Lexical Effects on Spoken Word Recognition in Persian-Speaking Preschool-Aged Children with Normal Hearing

Mohammad Majid Oryadi-Zanjani[a*]

[*]E-mail: oryadim@gmail.com

[a]Department of Speech Therapy, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Abiverdi1, Chamran Blvd., P.O. Box: 71345-1733, Shiraz, Iran, ORCID: 0000-0002-0366-967X

Abstract

The current study aimed to determine lexical effects on spoken word recognition in Persian-speaking preschool-aged children with normal hearing. The research, as a cross-sectional study, was administered in sixty-two 4-to-6-year-old children who were recruited using convenient sampling from a preschool center in Shiraz city, Iran. The preschool version of the Persian Lexical Neighborhood Tests (PLNTs-PV) was used, including four subscales. It has been demonstrated that word lexical difficulty and word length affected the Persian-speaking 4-to-6-year-old children's speech-in-noise performance. The PLNTs-PV can be used measuring speech-in-noise recognition in Persian-speaking preschool-aged children. We recommend managing the environment's noise as one of the practical solutions to improve preschool-aged children's speech recognition performance.

Keywords: Lexical neighborhood tests; speech perception; speech-in-noise recognition; hearing, Persian-speaking preschool-aged children

1. Introduction

Indeed, research evidence indicated that the essential issue in pediatric users of hearing aids (HAs) or cochlear implants (CIs) is speech recognition under spectrally degraded conditions (Caldwell & Nittrouer, 2013; Ching et al., 2018; Eisenberg et al., 2016; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; Ren et al., 2018; Zaltz et al., 2020). To deal with the issue, we need powerful assessment tools to detect not only the children's auditory dysfunction in noise but also to determine the probably underlying cognitive processes (Kirk, Diefendorf, et al., 1995; Kirk et al., 1998; Kirk & Hudgins, 2016; M. M. Oryadi-Zanjani & Zamani, 2020; Robbins & Kirk, 1996). According to the findings of several studies on different populations, lexically controlled tests can reliably be used to assess speech recognition performance in children with hearing loss (HL) and their peers with normal hearing (NH) (Eisenberg et al., 2002; Holt et al., 2011; Kirk, Diefendorf, et al., 1995; Kirk et al., 2000; Kirk, Pisoni, et al., 1995; Kirk et al., 2012; Krull et al., 2010; Lee & Sim, 2020; Mohammad Majid Oryadi-Zanjani, 2022; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020; Wang et al., 2010). Moreover, the children's speech-in-noise (SiN) performance is variable under lexical effects (Kirk, Pisoni, et al., 1995; Krull et al., 2010; Mohammad Majid Oryadi-Zanjani, 2023; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020; Wang et al., 2010).

So far, lexical neighborhood tests have been developed to assess speech recognition performance in children speaking in some different languages (Kirk et al., 1998; Krull et al., 2010; Lee & Sim, 2020; M. M. Oryadi-Zanjani & Zamani, 2020; Wang et al., 2010). Accordingly, linguistic properties of the stimulus words and word length, as two fundamental factors, affect spoken word recognition (SWR) under spectrally degraded conditions (Kirk, Pisoni, et al., 1995; Krull et al., 2010; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020). But interestingly, the findings demonstrated that lexical effects on SWR may depend on the children's language. Accordingly, in contrast to English (Kirk, Pisoni, et al., 1995; Krull et al., 2010) and Persian (Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020), lexical effects on Mandarin-speaking children with/without HL were just demonstrated in disyllabic words (Wang et al., 2010). The participants' age range, however, was different in these studies, including 7-to-12 in Kirk et al.'s (Kirk, Pisoni, et al., 1995), 5-to-12 in Krull et al.'s (Krull et al., 2010), 4-to-7 in Wang et al.'s (Wang et al., 2010), and 6-

to-13 years in Oryadi-Zanjani et al.'s studies (Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020).

