Speech-in-Noise Perception in Preschool-Aged Children with Hearing Loss Compared to Their Peers with Normal Hearing

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Abstract

The aim of the current study included: (I) determining lexical effects on SWR in the Persian-speaking preschool-aged children with HL and (II) comparing the SWR performance of the children to the preschool-aged children with NH. As a cross-sectional study, the study was administered to seventeen 5-to-6-year-old children of Soroush Rehabilitation Center for Children with Hearing Loss in Shiraz City, Iran. We used the preschool version of the Persian Lexical Neighborhood Tests (PLNTs-PV) to investigate the SWR performance of the children with HL. In addition, their scores on the PLNTs-PV were compared to the SWR performance of the children with NH. The SWR performance of the preschool-aged children with HL did not change by using the spoken words with different lexical difficulties under spectrally degraded conditions dissimilar to those with NH. According to the findings of this study, the processes of word recognition in preschool-aged children with HL were not influenced by lexical difficulty and word length under spectrally degraded conditions. In addition, the speech recognition processes of preschool-aged children with HL did not develop compared to those with NH. Therefore, managing background noise and early intervention to train SiN skills may be two practical solutions to improve speech perception in preschool-aged children with HL.

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

1. Introduction

Although the previous findings emphasized speech-in-noise (SiN) problems of children with hearing loss (HL) (Caldwell & Nittrouer, 2013; Ching et al., 2018; Eisenberg et al., 2016; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; Ren et al., 2018; Zaltz, Bugannim, Zechoval, Kishon-Rabin, & Perez, 2020), an essential question is why despite using cochlear implants (CIs) as the state-of-the-art therapy, pediatric users could not recognize speech under spectrally degraded conditions as well as their peers with normal hearing (NH) (Mohammad Majid Oryadi-Zanjani, 2022a; Mohammad Majid Oryadi-Zanjani & Vahab, 2021). But, to answer the question, we should shed light on the SiN performance of children with HL throughout preschool ages because the underlying auditory and cognitive process of SiN perception is organized in the early years of life (Chermak & Musiek, 2002).

According to the previous findings, lexically controlled tests may be the most effective tools to assess the children's SiN performance independent of their linguistic competence (Kirk, Diefendorf, Pisoni, & Robbins, 1995; Kirk, Eisenberg, Martinez, & Hay-McCutcheon, 1998; Kirk & Hudgins, 2016; Mohammad Majid Oryadi-Zanjani, 2022b; M. M. Oryadi-Zanjani & Zamani, 2020; Robbins & Kirk, 1996). It has been shown that children's spoken word recognition (SWR) is influenced by lexical effects using lexical neighborhood tests (Kirk, Pisoni, & Osberger, 1995;

Krull, Choi, Kirk, Prusick, & French, 2010; Mohammad Majid Oryadi-Zanjani, 2022a; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020; Wang, Wu, & Kirk, 2010).

Recently, using the preschool version of the Persian Lexical Neighborhood Tests (PLNTs-PV), the study on Persian-speaking 4-to-6-year-old children with NH indicated the children's SiN performance is essentially influenced by the lexical factors, including word lexical difficulty and word length under spectrally degraded conditions (Oryadi Zanjani, [Under review]). These findings were consistent with the previous research evidence of linguistic effects on children's SWR in noise performance in populations with different age ranges, language, and hearing statuses (Kirk, Pisoni, et al., 1995; Krull et al., 2010; Mohammad Majid Oryadi-Zanjani, 2022a; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020; Wang et al., 2010).

In conclusion, the aim of the current study included: (I) determining lexical effects on SWR in Persian-speaking 5-to-6-year-old children with HL and (II) comparing the SWR performance of the children with HL to the children with NH by using the PLNTs-PV. Accordingly, we had two hypothesizes: (I) both linguistic properties of the stimulus words and word length affect the SWR performance of the children with HL under spectrally degraded conditions, and (II) the SiN performance of the children with HL is significantly lower than the children with NH.

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.1401.013). The aims of this study were: (I) to assess SWR performance in Persian-speaking 5-to-6-year-old children with HL based on the Neighborhood Activation Model by using the PLNTs-PV (Oryadi Zanjani, [Under review]); and (II) to compare the results of the children with HL with the SWR performance of the children with NH (Oryadi Zanjani, [Under review]).

