DOI: *10.48305/jrrs.2025.42925.1102* *Published by* *Vesnu Publications*

The Effectiveness of Teaching the Suprasegmental Features of Stress and Intonation on the Reading Comprehension of Students with Cochlear Implant: A Single-Subject Study

Tahereh Khoshdel[1], Mohammad Amin Naseh[2], Hossein Navidinia[3], Faride Farhadi[4]

Original Article

Abstract

Introduction: Suprasegmental features such as "stress" and "intonation" play a crucial role in verbal communication by highlighting various semantic and practical aspects of language, particularly in children. Despite receiving treatment and rehabilitation after an early diagnosis of hearing loss, children in this group often perform worse than their hearing peers in certain areas of learning, especially in reading comprehension during primary school. It appears that rehabilitation programs for children with hearing impairments do not adequately address this issue. This study aimed to investigate the effectiveness of teaching suprasegmental features on the reading comprehension of these children.

Materials and Methods: This study used a single-subject research design with a 1-month follow-up. The training program focused on teaching the understanding of "stress" and "intonation" over five individual sessions for each participant. The measurement tool used was the "text understanding" sub-test from the "Nama" reading test, administered before the intervention, immediately after the intervention, and again after the follow-up period. The effectiveness of the training was determined through descriptive analysis and calculation of recovery percentage for each participant.

Results: All participants showed significant improvement in text comprehension scores, with increases of over 49% compared to baseline measurements. Scores obtained during the one-month follow-up demonstrated the stability of the training results.

Conclusion: Teaching suprasegmental speech features appears to enhance reading comprehension in children with hearing impairments. This program is recommended to therapists and educational planners involved in designing treatment and rehabilitation programs for these children.

Keywords: Hearing loss; Cochlear implants; Stress; Intonation

Citation: Khoshdel T, Naseh MA, Navidinia H, Farhadi F. **The Effectiveness of Teaching the Suprasegmental Features of Stress and Intonation on the Reading Comprehension of Students with Cochlear Implant: A Single-Subject Study.** J Res Rehabil Sci 2024; 20.

Received date: 31.12.2023 Accept date: 04.02.2024 Published: 03.04.2024

Introduction

Children with hearing impairment experience fewer difficulties in letter recognition; however, they are deficient in reading comprehension (1). Impairment in the perception of speech sounds prevents accurate recognition of these sounds and the identification of their articulatory, motor, and acoustic features, which in turn leads to reading disorders (2). Auditory

1- MSc Student, Department of Language and Linguistics, School of Literature and Humanities, Birjand University, Birjand, Iran
2- Assistant Professor, Department of Language and Linguistics, School of Literature and Humanities, Birjand University, Birjand, Iran
3- Associate Professor, Department of Language and Linguistics, School of Literature and Humanities, Birjand University, Birjand, Iran
4- Instructor, Department of Language and Linguistics, School of Literature and Humanities, Birjand University, Birjand, Iran
Corresponding Author: Mohammad Amin Naseh; Assistant Professor, Department of Language and Linguistics, School of Literature and Humanities, Birjand University, Birjand, Iran; Email: amin_nasseh@birjand.ac.ir

deprivation hinders the development of phonological codes and encoding abilities, which are the primary causes of reading difficulties at school. Consequently, individuals with hearing impairment may never reach the levels of reading comprehension achieved by their hearing peers (3). Reading comprehension is based on linguistic knowledge and awareness of the relationship between spoken and written language. Given that children with hearing impairment demonstrate deficiencies in both areas, their reading comprehension is also negatively affected (4). Numerous studies have compared the reading comprehension of children with and without hearing impairment (4-10). These findings consistently show that deaf children's reading comprehension scores are considerably lower than those of hearing children. The verbal communication difficulties of children with hearing loss are not limited to impairments in speech production or vocalization; rather, their main problem lies in their inability to discover and apply linguistic rules for conveying their ideas within appropriate linguistic structures, as well as in understanding sentence meanings (6).