As a result, considering the factor of age, there is a significant difference between the studies on Mandarin and Persian in comparison with the English ones; that is a lack of school-aged children in Wang et al.'s (Wang et al., 2010) and preschool-aged children in Oryadi-Zanjani et al.'s studies (Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020). Therefore, the findings may change if these age ranges are included in the studies on Mandarin- and Persian-speaking children with HL and their peers with NH. Furthermore, we need more studies to derive a definitive conclusion about the issue. Additionally, before studying the SiN performance of Persian-speaking preschool-aged children with NH, we need to elicit the information of their peers with NH using the Persian Lexical Neighborhood Tests (PLNTs).

In conclusion, the current study aimed to determine lexical effects on SWR in Persian-speaking preschool-aged children with NH using the PLNTs. We hypothesized that both linguistic properties of the stimulus words and word length affect the 4-to-6-year-old children's SWR performance under spectrally degraded conditions.

2. Methods

The research was administered as a cross-sectional study. Informed consent was obtained from the parents of the children participating in the study, and the research protocol was approved by the Ethics Committee of Shiraz University of Medical Sciences, Shiraz, Iran (the approval number: IR.SUMS.REHAB.REC.1401.015). The aim was to assess spoken word recognition in preschool-aged children with NH based on the Neighborhood Activation Model by using the PLNTs (M. M. Oryadi-Zanjani & Zamani, 2020).

2.1 Participants

Sixty-two 4-to-6-year-old children [(four years = 20, five years = 21, six years = 21) (female = 36, male = 26)] were recruited through convenient sampling from a preschool center in Shiraz City, Iran. The inclusion criteria included: age, gender, Persian-speaking, normal hearing thresholds, regular communication, speech skills, language skills, and no additional handicapping conditions. Each child's health status was verified according to the child's preschool health case and the teacher/parent's report.

2.2 Assessment tool

Oryadi-Zanjani et al. developed a lexically controlled assessment toolkit (4 subscales) entitled the Persian Lexical Neighborhood Tests (PLNTs) based on the Neighborhood Activation Model to measure spoken word recognition (SWR) in Persian-speaking children, which includes: The Persian Monosyllabic Lexical Neighborhood Tests (the PMLNT-easy [18 words], the PMLNT-hard [27 words]) and the Persian Disyllabic Lexical Neighborhood Test (the PDLNT-easy [18 words], the PDLNT-hard [27 words]). The PLNTs were administered to 33 school-aged children with HL and 20 of their peers with NH. They concluded that the PLNTs are a useful language-independent tool to assess the SWR of children with/without HL under spectrally degraded conditions (Mohammad Majid Oryadi-Zanjani, 2023; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020).

The number of test words was reduced to adapt the PLNTs to preschool-aged children's competency. Accordingly, the preschool version of the PLNTs (PLNTs-PV) includes The Persian Monosyllabic Lexical Neighborhood Tests (the PMLNT-easy [10 words], the PMLNT-hard [10 words]) and the Persian Disyllabic Lexical Neighborhood Test (the PDLNT-easy [11 words], the PDLNT-hard [11 words]). Therefore, the PLNTs-PV could administer quickly with minimal children's exhaustion.

2.3 Procedure

The experiments were administered using headphones at a preschool center because there was no adjusted acoustic room. Microsoft PowerPoint software was used to present the stimuli through a PC or Laptop. Accordingly, 12 subtests were administered based on SNRs levels. The signal-to-noise ratios (SNRs) of 0, 4, and 15 dB were chosen to make sure that floor or ceiling effects would not affect the children's performance (Table 1).

