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Verbal Working Memory and Syntax Comprehension Skills in Children with Developmental Language Disorders and Typically Developing Peers

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The intertwined nature of language with mental functions can be used in examining the relationships between different language components and mental functions. problems in understanding syntax, which may arise in the form of understanding the word order in the sentences and the relationships between words and sentence types, also make it difficult to understand verbal language in children with special needs. The aim of the study was to determine the relationship between verbal working memory and complex syntax comprehension skills in typically developing children and children with developmental language disorder. The Developmental Language Disorder (DLD) group consisted of 60 Arabic-speaking participants aged 6,;3 to 12,4 (Mage = 9,5; SD = 3,2), included 47 boys and 13 girls, all of them were monolinguals. The typically-developing group (TD) consisted of 60 Arabic -speaking monolingual participants aged 6,11 to 12,6 (Mage = 9,7; SD = 3,2), included 44 boys and 16 girls. Descriptive, correlational analysis statistics and simple regression analysis were used. The results of this study found a difference in syntax comprehension skills by typically developing children and those with developmental language disorder, and that difference was significant.

Keywords: verbal working memory, syntax comprehension skills, children with developmental language disorders, typically developing peers, language disorders

INTRODUCTION

According to the DSM-5, language disorder is a term used to describe persistent difficulties in the acquisition and use of language across modalities (i.e., spoken, written, sign language, or other) due to deficits in comprehension or production of vocabulary, sentences, or discourse. Additional diagnostic criteria from the DSM-5 include language abilities that are substantially and quantifiably below expectations resulting in functional limitations in communication, social participation, academic achievement or occupational performance (Archibald, 2024; Eissa & ElAdl, 2019; Głodkowska & Pągowska, 2020; Güler& Bedel, 2024; Khalik, 2014).

Developmental language disorder generally means significant delays or differences from normal in understanding and/or using language (Najjar, 2014; Paul, 2002). The difficulty experienced may be related only to understanding or expressing language, or

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it may include both (Eissa, 2018; Özcan & Kuruoğlu, 2018). Children with developmental language disorder can often follow the same developmental sequence in language development with a delay as normally developing children (Eissa, 2017; Justice, 2006; Paul, 2002), but specific problems may also be experienced depending on the diagnostic groups.

The intertwined nature of language with mental functions can be used in examining the relationships between different language components and mental functions. In line with the developments in the field of psycholinguistics, concepts such as language, mind and memory (Adamczyk et al., 2018; Eissa, 2021; ElAdl & Eissa, 2019). Theoretical and applied studies of memory and its functions have pointed out the existence of various subsystems of memory and have shown that working memory plays an active role, especially in language acquisition (Eissa, 2022; Torun & Altun, 2022).

In the literature, there are a number of studies aiming to evaluate the relationship between the verbal working memory and language comprehension skills of children diagnosed with autism. In a study conducted by Riches et al. (2010), the ability of adolescents diagnosed with specific language disorder and adolescents diagnosed with autism to understand and produce complex syntactic structures was compared. The results obtained showed that individuals diagnosed with autism exhibited better performance than individuals diagnosed with specific language disorders. This result was explained by the effect of limitations specific to short-term memory assessed using the sentence repetition test in individuals with specific language impairment.

Frizelle and Fletcher (2015) have reported that working memory (WM) scores significantly correlated with the production of relative clauses in a group of children with developmental language disorder (DLD) aged 6 to 8. The participants of this study were asked to repeat complex sentences which consisted of sentences involving different types of embedded clauses with varying degrees of complexity. Results showed that, on the one hand, simple span scores, including word/non-word repetition and forward digit span, correlated with simple embedded clauses such as relative clauses that express a single proposition. On the other hand, complex span scores, including listening recall, counting recall, and backward digit span, strongly correlated with syntactically more complex embedded clauses such as bicausal relative constructions.