Segmental units are independent phonemes that appear in the speech chain and are categorized into two basic classes: vowels and consonants (11). Features that extend beyond a single phoneme are referred to as suprasegmental features of language (12), which are not recognizable as individual phonemes. The terms *prosodic* or *suprasegmental* are used to denote various phenomena such as stress, tone, intonation, length, and pause (13). Variations in speech pitch at the syllable level are referred to as *stress*, at the word level as *tone*, and at the utterance level as *intonation* (12). Intonation plays a critical role in enhancing speech intelligibility and in conveying meaning accurately (14). It is among the suprasegmental features that are essential to meaning transmission in most languages of the world (12). Persian is an intonation language (11, 12). Utterances that differ only in intonation carry distinct meanings, though these distinctions are not lexical but rather reflect the speaker’s emotional and affective stance toward the message (14). Intonation thus conveys emotions such as sadness or joy, contributing significantly to speaker–listener interaction, and its pragmatic role is undeniable (12).

The prominence of one syllable over others within a word is termed *stress* (15). Stressed syllables are produced with greater physical effort compared to unstressed ones. This physical effort manifests in increased laryngeal muscle activity, greater subglottal air pressure, longer duration of articulatory postures, or a combination of these factors (13). Two types of stress are recognized: *syllabic stress* and *focal stress*. Syllabic stress refers to the prominence of syllables within words, while focal stress denotes the prominence of words within sentences (14, 15). The prosodic pattern of Persian speech results from the sequence of stressed and unstressed syllables; altering this pattern can obscure the linguistic message (15). Stress can serve multiple roles in language; for example, in Persian, although rare, stress placement may change both lexical category and meaning. For instance, in the word *vali*, stress on the first syllable [‘Væ.Li] means *but*, whereas stress on the second syllable [Væ.‘Li] means *guardian*. Thus, understanding aspects of stress and intonation is crucial for comprehending linguistic messages and written texts (13).

Brown and McDowall examined changes in speech production among children with cochlear implants and concluded that implantation improves vocabulary size, segmental and suprasegmental speech features, and overall clarity (16). However, other researchers investigating suprasegmental features in children with hearing loss reported weak performance in the use of speech acoustic correlates (14, 17-21). The mean scores of intonation, syllabic stress, focal stress, and word pattern perception in cochlear-implanted children were lower than those of normal-hearing children (21). Similarly, the mean scores for speech intelligibility in declarative and interrogative sentences were significantly lower in the cochlear-implanted group compared to the normal-hearing group (14). Intonation production in these children was also impaired in imitation tasks; thus, intonation is considered the most challenging suprasegmental feature for children with cochlear implants (20).

Despite these findings indicating weaknesses in children with hearing loss's perception of suprasegmental features, to the researchers' knowledge, no domestic or international studies have investigated systematic educational programs designed to enhance these skills. Given that comprehension of stress and intonation is essential for understanding linguistic messages and written texts, and considering that multiple studies indicate limited proficiency of children with hearing impairment in these domains, the present study incorporated *stress* and *intonation* as suprasegmental elements into an educational program for children with hearing impairment.

Materials and Methods

This study was designed as a single-subject experimental case study to examine the effect of suprasegmental-feature training on reading comprehension in students with cochlear implants. The study population consisted of all elementary school students with cochlear implants enrolled in mainstream schools in Birjand during the 2022-2023 academic year. The inclusion criteria were: congenital bilateral sensorineural hearing loss ranging from moderate to profound, use of a cochlear implant device, normal intelligence quotient (based on records in the health assessment booklet), use of Persian as the primary language of communication, absence of any structural speech problems (including jaw and articulatory muscle issues), and absence of any additional disabilities (e.g., visual, physical, motor, or intellectual impairments other than hearing loss). These criteria were set to ensure homogeneity among participants and to ensure that hearing loss remained the only disability under investigation. To verify these conditions, in addition to reviewing students' initial health records, consultations were conducted with speech therapists, intelligence test examiners, and school staff from the first and second grades. Moreover, the hearing levels of participants were assessed and confirmed by the first author, who is an audiologist at the Department of Special Education in Birjand. The list of students with cochlear implants was obtained from the Welfare Organization and the Department of Special Education of South Khorasan Province. The main exclusion criteria included lack of parental consent, grade repetition, and the presence of any underlying disability or medical condition. After screening the requirements and obtaining parental consent, four students from four mainstream schools in Birjand, all of whom had completed the second grade of elementary school, were selected.