Table 1: The characteristics of the subtests

Subtests	0 dB	4 dB	15 dB
PMLNT-easy	X1	X2	X3
PDLNT-easy	X4	X5	X6
PMLNT-hard	X7	X8	X9
PDLNT-hard	X10	X11	X12

First, a training pretest was administered using eight practice words in the 4 dB SNR through auditory modality including two monosyllabic easy, two monosyllabic hard, two disyllabic easy, and two disyllabic hard. Two trained undergraduate students administered the experiments as the examiners. Examiner 1 sat near the participant to carry out each test on the PC or Laptop. She played each auditory, visual, or audiovisual file, and then the participant should repeat the word. Examiner 2 sat behind the children to transcript what was repeated by them. Each test item was played once but repeated one more time if needed. A short rest took after each subtest. The test was stopped after five consecutive or ten different failures to repeat the words to prevent any adverse psychological effects on the children. The children's scores on each subscale were calculated based on the number of words repeated correctly divided by the total number of words. The data were analyzed using IBM SPSS version 23.

3. Results

3.1 Effect of lexical difficulty on spoken word recognition

To investigate the effect of lexical difficulty on the SWR, the children's mean scores compared between the PMLNT-easy versus the PMLNT-hard and the PDLNT-easy versus the PDLNT-hard by the Independent-Samples T-Test (Table 2). Accordingly, a significant difference was found in the children's SWR performance using the PDLNT-easy and the PDLNT-hard in all the SNRs; that is, the children's performance on the disyllabic easy words was better than their performance on the disyllabic hard words. But, regarding the PMLNT-easy and the PMLNT-hard, although the children's scores of the easy monosyllabic words were higher than the hard monosyllabic words in all the SNRs, the difference was significant just in 4 dB SNR. Therefore, the children's SWR performance can be variable according to word length and lexical difficulty under spectrally degraded conditions (Figure).

Table 2: Comparison of the scores means of children with normal hearing between subscales based on lexical difficulty

Word length	SNR (dB)	Lexical difficulty	N	Mean	Standard deviation	P
Monosyllabic	0	Easy	62	4.741	2.071	> 0.05
		Hard	62	4.322	1.998	
	4	Easy	62	6.822	2.044	< 0.01
		Hard	62	5.790	1.590	
	15	Easy	62	8.419	2.092	> 0.05
		Hard	62	8.000	1.717	
Disyllabic	0	Easy	62	7.516	1.973	< 0.01
		Hard	62	5.500	1.956	
	4	Easy	62	9.016	2.176	< 0.01
		Hard	62	6.871	1.979	
	15	Easy	62	9.612	1.813	< 0.01
		Hard	62	8.290	1.786	

