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Investigation of the Effect of Gazi Reading Writing Education Program on Children's Auditory Processing Skills*

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ABSTRACT

This research examines whether children with Reading and Writing Difficulties (RWD) have auditory processing difficulties and investigates which educational therapy programs can effectively eliminate children's existing problems. Quantitative research was conducted, and a total of 30 children with an average mean of 84 months were added to the study, including Control 1 (non-RWD), Control 2 (RWD), and Experimental (RWD) groups. The Gazi Reading Writing Education Program (GRWEP), developed to overcome literacy problems, was applied to the experimental group for 12 weeks. The results were compared between the groups. The results of the experimental group's post-test showed a significant increase in literacy skills. The auditory processing tests were compared with the available data. The results showed auditory processing difficulty impacts the ability to recognize the sounds of written words and reading learning. The study's findings revealed that the GRWEP method is effective in the educational therapy of children with reading and writing difficulties.

Keywords: Auditory processing disorder, phonology, reading, writing, teaching

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1. INTRODUCTION

Auditory processing involves listening to and comprehending the environmental information we receive through hearing. Auditory processing mechanisms are involved in selecting speech material for sounds propagating into space, allowing listening to units of speech that involve the comprehension of heard sounds, and processing sensory stimuli simultaneously when multiple auditory stimuli are present amid background noise. The processing of these functions within the auditory pathways is essential for comprehending hearing and speech (Association; Medwetsky, 2011; Mohideen & Thangaraj, 2022). Furthermore, auditory processing is filtering acoustic stimuli (meaningful or meaningless sounds, noise, unpredicted sound, familiar sound) like a sieve and making speech sounds audible, recognizable, and distinguishable according to their acoustic properties (Jerger & Musiek, 2000).

The processing of acoustic-phonetic features mainly occurs in the posterior superior temporal regions of the left hemisphere (Hickok & Poeppel, 2000; Scott & Johnsrude, 2003). If the physiology of the auditory system is impaired, the impaired functions will be reflected in behavior in the test (Bailey, 2010; Kraus et al., 1996). In this context, considering that auditory processing difficulty is the difficulty in processing the phonemes contained in a language, it has been stated that it can cause several learning disorders, including reading and writing difficulties (Mallen, 2010; C. A. Miller & Wagstaff, 2011; Musiek et al., 2010). Therefore, learning to write and read is directly related to auditory processing mechanisms.

A child must have developed phonological skills, which involve the mastery of speech sounds, in order to learn reading and writing. Roepke (2024) defined phonological processing skills as the use of phoneme knowledge to process language and stated that they are an essential indicator of future reading skills in preschool and kindergarten children.

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Also, decoding is the conversion of letters into speech sounds, and its difficulty leads to phonological processing difficulty. It is connected to phonological awareness, which is the ability to manipulate and blend sounds in words; the memory of phonology refers to the talent to store and rehearse verbal information, while lexical retrieval is the skill to rapidly access the information of phonology stored in long-term memory during Rapid Automated Naming (RAN) tasks involving objects, numbers, letters, or colors (G. J. Miller & Lewis, 2022).

The reading and writing education program mentioned in this study was developed using the above information. In this regard, a Phonemic Training Program (PTP) has been shown to enhance speech processing, word reading, and auditory spelling abilities in bodies with Central Auditory Processing Disorder (CAPD). The reason for such a significant difference is that the method is an educational treatment appropriate to the nature of the disorder. For this reason, the PTP technique has been recommended for use in various settings, from kindergarten children to seniors (Jack Katz, 2009). The connection between PTP and difficulties in reading and writing lies in the fact that PTP is a fundamental training program to enhance auditory decoding skills.

The Gazi Reading and Writing Education Program (GRWEP) was created based on the principles of PTP. Decoding refers to the ability to recognize speech sounds (phonemes) by swiftly and accurately processing the acoustic properties such as frequency, intensity, and duration of the spoken language. When decoding is compromised, speech sounds are perceived but not differentiated. It is typically the most prevalent form of central auditory processing disorder. Decoding is closely related to the functions of the auditory cortex. The decoding function must be corrected for the auditory cortex to identify sounds correctly and for speech to be understood correctly. Therapy is applied to improve speech comprehension, to learn to read fluently, and to reduce deficits in other auditory functions. The training in therapies is training in decoding speech sounds (J Katz, Ferre, Keith, & Alexander, 2015). In this context, the philosophy of the PTP was associated with the GRWEP. Speech sounds were introduced based on phonemes, a sound-symbol relationship was established, and reading and writing education was provided with concretized activities. While determining the sequence of phonemes to be given in the GRWEP, the level of the program was prepared according to the frequency of speech sounds (towards medium, low, and high frequencies), the developmental order in the acquisition, the manner and place of the articulation, and the features of being voiced and voiceless.