All participants had undergone cochlear implantation before age three and had completed post-implant rehabilitation. The study was conducted during the summer vacation of 2023, after completing second grade. Implementation was conditional on parental consent and assurance that the students would not attend any other educational programs during the study period. The Research instrument used was the “Text Comprehension” subtest of the NAMA Reading Test for second-grade students. The test, developed by Kormi Nouri and Moradi in 2008, consists of 10 subtests (22). The maximum participation for each student in evaluation or training was scheduled for up to 3 sessions per week, every other day. Before the intervention phase, the "Text Comprehension" subtest was administered three times at baseline, and participants' scores were recorded each time. During the intervention, each participant received five individual 45-minute instructional sessions. In the course of these sessions, further evaluations were conducted after the second, fourth, and fifth sessions to monitor progress. To assess maintenance of the intervention effects, three additional assessments were performed 1 month after the program's completion. The "Text Comprehension" subtest includes both a standard text for all grades and two grade-specific texts (22). In this study, the text specific to the second grade was used. In this subtest, the examiner reads a story aloud to the student. The student's task is to listen carefully and then answer the examiner's questions about the story. After each story, the examiner reads the questions and response options aloud, and the student selects the option they believe to be correct. To enhance comprehension, a written copy of the questions and options was also provided to the students. The examiner recorded the students' responses on the answer sheet.

Training Program

The instructional program focused on suprasegmental features of stress and intonation. Training was delivered individually to each participant in five sessions, as outlined in Table 1. A detailed description of the training sessions is provided below.

Syllabic Stress comprehension: A stressed syllable is produced with greater energy compared to an unstressed syllable, making it more prominent in speech (23). In Persian, only a few words are distinguished by stress differences. In this program, training in syllabic stress comprehension was conducted using bisyllabic homonyms (words identical in form but differing in stress patterns).

Table 1. Training Program

Session	Title	Procedure
First	Comprehension of Syllabic Stress	Using pairs of sentences containing bisyllabic words with different stress patterns.
Second	Comprehension of Focal Stress	Using sentences composed of three words, presented and read aloud in three different focal stress patterns.
Third & Fourth	Comprehension of Intonation	Two lists of sentences were presented in pairs (declarative vs. interrogative). After each sentence was read aloud, the student pointed to the corresponding sentence, thereby becoming familiar with differences in speech intonation.
Fifth	Review of Previous Sessions	A review and reinforcement of the material covered in the earlier sessions.

Sentences containing such word pairs were provided to the students in written form. The instructor pronounced one of the two words with the target stress pattern and asked the student to identify and select the corresponding sentence from the list in front of them. For example, sentence pairs such as:

- ***mahi*** *dær ʔab ʃena mi-kon-æd* (“The fish swims in the water”) vs. mæn ***mah-i*** *jek bar be sæfær mi-ræv-æm* (“I travel once a month”),
- **særd-i**-*je ræft-ar-e ʔu mæ-ra narahæt kærd* (“His cold behavior upset me”) vs. *zem-estan hæva-je* ***særd-i*** *dar-æd* (“Winter has cold weather”),
- *emruz* **ʃad-*i*** *be mædrese næ-jam-æd* (“Today Shadi did not come to school”) vs. m*a xanevade-je* ***ʃad-i*** *hæst-im* (“We are a happy family”),
- **sæbz-i**-*je tæbiʔæt-e bæhar zib-a-st* (“The greenery of spring is beautiful”) vs. *mæsræf-e* ***sæbz-i*** *bæraje hefz-e sælam-æt-i lazem ʔæst* (“Eating vegetables is necessary for maintaining health”).

Focal Stress comprehension: Focal (contrastive) stress occurs when part of an utterance is emphasized to highlight specific information or intent (24). For training in comprehension of focal stress, three-word sentences were used. Each sentence was written three times, with the first, second, and third words highlighted in bold or a different color to indicate stress (Example 1).

Example 1: Training focal stress with three-word sentences:

a. baba ʔaʃ xor-d (“Dad ate soup”).
b. baba ʔaʃ xor-d (“Dad ate soup [not water]”).
c. baba ʔaʃ xor-d (“Dad ate soup [not cooked it]”).

To facilitate understanding, the instructor posed contrastive questions for each option:

- (1a) baba ʔaʃ xor-d ja maman? (Did Dad eat the soup, or did Mom?)
- (1b) baba ʔaʃ xor-d ja ʔab xor-d? (Did Dad eat soup, or did he drink water?)
- (1c) baba ʔaʃ xor-d ja baba ʔaʃ poxt? (Did Dad eat the soup, or did Dad cook it?)

Intonation comprehension: For training, pairs of declarative and interrogative sentences were used. Sentences were presented in writing, with corresponding prosodic markers (Example 2).