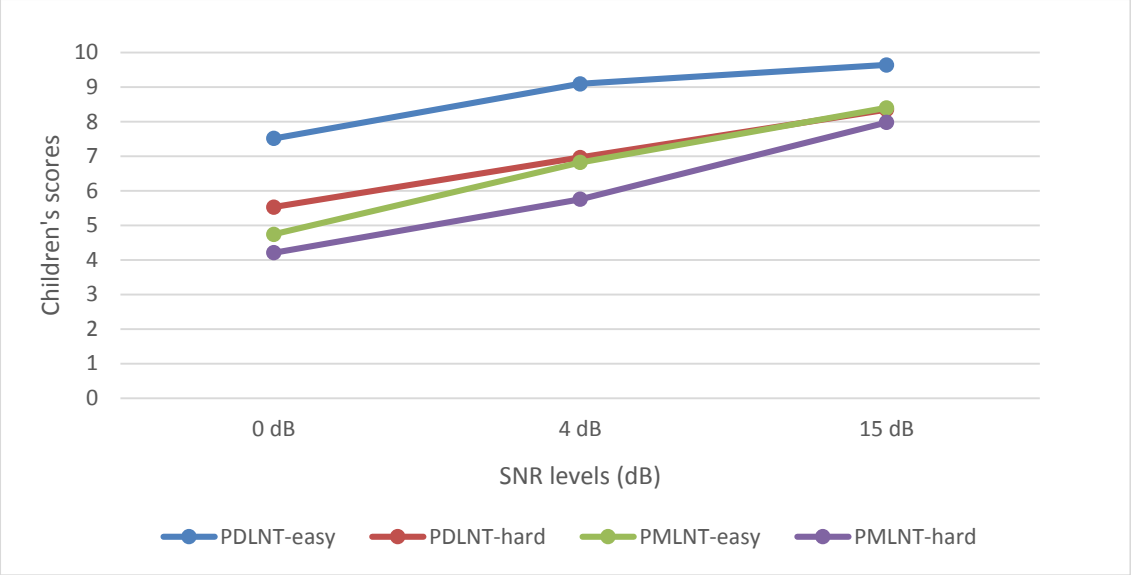

Figure: Children's scores in subscales based on SNR levels

3.2 Effect of word length on spoken word recognition

To investigate the effect of word length on the SWR, the children's mean scores compared between the PMLNT-easy versus the PDLNT-easy and the PMLNT-hard versus the PDLNT-hard by the Independent-Samples T-Test (Table 3). Accordingly, a significant difference was found in the children's SWR performance using the PMLNT-easy and the PDLNT-easy in all the SNRs; that is, the children's performance on the easy disyllabic words was better than their performance on the easy monosyllabic words. But, regarding the PMLNT-hard and the PDLNT-hard, although the children's scores of the disyllabic hard words were higher than the monosyllabic hard words in all the SNRs, the difference was significant in 0 dB and 4 dB SNR. Therefore, word length affected the children's SWR performance under spectrally degraded conditions (Figure).

Table 3: Comparison of the scores means of children with normal hearing between subscales based on word length

Word length	SNR (dB)	Lexical difficulty	N	Mean	Standard deviation	P
Easy	0	Monosyllabic	62	4.741	2.071	< 0.01
		Disyllabic	62	7.516	1.973	
	4	Monosyllabic	62	6.822	2.044	< 0.01
		Disyllabic	62	9.016	2.176	
	15	Monosyllabic	62	8.419	2.092	< 0.01
		Disyllabic	62	9.612	1.813	
Hard	0	Monosyllabic	62	4.322	1.998	< 0.01
		Disyllabic	62	5.500	1.956	
	4	Monosyllabic	62	5.790	1.590	< 0.01
		Disyllabic	62	6.871	1.979	
	15	Monosyllabic	62	8.000	1.717	> 0.05
		Disyllabic	62	8.290	1.786	

3.3 Effect of Signal-to-Noise Ratio Levels on spoken word recognition

To investigate the effect of SNR levels on the SWR, the children's mean scores of each PLNTs subscale were compared among the different SNRs by the Repeated Measures ANOVA (Table 4). Accordingly, using Bonferroni correction, there was a significant difference in the children's PLNTs scores under spectrally degraded conditions from 0 to 15 dB SNR (Figure). The children's SWR performance improved entirely with increasing the SNR level.

Table 4: Comparison of the scores means between children with normal hearing based on SNR

Lexical difficulty	Word length	N	0 vs. 4 dB	4 vs. 15 dB	0 vs. 15 dB
			P	P	P
Easy	Mono	62	< 0.01	< 0.01	< 0.01
	Di	62	< 0.01	< 0.05	< 0.01
Hard	Mono	62	< 0.01	< 0.01	< 0.01
	Di	62	< 0.01	< 0.01	< 0.01

3.4 Effect of sex on spoken word recognition

As shown in Table 5, the children's mean scores of the PLNTs were compared between the girls and the boys in all the SNRs by the Independent-Samples T-Test. Hence, no significant difference was found in SWR performance between them.

Table 5: Comparison of the scores means of children with normal hearing between subscales based on sex

