

# Evaluation of Attention and Memory Skills in Normal-Hearing Children with Speech and Sound Disorders

## Konuşma Sesi Bozuklukları Olan Normal İşiten Çocuklarda Dikkat ve Hafıza Becerilerinin Değerlendirilmesi

<sup>1</sup> Nuriye YILDIRIM GÖKAY<sup>a</sup>, <sup>2</sup> Güzide ATALIK<sup>b</sup>, <sup>3</sup> Hakan GÖLAÇ<sup>b</sup>

<sup>a</sup>Gazi University Faculty of Health Sciences, Department of Audiology, Ankara, Türkiye

<sup>b</sup>Gazi University Faculty of Health Sciences, Department of Speech and Language Therapy, Ankara, Türkiye

This study is partially presented in 30<sup>th</sup> Union of the European Phoniatics Congress, April 27-30, 2023, Antalya, Türkiye.

**ABSTRACT Objective:** The improvement of children's language and communication abilities plays a vital role in shaping cognitive functions. This study focuses on the assessment of language, attention, and memory skills in typical hearing children with and without speech sound disorders (SSD). **Material and Methods:** A total of 60 volunteer children aged between 6 and 9 years, both with and without SSD, were included. The diagnosis of SSD was determined using The Turkish Articulation and Phonology Test, language skills were assessed with the Test of Language Development-Primary: Fourth Edition (TOLD-P:4), memory skills with the Visual Auditory Digit Span (VADS) Test, and attention skills with the STROOP test. The language and cognitive test scores in children with and without SSD were compared using the Independent Samples t-test. The relationship between language and cognitive skills was examined using Pearson correlation analysis. The statistical significance level was determined as 0.05. **Results:** Significant differences were found between children with and without SSD in the TOLD-P:4 morpheme completion subtest ( $p=0.005$ ), in the STROOP test 5th section ( $p=0.045$ ), and the VADS visual-written subtest ( $p=0.002$ ). Additionally, significant differences in STROOP and VADS scores were observed between children aged 7 and below based on literacy experience ( $p<0.05$ ). **Conclusion:** The results of the study emphasize that children with SSD not only experience difficulties in language skills but also in attention and memory domains. Therefore, it is important to adopt a holistic approach in the educational and therapeutic programs for these children.

**Keywords:** Speech sound disorders; attention; memory; language

**ÖZET Amaç:** Çocukların dil ve iletişim becerilerinin gelişimi, bilişsel işlevleri etkileyen kritik bir faktördür. Bu çalışma, konuşma sesi bozukluğu (KSB) olan ve olmayan normal işiten çocuklarda dil, dikkat ve bellek becerilerinin değerlendirilmesini amaçlamaktadır. **Gereç ve Yöntemler:** Çalışmaya, 6-9 yaş aralığında, KSB tanısı olan ve olmayan toplam 60 gönüllü çocuk dâhil edilmiştir. KSB tanısı, Türkçe Artikülasyon ve Fonoloji Testi ile değerlendirilmiştir; dil becerileri, Türkçe Okul Çağı Dil Gelişimi Testi (TODİL) ile bellek becerileri, Görsel İşitsel Sayı Dizisi (GİSD) Testi ve dikkat becerileri ise STROOP testi ile değerlendirilmiştir. KSB olan ve olmayan çocuklarda dil ve bilişsel test puanları Bağımsız Gruplarda t-testi ile karşılaştırılmıştır. Dil ve bilişsel beceriler arasındaki ilişki, Pearson korelasyon analizi kullanılarak incelenmiştir. İstatistiksel anlamlılık düzeyi 0,05 olarak belirlenmiştir. **Bulgular:** KSB olan ve olmayan çocuklar arasında; TODİL morfem tamamlama alt testi ( $p=0,005$ ), STROOP testi 5. Bölüm ( $p=0,045$ ) ve GİSD görsel-yazılı alt testi ( $p=0,002$ ) sonuçlarında anlamlı farklılıklar saptanmıştır. Ayrıca, okuryazarlık deneyimine bağlı olarak 7 yaş ve altındaki çocuklar arasında STROOP ve GİSD puanlarında anlamlı farklılıklar gözlemlenmiştir ( $p<0,05$ ). **Sonuç:** KSB olan çocukların yalnızca dil becerilerinde değil, aynı zamanda dikkat ve bellek alanlarında da zorluklar yaşadığı vurgulanmaktadır. Bu nedenle, bu çocuklara yönelik eğitim ve terapötik programlarda bütüncül bir yaklaşım benimsenmesi önemlidir.