Students practiced identifying prosodic differences between declaratives and interrogatives. Declarative sentences were modeled with a level pitch contour (marked with a period and a flat arrow: →), while interrogatives were modeled with a rising contour (marked with a question mark and an upward arrow: ↗). Students were taught that declarative sentences typically maintain a relatively flat pitch throughout, with only a natural fall at the end, and that speakers do not expect a response from the listener. In contrast, interrogatives with rising pitch signal that the speaker expects a response (e.g., yes/no).

Additionally, students were instructed that wh-questions (e.g., “what,” “how,” “when,” “where,” “which,” “why”) in Persian often carry a falling intonation (marked with a downward arrow: ↘), and pragmatically, they require informative responses rather than yes/no answers.

Example 2: Training intonation with declarative and interrogative sentences:

a. [ʔæli be mædrese mi-ræv-æd.] → / [ʔæli be mædrese mirævæd?] ↗ / [ʧe moqe ʔæli be mædrese mi-ræv-æd?] ↘

b. [dær zem-estan bærf mi-bar-æd.] → / [dær zem-estan bærf mi-bar-æd?] ↗ / [ʧera dær zem-estan bærf mi-bar-æd?] ↘

c. [bæʧʧe gerje mi-kon-æd.] → / [bæʧʧe gerje mi-kon-æd?] ↗ / [kodam bæʧʧe gerje mi-kon-æd?] ↘

Statistical Methods: To determine the intervention's effect, a descriptive table of participants' scores was prepared. Improvement was analyzed using the Improvement Percentage Formula, first introduced by Blanchard and Schwars (25) for analyzing single-subject experimental data. In this formula, the pre-test score is subtracted from the post-test score, divided by the pre-test score, and multiplied by 100. According to this criterion, a 50% reduction in symptoms is considered successful treatment, scores between 25-49% indicate slight Improvement, and reductions below 25% are considered treatment failure (26).

$$\text{Improvement Percentage}=\frac{\text{Post}-\text{test Score}-\text{Pre}-\text{test Score}}{Pre_{test}Score}\times 100$$

The primary method for evaluating interventions in single-subject designs is to analyze changes in data across adjacent phases. This is carried out using inter-situational analysis, where the Percentage of Non-overlapping Data (PND) is a preferred index (25). To calculate PND, the highest baseline score is identified, and the number of data points exceeding it is counted. If the intervention aims to reduce a variable, the lowest baseline score is determined, and data points below it are counted. Similarly, the Percentage of Overlapping Data (POD) can be calculated. For POD, the highest baseline score is identified, and the number of data points equal to or lower than it is counted. If the intervention aims to reduce a variable, the lowest baseline score is identified, and data points equal to or above it are counted. A higher PND (or lower POD) between two adjacent phases indicates greater confidence in the intervention’s effectiveness (26).

Results

The students' demographic information is presented in Table 2.

The scores obtained by the subjects in the "Text Comprehension" subtest in the three stages of baseline, intervention, and follow-up are shown in Table 3.

As shown in Table 3, all participants demonstrated a rising trend in their scores relative to the baseline phase, indicating Improvement in reading comprehension. Given the overall improvement percentages, all above 49%, the intervention program can be considered effective. Figure 1 illustrates the progression of participants' scores across the three assessment phases.

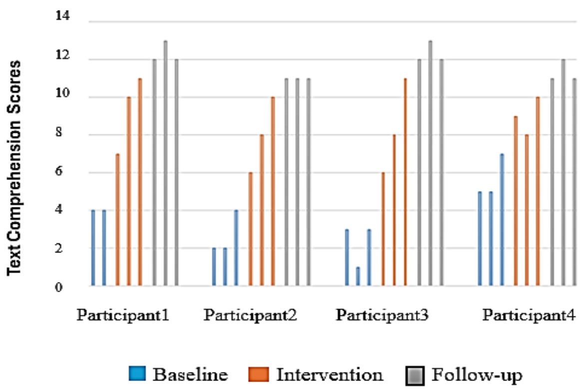

Figure 1. Trend of changes in text comprehension scores of four subjects in the NAMA test

Furthermore, the inter-phase analysis indicated the following:

- When comparing baseline with intervention, 100% of intervention data points exceeded the highest baseline score (PND = 100%), and 0% fell below it (POD = 0%).
- When comparing baseline with follow-up, 100% of follow-up data points exceeded the highest baseline score (PND = 100%), and 0% fell below it (POD = 0%).
- When comparing intervention with follow-up, 100% of follow-up data points exceeded the highest intervention score (PND = 100%), and 0% fell below it (POD = 0%).