Word length	SNR (dB)	Lexical difficulty	Sex	N	Mean	Standard deviation	P
Easy	0	Monosyllabic	Female	36	4.916	2.143	> 0.05
			Male	26	4.500	1.984	
		Disyllabic	Female	36	7.694	1.924	> 0.05
			Male	26	7.269	2.050	
	4	Monosyllabic	Female	36	7.166	2.021	> 0.05
			Male	26	6.346	2.018	
		Disyllabic	Female	36	9.277	1.733	> 0.05
			Male	26	8.846	2.411	
	15	Monosyllabic	Female	36	8.722	1.861	> 0.05
			Male	26	7.961	2.391	
		Disyllabic	Female	36	9.777	1.333	> 0.05
			Male	26	9.461	2.213	
Hard	0	Monosyllabic	Female	36	4.416	2.075	> 0.05
			Male	26	3.923	1.853	
		Disyllabic	Female	36	5.666	1.912	> 0.05
			Male	26	5.346	2.058	
	4	Monosyllabic	Female	36	5.777	1.456	> 0.05
			Male	26	5.730	1.778	
		Disyllabic	Female	36	7.111	1.878	> 0.05
			Male	26	6.769	1.773	
	15	Monosyllabic	Female	36	7.972	1.482	> 0.05
			Male	26	8.000	2.059	
		Disyllabic	Female	36	8.638	1.606	> 0.05
			Male	26	7.961	1.865	

4. Discussion

According to the findings, the preschool version of the PLNTs (PLNTs-PV) could use assessing Persian-speaking 4-to-6-year-old children's SWR performance. The PLNTs-PV, as the shorter form of the PLNTs (M. M. Oryadi-Zanjani & Zamani, 2020) with fewer items, includes the PMLNT-easy [10 words], the PMLNT-hard [10 words], the PDLNT-easy [10 words], and the PDLNT-hard [10 words]. Thus, it could use testing young children's speech recognition by spending less time and energy. In addition, The PLNTs-PV, as a lexically controlled test, has been presented to assess Persian-speaking preschool-aged children's SiN skills for the first time (Mohammad Majid Oryadi-Zanjani, 2022).

Using the PLNTs-PV, it has generally been demonstrated that word lexical difficulty and word length affected the Persian-speaking 4-to-6-year-old children's SiN performance. The children's SWR performance improved

entirely with increasing the SNR level from 0 dB to 15 dB, similar to the findings of the previous studies (Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020). Therefore, it can be derived that reducing environmental noise may be one of the essential solutions to improve children's speech recognition performance. Furthermore, it found that lexical effects operate on the speech recognition process regardless of the children's sexuality, consistent with the previous findings (Eisenberg et al., 2002; Kirk et al., 1998; Kirk et al., 2000; Mohammad Majid Oryadi-Zanjani et al., 2021; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; Wang et al., 2010),

According to the Neighborhood Activation Model (Luce, 1986), the results showed that easy words are recognized with greater accuracy than hard words by 4-to-6-year-old children; that is, organizing and accessing spoken words from long-term lexical memory are influenced by both word frequency and acoustic-phonetic similarity of other words from 4 years of age. Accordingly, unlike Mandarin-speaking 4-to-7-year-old children (Wang et al., 2010), lexical effects on SWR were demonstrated among both monosyllabic and disyllabic words, similar to the findings related to Persian-speaking 6-to-13-year-old children (Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020) and English-speaking-5-to-14 year-old children (Eisenberg et al., 2002; Kirk et al., 1998; Kirk et al., 2000; Kirk, Pisoni, et al., 1995; Krull et al., 2010). Thus, lexical effects affect SWR performance regardless of children's age range.

Following the findings of the previous studies, it found that the 4-to-6-year-old children with NH could recognize the spoken disyllabic words with greater accuracy than the monosyllabic ones under spectrally degraded conditions (Eisenberg et al., 2002; Kirk et al., 1998; Kirk et al., 2000; Kirk, Pisoni, et al., 1995; Krull et al., 2010; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020; Wang et al., 2010). This finding confirms that lexical effects are most likely to account for the difference in preschool-aged children's performance on the SWR as a function of word length; That is, disyllabic words have relatively less lexical neighborhood densities and more linguistic redundancy than monosyllabic words (Kirk et al., 2000).

Finally, 4 dB SNR may be the optimal SNR to examine preschool-aged children's SWR performance. Because 0 dB SNR may be too demanding and 15 dB SNR may be too easy to investigate lexical effects on the speech recognition process under spectrally degraded conditions.