In the Delage and Frauenfelder's study (2020), performance of participants with with developmental language disorder (DLD)aged 5 to 14 were compared to typically-developing (TD) participants of the same age in WM, with simple and complex-span tasks, and in complex syntax: production, repetition and comprehension of complex sentences. Results showed that age and simple and complex-span scores accounted for major parts of the variance (50%–58%) of scores in the complex sentence comprehension and repetition tasks, in both TD and DLD groups.

Individuals with Down Syndrome, in addition to physical and medical disabilities, have cognitive disabilities, including language impairment, and mental disabilities of varying degrees (Eissa & Borowska-Beszta, 2019; Lanfranchi et al., 2009). In this diagnostic group, although the severity of language impairment varies, different language components may be affected to different degrees. Studies in the literature indicate that expressive language skills are generally weaker compared to receptive language skills (Miolo et al., 2005). It is suggested that difficulties in language skills are mostly in the phonological component of the language, and in syntax compared to vocabulary and usage (Lanfranchi et al., 2009). Studies examining the reasons for the differences in language skills of individuals with Down Syndrome have focused especially on the characteristics of the components of working memory and differences in processing capacity (Hick et al., 2005; Price et al., 2007).

It is known that grammatical development and vocabulary, especially in individuals with Down Syndrome, are slower than chronological age and/or mental age (Hick et al., 2005). Studies conducted to evaluate the working memory of individuals with Down Syndrome have shown that there are more difficulties in the verbal component of working memory than in the visuospatial component. It has been observed that the verbal working memory of individuals with Down syndrome is weaker than their general mental processing performance, thus indicating the existence of a specific difficulty in verbal working memory in this diagnostic group (Baddeley & Jarrold, 2007). In studies where individuals with Down Syndrome were matched with typically developing children according to their mental age, the consistent observation of difficulty in the verbal component of working memory supports the view that there are verbal working memory deficits specific to this diagnostic group (Hick et al., 2005).

In the literature, in addition to studies examining the working memory characteristics of individuals with Down Syndrome, there are also studies focusing on evaluating language comprehension skills. Studies have shown that there is a relationship between language comprehension skills and verbal working memory in this group, and as the capacity of verbal working memory improves, language comprehension skills also improve (Price et al., 2007; Thomason et al., 2008). In some studies aiming to evaluate the ability to understand complex syntax found that the non-verbal mental age, average utterance length and working memory performance of individuals with Down Syndrome are among the important variables predicting both understanding syntax and using complex syntax (Chapman et al., 2002).

Specific learning disabilities may be directly related to impairments in working memory (Gathercole et al., 2006). In addition, it has been shown that the specific type of learning disability (reading difficulty/mathematics difficulty/writing difficulty, etc.) is associated with different components of working memory, and it has been found that those who have difficulties in reading experience difficulties with the verbal component of working memory, not with the visual-spatial component (Schuchardt et al., 2008). Since learning disabilities are usually noticed and diagnosed during school years, studies conducted in this group have mostly focused on the relationship between reading comprehension and memory. The number of studies evaluating the relationship between working memory and verbal language comprehension is limited.

Many studies in the literature have examined the relationship between verbal working memory and language comprehension skills in typically developing children. Research results have revealed that different components of working memory are related to different dimensions of language comprehension skills (Alloway et al., 2009; Chapman et al., 2002; Montgomery and Evans, 2009). In addition to being related to skills such as learning new words, understanding verbal language, and understanding abstract expressions, verbal working memory is predictive of these skills. As can be seen ,the number of studies conducted with children with special needs that focused on understanding verbal language is limited, and mostly focus on the dimensions of understanding idioms, understanding stories by using clues in the context, and understanding instructions. However, problems in understanding syntax, which may arise in the form of understanding the word order in the sentences and the relationships between words and sentence types, also make it difficult to understand verbal language in children with special needs.

The aim of the research is to examine the relationship between complex syntax comprehension skills and verbal working memory in children with and without developmental language disorder.