This study examines the effectiveness of the GRWEP in improving auditory processing in children with reading and writing difficulties (RWD). The research questions are as follows.

1. How does the GRWEP intervention affect the auditory processing assessment results of children with RWD in the experimental group concerning those in the control group?

2. What are the differences between the groups regarding speech sound development following the GRWEP intervention?

2. METHODOLOGY

It is a quantitative study to examine the effectiveness of the GRWEP in terms of auditory processing and is a research plan with a quasi-experimental design. The study included pre-tests for control group 1 (non-RWD), control group 2 (RWD), and the experimental group (RWD). The experimental group then underwent a 12-week GRWEP intervention, followed by post-tests for both the study groups, the control 2 and the experimental.

Control group 1 was not part of the post-tests as it demonstrated typical development and did not have reading and writing difficulties.

2.1. Participants

The study population consisted of first-grade primary school students attending public schools in seven districts of Ankara province. The study information was provided to schools via an informed consent letter from the Ankara Governorship Provincial Directorate of National Education. The researcher developed a questionnaire assessing auditory processing skills to reach the participants and administered it to classroom teachers (Küçükünal, Özçelik, & Yalçınkaya, 2020). A total of 328 children were reached in schools. Out of 272 children without writing and reading difficulties, 10 were chosen for the control 1 group, which had no RWD. Among the 56 children with reading and writing difficulties, 10 were assigned to the control 2 group, and 10 to the experimental group. In total, there were 30 children both groups.

The exclusion criteria were hearing impairment, psychological-emotional disorders, neurological disorders, and physical and developmental delay. For the inclusion criteria, the school files of the classroom teachers were examined. The children included in the study were in the normal distribution. Typically developing children with and without RWD who did not have a diagnosis following the exclusion criteria in the class teacher's file were included in the study. A personal information form was created to gather details about the children. The form included questions regarding the child's age, the mother's education level, age, and occupation; the father's education level, age, and occupation; the age at which the child first spoke words; the age at which the child formed two-word sentences; family history of speech delays; the age when the child started preschool; as well as prenatal, natal, and postnatal history.

2.2. Data Collection Tools

2.2.1. Auditory processing tests (SCAN-C)

The test developed by Keith in 1986 was standardized in 2000 and adapted into Turkish by Yalçınkaya in 2005. The Cronbach's alpha coefficient for the SCAN-C test is 0.86. It evaluates the transmission of sounds in auditory pathways. Subtest 3 Dichotic Words sections were used in the study. Subtest 3 Dichotic Words (DW): In dichotic listening, two stimuli are simultaneously presented to the right and left ear. The stimulus from the right ear is transmitted directly to the left hemisphere, while the stimulus from the left ear is sent directly to the right hemisphere, and the child then repeats the word they hear. Twenty-five monosyllabic words are played to the child with headphones, and 1 point is given for the word the child repeats correctly (Keith, 2000; Yalçinkaya, Türkyilmaz, Keith, & Harris, 2015).

2.2.2. Speech Sound Recognition Test (SSRT)

Katz created the test's validity and reliability study in 1996. In creating the test, it was emphasized that each speech sound should be understood individually to realize speech comprehension skills. Imitation of the speech sound with the feedback mechanism indicates that the phoneme is processed in the auditory pathways by preserving its acoustic properties. Nevertheless, this does not mean the meaning of the phoneme is acquired. In the test, the pre-processing of the acoustic-phonetic features of the speech sound takes place (phonemic level recognition). A male announcer recorded the test in a sound recording studio. The 29 speech sounds in Turkish (21 consonant and eight vowel sounds) were recorded twice at 5-second intervals, resulting in 58 sounds. The child was asked to say and write them down as soon as s/he heard them. One point was given for each correct answer (Küçükünal & Yücel, 2023).