In conclusion, linguistic properties of the stimulus words and word length affect the 4-to-6-year-old children's SWR performance under spectrally degraded conditions. Therefore, the PLNTs-PV as a lexically controlled test independent of vocabulary and language competency can be used to measure SiN recognition in Persian-speaking 4-to-6-year-old children. For future research, cross-sectional studies are planned which will use the PLNTs-PV: (I) to measure SWR performance in Persian-speaking preschool-aged children with HL; and (II) to compare visual, auditory, and audiovisual SWR performance in Persian-speaking preschool-aged children with HL with their typical peers.

5. Conclusion

Using the PLNTs-PV as a quick form of the PLNTs, it has been demonstrated that both linguistic properties of the stimulus words and word length affect the Persian-speaking preschool-aged children's spoken word recognition performance under spectrally degraded conditions. Therefore, the PLNTs-PV, as a lexically controlled assessment toolkit independent of vocabulary and language competency, can be used measuring speech-in-noise recognition in Persian-speaking preschool-aged children. We recommend managing the environment's noise as one of the practical solutions to improve preschool-aged children's speech recognition performance.

Acknowledgements

The authors would like to thank the undergraduate students for their valuable general assistant, Dr. E. Sadeghi, for his careful statistical advice. Special thanks are expressed to the families and children who participated in the research.

References

Caldwell, A., & Nittrouer, S. (2013). Speech perception in noise by children with cochlear implants. Journal of Speech, Language, and Hearing Research, 56(1), 13-30. https://doi.org/10.1044/1092-4388(2012/11-0338)

Ching, T. Y., Zhang, V. W., Flynn, C., Burns, L., Button, L., Hou, S., McGhie, K., & Van Buynder, P. (2018). Factors influencing speech perception in noise for 5-year-old children using hearing aids or cochlear implants. International Journal of Audiology, 57(sup2), S70-S80. https://doi.org/10.1080/14992027.2017.1346307

Eisenberg, L. S., Fisher, L. M., Johnson, K. C., Ganguly, D. H., Grace, T., Niparko, J. K., & Team, C. D. I. (2016). Sentence recognition in quiet and noise by pediatric cochlear implant users: Relationships to spoken language. Otology & neurotology, 37(2), e75-81. https://doi.org/10.1097/MAO.0000000000000910

Eisenberg, L. S., Martinez, A. S., Holowecky, S. R., & Pogorelsky, S. (2002). Recognition of lexically controlled words and sentences by children with normal hearing and children with cochlear implants. Ear and hearing, 23(5), 450-462. https://doi.org/10.1097/01.Aud.0000034736.42644.Be

Holt, R. F., Kirk, K. I., & Hay-McCutcheon, M. (2011). Assessing multimodal spoken word-in-sentence recognition in children with normal hearing and children with cochlear implants. Journal of Speech, Language, and Hearing Research, 54(2), 632-657. https://doi.org/10.1044/1092-4388(2010/09-0148)

Kirk, K. I., Diefendorf, A. O., Pisoni, D. B., & Robbins, A. M. (1995). Assessing speech perception in children (No. 20

Kirk, K. I., Eisenberg, L. S., Martinez, A. S., & Hay-McCutcheon, M. (1998). The lexical neighborhood test: Test-retest reliability and inter-list equivalency (No. 22

Kirk, K. I., Hay-McCutcheon, M., Sehgal, S. T., & Miyamoto, R. T. (2000). Speech perception in children with cochlear implants: effects of lexical difficulty, talker variability, and word length. The Annals of otology, rhinology & laryngology. Supplement, 185, 79-81. https://doi.org/10.1177/0003489400109s1234

Kirk, K. I., & Hudgins, M. (2016). Speech perception and spoken word recognition in children with cochlear implants. In N. M. Young & K. I. Kirk (Eds.), Pediatric Cochlear Implantation (pp. 145-161). Springer Nature. https://doi.org/10.1007/978-1-4939-2788-3_9