METHOD

Participants

The Developmental Language Disorder (DLD) group consisted of 60 Arabic-speaking participants aged 6 to 13 (Mage = 9,5), and included 47 boys and 13 girls, all of them were monolinguals. The typically-developing (TD) group consisted of 60 Arabic - speaking monolingual participants aged 6,11 to 12,6 (Mage = 9,7), and included 44 boys and 16 girls. A Kruskal-Wallis test by rank, performed on the four groups (typically-developing "TD", specific learning disorder" SLD", Down syndrome "DS", and autism spectrum disorder "ASD"), confirmed that there was not a significant effect of age (0.830, p>0.01). Participants were recruited according to the following criteria: The inclusion criteria for DLD group were having been diagnosed with SLD, DS, and ASD, being monolingual, being 6-13 years old, and lacking significant medical conditions (e.g. deafness, blindness, etc.) or other neurological disorders (e.g. epilepsy, cerebral palsy, etc.). As for typically-developing (TD)group, (i) their age had to be between 6 and 12 years old in order to match the DLD sample; (ii) they were required to have never been diagnosed with any language impairment; (iii) they needed to be Arabic-speaking monolinguals (see Table 1).

Table 1
Characteristics of participants

Group	N	Mean Age	Age Range	Gender
Developmental Language Disorder (DLD)group				
SLD	20	9.1	6.1-12.2	Girls:9 Boys :11
DS	20	9.5	6.2-12.0	Girls:7 Boys :13
ASD	20	9.4	6.6-12.4	Girls:6 Boys :14
typically-developing (TD)group				
SLD	60	9.2	6.1-12.4	Girls:29 Boys :31

Data Collection Tools

The Tool for Assessing Complex Syntax Comprehension Skills. The tool used in the research to evaluate complex syntax comprehension skills was created within the scope of this study. The test has six subscales: Demonstrative pronouns in Arabic subscale, Nominal sentences subscale, Solar lam and lunar Lam subscale, Audio syllables subscale, Prepositions subscale, and Arabic Pronouns subscale. The right answer is given one point, while the wrong one is given zero. Each subscale consists of 10 questions. The total score ranges from zero-to seventy. These subscales are as follows:

Demonstrative pronouns in Arabic subscale. It focuses on demonstrative Pronouns (أسماء الإشارة) that are used for males and females, and those indicate nearness and farness for single, double and plural nouns. " هذا - هذه - هذان - هاتان - هؤلاء - ذلك - تلك - اولئك"

Nominal sentences subscale. Arabic nominal sentences "الجمل الاسمية" (al-jumal al-ismiyya), Nominal sentences don't start with a verb and rely primarily on nouns at its beginning or adjectives to convey meaning. In these sentences, the subject is always a noun and predicate are usually nouns, or short sentences.

Solar lam and lunar Lam subscale. Understanding (اللام الشمسية والقمرية) whether Lam, in (alif lam) that are used before certain words referring to assimilation, is solar or lunar is crucial for correct pronunciation and comprehension in Arabic. The assimilation (solar) or separation (lunar) of the definite article impacts the phonetic pronunciation and flow of speech.

Audio syllables subscale. Sound patterns and listening exercises were used in these models to teach the segmentation and pronunciation of syllables in Arabic words to students.

Prepositions subscale. (حروف الجر). Employing visual aids or interactive exercises were used in these models to demonstrate the usage and meanings of prepositions in various contexts.

Arabic Pronouns subscale. It has three types: Arabic Subject Pronouns – ضمائر الفاعل (Damaa'ir al-faa3il, e.g. أنا (ana)أنا أتحدث العربية ('ana 'atahadath alearabia) – I speak Arabic.), Arabic Object Pronouns – ضمائر المفعول به (Damaa'ir al-maf3uul bihi, e.g. كلمني (kalmuni) – Call me!,), and Arabic Possessive Pronouns كلبي (klbi) – my dog) The content validity of the scale was examined by a group of 10 experts. They assessed the relevance of each item using a four-point Likert scale (where 1 represents "irrelevant" and 4 represents "highly relevant"). The 15 items were judged to be quite or highly relevant. A content validity index was calculated at the item level (I-CVI = 0.90). The scale has internal reliability of r=. 91and test-retest reliability of .75. (see Figure 1 for test sample).