2.2.3. Writing Skills Scale

Using the Writing Skill Scale, students were asked to write five sentences using their learned letters. Each scale contains five sentences containing 19 words. Children were given one point for each word they wrote correctly and zero points for each word incorrectly. The maximum score on the scale is 19 (Erdoğan, 2009).

2.2.4. False Analysis Inventory

It includes the Vocalization and Environment scales, which were derived from May (1986), and the Word Comprehension and Percentage Determination Guide, which was modified by Akyol (2016) from Ekwall and Shanker (1988). According to the reading skill, two texts were read at the expected low and medium level and scored on the number of words (Akyol, 2016). The scoring of the error analysis inventory, which will be used for detecting reading errors, was scored as 0 to 5 points. According to the reading skill, two texts were read at the expected low and medium level and scored on the number of words.

2.3. Data Collection Process

For the data collection process, a room away from sources of noise was provided in the schools. Libraries and basements of schools were preferred, and care was taken to test children during class hours. In the ambient noise measurements, a noise level of 30 dB(A) was determined, and care was taken to ensure that the environment was quiet enough for a child to hear the test frequencies at a sound level of 15 dB with headphones at the time of the test. A CEM DT-8852 portable noise meter was used to measure noise.

2.4. Hearing Test and Hearing Threshold

Using Resonance r37a Clinical Audiometer and TDH39 headphones, hearing thresholds of 15 dB and below in at least four frequencies at 0.5, 1, 2, and 4 kHz were accepted as normal hearing. The highest mean hearing thresholds of the three groups were 15 dB and below, and bilateral hearing was found to be expected.

2.5. Data Analysis

Descriptive statistics for continuous data included the Standard Deviation, Median, Maximum, Minimum, and Mean values. The pre-test and post-test scores of the children in both the experimental and control groups were independently compared using the Wilcoxon test. The Kruskal-Wallis Analysis of Variance was used to compare the pre-test and post-test scores of the children in both groups. The Kruskal-Wallis Analysis of Variance multiple comparison tests further significantly explored any differences between the groups. The evaluations were carried out using the IBM SPSS Statistics 20 software, with statistical significance determined at $p<0.05$.

3. FINDINGS

The results of the Auditory Processing Test across groups at the end of the GRWEP implementation were analyzed, and the Dichotic Words (DW) post-test results by group are presented in Table 1 below.

Table 1.
Kruskal Wallis Variance Analysis Results of Groups' DW Test Findings According to Post-Tests

Final Test	**Mean ± SD**	**Median (Min-max)**	**Test Statistic**	**P***
DW First right/right ear				
Experiment (RWD present)	49.33±7.27	49.6 (35.4-58.9)	Chi-Square=2.952	0.229
Control 2 (RWD present)	43.78±9.90	41.2 (32-55.5)		
Control 1 (RWD absent)	50.00±10.00	58.9 (35.4-60.6)		
DW First right/left ear				
Experiment (RWD present)	43.31±5.77	44.5 (34.4-51.5)	Chi-Square =7.229	0.027*
Control 2 (RWD present)	38.65±5.77	37.5 (29.8-48.4)		
Control 1 (RWD absent)	50.00±10.00	55.4 (31.3-60.9)		
DW First correct ear/right left ear total				
Experiment (RWD present)	46.15±6.22	45.3 (34.7-55.2)	Chi-Square =5.911	0.052
Control 2 (RWD present)	40.99±6.18	40.42 (33,1-51.9)		
Control 1 (RWD absent)	50.00±10.00	54.7 (33.1-60.1)		
DW First left/right ear				
Experiment (RWD present)	44.20±8.84	43.9 (30.7-57.2)	Chi-Square =6.620	0.037*
Control 2 (RWD present)	38.40±7.96	36.7 (30.7-52.4)		
Control 1 (RWD absent)	50.00±10.00	52.42 (28.2-66.9)		
DW First left/left ear				
Experiment (RWD present)	41.59±9.03	44.2 (28-51.7)	Chi-Square =9.423	0.009*
Control 2 (RWD present)	34.69±8.16	32.3 (23.7-51.7)		
Control 1 (RWD absent)	50.00±10.00	49.5 (32.3-64.6)		
DW First left ear/right left ear total				
Experiment (RWD present)	4259±8.92	44.5 (28.6-53.3)	Chi-Square =9.353	0.009*
Control 2 (RWD present)	35.99±6.25	35.6 (29.7-52.1)		
Control 1 (RWD absent)	50.00±10.00	51.3 (29.7-66.2)		
DW Total right ear				
Experiment (RWD present)	47.07±7.51	49.8 (32.5-56.6)	Chi-Square =4.665	0.097
Control 2 (RWD present)	41.12±9.05	36.2 (31.5-54.5)		
Control 1 (RWD absent)	50.00±10.00	52.9 (31,5-63.9)		
DW Total left ear				
Experiment (RWD present)	42.40±6.92	42.8 (32.2-51.7)	Chi-Square =10.273	0.006*
Control 2 (RWD present)	36.65±6.42	36.4 (28.5-49.8)		
Control 1 (RWD absent)	50.00±10.00	53.5 (31.3-61.8)		