Kirk, K. I., Pisoni, D. B., & Osberger, M. J. (1995). Lexical effects on spoken word recognition by pediatric cochlear implant users. Ear and hearing, 16(5), 470-481. http://www.ncbi.nlm.nih.gov/pubmed/8654902

Kirk, K. I., Prusick, L., French, B., Gotch, C., Eisenberg, L. S., & Young, N. (2012). Assessing spoken word recognition in children who are deaf or hard of hearing: A translational approach. Journal of the American Academy of Audiology, 23(6), 464-475. https://doi.org/10.3766/jaaa.23.6.8

Krull, V., Choi, S., Kirk, K. I., Prusick, L., & French, B. (2010). Lexical effects on spoken word recognition in children with normal hearing Ear and hearing, 31(1), 102-114.

Lee, Y., & Sim, H. (2020). Bilateral cochlear implantation versus unilateral cochlear implantation in deaf children: Effects of sentence context and listening conditions on recognition of spoken words in sentences. International Journal of Pediatric Otorhinolaryngology, 137, 110237. https://doi.org/10.1016/j.ijporl.2020.110237

Luce, P. A. (1986). Neighborhoods of words in the mental lexicon (No. 6

Oryadi-Zanjani, M. M. (2022). A systematic review of speech recognition assessment tools for Persian-speaking children with and without hearing disorders. Journal of Rehabilitation Sciences & Research, 9(4), 143-150. https://doi.org/10.30476/jrsr.2022.93971.1255

Oryadi-Zanjani, M. M. (2023). Speech-in-noise perception in school-aged children with hearing loss compared to their peers with normal hearing: evidence of a critical condition. Cochlear implants international, [Under Review]. https://doi.org/10.21203/rs.3.rs-1912101/v1

Oryadi-Zanjani, M. M., Mohammadi, T., Mohammadi, Z., & Vahab, M. (2021). Predictive Factors of Language Development in Persian-speaking Children Using Cochlear Implants: A Pilot Study. Journal of Rehabilitation Sciences and Research, 8(3), 126-131. https://doi.org/10.30476/jrsr.2021.90722.1154

Oryadi-Zanjani, M. M., & Vahab, M. (2021). Lexical effects on spoken word recognition in children with hearing impairment: Test-Retest Reliability of the Persian Lexical Neighborhood Tests. Journal of Rehabilitation Sciences & Research, 8(4), 169-175. https://doi.org/10.30476/jrsr.2021.92117.1201

Oryadi-Zanjani, M. M., & Zamani, A. (2020). Development of Persian lexical neighborhood tests. International Journal of Pediatric Otorhinolaryngology, 139, 110406. https://doi.org/10.1016/j.ijporl.2020.110406

Ren, C., Yang, J., Zha, D., Lin, Y., Liu, H., Kong, Y., Liu, S., & Xu, L. (2018). Spoken word recognition in noise in Mandarin-speaking pediatric cochlear implant users. International Journal of Pediatric Otorhinolaryngology, 113, 124-130. https://doi.org/10.1016/j.ijporl.2018.07.039

Robbins, A. M., & Kirk, K. I. (1996). Speech perception assessment and performance in pediatric cochlear implant users. Seminars in Hearing, 17(4), 353-369.

Wang, N. M., Wu, C. M., & Kirk, K. I. (2010). Lexical effects on spoken word recognition performance among Mandarin-speaking children with normal hearing and cochlear implants. International Journal of Pediatric Otorhinolaryngology, 74(8), 883-890. https://doi.org/10.1016/j.ijporl.2010.05.005

Zaltz, Y., Bugannim, Y., Zechoval, D., Kishon-Rabin, L., & Perez, R. (2020). Listening in noise remains a significant challenge for cochlear implant users: Evidence from early deafened and those with progressive hearing loss compared to peers with normal hearing. Journal of clinical medicine, 9(5). https://doi.org/10.3390/jcm9051381