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PHONOLOGICAL WORKING MEMORY IN CHILDREN WITH DEVELOPMENTAL LANGUAGE DISORDER AND TYPICALLY DEVELOPING CHILDREN

Introduction: One of the fundamental abilities underlying language development is phonological working memory. In this regard, the hypothesis is that children with specific language impairments have difficulties with phonological working memory, which may limit their language development.

Objective: The aim of this study is to examine phonological working memory in children with typical language development and children with specific language impairments and to determine if there are differences in phonological working memory between these two groups of children.

Method: The study included 120 children aged five years and eleven months to seven years, divided into two groups. The clinical group consisted of 40 children with a diagnosed specific language impairment, while the control group consisted of 80 children with typical language development.

Instrument: To assess phonological working memory, we used tasks from the PreChip test, specifically tasks involving repetition of pseudowords and repetition of sentences.

Results: It was found that children with specific language impairments performed worse than typically developing children on both pseudoword repetition and sentence repetition tasks. The performance on the pseudoword repetition task was statistically significantly different between the two groups ($p = 0.000$; $r = 0.741$), as was the performance on the sentence repetition task ($p = 0.000$; $r = 0.827$).

Conclusion: Based on the results, it can be concluded that children with specific language impairments have difficulties with pseudoword and sentence repetition, implying that these children have difficulties with phonological working memory.

Keywords: *phonological working memory, specific language impairment, typical language development.*

Introduction

In the literature, there is a generally accepted view that working memory and language are closely related cognitive abilities (see Deldar, Gevers-Montoro, Khatibi, & Ghazi-Saidi, 2020; Kondo, 2021). The correlation between language and verbal working memory suggests that the processes of language comprehension and production are limited by the capacity of verbal working memory (Baddeley, 2003; Schwering & MacDonald, 2020).

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As an active cognitive system, working memory is crucial for temporarily storing, processing, and manipulating information. This capacity is essential for complex cognitive tasks, such as language comprehension and production. The core function of working memory is to allow individuals to hold and process information over short periods, which is necessary for tasks like problem-solving, decision-making and language processing.

A central aspect of working memory is phonological working memory, which specifically handles phonological information including sounds, syllables, words and sentences (Torgesen et al., 1999) and it's fundamental for tasks like word recognition, sentence comprehension and language production commonly associated with the phonological loop (Baddeley & Hitch, 2000). Children with a larger span of phonological working memory tend to learn words more efficiently, maintain unfamiliar words in short-term memory and are better at encoding these words into long-term memory. This aligns with cognitive theories which posit that the ability to manipulate and store verbal information in working memory is essential for language learning (Baddeley, 2003; Neveu & Kaushanskaya, 2023).

The phonological loop consists two key subcomponents: phonological storage (or passive component) — stores verbal information for short durations and articulatory rehearsal system (or active component) — allows for the manipulation and rehearsal of verbal information to maintain it in memory. These components work together to support the processing and temporary storage of language information, such as words and sentences which is essential for understanding and producing language (Grivol & Hage, 2011).

In addition to the phonological loop, the executive function plays a crucial role in managing and coordinating cognitive resources. This component interacts with long-term memory and other cognitive systems to oversee and direct attention, allowing individuals to focus on relevant language information in a given context. The central executive's role is particularly significant in language acquisition, as it helps integrate newly encountered linguistic information with existing knowledge, thereby facilitating language learning. The limited capacity of working memory may constrain the processing and retention of language information that leads to delayed learning new words or complex sentence structures (Cowan, 2008).

This suggests that individual differences in working memory capacity could influence language learning abilities, particularly in tasks that require the temporary storage and manipulation of language-related information. On the other hand, language acquisition itself may enhance working memory capacity. The more individuals engage with complex language structures, the more they may develop their cognitive abilities to manage and process information. This mutual interaction indicates that as individuals learn more complex linguistic patterns and structures, their cognitive systems, including working memory, adapt and become more efficient, ultimately supporting more advanced learning of language over time (Adams & Gathercole, 2000; Gupta & Tisdale, 2009).

A large number of research studies have confirmed the strong correlation between working memory capacity and language acquisition and functioning, as well as the presence of working memory deficits in children with developmental language disorder, suggesting that the cause of developmental language disorder is primarily a deficit in phonological working memory, although other possible causes are not excluded (Popovic, 2017; Roepke, Bower, Miller, & Brosseau-Lapre, 2020; Sahar, Hossam, Rasha, Ayatallah, & Hussein, 2020).

Aim

The aim of the study is to examine phonological working memory in children with typical language development and children with developmental language disorder to determine possible differences in phonological working memory between these two groups of children.