Given the consistently high PND (100%) and minimal POD (0%), both the intervention and follow-up phases can be considered highly effective.

Discussion

The present study aimed to design and implement a training program focused on suprasegmental features, specifically stress and intonation, and to examine its effect on reading comprehension in children with cochlear implants. The findings indicated that the applied intervention program was effective in enhancing reading comprehension among students with cochlear implants.

Results from the text comprehension subtest administered before the intervention indicated that all children with cochlear implants scored below the standard threshold, reflecting their weak performance in this skill. Previous research has similarly reported differences in reading comprehension, text comprehension, and understanding of written sentences between children with normal hearing and those with hearing impairments (4-10). Earlier studies showed that children who had used their prosthesis for six months scored higher than those who had used it for only three months (16-19, 21). Moreover, children who underwent implantation at an earlier age, before language acquisition, demonstrated better performance (21). Consistent with these findings, the present study showed that, before intervention, the text comprehension scores of Participants 1 and 4—who received their implants before the age of two—were notably higher than those of Participants 2 and 3, who received their implants later. Three factors—age at implantation, duration of device use, and length of special training—appear to play a decisive role in children's performance (17).

Although significant progress has been made in the rehabilitation of children with hearing loss, these children continue to perform at a lower level than their peers in skills such as reading speed and comprehension (4-10). Intonation, as a suprasegmental feature, plays a crucial role in improving speech intelligibility (14). Research shows that intonation is the most difficult suprasegmental feature for children with cochlear implants to perceive (20, 21). Difficulties in reading comprehension often accompany problems in speech perception.

Table 2. Demographic information

Participant	Chronological Age (months)	Hearing Age (months)	Age at Surgery (months)	Gender
Participant 1	103 (8.5 years)	82	21	Female
Participant 2	106 (8.5 years)	77	29	Male
Participant 3	98 (8 years)	60	36	Male
Participant 4	99 (8 years)	78	21	Male

Table 3. Subjects' scores at different stages of assessment

Assessment Phases	Participant 1	Participant 2	Participant 3	Participant 4
Baseline 1	5	2	3	5
Baseline 2	4	2	1	5
Baseline 3	4	4	3	7
Intervention 1	7	6	6	9
Intervention 2	10	8	8	8
Intervention 3	11	10	11	10
Improvement (%)	54.54	80.00	72.72	50.00
Follow-up 1	12	11	12	11
Follow-up 2	13	11	13	12
Follow-up 3	12	11	12	11
Improvement (%)	66.41	45.45	50.00	18.18
Overall Improvement (%)	33.58	81.81	75.00	54.54

A child who can speak but cannot convey thoughts orally is also likely to struggle with written expression. Programs that focus excessively on letter–sound correspondence while paying less attention to word usage and comprehension are unlikely to improve reading in children with dyslexia significantly. Students must be able to recognize the role of letter–sound correspondence in reading and writing to apply it meaningfully within a text (27).

The limited ability of children with hearing loss in sentence writing and comprehension of written sentences may stem from a lack of awareness of linguistic rules and failure to grasp the relationships between words and their roles in representing events (6). Similar to deaf children, children with cochlear implants often rely heavily on certain content words during reading and text comprehension, while being deprived of functional sentence elements (i.e., suprasegmental features) due to their linguistic limitations (28). Therefore, focusing on the receptive aspects of language (particularly suprasegmental features such as intonation beyond the word level) is of great importance. In addition, in the expressive domain, the discovery and use of rules governing inter-word relationships are essential for the transfer of meanings and intentions conveyed through sentences and larger units of discourse, thus playing a fundamental role in the development of linguistic skills (6).

The contribution of intonation to speech intelligibility varies across languages, but the role of other factors influencing speech comprehensibility in children with cochlear implants remains unclear (14). For example, an investigation of stress, speech rate, and fluency in six children aged 3–6 years, all of whom had undergone cochlear implantation before language acquisition, revealed that these children had difficulties with stress. In contrast, their fluency and speech rate were relatively good (29).

In another study involving 25 children with cochlear implants and 25 children with normal hearing, significant correlations were found between intonation and speech intelligibility, as well as between the duration of cochlear implant use and intelligibility scores. In other words, children with cochlear implants often had difficulties manipulating pitch, duration, and prosodic contours to produce appropriate intonation. As a result, their speech was less intelligible than that of children with normal hearing (14). The present study also confirmed that, prior to the intervention, text comprehension scores were higher for Participants 1 and 4 (implanted before age 2) than for Participants 2 and 3 (implanted later).