Figure 1
Test sample for Arabic complex syntax comprehension skills

Competing Language Processing Task: This task is used in the research to evaluate verbal working memory and was created within the scope of this study. It was based on the research of Daneman and Carpenter (1980), but uses shorter and less difficult sentences than those used in Daneman and Carpenter's listening span test. It requires subject to semantically organize and verify the truth of sentences while holding the last word of each sentence in working memory for recall at the end of each group. As in the listening span test, the requirement of a response ensures that sentence comprehension takes place and prevents subjects from concentrating solely on the word-recall task. The task contains 40 true and false statements arranged in five levels of difficulty (4,6,8,10,12). Each statement contains three words (subject verb-object, subject-verb-modifier, or subject-auxiliary-main verb). The subjects were asked to respond "yes" or "no" to each statement as quickly as they could without making mistakes. Each stimulus sentence was presented by the researcher at a speaking rate of approximately 1.5 words per sec. using live voice. A content validity index was calculated at the item level (I-CVI = 0.90). The scale has internal reliability of r=. 83 and test-retest reliability of .67. (see Figure 2 for test sample).

العبارة	المستوى	استجابة الطفل		الكلمة المراد تذكرها
		صح	خطأ	
١.الطيور تطير	الاول			
٢.الحمام يمكن ان يأكل				
٣.اركب الدراجة				
٤.الثلج ساخن				
١. السيارات تبني الكباري	الثاني			
٢. الشجر لونه أسود				
٣. للخيل أقدام				
٤. يمكن للخيل ان تتكلم				
٥.السكر مالح				
٦. يمكن السيارات ان تتكلم				
١.التفاح لونه اسود	الثالث			
٢.التفاح مستطيل				
٣.يمكن للبيوت ان تقفز				
٤.تأكل الكراسي الحلوى				
٥. يقود الطفل السيارة				
٦. اللبن لونه أبيض				
٧.يمكن للجزر ان يرقص				
٨. للسيارات عجلات				
١.يمكن للسمك ان يعوم	الرابع			
٢. الطيارة لا تطير				
٣. الماعز لا تتكلم				
٤.الليمون لونه اصفر				
٥. السيارة تجري				
٦. يمكن البقرة ان تأكل				
٧. السفينة تسير في البحر				
٨. الماعز تأكل الاسد				
٩. التفاح لونه أحمر				
١٠. السكر حلو				
١. السحب ترتدي الملابس	الخامس			
٢. الخيل تحمل الانسان				
٣. نحن نسير على الارض				
٤.للانسان عينان				
٥. الشجر لونه أخضر				
٦. ليس للخيل أقدام				
٧. الماعز تأكل الحشائش				
٨. السفينة تسير على الطريق				
٩. نحن نلعب الكرة				
١٠. نحن نكتب بالقلم				
١١. السحب لونها ابيض				
١٢. يمكن البقرة ان تشرب الماء				

Figure 2
Test sample for competing language processing task

Ethical considerations

There are four main ethical principles: beneficence, respect, justice, and informed consent. The human dignity of all participants was respected, and the researcher assured the children, their parents and teachers that their participation, or non-participation, would not affect them in any way. No personal identifying information was included in the results of any aspects of the study. Furthermore, children would not be required to identify themselves on the questionnaires. Regarding issues of confidentiality and anonymity, only the researchers had access to the raw data, which remained confidential. As their participation was completely voluntary, without cash or product incentive, children were free to disengage at any time during the study. It was determined that this study included no inherent risk.

Procedures

Before participating in the study, the parents were asked to provide consent to declare their voluntary participation, and they were free to decline to participate at any step of the study. The participants were informed that their responses would be confidential. The purpose, content and procedures of the study were explained in detail. Tests were administered to both groups (for the DLD group in one center for Language and communication disorder in Riyadh, and for TD in one room in a school for primary in Riyadh as well) by the researcher himself in a quiet room during December, 2023. During the administration, children were first informed about the procedure to be done, and the children were helped to learn the procedure to be performed with the practice questions of each test.