Method

Sample

The sample size included 120 children (72 boys and 48 girls) from 5,11 to 7. The sample was divided into two groups. The first group was the clinical group of 40 children with developmental language disorder (DLD). The second group was control group of 80 children with typical language development (TLD). The average age of participants in the clinical group is 77.95 months ($SD = 4.47$). On the other hand, the average age of participants in the control group is 75.93 months ($SD = 4.47$).

Table A. Descriptive measures of participants age

Age (in Month)	DLD (40)	TLD(80)
Min	71	71
Max	84	84
Range	13	13
M(SD)	77,95 (4,47)	75,93 (4,47)
95% Cla	76,52-79,38	74,93- 76,92
Mdn (IQR)	78,00 (7,75)	74,50 (8,75)

DLD – children with developmental language disorder (clinical group) TLD - children with typical language development (control group)

Table B. Age comparison of participants

Group	Age		t(df)	p	η^2	MD	SED	95%CL	
	M	SD						LL	UL
DLD	77,95	4,47							
TLD	75,93	4,47	2,34(118)	0,021	0,04	2,03	0,87	0,31	3,74

Age in month; MD – mean difference; SED – standard error of the difference; LL – lower limit; UL – upper limit

A statistically significant age difference of small effect size was confirmed ($p = 0.021$, $\eta^2 = 0.04$) with a mean age difference of two months between the groups (95% CI: 0.31–3.74). We intentionally attempted to include younger children with typical language development compared to those with developmental language disorder, aiming to highlight the significance of the language deviation in children with developmental language disorder.

Inclusion criterias for children in clinical group were diagnostic of developmental language disorder and absence of of neurological, motor or other sensory disorders. Control group of children was without of neurological, motor or other sensory disorders, with typical speech and language development and average intellectual abilities. Parental consent was obtained for the participation of children in the study.

The study was conducted in three Belgrade centers where children with developmental language disorder were diagnosed: the Institute for Psychophysiological Disorders and Speech Pathology, and the Health Center in Vozdovac, as well as in two preschool institutions from which children for the control group were selected.

Instruments and Procedure

For research purposes, two subtests from the PreCip test (Kuvac-Kraljevic & Lencek, 2012) were used to assess phonological memory. The first subtest consists of seven pseudowords (words that have a phonological structure but no meaning) that the participant needs to repeat, while the second subtest consists of seven sentences that the participant must repeat exactly. Each task that was correctly repeated was scored with 1, and each task that was incorrectly repeated was scored with 0.

Data Analysis

Descriptive statistical measures, including mean, standard deviation, minimum and maximum values were calculated to summarize the results. To analyze inferences regarding the phonological working memory capacity of the children with and without developmental language disorder were used Chi-square test for categorical variables and the Mann-Whitney U test for working memory capacity comparisons between two groups of children.

Results

The descriptive data for the pseudoword repetition task for both groups of participants (children with specific language impairment and children with typical language development) are presented in Table 1.

Table 1. Results on the pseudoword repetition task for the children with DLD and control group of children

Task	Children	Min	Max	M	SD	95%CI	SE	Mdn	IQR	Mo
pseudoword repetition	DLD	0	7	4,45	2,05	3,79-5,11	0,32	5,00	3,00	5
	without DLD	4	7	6,86	0,55	6,74-6,98	0,06	7,00	0,00	7

DLD – children with developmental language disorder (clinical group); without DLD - children with typical language development (control group)

The average performance on the pseudoword repetition task in children with DLD was four words and in children without language disorder seven words. In both groups of tested children were children who successfully repeated all seven pseudowords (Max=7).

On the other hand, unlike the group of children without DLD, where there were children who repeated minimum four pseudowords, in the group of children with DLD, there were children who could not repeat any pseudoword on the pseudoword repetition task (children without DLD: Min=4, children with DLD: Min=0).

Table 2. Comparison of results on the pseudoword repetition task between children with and without DLD

Task	Children	average rank	Mann-Whitney test	U – test
pseudoword repetition	DLD	30,44	U = 397,5	z = - 8,12
	without DLD	75,53	p = 0,000	r = 0,741

There were significant between-groups differences for the pseudoword repetition task ($p = 0.000$; $r = 0.741$).