Auditory experience plays a key role in the development of language skills, and early hearing impairment often results in long-term deficits in auditory processing and linguistic sound perception (4, 30). Deaf children frequently encounter difficulties in text comprehension due to challenges in word production and in linking written symbols with sounds (30). Even if sound production in these children is fully corrected, their verbal communication remains inefficient because they cannot construct and comprehend sentences (6). Consequently, they tend to be weaker across most reading skills (7, 8, 30).

Researchers have employed a variety of programs to enhance reading comprehension skills in children with hearing impairments. These include phonological interventions (31), phonological awareness training (32), metacognitive strategies (33, 34), multimodal occupational therapy (35), Cued Speech training in Persian (36), multimedia learning (37), and multisensory approaches (3). However, none of these methods has specifically addressed suprasegmental features.

Cochlear implantation has been shown to improve vocabulary, the production of segmental and suprasegmental speech features, and overall speech clarity (16). Nevertheless, studies investigating suprasegmental features in children with hearing impairments (14, 17-21) have reported that these children perform poorly in using acoustic speech correlates. Specifically, mean scores for intonation, lexical stress, emphatic stress, and word pattern recognition were lower among cochlear implant users than among normal-hearing peers. Intonation is one of the most affected speech features in children with cochlear implants, leading to difficulties conveying emotions and influencing others through speech (20). Evidence suggests that the younger the age at implantation, the better the perception of suprasegmental features, and vice versa (21).

Limitations

The study was conducted as a single-subject design due to the small number of cochlear implant users in a specific grade. The dispersion of cochlear implant children, the long geographical distance of some eligible participants from the intervention site, and the financial and time costs of their commuting to participate in the study were among the limitations of this research. After extensive screening of elementary school students in Birjand city, the researchers selected up to 4 second-grade students. Since the participants were not supposed to receive any other simultaneous training during the study, the summer vacation was chosen for implementation. However, this made coordination for transportation and the participants' attendance somewhat difficult and prolonged the research process. One participant was temporarily banned from using the device due to a scalp injury at the implant site until recovery occurred.

Nevertheless, because of the program's individualized nature, this did not affect the progress of the other participants and only extended the study's duration. Another limitation was the lack of specialized tools for studying suprasegmental features in individuals with hearing loss. However, the Shirazi and Nilipoor Reading Test (38) may also be suggested to researchers as an alternative tool to evaluate its suitability for therapeutic goals in such studies. It should be noted that the participants were never informed of the correct answers to the test questions at any stage, so it is unlikely that test repetition affected the responses. Moreover, the examiner did not observe any indication that familiarity with the test structure influenced performance. Another limitation was the inability to assess the intervention's impact on students' performance in real-life contexts (e.g., Improvements in reading textbooks and age-appropriate stories).

Recommendations

It is recommended that similar research be conducted on students with hearing loss who use hearing aids and cochlear implants at different preschool ages and at other grade levels. In the present training program, emphasis was placed on prosodic features, including intonation, stress, and syllabic stress. Given the importance of the suprasegmental feature of "pitch" in establishing communication with children and in advancing their language acquisition, it is suggested that this dimension also be examined in future academic research.

Conclusion

The present study found that the designed program for teaching suprasegmental features of intonation and stress was effective in improving the reading comprehension of children with cochlear implants. Therefore, it is suggested that therapists and educational program designers in the field of hearing rehabilitation take this into account to provide more comprehensive reading instruction for this group of children.

Acknowledgments

We hereby express our gratitude to the South Khorasan Department of Exceptional Education, the managerial of Wasal Birjand School, and the families and students who collaborated in conducting this research. In addition, we would like to thank Mr. Dr. Mohammad Khorashadizadeh and Ms. Mahna Imani for their cooperation in statistical analysis.