Analysis of data

SPSS Package Program version 23 was used to analyze the data. Descriptive, correlational analysis statistics and simple regression analysis were used.

FINDINGS

This section aims to determine the relationships between different language components and mental functions in (TD) children and DLD group. Table 2 shows the mean and standard deviation of verbal working memory and complex syntax comprehension performances of (TD) children and DLD group. As for (VWM), as shown in Table 2, TD children had the highest mean (M=30.2, SD= 1.9, Range=23-34), while those with Down Syndrome had the lowest mean (M=14.3, SD= 2.7, Range=11-16). Concerning complex syntax comprehension performance, TD children had the highest mean as well, (M=50.4, SD= 1.4, Range=43-52), while those with Down Syndrome had the lowest mean (M=22.1, SD= 2.4, Range=18-25).

Table 2
Mean and standard deviation of verbal working memory and complex syntax comprehension performances of (TD) children and DLD group

Variable	TD			DS			SLD			ASD		
	M	SD	Range	M	SD	Range	M	SD	Range	M	SD	Range
VWM	30.2	1.9	23-34	14.3	2.7	11-16	18.0	2.3	10-22	22.5	1.8	13-26
CSC	50.4	1.4	43-52	22.1	2.4	18-25	29.6	2.8	19-33	27.3	1.6	16-30

Note: VWM= verbal working memory, CSC= complex syntax comprehension, TD= typically developing, DLD= developmental language disorders, M = mean, SD= standard deviation, SLD= Specific Learning Disorder

Correlation analysis was performed to determine whether there were relationships between different language components and mental functions of (TD) children. The results of the correlation analysis are shown in Table 3. As shown in Table 3, there is a correlation between verbal working memory and complex syntax comprehension (R=.42).

Table 3
The relationship between verbal working memory and complex syntax comprehension performances of (TD) children

Variables	1	2
1.VWM	-	.42**
2.CSC		-

Note: **P < 0.01

Results presented in Table 4 show that the independent variable (verbal working memory: VWM) yielded a coefficient of simple regression (R) of 0. 421 and a multiple correlation square of 0. 402. This shows that 42.1% of the total variance in complex syntax comprehension skills of those with DLD (SLD, ASD, DS) is accounted for (VWM). Table 5 indicates that the analysis of variance of the simple regression data produced an F-ratio value significant at 0.01 level (F: 1, 59) = 16.334; P < 0.02).

Table 4
The regression results of the predictor variable (VWM) and the outcome measure (complex syntax comprehension skills) of those with DLD (SLD, ASD, DS)

Dependent Variable	Complex syntax comprehension skills
N	60
Multiple R	.429a
Squared Multiple R	.421
Adjusted squared Multiple R	.421
Std. Error of the Estimate	3.02644

Table 5
Summary of simple regression analysis between the predictor variable and the outcome measure; ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	645.337	1	645.337	16.334	.002a
Residual	711.330	58	12.2643		
Total	1043.602	59			

As for results displayed in Table 6, the independent variable made significant individual contribution to the prediction of outcome measure. The results indicated that the following beta weight which represented the relative contribution of the independent variable to the prediction was observed (VWM) (b 0.344, t = 3.128; P < 0.01).

Table 6
Relative contribution of the independent variable to the prediction of complex syntax comprehension skills; Coefficients a

Model	Unstandarized coefficients		Standarized coefficients	t	sig
	B	Std error	Beta		
1 (constant)	5.839	2.897		2.051	.003
VWM	0.344	0.090	0.322	3.128	.002

Results presented in Table 7 show that the independent variable (VWM) yielded a coefficient of simple regression (R) of 0. 611 and a simple correlation square of 0. 600. This shows that 61.1% of the total variance in complex syntax comprehension skills of TD children is accounted for VWM. Table 8 indicates that the analysis of variance of the simple regression data produced an F-ratio value significant at 0.01 level (F(1, 59) = 22.112; P < 0.01).