Table 3. Results on the sentence repetition task for the children with DLD and control group of children

Task	Group of children	Min	Max	M	SD	95%CI	SE	Mdn	IQR	Mo
Sentence repetition	with DLD	1	6	3,78	1,51	3,29-4,26	0,24	4,00	2,00	5
	without DLD	3	7	6,70	0,68	6,55-6,58	0,08	7,00	0,00	7

In children without DLD was registered higher average score in sentence repetition than in children with DLD. Furthermore, children with DLD have greater variability in results ($SD = 1.51$) and a wider range compared to the children without DLD (results on the sentence repetition task in children without DLD appear more homogeneous ($SD = 0.68$)).

Table 4. Comparison of results on the sentence repetition task between children with and without DLD

Task	Group of children	average rank	Mann-Whitney test	U – test
Sentence repetition	with DLD	22,96	U = 98,5	z = - 9,06
	without DLD	79,27	p = 0,000	r = 0,827

In the sentence repetition task, a statistically significant difference was also observed among the compared groups of children ($p = 0,000$), with a large effect size ($r = 0,827$). The obtained rank sums indicate that children without developmental language disorder achieved better results in accurate sentence repetition compared to children diagnosed with DLD.

Discussion

The primary aim of this study was to investigate phonological memory in children with developmental language disorder compared to children with typical language development and to compare performance outcomes between these two groups.

The findings demonstrate that children with DLD performed significantly worse on both the pseudoword repetition and sentence repetition tasks than children with TLD. This difference was found to be statistically significant, which aligns with existing literature and supports the hypothesis that phonological memory is impaired in children with DLD (Camas & Leon-Rojas, 2023; Delcenserie, Genesee, Trudeau, & Champoux, 2021; Maleki Shahmahmood et al., 2020; Popovic, 2017).

One particularly noteworthy international study that examined this issue employed a meta-analysis approach to assess differences in pseudoword repetition task performance between children with and without DLD. This analysis explored how factors such as pseudoword type, length and the age of children with DLD influenced performance outcomes. Results revealed that children with DLD exhibited significantly weaker performance on pseudoword repetition tasks, with the performance gap between children with DLD and their peers with TLD being notably larger when pseudowords consisted of three or four syllables. These findings highlight the increasing difficulty for children with DLD as the complexity of the linguistic material increases. Importantly, even when tasks involved simpler, one-syllable words, children with DLD still showed a marked difference in performance compared to their TLD peers (Graf Estes, Evans, & Else-Quest, 2007).

This pattern suggests that deficits in phonological working memory are pervasive across different levels of linguistic complexity for children with DLD, supporting the view that phonological memory deficits play a key role in the language difficulties observed in this population. Moreover, these results underline the importance of considering task complexity and the specific nature of language impairments when designing assessments or interventions for children with DLD. The findings also

call for further research into how phonological memory deficits may interact with other cognitive and linguistic factors in children with language impairments.

The findings from the pseudoword repetition task reveal important insights into the phonological memory performance of children with DLD compared to children with typical language development. On average, children with DLD successfully repeated four pseudowords, whereas children in the control group (TLD) successfully repeated nearly seven pseudowords (see M and Mo for both groups). This notable difference highlights the challenges that children with DLD face in phonological memory tasks in context of redintegration.

The observed difference in standard deviations between the two groups further underscores the disparity in performance. The standard deviation was higher in the clinical group, indicating greater variability in their results. This suggests that children with DLD exhibit a more heterogeneous pattern of performance, with a wider range of outcomes, including both low and high performers. In contrast, the control group demonstrated less variability, reflecting a more consistent ability to perform the task successfully (see Table 1, data on 95% CI, SE, and IQR for both groups).

The heterogeneity within the DLD group is an important finding, as it suggests that not all children with DLD experience the same degree of difficulty with phonological memory tasks. The presence of children in the clinical group who achieved maximum scores on the pseudoword repetition task further supports the notion that phonological working memory deficits are not universal across all children with DLD. This variability points to the potential existence of subgroups within the DLD population, each potentially exhibiting different underlying cognitive profiles and varying levels of phonological memory impairment.

Additionally, the study's results align with the view that DLD is not solely attributable to deficits in working memory. Some researchers propose that other factors, such as auditory input perception or general processing limitations, may also contribute to the language difficulties observed in children with DLD (Leonard, 2014). This perspective challenges the oversimplification of DLD and highlights the complexity of language impairments.

Overall, the findings emphasize the need for a nuanced approach to understanding DLD, considering not only the variability within the population but also the interplay of multiple cognitive factors contributing to language difficulties. Further research should aim to identify distinct subgroups within the DLD population and explore how these subgroups differ in terms of their phonological profiles and language development outcomes.