Authors' Contribution

Project design and conceptualization: Mohammad Amin Naseh
Attracting financial resources to carry out the project: Mohammad Amin Naseh
Project support, scientific and executive services: Mohammad Amin Naseh
Providing equipments and statistical sample: Tahereh Khoshde
Data collection: Tahereh Khoshdel
Analysis and interpretation of the results: Mohammad Amin Naseh, Tahereh Khoshdel
Specialized statistics services: Tahereh Khoshdel, Farideh Farhadi.
Manuscript preparation: Mohammad Amin Naseh, Tahereh Khoshdel, Hossein Navidinia, Farideh Farhadi.
Critical scientific evaluation of the manuscript: Mohammad Amin Naseh, Tahereh Khoshdel, Hossein Navidinia, Farideh Farhadi.
Approving the final manuscript to be submitted to the journal: Mohammad Amin Naseh, Tahereh Khoshdel, Hossein Navidinia, Farideh Farhadi.
Maintaining the integrity of the study process from the beginning to the publication, and responding to the

reviewers' comments: Mohammad Amin Naseh, Tahereh Khoshdel

Funding

This study was prepared based on the analysis of a part of the data extracted from the Master's thesis in linguistics by Tahereh Khoshdel (registration code: 10684, Ethics code: IR.BIRJAND.REC.1403.008, and IRCT code: IRCT20240708062364N1), with the financial support from Birjand University. Birjand University did not interfere with the data collection, analysis and reporting, manuscript preparation and final approval of study for publication.

Conflict of Interest

The authors did not have a conflict of interest.

References

1. Nippold MA. Word definition in adolescents as a function of reading proficiency: A research note. Child Lang Teach Ther 1999; 15(2): 171-6.
2. Kirk S, Gallagher JJ, Coleman MR. Educating Exceptional Children. 14th ed. Boston, MA: Cengage Learning; 2014.
3. Daza Gonzalez MT, Phillips-Silver J, Maurno NG, García LF, Ruiz-Castañeda P. Improving phonological skills and reading comprehension in deaf children: A new multisensory approach. Sci Stud Read 2023; 27(2): 119-35.
4. Gholamiyan Arefi M, Azarin far M, Hosseini SF, Sobhani-Rad D. Comparison of Vocabulary and Reading Comprehension Skills between The Three Groups of Fourth Grade Students Who Received Hearing Aid, Cochlear Implant and Normal in Mashhad. J Paramed Sci Rehabil 2020; 9(2): 7-15. [In Persian].
5. Asker-Árnason L, Wass M, Gustafsson F, Sahlén B. Reading comprehension and working memory capacity in children with hearing loss and cochlear implants or hearing aids. Volta Rev 2015; 115(1): 35-65.
6. Yaghobi A, Ghorbani A. Sentence writing and perception of written sentences in hearing-impaired and normal-hearing primary school students in Hamadan, western Iran. Audiol 2010; 19(1): 31-8. [In Persian].
7. Nikkhou F, Hasanzadeh S, Afrooz G. The comparative study of reading comprehension in normal-hearing and hearing-loss student. Audiol 2012; 21(2): 71-7. [In Persian].
8. Rezaei M, Rashedi V, Gholami Tehrani L, Daroei A. Comparison of reading comprehension and working memory in hearing-impaired and normal-hearing children. Audiol 2013; 22(1): 67-74. [In Persian].
9. Raghibdoust S, Kamari E. Examination of Deaf and Hearing Students' Reading Comprehension Strategies in the Fifth Grade of Elementary School. Lang Sci 2014; 2(2): 37-52. [In Persian].
10. Mokhlesin M, Kasbi F, Ahadi H, Sojoudi F. Phonological awareness, working memory and reading comprehension in deaf children. Koomesh 2014; 16(2): 128-35. [In Persian].
11. Haghshenas A. Phonetics. 14th ed. Tehran, Iran: Agah; 2013. p. 192. [In Persian].
12. Alinezhad B. Fundamental of phonology. 2th ed. Isfahan, Iran: University of Isfahan; 2020. [In Persian].
13. Modarresi Ghavami G. Phonetics: The Scientific Study of Speech. 6th ed. Tehran, Iran: SAMT; 2019. p. 216. [In Persian].
14. Kord N, Shahbodaghi MR, Khodami SM, Nourbakhsh M, Jalaei S. Investigation of acoustic correlation of intonation and intelligibility of speech in children with cochlear implant and comparison with normal hearing children. Mod Rehabil 2013; 6(4): 38-43. [In Persian].
15. Bijankhan M. Phonetic system of the Persian Language. 1th ed. Tehran, Iran: SAMT; 2013. p. 372. [In Persian].
16. Brown C, McDowall DW. Speech Production Results in Children Implanted with the Clarion® Implant. Ann Otol Rhinol Laryngol 1999; 108(4-suppl): 110-2.
17. Lee KY, Van Hasselt CA, Chiu SN, Cheung DM. Cantonese tone perception ability of cochlear implant children in comparison with normal-hearing children. Int J Pediatr Otorhinolaryngol 2002; 63(2): 137-47.
18. Han D, Zhou N, Li Y, Chen X, Zhao X, Xu L. Tone production of Mandarin Chinese speaking children with cochlear implants. Int J Pediatr Otorhinolaryngol 2007; 71(6): 875-80.
19. Peng SC, Tomblin JB, Turner CW. Production and perception of speech intonation in pediatric cochlear implant recipients and individuals with normal hearing. Ear Hear 2008; 29(3): 336-51.
20. Hasanvand M, Torabinezhad F, Abolghasemi J, Eslami M. Investigation of Speech Intonation in Cochlear Implant Children in the Imitation and Reading Tasks. Sci J Rehabil Med 2020; 9(1): 194-200. [In Persian].
21. Khoshnood T. The Study and Analysis of Perception of Some Suprasegmental Features in Cochlear Implant Children in Comparison with Hearing Pairs and also Considering the Effect of Gender and Age at Implantation. Zahedan, Iran: University of Sistan and Baluchestan; 2014. [In Persian].
22. Koromi-Nouri R, Moradi A. Reading and Dyslexia Test (NAMA). Tehran, Iran: Tarbiat Moallem University; 2008. [In Persian].
23. Ladefoged P. A Course in Phonetics. 5th ed. Boston, MA: Thomson Wadsworth; 2006. p. 336.
24. Yarmohammadi L. A contrastive analysis of Persian and English: Grammar, vocabulary and phonology. Tehran, Iran: Payame Noor University; 2002. p. 272. [In Persian].
25. Noferesti A, Hassanabadi HR. Data analysis in single case experimental design studies. Rooyesh 2019; 7(12): 291-306. [In Persian].
26. Pouladi S, Hasanshahi MM, Rabiei M, Baghery N. The effect of unified transdiagnostic treatment on the improvement of internalizing behavioral problems, emotional regulation, and empathy in children with anxiety disorders. Res Cogn Behav Sci