Table 7
The regression results of the predictor variable (VWM) and the outcome measure (complex syntax comprehension skills) of TD children

Dependent Variable	Complex syntax comprehension skills
N	60
Multiple R	.624a
Squared Multiple R	.611
Adjusted squared Multiple R	.611
Std. Error of the Estimate	4.5321

Table 8
Summary of simple regression analysis between the predictor variable and the outcome measure; ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	945.344	1	945.344	22.112	.000a
Residual	1201.221	58	20.710		
Total	1417.634	59			

As for results displayed in Table 9, the independent variable made significant individual contribution to the prediction of outcome measure. The results indicated that the following beta weight which represented the relative contribution of the independent variable to the prediction was observed. VWM (b .346, t = 4.625; P < 0.01).

Table 9
Relative contribution of the independent variable to the prediction of complex syntax comprehension skills; Coefficients a

Model	Unstandarized coefficients		Standarized coefficients	t	sig
	B	Std error	Beta		
1 (constant)	9.973	2.114		5.228	.000
VWM	.346	0.007	.382	4.625	.000

DISCUSSION

The aim was to determine the relationship between VWM and complex syntax comprehension skills in TD children and those with DLD (SLD, ASD, DS). The tool for Assessing Complex Syntax Comprehension Skills and Competing Language Processing Task were used to collect and analyze data.

Similar to the results of studies in the literature (e.g. Chapman et al. 2002; Chiat and Roy, 2007; Hewitt et al., 2005; Laws, 2004; Miolo et al., 2005; Shriberg et al., 2009), it has been observed that TD children outperformed children with DLD (SLD, ASD, DS) in complex syntax comprehension skills and competing language processing task. Although typically developing and developmental language disordered children were matched on their nonverbal intelligence and age, TD children outperformed children with DLD (SLD, ASD, DS) in complex syntax comprehension skills and competing language processing task which supports the idea that there are different variables other than nonverbal intelligence that affect the development of complex syntax comprehension skills and competing language processing task (Estes et al., 2007).

In a study by Asbjornsen and Helland (2006) comparing the language performances of typically developing children and those diagnosed with learning disabilities, it was found that there was a positive and significant correlation between reading skills and language comprehension. In a study conducted by Conners et al. (2008) to evaluate the effect of memory training on children with Down Syndrome, it was found that memory-based interventions are more successful in cases where reading comprehension skills are more developed, suggesting that there is a mutual relationship between memory and language.

In the literature, it is stated that working memory measurements made through nonsense word repetitions are clinically distinctive in some groups that have difficulty in cognitive processing (Ebert et al., 2008; Montgomery and Windsor, 2007). Many studies in the literature mention the existence of a relationship between verbal working memory and language comprehension (Jha and Kiyonaga, 2010; Laws, 2004; Montgomery and Evans, 2009). Miolo et al. (2005) found that the working memory performance of children with language delay, assessed by the nonword repetition test, was significantly lower than that of children of the same age with typical language development.

In studies conducted with groups diagnosed with specific language disorders, it has been emphasized that limitations in processing capacity affect comprehension and production, and it has been pointed out that deficits in verbal working memory are among the underlying causes of language disorders (Archibald & Gathercole 2007; Engel et al., 2008).

It has been observed that the performance of children with specific learning disabilities in terms of verbal working memory and complex syntax comprehension skills is higher than both typically developing children and other children with developmental language disorders. Baddeley and Jarrold (2007) stated that at younger ages, nonsense word repetition performance predicts vocabulary performance, but as advanced language structures begin to be used, the relationship between nonsense word repetition and vocabulary performance becomes reciprocal, and that nonword repetition performance of individuals with larger vocabularies increases. From this point of view, it appears that children diagnosed with specific learning disabilities, whose chronological average age is higher than other diagnosis groups and typically developing children, have a more developed vocabulary and may be effective in their better performance in verbal working memory.