RWD; Reading and Writing Difficulty, Mean; Average, SD; Standard Deviation, Min; Minimum, Max; Maximum, $p<0.05$, Test Statistic p*****.

The statistical analyses showed no significant difference between the groups, experimental and control ($p > 0.05$). However, a difference was seen between control group 1 and control group 2 significantly ($p < 0.05$). In the post-test "First right/left ear" scores when comparing children in control group 2 to those in control group 1, a significant difference was found statistically. A statistically significant difference was found in the "First right/left ear" scores, with children in control group 2 exhibiting significantly lower scores than those in control group 1 (non-RWD). Consistent with these findings, the control 2 group (with RWD) and the experimental group (with RWD) were found to have no significant difference. However, the lack of a difference between the control 1 group (non-RWD) and the experimental group suggests that the experimental group is similar to control 1, constituting a significant finding regarding auditory processing.

Table 2 below displays the post-test results for the SSRT Expressing and SSRT Writing groups.

Table 2.
Kruskal-Wallis Variance Analysis Results Based on the Post-Test Findings of the SSRT Expressing and SSRT Writing Groups

Final Test	**Mean ± SD**	**Median (Min-max)**	**Test Statistic**	**P***
SSRT Expressing				
Experiment (RWD present)	45.40±14.42	52.5 (17-56)	Chi-Square=9.830	0.007*
Control 2 (RWD present)	41.00±3.97	41.5 (34-48)		
Control 1 (RWD absent)	50.60±3.09	51.5 (45-54)		
SSRT Writing				
Experiment (RWD present)	47.10±3.87	48.5 (40-52)	Chi-Square=20.330	0.000*
Control 2 (RWD present)	29.10±10.07	28.5 (14-44)		
Control 1 (RWD absent)	51.30±3.62	51.5 (45-58)		

RWD; Reading and Writing Difficulty, Mean; Average, SD; Standard Deviation, Min; Minimum, Max; Maximum, $p<0.01$

A difference was observed in the number of utterances in the SSRT across the experimental, Control 2, and Control 1 groups (p<0.01). No significant difference was found between the control 1 and the experimental groups in the number of post-tests SSRT utterances produced (p>0.05). It suggests that the experimental group produced speech sounds similar to the control 1 group following the training. Additionally, no difference was found between the post-tests SSRT writing scores in the experimental group and those in the control 1 group (non-RWD) (p>0.05). It suggests that, after the training, the experimental group performed similarly to the control 1 group in writing speech sounds, further reinforcing the results of the Writing Skill Scale.