2022; 12(1): 141-64. [In Persian].
27. National Reading Panel (US), National Institute of Child Health, Human Development (US). Report of the National Reading Panel: Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction: Reports of the subgroups. Maryland, MD: National Institute of Child Health and Human Development, National Institutes of Health; 2000.
28. Domínguez AB, Carrillo MS, González V, Alegria J. How Do Deaf Children With and Without Cochlear Implants Manage to Read Sentences: The Key Word Strategy. J Deaf Stud Deaf Educ 2016; 21(3): 280-92.
29. Lenden JM, Flipsen P, Jr. Prosody and voice characteristics of children with cochlear implants. J Commun Disord 2007; 40(1): 66-81.
30. Wolfe P. Brain matters: Translating research into classroom practice. Arlington, VA: ASCD; 2010.
31. Palmer S. Assessing the benefits of phonics intervention on hearing-impaired children's word reading. Deaf Educ Int 2000; 2(3): 165-78.
32. Mohseni MH. Designing and studying a phonological awareness training program on the development of reading skills among students with hearing impairments. Tehran, Iran: University of Tehran; 2011. [In Persian].
33. Tajalli P, Satari S. Effectiveness of Metacognitive Strategies on Reading Skills of Students with Hearing Disorders. Procedia Soc Behav Sci 2013; 84: 139-43.
34. Jalil Abkenar SS, Ashoori M, Movalleli G. The effect of meta cognitive instructions on reading of children with hearing impairment. J Except Educ 2011; 2(108): 38-47. [In Persian].
35. Ghorbani A. The Impact of Multidisciplinary Occupational Therapy on Reading Improvement of Children with Hearing Impairment (case study). J Except Educ 2016; 5(142): 59-63. [In Persian].
36. Pouryan A, Movallali G, Zarifian T, Ahmadi S. The effect of Cued Speech on Improving the reading accuracy and comprehension of the late diagnosed first grade deaf students. J Rehabil Med 2019; 8(2): 80-5. [In Persian].
37. Triarini WD, Degeng INS, Efendi M, Toenlioe A. The effectiveness on the use of multimedia to improve basic reading skill of hearing-impaired students. Eur J Spec Educ Res 2017; 2(5).
38. Sima-Shirazi T, Nili-Pour R. Developing and Standardization of a Diagnostic Reading Test. J Rehabil 2004; 5(16-17): 7-11. [In Persian].