In a study conducted by Schuchardt et al. (2008), the verbal, visuospatial, and executive function components of working memory were evaluated in children with specific learning disabilities. The results of the study found that children diagnosed with reading disorder had difficulty in verbal working memory, and children with difficulties in mathematics (dyscalculia) had difficulty in visual spatial working memory, but there was no difficulty in verbal working memory. The results obtained were interpreted as deficiencies in verbal working memory could predict reading disorder, and deficiencies in the visuospatial area could predict mathematics disorder. In this study, it is not known in which academic field children diagnosed with specific learning disabilities experienced difficulties. The information obtained regarding the children's diagnoses was limited to "specific learning disability". However, it appears that receiving education to support reading for children in this diagnosis group may have had a positive impact on their verbal working memory performance, even if they had difficulty in verbal working memory.

The fact that the group diagnosed with specific learning disabilities showed a higher performance than the other groups in understanding complex syntax was due to the fact that this group did not have a diagnosed intellectual disability and could write complex sentence structures depending on their existing reading and writing skills. This suggests that their more verbal exposure and past literacy experiences are effective.

Montgomery (2002) found that the storage and processing capacity of working memory increases at approximately age 10 due to an increase in receptive language vocabulary. He also suggested that the performance of children with specific language disorders in sentence comprehension processes decreases as the sentences become more complex, and that this is due to the difficulty in storing the sentences.

In the study, it was observed that the verbal working memory averages of normally developing children, evaluated with the nonword repetition list, and the averages of complex syntax comprehension performance evaluated with the complex syntax comprehension skills tool, were higher than those of children with developmental language disorder. In a study by Chiat and Roy (2007), typically developing children who were diagnosed with language delay were evaluated in terms of their working memory performance through preschool meaningful and nonsense word repetition tests, and their receptive and expressive language skills through standardized tests. The results showed that there was a moderate correlation between receptive language vocabulary and repetition tests in both groups, and that in general, the group with language delay in language development performed lower than typically developing children in the repetition test and nonword repetitions. Laws (2004) stated that individuals with specific language disorders and Down Syndrome experience significant difficulties in repeating nonsense words.

Children with Down Syndrome appear to be the group with the lowest performance in verbal working memory and complex syntax comprehension skills. Conners (2003) stated in his study that the verbal working memory of individuals with Down Syndrome may be weaker than the other components of working memory, and this may cause them to exhibit poorer performance than normally developing children of the same mental age and other individuals equally affected by intellectual disability. Lanfranchi et al. (2009) found that the verbal working memory skills and executive functions of children with Down Syndrome were behind those of typically developing children.

Gathercole and Baddeley (1990) suggested that the short-term storage function of verbal working memory plays an important role in understanding syntactically complex sentences, and that it is more difficult for individuals with Down Syndrome to understand linguistic forms such as complex sentences than their typically developing peers, due to the damage to their verbal working memory.

In a study conducted by Cairns and Jarrold (2005), it was observed that the nonword repetition performance of children with Down Syndrome was significantly behind that of typically developing children, even when matched according to receptive language age. The results obtained from the research conducted are similar to the results of the studies in the literature. In this study, it was found that the verbal working memory performance of children with Down Syndrome was poorer than that of typically developing children and other diagnostic groups. It appears that the lower performance of children with Down Syndrome in understanding complex syntax skills than other groups is caused by their difficulties in verbal working memory.

In a study conducted by Alloway et al. (2009) aiming to evaluate the working memory of children diagnosed with specific learning disabilities, developmental coordination disorder, Asperger's Syndrome, and attention deficit and hyperactivity disorder, it was found that groups other than developmental coordination disorder had better memory performance. It also was found that they had difficulty in verbal working memory. It has been stated that the difficulties specific to verbal working memory in children with Asperger Syndrome may be due to communication-based problems. The results obtained in this study regarding the verbal working memory of children with autism are similar to the results of studies in the literature.

In a study conducted by Chan et al. (2005), no significant difference was found between typically developing children and children diagnosed with autism in terms of understanding verbal language. However, children with high- and low-functioning autism had significant differences in language comprehension and expression. Additionally, in the same study, similar to the findings of Bartak et al. (1977), it was stated that children with autism showed lower performance in understanding language than in expressive language.