**Anahtar Kelimeler:** Konuşma sesi bozuklukları; dikkat; bellek; dil

The development of children's language and communication skills is a crucial factor influencing cognitive functions. Despite having normal hearing performance, children with speech sound disorders (SSD) may exhibit differences in attention and mem-

ory skills, along with difficulties in language and communication.

There is a highly strong relationship between attention, memory skills, and language. Vygotsky, a prominent figure in developmental psychology, as-

**TO CITE THIS ARTICLE:**

Yıldırım Gökay N, Atalık G, Gölaç H. Evaluation of Attention and Memory Skills in Normal-Hearing Children with Speech and Sound Disorders. Journal of Ear Nose Throat and Head Neck Surgery. 2025;33(2):63-9.

**Correspondence:** Nuriye YILDIRIM GÖKAY  
Gazi University Faculty of Health Sciences, Department of Audiology, Ankara, Türkiye  
**E-mail:** nuriye.yildirim94@gmail.com



Peer review under responsibility of Journal of Ear Nose Throat and Head Neck Surgery.

**Received:** 15 Nov 2024 **Accepted:** 20. Jan 2025 **Available online:** 05 Feb 2025

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serted that the development of cognitive skills such as planning, problem-solving, and self-regulation is significantly influenced by the acquisition of speech abilities.<sup>1</sup> Many researchers in the field of language and cognitive skills have stated that language development is closely related to attention and memory skills. The use of language and understanding of images, fluent language use, receptive-expressive language skills, and gesture-facial expression use have been reported to be associated with cognitive competence.<sup>2-5</sup> Preschool children with better language and speech skills in terms of receptive language, expressive language, content, and structure have been observed to exhibit superior attention and memory abilities. Especially in the skills of reading and writing, words and sentences are processed, and working memory and attention skills play a crucial role.<sup>6,7</sup> Murphy et al. observed hypoactivation in relevant brain regions during a working memory task, specifically meaningless word repetition, in adolescents with speech sound complaints when compared to the control group in an fMRI study.<sup>8</sup> In another study, Engelhardt et al. proposed that individuals with attention deficit hyperactivity disorder (ADHD) exhibit certain drawbacks in speech production, suggesting that these difficulties stem from suppressed cognitive skills due to this disorder.<sup>9</sup> To the best of the authors' knowledge, it has been determined that the findings obtained from individuals with language and speech problems using the methodology in the current study are limited. In a study using a similar methodology with children diagnosed with ADHD, weak performance was observed in memory and sustained attention skills.<sup>10</sup> Some difficulties in cognitive skills were observed in children with language and speech complaints.<sup>11</sup>

Based on all these studies, the current study has set out to investigate whether there is an impact on cognitive abilities in children with SSD. The starting point of this study is also the strong relationship frequently mentioned in the literature between cognitive abilities and language skills. In this context, SSD typically involves situations in which speech sounds cannot be produced accurately or understood. This situation can impact children's social interactions, academic achievements, and overall quality of life. At this point, understanding how difficulties in lan-

guage development affect cognitive processes has become an important research topic.

This study aimed to assess attention and memory skills in children with speech sound complaints who have normal hearing, using a unique methodology. It is assumed that the current study will be highly beneficial in guiding professionals in the field and contributing to the literature. This research will be a crucial step in identifying the needs of children within this specific group and developing effective intervention strategies.

## MATERIAL AND METHODS

The current research has been approved ethically by the University Ethics Committee with research code 2022-1064 and decision no. 15. Informed consent have been obtained from all participants. This study was conducted in accordance with the principles of the Declaration of Helsinki. The preliminary findings of this study were presented as an abstract at the 30<sup>th</sup> Union of the European Phoniatics Congress.

This study included 60 voluntary children, aged between 6 and 9, both with (n=30) and without (n=30) complaints of SSD who have normal hearing. The hearing thresholds of the children were tested with supra-aural headphones using pure tone audiometry in octave bands between 250 and 8000 Hz. All children obtained hearing thresholds of no more than 15 dB HL at any frequency. The inclusion criteria for the study include having normal hearing, being between the ages of 6 and 9, and demonstrating cooperation during the tests. Furthermore, since all children are assessed multidisciplinary for the presence of additional diagnosis in cognitive, psychological, and other areas as part of the routine procedure before SSD therapy, all children in this study were at similar levels cognitively to their healthy peers. The diagnosis of SSD in children was determined using The Turkish Articulation and Phonology Test, and these findings were solely used for forming the groups.<sup>12</sup> The exclusion criteria for the study involve having hearing loss, a history of previous ear infection/surgery, a diagnosis of additional problems in physical, psychological, neurological, etc., areas, and having undergone the same tests previously.