2.1 Participants

Seventeen 5-to-6-year-old children [(five years = 8, six years = 9) (female = 11, male = 6) (12 unilateral CIs = 12, bilateral HAs = 5)] were recruited through using convenient sampling from Soroush Rehabilitation Center for Children with Hearing Loss in Shiraz city, Iran. All participants met the following inclusion criteria: spoken Persian as the primary language, a bilateral symmetrical sensorineural hearing loss with pure tone average thresholds >30dB HL, normal tympanometry bilaterally, using oral language as a communication method pre- and post-implantation, using HAs as a trial before cochlear implantation, educated in Soroush Rehabilitation Center for Children with Hearing Loss, and no additional handicapping conditions.

2.2 Assessment tool

The preschool version of the PLNT (PLNTs-PV) includes the Persian Monosyllabic Lexical Neighborhood Tests (PMLNT-easy [10 words] and PMLNT-hard [10 words]) and the Persian Disyllabic Lexical Neighborhood Test (PDLNT-easy [10 words] and PDLNT-hard [10 words]). The PLNTs-PV, as a lexically controlled assessment toolkit, can be used measuring speech-in-noise recognition in Persian-speaking preschool-aged children (Oryadi Zanjani, [Under review]).

2.3 Procedure

The experiments were administered using a sound field at the Hearing-Speech Lab of Soroush Rehabilitation Center for Children with Hearing Loss. Two PC speakers were fixed in the center position near the PC on a table. The sound intensity of the speakers was set at the maximum, and the good power of the system (Realtek Digital Output) was set at 65 dB. Microsoft PowerPoint software was used to present the stimuli through a PC or Laptop. Accordingly, 12 subtests were administered based on SNRs levels. Considering floor or ceiling effects on the children's performance, the three SNRs were determined to include 0, 4, and 15 dB (Table 1). The experiments were repeated with a two weeks break (retest phase) to verify the reliability of The PLNTs-PV.

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

A training pretest, including two monosyllabic easy, two monosyllabic hard, two disyllabic easy, and two disyllabic hard, was administered by auditory modality in the 4 dB SNR. Two trained undergraduate students assisted in 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 participant to write what was repeated by them. Each word 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 failures to replicate 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. Their scores on the PLNTs-PV were compared to the study's findings on the Persian-speaking 4-to-6-year-old children with NH (Oryadi Zanjani, [Under review]). The data were analyzed using IBM SPSS version 23.

3. Results

3.1 Comparison of mean scores on the PLNTs-PV within children with hearing loss

3.1.1 Effect of lexical difficulty on spoken word recognition

To investigate effect of lexical difficulty on the SWR, the children's mean scores were 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 none of the experiments in both the test and the retest phases (Figure 1 & Figure 2); That is, the children's SWR performance was persistent throughout different testing conditions using easy or hard words. Therefore, the lexical difficulty did not affect the children's SWR performance under spectrally degraded conditions.

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

Phase	Word length	SNR (dB)	Lexical difficulty	N	Mean	Standard deviation	P
Test	Monosyllabic	0	Easy	17	0.176	0.392	> 0.05
			Hard	17	0.176	0.528	
		4	Easy	17	0.764	0.831	> 0.05
			Hard	17	0.470	0.799	
		15	Easy	17	1.823	1.424	> 0.05
			Hard	17	1.352	1.320	
	Disyllabic	0	Easy	17	0.588	1.064	> 0.05
			Hard	17	0.529	0.874	
		4	Easy	17	0.882	0.927	> 0.05
			Hard	17	1.411	1.583	
		15	Easy	17	2.588	2.237	> 0.05
			Hard	17	3.058	2.276	
Retest	Monosyllabic	0	Easy	17	1.000	1.000	> 0.05
			Hard	17	0.588	1.064	
		4	Easy	17	1.647	1.221	> 0.05
			Hard	17	1.000	1.000	
		15	Easy	17	3.411	2.032	> 0.05
			Hard	17	2.823	1.424	
	Disyllabic	0	Easy	17	2.058	2.304	> 0.05
			Hard	17	1.823	1.629	
		4	Easy	17	2.705	2.257	> 0.05
			Hard	17	2.705	1.358	
		15	Easy	17	3.764	2.250	> 0.05
			Hard	17	4.470	1.419	