The main findings of Kjelgaard & Tager-Flusberg (2001) were that among the children with autism there was significant heterogeneity in their language skills, although across all the children, articulation skills were spared. Different subgroups of children with autism were identified on the basis on their performance on the language measures. Some children with autism have normal language skills; for other children, their language skills are significantly below age expectations. Gabig (2008) also determined that the verbal working memory performance of children diagnosed with autism was lower than that of typically developing children who were matched on age.

In addition, in the context of syntax comprehension, the results are thought to support the working memory model put forward by Just & Carpenter (1992), which focuses more on mature adult language. According to this model, while verbal information is stored in working memory, various comprehension processes are simultaneously transferred to working memory. Since storage and processing functions share a limited resource pool in understanding language, when the amount of verbal information exceeds the available capacity of working memory, it may be necessary to choose between storage and processing in order to understand the language. In the research conducted, children with Down Syndrome often make the mistake of omitting the clause from the sentence during the process of understanding complex syntax, suggesting that they respond by choosing between processing and storage.

In our study, children with autism showed higher performance than children with Down Syndrome, both in terms of verbal working memory, and ability to understand complex syntax. The fact that the results obtained from the studies in the literature and the research conducted differ supports the view that the language characteristics of children diagnosed with autism and Down Syndrome are heterogeneous.

The fact that the relationship between the total scores of complex syntax comprehension skills of children with developmental language disorder and their accuracy rates in four-syllable nonsense words is high, positive and significant, supports the idea that word/sentence length may be one of the effective variables in complex syntax comprehension skills in this group.

CONCLUSION

The results obtained from the analyzes carried out to compare the complex syntax comprehension performances of the two groups also showed that the difference between the groups was significant. It has been determined that this difference is due to the fact that the complex syntax comprehension performance of children with Down Syndrome is lower than that of normally developing children and children with specific learning disabilities, and that the complex syntax comprehension performance of typically developing children and those diagnosed with autism is lower than that of children diagnosed with specific learning disabilities.

It has been stated that the basis of language comprehension difficulties in individuals with developmental language disorder may be deficiencies in the ability to understand syntax, and these deficiencies, which are related to processing skills in working memory, may cause difficulty in distinguishing the differences in meaning caused by the differences in the order of words in the sentence. In this regard, it is of great importance to examine difficulties related to understanding syntax, which significantly affect the quality of communication, in terms of language profiles specific to diagnostic groups. The research has shown that there is a relationship between verbal working memory and complex syntax comprehension skills in groups with normal development and developmental language disorder, and provides results that theoretically support the language-related functions of verbal working memory proposed by Baddeley (2003).

CLINICAL UTILITY

Understanding sentences containing participles, which individuals with Down Syndrome have difficulty can also play an important role in the evaluation. Identifying structures that may be clinically distinctive in Arabic will only be possible with a study involving a larger number of sentences and more participants. In Baddeley's (2003) model, verbal working memory includes the listener's ability to order spoken words accurately and completely during cognitive functions such as verbal reasoning or auditory comprehension. Thus, in cases where the order of verbal structures is important, the listener processes the verbal input in a certain period of time and thus comprehension occurs. Considering the errors made by the diagnostic groups regarding word order during the process of understanding complex syntax in this study, it can be thought that this situation depends on the processing/coding of verbal input. Considering the structures and error types experienced by children with Down Syndrome, it can be thought that individuals who have difficulties specific to working memory are likely to have difficulties in understanding adjective verb sentences, and sentences containing adjective verbs can play a clinically important role in the evaluation.

It is thought that evaluating children with developmental language disorders based on their verbal working memory performance using nonsense word repetitions will contribute to our literature and may be an important step for our country in distinguishing specific language disorders from other difficulties.

AUTHOR CONTRIBUTION

The author is the only person who contributed to this study

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INFORMED CONSENT STATEMENT

Informed consent was obtained from all subjects involved in the study. Participation could be discontinued at any time.

DATA AVAILABILITY STATEMENT

For data supporting the reported results, please consult the author.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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