The Test of Language Development-Primary: Fourth Edition (TOLD-P:4) was administered to assess the school-age language skills of the children. This test is a valid and reliable adaptation into Turkish of the original test created by Newcomer and Hamill (Yolal Y. Test of language development-primary: (told-p: 4) testinin Türkçe uyarlanmasında madde analizi: ön bulgular. Anadolu University Türkiye; 2012).<sup>13-15</sup> TOLD-P:4 enables the assessment of children's abilities in the phonetic, semantic, syntactic, and morphological aspects of language. TOLD-P:4 consists of 6 core subtests: picture-vocabulary test, related word test, word description, sentence comprehension, sentence repetition, and morpheme completion. The scaled scores, matched with age, based on the number of correct responses in these tests, were used in this study. The scaled scores on the TOLD-P:4 have been determined in comparison to typically developing children and consist of seven categories ranging from very weak to very advanced. Accordingly, those with scaled scores of 6-7 compared to their typically developing peers are categorized as below average, those with scores of 8-12 as average, and those with scores of 13-14 as above average.<sup>13,14</sup> The sum of scores from all subtests represents the child's verbal language score. The age-matched index score on verbal language skills was analyzed.

The valid and reliable Visual Auditory Digit Span (VADS) Test, which assesses cognitive skills such as short-term memory and working memory, was performed.<sup>15,16</sup> In this test, the child was asked to sequentially repeat or write down digits heard or seen. The digit sequences ranged from 3 to 9 digits. The score was recorded as the maximum number of digits the child could successfully repeat (e.g., repeating 7 digits). Auditory presentation followed by verbal repetition constitutes the auditory-verbal score, whereas auditory presentation followed by written repetition constitutes the auditory-written score. In addition, the visual presentation followed by verbal repetition and the visual presentation followed by written repetition constitute the visual-verbal score and the visual-written score, respectively.

The STROOP test was used to assess selective attention, the Stroop effect, and focused attention

skills.<sup>17,18</sup> The Stroop effect occurs when the word meaning differs from the color in which the word is written. The child is asked to say not what is written, but the color in which it is written. (For example, the word "blue" written in green). This test includes two cards with color names printed in black and color, one card with neutral words printed in color, and one card with colored balls. In the first condition (STROOP1), the child was asked to read the color names printed in black, in the second condition (STROOP2) to read the color names of the words printed in color, in the third condition (STROOP3) to state the color of a ball, in the fourth condition (STROOP4) to state the color of neutral words without color names, and finally, in the fifth condition (STROOP5), to state the color of words with color names (e.g., saying 'red' when it is written in blue). For each condition, the completion time, error, and correction numbers were analyzed in this study

The normality of the data was tested using histogram graphs and normality analyses. Because all findings exhibited a normal distribution, descriptive statistics were presented as the mean and standard deviation. Independent samples t-tests were conducted to compare language and cognitive test scores between children with and without speech sound complaints. The relationship between language and cognitive skills was examined using Pearson correlation analysis. The statistical significance level was set at 0.05.

## RESULTS

The study included 30 healthy volunteer children (16 are girls and 14 are boys) with an average age of  $M=87.33$ ,  $SD=8.50$  months and 30 children (16 are girls, and 14 are boys) with an average age of  $M=87.13$ ,  $SD=6.82$  months, exhibiting SSD. There were no statistically significant differences observed in terms of age and gender between children with and without SSD ( $p=0.290$ ). The authors take care to ensure a homogenous distribution of the groups in terms of age and gender.

The VADS scores for children's short-term memory skills are presented in Table 1. According to this, no statistically significant differences were found among the groups in auditory-verbal, auditory-

**TABLE 1:** Visual aural digit span test scores of groups.

	Control Group		Study Group		p value
	$\bar{X}\pm SD$	Maximum-minimum	$\bar{X}\pm SD$	Maximum-minimum	
Auditory verbal	5.40±0.97	7-4	5.53±0.90	7-4	0.583
Visual verbal	4.54±0.52	5-4	4.57±0.73	6-3	0.908
Auditory written	4.50±0.73	6-3	4.80±0.89	6-3	0.158
Visual written	3.91±0.79	5-3	3.08±0.49	4-2	0.002*

SD: Standard deviation; \*There is a statistically significant difference;  $p < 0.05$ .

written, and visual-verbal scores. However, in the visual-written score, children with SSD demonstrated significantly weaker performance ( $p=0.002$ ). In the auditory-verbal test, children in both groups could repeat between 4 and 7 digits. Similarly, in the auditory-written test, children in both groups could write between 3 and 6 digits.