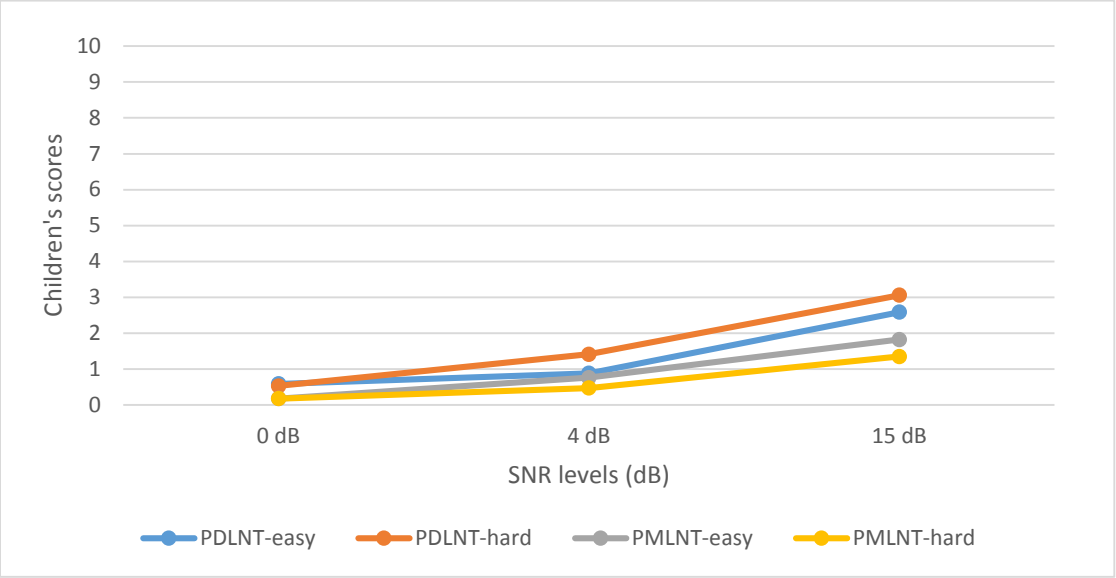

Figure 1: The scores of children with hearing loss in the subscales based on SNR levels in test phase

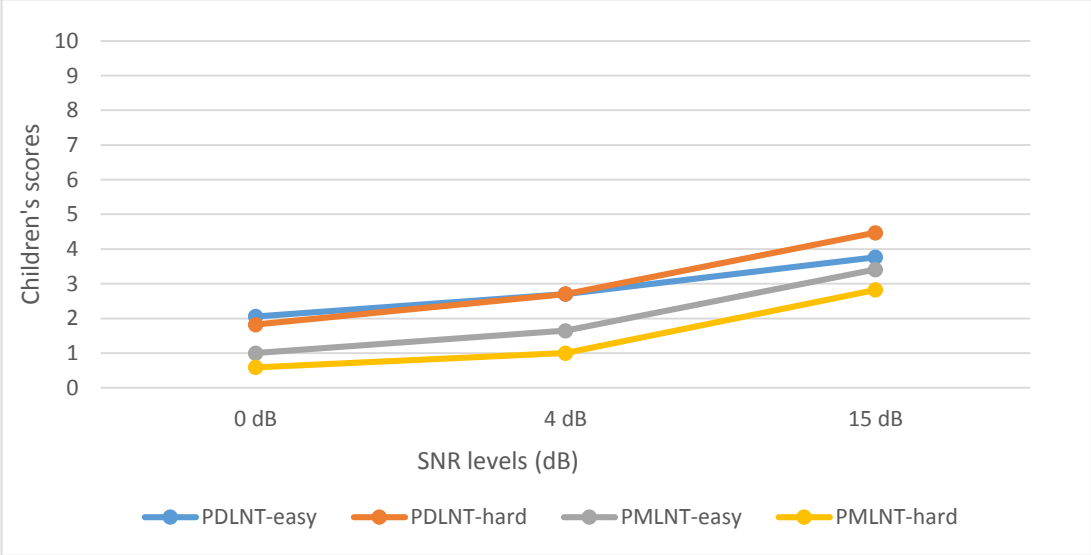

Figure 2: The scores of children with hearing loss in the subscales based on SNR levels in retest phase

3.1.2 Effect of word length on spoken word recognition

To investigate 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, no significant difference was found in the children's SWR performance using the PMLNT-easy and the PDLNT-easy throughout the experiments in both the test and the retest phases (Figure 1 & Figure 2); that is, the children's performance on the easy words was persistent using mono- or disyllabic words. But, there was a significant difference between the PMLNT-hard and the PDLNT-hard in most of the SNRs throughout the experiments in both the test and the retest phases, except 0 dB SNR in the test phase (Figure 1 & Figure 2); that is, the children's scores of

the disyllabic hard words were higher than the monosyllabic hard words in the most of the experiments. Therefore, Therefore, the children's SWR performance can be variable according to word length along with the lexical difficulty under spectrally degraded conditions.