The findings from studies on Developmental Language Disorder in children across various languages consistently highlight significant deficits in grammatical processing and phonological short-term memory (Chiat & Polisenka, 2015; Dispaldro, Leonard, & Deevy, 2013; Radeborg, Barthelom, Sjoberg, & Sahlen, 2006). This pattern is particularly evident in the research who examined clinical indicators of DLD in children whose native language is Italian (Dispaldro et al., 2013). Their study found that children with DLD exhibited uniformly poor performance on tasks designed to measure grammatical ability, particularly in the use of third-person plural inflections and direct object clitic pronouns.

Errors in morphosyntactic structures such as inflections and clitics—are of particular interest as they demonstrate pronounced weaknesses in the grammatical competence of children with DLD, which are not simply attributable to limitations in sentence length or complexity. This distinction suggests that the difficulties in grammatical processing in DLD are not just a result of the processing demands associated with longer sentences, but rather an intrinsic deficit in the grammatical system itself. These findings suggest that such markers can be used for identifying children with DLD across

different linguistic contexts, further supporting the validity and utility of these indicators in clinical practice.

Unlike grammatical weaknesses, which are considered uniform deficits in children with developmental language disorder, weaknesses in phonological working memory, although observed in children with DLD, are not considered a dominant clinical indicator of the disorder. Based on the results of an investigation into phonological working memory and vocabulary in children with DLD and typical language development, it was concluded that children with DLD have lower performance compared to their typically developing peers, although an overlap in pseudoword repetition achievement was observed between children with typical language development, development of children with DLD (Oberg & Bohnacker, 2022).

Although numerous studies suggest that pseudoword repetition tasks and sentence repetition tasks can be used as differential diagnostic markers, i.e., they can distinguish children with developmental language disorder from their typically developing peers of the same age (see Popovic, 2017), some studies do not fully confirm this view.

One of these studies showed that DLD group of children did not score significantly lower than the typically developing age-matched group of children on the test of nonword repetition. There were no significant group differences on IN syllables but not on OUT syllables. The results do not suggest a limitation in phonological working memory in tested group of children with developmental language disorder. On the other hand, the sentence repetition task discriminated between children and their typically developing age-matched peers but not between children with DLD and their younger typically developing peers matched for mean length of utterance (Stokes, Wong, Flecher, & Leonard, 2006). These authors suggest that sentence repetition but not nonword repetition makes a difference between children with developmental language disorder and their typically developing age-matched peers. Poorer nonword repetition for English-speaking children with DLD might be attributable to weaker use of the redintegration strategy in word repetition (Stokes et al., 2006).

Although redintegration in the context of children with DLD might involve tendency to substitute or "fill in" missing parts of a task (e.g., pseudoword repetition) with words or structures they are familiar with, potentially distorting the task and affecting their performance, in our research variability in the pseudoword repetition task ($SD = 2.05$) between children with and without DLD rather shows difficulties in phonological working memory in children with DLD than weaker use of the redintegration strategy in word repetition.

On the other hands statistical difference between children with and without DLD in the sentence repetition task ($SD=1.5$) in our research confirms weaker phonological working memory in tested children with DLD.

Conclusion

Although the results of this study provide strong evidence that children with developmental language disorder exhibit significant difficulties in phonological memory compared to their typically developing peers, variability in repetition tasks within group of children with DLD suggests the presence of subgroups, each potentially exhibiting different underlying cognitive profiles and varying degrees of phonological working memory weakness. This finding emphasizes the heterogeneity of DLD and highlights the need for more research in this field, especially in context of repetition which involve many language processes, such as speech perception and discrimination, phonological encoding, phonological memory, phonological processing, motor planning and articulation, vocabulary and both lexical and sublexical characteristics (Coady & Evans, 2008).

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Prof. dr Neda Milošević Dedakin je logoped i vanredni profesor na Akademiji za humani razvoj u Beogradu, gde obavlja funkciju šefa katedre za logopediju. Osnivač je ustanove “Logomedika” u Beogradu i rukovodilac njenog odeljenja na Vračaru. Njena uža specijalnost su rana intervencija, prevencija, dijagnostika i tretman jezičkih, govornih i slušnih poremećaja kod dece i odraslih. Dodatno se usavršavala na Harvard Graduate School of Education i University of London. Član je predsedništva u Srpskoj Logopedskoj asocijaciji. Dobitnica je nekoliko priznanja za doprinos u razvoju logopedije. Prof. dr Neda Milošević Dedakin je autorka i urednik prvih standardizovanih testova na srpskom jeziku za dijagnostiku jezičkih poremećaja - Reynell test i prevenciju poremećaja čitanja i pisanja - PredČip test.

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