In terms of the completion times for the STROOP test, a statistically significant difference was observed only in the STROOP5 subtest between children with and without SSD ( $p=0.045$ ). Accordingly, healthy children completed the STROOP5 subtest in an average of  $M=30.42$ ,  $SD=7.40$  seconds,

while children with SSD completed it in an average of  $M=34.65$ ,  $SD=8.53$  seconds. Additionally, children in both groups exhibited similar performance in the STROOP1, 2, 3, and 4 subtests (Table 2).

To assess children's school-age language abilities, the Test of Language Development-Primary: Fourth Edition (TOLD-P:4) was performed, including 6 core subtests. A statistically significant difference was found only in the morpheme completion test among the TOLD-P:4 subtests ( $p=0.005$ ). The children with SSD obtained an average scaled score of  $M=8.73$ ,  $SD=1.08$  in morpheme completion skills, whereas healthy children scored  $M=9.50$ ,  $SD=0.97$ . More-

**TABLE 2:** STROOP test scores of groups.

	Control Group		Study Group		p value
	$\bar{X}\pm SD$	Maximum-minimum	$\bar{X}\pm SD$	Maximum-minimum	
STROOP 1	19.84±8.73	36.90-10.60	19.57±6.50	33.13-10.30	0.891
STROOP 2	21.01±8.31	38.80-12.90	19.55±5.65	38.67-10.60	0.429
STROOP 3	21.91±7.24	38.80-14.40	21.34±4.26	33.20-15.90	0.709
STROOP 4	24.01±7.65	37.10-13.45	25.23±6.13	36.90-14.70	0.498
STROOP 5	30.42±7.40	42.90-18.89	34.65±8.53	50.20-21.90	0.045*

SD: Standard deviation; \*there is a statistically significant difference;  $p < 0.05$ .

**TABLE 3:** TOLD-P:4 test scores of groups.

	Control Group		Study Group		p value
	$\bar{X}\pm SD$	Maximum-minimum	$\bar{X}\pm SD$	Maximum-minimum	
Picture-vocabulary	10.53±1.17	12-9	10.13±1.07	12-8	0.172
Related word test	9.87±0.97	12-8	10.10±1.30	12-8	0.434
Word description	8.90±1.03	11-7	9.07±1.39	12-7	0.599
Sentence comprehension	8.83±1.02	11-7	9.10±0.80	10-8	0.265
Sentence repetition	9.63±1.35	12-8	9.90±1.12	12-8	0.410
Morpheme completion	9.50±0.97	11-8	8.73±1.08	11-7	0.005*
Verbal language	95.70±7.34	107-80	96.03±7.24	107-83	0.860

SD: Standard deviation; \*there is a statistically significant difference;  $p < 0.05$ .

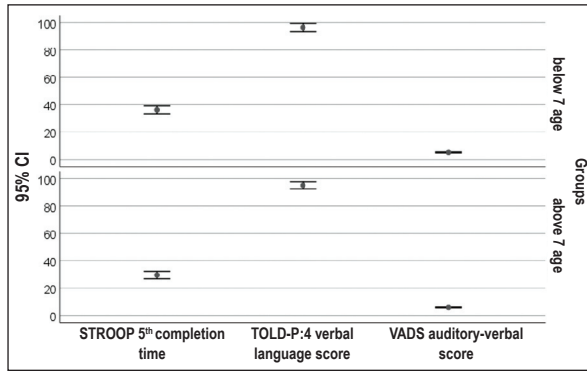


FIGURE 1: Error bars of tests.

over, the children demonstrated similar performance in the remaining subtests, including picture-vocabulary, related word, word description; sentence comprehension, sentence repetition, and the total verbal language score (Table 3).

According to the literacy status of children, it has been observed that in children aged 7 and above, those who are literate perform better in all subtests of the STROOP task. Literate children completed the STROOP test subtests in a shorter time ( $p < 0.05$ ). Similarly, when grouped by age, children aged 7 and above demonstrated better performance in the VADS memory tasks, specifically in auditory-verbal, auditory-written, and visual-verbal scores ( $p < 0.05$ ). Finally, no statistically significant differences were found in the TOLD-P:4 language test scaled scores based on age ( $p > 0.05$ ) (Figure 1).