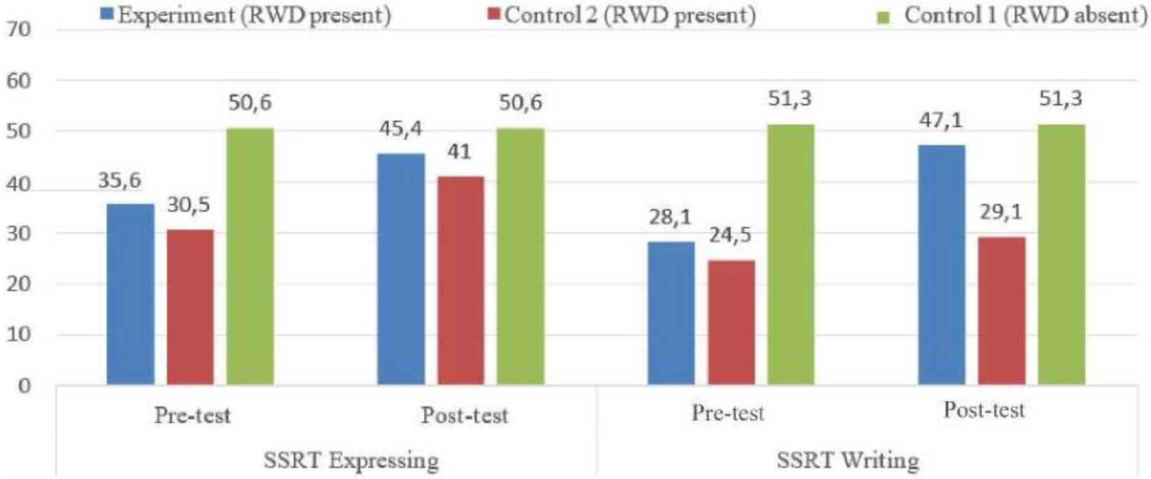

Figure 1 Pre-tests and post-tests numbers in the experimental, control 2 (RWD), and control 1 (non-RWD) groups for expressing and writing in the SSRT.

The post-test "Writing Skill Scale" points in the experimental and the control 2 groups were found to differ from the control 1 group. However, in both the pre-test and post-test assessments, correct answer numbers were significantly increased on the Writing Skill Scale for both Control 2 and experimental groups. Upon analyzing which group saw this increase, a difference was shown between the Control 2 and experimental groups (p<0.01). A substantially higher level of increase shown in the experimental group demonstrated that the Control 2 group, highlighting the potential educational significance of this finding. Additionally, when the Error Analysis Inventory results were analyzed, a difference was found between the Experimental, Control 2, and Control 1 groups (p<0.01).

4. RESULTS, DISCUSSION AND RECOMMENDATIONS

In this study, the absence of a difference between the Control 1 (non-RWD) and Experimental groups in the SSRT results indicates that phonological processes were acquired after the GRWEP. It is known that learning disorders, including reading and writing, are related to phonological processes.

Children with speech sound disorders (SSD) who struggle with phonological processing are more likely to have difficulties reading. Therefore, regardless of the subtype of SSD a child presents with, physicians should consider testing phonological processing skills in children with SSD. Accurate evaluation considers the person's unique speech production profile when assessing tools. The capacity to translate written symbols into phonemes is known as phonological retrieval. Reading proficiency is correlated with phonological retrieval. Phonological awareness and decoding skills are linked, although reading fluency seems to be more strongly correlated with phonological retrieval (Roepke, 2024). Deficits in the phonological aspect of language can result in the absence of segmented representations, poorly defined or less distinct phonological representations, and difficulties in learning and automating the connections between orthography and phonology (G. J. Miller & Lewis, 2022).

Daily speech stimuli from both ears are received through dichotic listening. The information from both ears and hemispheres (right and left) is perceived as a single sentence in the auditory cortex by establishing inter-hemispheric communication via the corpus callosum. These functions are necessary for standard auditory processing. Differences between right and left ear performances provide information about auditory processing and interhemispheric functions via the corpus callosum functions, message exchange between the hemispheres, and their functioning. Language learning disorders, learning disorders, and reading disorders are observed in auditory processing difficulties or impairment due to delayed auditory maturation (Bamiou et al., 2004; Murphy, Stavrinos, Chong, Sirimanna, & Bamiou, 2017; Sharma, Purdy, & Humburg, 2019). Our study examined the difference in right and left ear dichotic listening skills in children with reading and writing challenges before and after the training, revealing that the group with RWD had auditory processing difficulties. These findings are essential in showing that the correct scores increased after the training and that the disorders improved with listening training for auditory processing skills.

As stated in the literature, phonemic awareness is one of the main areas for identifying preschool and primary school children. It is suggested that the development of phonological awareness and auditory perception, key components of auditory education, serve as predictors for the development of reading and writing skills (Kasten & Rueger, 2022; Žovinec, Duchovičová, & Sender, 2023). The term phonemic awareness is also used when the focus of analysis is at the phoneme level (Werfel & Hendricks, 2023). Therefore, phonological processing is directly related to central auditory processing. Due to the neurological connections between language, reading, and auditory processing issues, phonologically based rapid auditory processing training may dramatically enhance the efficacy of therapy (ElShafaei, Kozou, Maghraby, & Hamouda, 2022). In this context, phonemes were introduced auditorily and visually to develop phonemic awareness, a sound-symbol relationship was established, and reading and writing education was provided with objectification activities. Upon completion of the training, the experimental group demonstrated a significant statistical improvement in their performance on the Dichotic Words test, as evidenced by comparing pre and post-test scores. Matson (2005) attributes auditory decoding disorder to improper processing by the dominant brain hemisphere for language (especially the primary auditory cortex). Educational implications involve difficulties with writing, hearing in noisy environments, blending phonemes, and weak analytical skills. Recommended remediation strategies include enhancing acoustic clarity, speech sound training, auditory discrimination exercises, and speech-writing skills development.

