017) were contradicted by our results.

Differences between groups in previous findings (Pesu, Viljaranta, & Aunola, 2016) revealed that the linguistic self-concept of girls is more positive than that of boys. Our results validated this difference only in the reading comprehension problems group, but supposedly the differences will show up in time (Xia, Gu, & Li, 2019). Girls looks to reading as a valuable activity (Bozack & Salvaggio, 2013; Schaffner, Schiefele, & Ulferts, 2013; Cartwright, Marshall, & Wray, 2016; Katzir, Leseaux, & Kim, 2009), but our results underlined this only for the neurotypical group. By comparison, in the boys' groups, significant differences were present. From these differences the outcome was a short, unorganized, and undetailed written texts (Saddler, Ellis-Robinson, & Asaro-Saddler, 2018). In our schools, where the evaluations are mostly written tasks, these children become even more disadvantaged.

Parental resources were intensely present in the group of girls with problems. They were sustained by their parents; parental support was significantly higher than in other groups. Their parents talked significantly more with them, offered implicit models of behavior, challenging them with questions, and all learning activities were monitored and supervised by parents.

The knowledge about human cognition put the theory of cognitive load on the base of an efficient instructional design (Sweller, Ayres, & Kalyuga, 2011). Such a program facilitates the development of cognitive schemes (Abdullah & Abdullah, 2021). This kind of design is indispensable in the case of children with problems, as other children are not significantly affected by the cognitive load (Stipek & Chiatovich, 2017).

Girls have direct access to linguistic resources (Miller, McCardle, & Connelly, 2018), and they are more competent in accessing them (Pesu, Viljaranta, & Aunola, 2016). By this, one can explain the better performance of girls in cognitive load tasks. Differences in reading comprehension were present only in the group with problems. In tasks with extraneous load the comprehension level has a main effect with moderate effect size. These results are in line with previous findings (Elliot, Kettler, Beddow, & Kurz, 2018), which sustained that the cognitive overload is more intense for children with reading comprehension problems. The sudoku tasks with letters were difficult for girls with problems; this group scored the lowest.

The last study was on remediation with the Sindelar cognitive training method of reading and comprehension problems. This research is a one-subject experiment, based on the multiple cognitive theory of reading (Parrila & McQuarrie, 2014), and the model of learning, conceptualized by Brigitte Sindelar (2010). All children presented a significant development; distractibility and the reading and spelling errors decreased, the number of read and written words increased, and reading comprehension developed.

Considering the results of the performed studies we can conclude that children with reading problems differ from neurotypical children. Motivation and environment may play a protective role. Behavior problems are not predictors for reading difficulties, but they can be their consequence. Even in this case, the environment can facilitate the proper behavior. Children with comprehension problems need an instructional design based on cognitive load theory, and a personalized intervention program will diminish their symptoms.

Theoretical contributions

The topic and results of this dissertation enrich the literature of reading and comprehension difficulties. Our theoretical contributions reveal the relationships and the role of cognitive, motivational, behavioral, and environmental factors in the development or remediation of the symptomatology.

An interesting result is the parents' role in remediation of reading problems encountered at girls. This issue was not addressed in previous studies. Our results show that parents dedicate much longer time to their girls, present models, facilitate the process of learning, and discuss the academic progresses with their daughter. This result raised a fundamental question about the prevalence of reading problems about genders.

Another theoretical contribution is the meta-analysis based on visuospatial information processing. To the best of our knowledge, this is the very first investigation of this kind in the literature, and it represents a novelty for different subcomponents and for the neurotypical and dyslexic participants

Methodological contributions

Articles are published daily on the topic of reading in general, on reading and comprehension problems, but most of them approach these questions from the phonological

perspective. There are only a few papers based on visuospatial or on cognitive load theory.

Our methodological contributions are primarily the used evaluation tools. The set of items used for measuring different types of cognitive loads is original, being based on the ideas of previous research related to university students. The use of Sindelar's method needed complementary research for adapting handwritten pages to our educational system.

Practical contributions

Based on obtained results the Sindelar cognitive training has proven efficient for Hungarian speaking Transylvanian children, so it can be used further for remediation of reading problems. Based on the revealed relations between the cognitive and reading factors, every program can be personalized from many standpoints, and the applicability of cognitive load theory can benefit classwork not only for dyslexic children, but also for medium achiever girls.

Limitations and further directions of research

A limitation of this work is the reduced number of participants, being on the limit of acceptance of 80%. The group age was limited, as only children attending three and four elementary grades were accepted. We made this choice because of two facts: (i) reading comprehension problems can be detected at this age, and (ii) no secondary behavioral problems are yet present in this age group. Another limitation comes from the not standardized assessment tools and the unfamiliarity of tasks. Familiarization with these tasks was not possible because of the limited time agreement with schools.

The main themes and questions remain opened and as a further direction of research we can assess all possible influences and comorbidities, or other factors in reading, based not only on the visuospatial but also on phonological theories.

Based on our results one can further develop programs focused on parents and communities. Should parents' expectancies be modified, and the time spent in communities grow, parental resources would be adapted to the needs of their children. By this, the children's motivation will increase, and their performance will improve. If school-based activities have the framework of cognitive load theory, the teachers will be able to diminish the cognitive load and to raise achievement. In this way the sensation and satisfaction of success would be guaranteed to each child. Consequently, teachers will be offered an opportunity to collaborate with motivated and curious children, who accomplish school tasks and put in the effort needed for coping with these tasks.

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