Lastly, the relationship between the language, memory, and attention skills of all children was examined through correlation analyses. According to the results, no statistically significant correlations were found between any two subskills ( $p > 0.05$ ).

## DISCUSSION

The main objective of this study was to examine potential differences in attention, memory, and language skills between children with and without SSD. The findings demonstrated the presence of distinct characteristics in cognitive skills among children with SSD. These results indicate that the difficulties in language skills among children with SSD are not lim-

ited solely to speech production but also affect general cognitive processes.

## SELECTIVE ATTENTION AND THE STROOP EFFECT

Children with SSD have been observed to experience a significant decrease in attention skills. The potential reason for the observed difference between children with and without SSD in the STROOP test in the fifth section may be inherent to the nature of the test. Indeed, in the STROOP5 section, the situation arises where the written color name differs from the actual color. This situation can lead to cognitive conflict and an increase in the response times. The current study demonstrates that SSD not only affects the speech production process but also negatively impacts these attention mechanisms. It can be anticipated that children with SSD face difficulties in sustaining attention and focus during speech. Similar studies have demonstrated that children with SSD exhibited weaker performance in auditory and visual sustained attention tasks.<sup>8,19</sup> Despite the limited number of studies investigating the STROOP effect and attention skills in individuals with speech disorders, these studies unanimously agree on the negative impact on attention processes.<sup>20,21</sup> The current findings are consistent with the studies in the literature.

## MEMORY

There are numerous studies investigating memory performance, such as working memory and short-term memory, in children with SSD.<sup>22-26</sup> Accordingly, these studies reveal a significant decline in memory skills among children with SSD. This study similarly obtained meaningful differences in the visual-written memory task between children with and without SSD. This finding indicates that children with speech sound disorders may face challenges in memory subdomains, such as verbal memory, auditory memory, or visual memory. The absence of significant differences in the auditory-verbal and auditory-written memory tests may be attributed to the children having normal hearing abilities. In conclusion, it is anticipated that children with SSD will encounter difficulties in sustaining and organizing information during the speech process.

## LANGUAGE

The language and speech perception skills in children with SSD have been a notable subject of research for years.<sup>27-30</sup> In the current study, the phonological, morphological, semantic, and syntactic skills of language were assessed using the TOLD-P:4 test. The results indicate significant differences in morpheme completion skills among children with SSD. This suggests that these children face challenges not only in speech production but also in understanding and using the structure of language. The lower performance in morpheme completion skills underscores the general difficulties in language development. Similarly, the presence of poor speech perception in children with SSD has also been demonstrated in a review and meta-analysis study.<sup>28</sup> Furthermore, the difference in attention and memory performance in children aged 7 and below may stem from the inclusion of cognitive tests involving literacy skills. Children who are literate and relatively more experienced have shown better success in these cognitive tests.<sup>31,32</sup>

On the other hand, the relationship between language, attention, and memory skills is also noticeable in children with SSD.<sup>33,34</sup> This study also showed that difficulties resulting from SSD can negatively affect short-term memory, working memory, selective attention, and skills related to the components of language. In association with this, the long-term effects that emerge over time can lead to much different outcomes.<sup>35</sup>

## CONCLUSION

The current findings indicate that children with SSD face comprehensive challenges in both language and

cognitive skills. Therefore, adopting a more holistic approach to the educational and therapeutic programs for these children is crucial. Additionally, based on the results of this study, there is a need for further research to gain a deeper understanding of the cognitive difficulties associated with SSD. Such research efforts can contribute to the development of more effective intervention strategies.

### Source of Finance

*During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.*

### Conflict of Interest

*No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.*

### Authorship Contributions

**Idea/Concept:** Nuriye Yıldırım Gökay; **Design:** Nuriye Yıldırım Gökay; **Control/Supervision:** Nuriye Yıldırım Gökay; **Data Collection and/or Processing:** Nuriye Yıldırım Gökay, Hakan Gölaç, Güzide Atalık; **Analysis and/or Interpretation:** Nuriye Yıldırım Gökay, Hakan Gölaç, Güzide Atalık; **Literature Review:** Nuriye Yıldırım Gökay, Hakan Gölaç, Güzide Atalık; **Writing the Article:** Nuriye Yıldırım Gökay, Hakan Gölaç, Güzide Atalık; **Critical Review:** Nuriye Yıldırım Gökay, Hakan Gölaç, Güzide Atalık; **References and Fundings:** Nuriye Yıldırım Gökay, Hakan Gölaç, Güzide Atalık; **Materials:** Nuriye Yıldırım Gökay, Hakan Gölaç, Güzide Atalık.

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