Therapy programs for children with RWD, particularly those stemming from auditory processing challenges, are increasingly recognized as essential for fostering compelling reading and writing skills. These programs often integrate auditory training with literacy instruction to enhance auditory processing abilities and literacy outcomes.

One practical approach is the incorporation of phonological awareness training within literacy interventions. Phonological awareness, which involves recognizing and manipulating sounds in spoken language, is crucial for reading development. Programs that strengthen phonological skills have proven effective in improving literacy outcomes for children with auditory processing challenges. For example, the Boost Program, which focuses on phonological awareness in parents of at-risk children, has positively impacted children's literacy skills. By providing parents with strategies to support their children's phonological development, these programs help create a supportive home environment that reinforces the skills acquired in therapy (Boyes et al., 2017). Programs that involve parents in shared reading activities enhance children's literacy skills and strengthen the parent-child relationship, fostering a love of reading (Meyer et al., 2016). For instance, family literacy programs encouraging parents to read with their children and engage in literacy-related activities have enhanced children's literacy skills (Kim & Byington, 2016). This collaborative approach ensures that the strategies learned in therapy are reinforced at home, creating a consistent learning environment.

Moreover, integrating technology into literacy therapy programs has emerged as a promising strategy. Digital literacy tools and applications can provide interactive and engaging ways for children to practice their reading skills, particularly for those who struggle with traditional methods. Research has shown that children who use technology-based literacy interventions demonstrate significant gains in reading skills compared to those who do not (Wasik & Hindman, 2011). Additionally, addressing the emotional and psychological aspects of literacy difficulties is vital for the success of therapy programs. Children with literacy challenges often experience anxiety and low self-esteem, which can further hinder their learning (Kargiotidis & Manolitsis, 2024). Therapy programs incorporating social-emotional learning strategies can help children build resilience and confidence in their literacy abilities. By creating a supportive and encouraging therapeutic environment, practitioners can help children overcome the emotional barriers that may impede their progress.

Therapy programs for children with RWD, stemming from auditory processing difficulties, should take a comprehensive approach. Incorporating phonological awareness training, engaging families, utilizing technology, addressing emotional needs, and improving the home literacy environment can significantly support the development of children's reading and writing skills. Ongoing research and innovation in this area will be crucial for refining these strategies and ensuring that all children thrive in their literacy pursuits.

Despite the sensitive methodology of this study, there are some limitations. While 30 individuals is sufficient for the scope of this study, the findings may need to be revised in their applicability to a larger group. Since the researcher would apply GRWEP to each child in the experimental group, conducting therapy with ten children per week was possible. Thus, the control 1 and control 2 groups were also matched with ten children each. It should also be noted that the study was conducted for 12 weeks, and its long-term effects were not investigated. Another area for improvement is that the results of this study could not be compared with other existing therapy programs. Despite these limitations, the study's findings help address reading and writing difficulties.

In conclusion, this study demonstrated that the educational treatment method based on auditory processing, GRWEP, effectively eliminated RWD in children within the normal distribution. The experimental group identified phonemes following GRWEP implementation, indicating that these children had trouble recognizing the words they heard or read before training, the speech sounds that makeup syllables, and the order of phonemes in words. This finding was identified as the source of reading and writing difficulties. Future studies should look into the program in children with additional disorders, such as learning disabilities or hearing loss, and who utilize hearing aids or cochlear implants.

Research and Publication Ethics Statement

This study was approved by the Gazi University Ethics Committee (approval no. 2017-391).

Contribution Rates of Authors to the Article

All authors contributed to the study's conception and design. The first draft of the manuscript was written by [ISK], and all authors read and approved the final manuscript.

Statement of Interest

There is no conflict of interest between the authors.

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