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

Phase	Word length	SNR (dB)	Lexical difficulty	N	Mean	Standard deviation	P
Test	Easy	0	Monosyllabic	17	0.176	0.392	> 0.05
			Disyllabic	17	0.588	1.064	
		4	Monosyllabic	17	0.764	0.831	> 0.05
			Disyllabic	17	0.882	0.927	
		15	Monosyllabic	17	1.823	1.424	> 0.05
			Disyllabic	17	2.588	2.237	
	Hard	0	Monosyllabic	17	0.176	0.528	> 0.05
			Disyllabic	17	0.529	0.874	
		4	Monosyllabic	17	0.470	0.799	< 0.05
			Disyllabic	17	1.411	1.583	
		15	Monosyllabic	17	1.352	1.320	< 0.05
			Disyllabic	17	3.058	2.276	
Retest	Easy	0	Monosyllabic	17	1.000	1.000	> 0.05
			Disyllabic	17	2.058	2.304	
		4	Monosyllabic	17	1.647	1.221	> 0.05
			Disyllabic	17	2.705	2.257	
		15	Monosyllabic	17	3.411	2.032	> 0.05
			Disyllabic	17	3.764	2.250	
	Hard	0	Monosyllabic	17	0.588	1.064	< 0.05
			Disyllabic	17	1.823	1.629	
		4	Monosyllabic	17	1.000	1.000	< 0.01
			Disyllabic	17	2.705	1.358	
		15	Monosyllabic	17	2.823	1.424	< 0.01
			Disyllabic	17	4.470	1.419	

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

To investigate effect of SNR levels on the SWR, the children's mean scores of PLNTs-PV subscales were compared among the different SNRs by the Repeated Measures ANOVA (Table 4). Using Bonferroni correction, there was: (I) a significant difference in the children's scores of the PMLNT-easy and the PDLNT-hard from 0 to 15 dB SNR; (II) a significant difference in the children's scores of the PDLNT-easy from 4 to 15 dB SNR; and (III) a significant difference in the children's scores of the PMLNT-hard in 15 dB SNR (Figure 1 & Figure 2). Therefore, the children's SWR performance was variable depending on the PLNTs-PV subscales properties under spectrally degraded conditions from 0 to 15 dB SNR.

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

				0 vs. 4 dB	4 vs. 15 dB	0 vs. 15 dB
Phase	Lexical difficulty	Word length	N	P	P	P
Test	Easy	Mono	17	< 0.01	< 0.01	< 0.01
		Di	17	> 0.05	< 0.01	< 0.01
	Hard	Mono	17	> 0.05	> 0.05	< 0.01
		Di	17	< 0.05	< 0.01	< 0.01
Retest	Easy	Mono	17	> 0.05	< 0.01	< 0.01
		Di	17	> 0.05	> 0.05	> 0.05
	Hard	Mono	17	> 0.05	< 0.01	< 0.01
		Di	17	> 0.05	< 0.01	< 0.01

3.1.4 Effect of sex on spoken word recognition

As shown in Table 5, the children's mean scores of the PLNTs-PV subscales were compared between the girls and the boys in all the SNRs by the Independent-Samples T-Test. Accordingly, no significant difference was found between the two groups in SWR performance using the PMLNT-easy and the PDLNT-easy under spectrally degraded conditions. But, a significant difference was found between the two groups in SWR performance using the PMLNT-hard and the PDLNT-hard in 4 dB SNR and the PDLNT-hard in 15 dB SNR; That is, the females' SWR performance was significantly better than the males' SWR performance depending on lexical difficulty, word length, and SNR level.

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

Word length	SNR (dB)	Lexical difficulty	Sex	N	Mean	Standard deviation	P
Easy	0	Monosyllabic	Female	11	0.272	0.467	> 0.05
			Male	6	0.000	0.000	
		Disyllabic	Female	11	0.545	1.213	> 0.05
			Male	6	0.666	0.816	
	4	Monosyllabic	Female	11	1.000	0.894	> 0.05
			Male	6	0.333	0.516	
		Disyllabic	Female	11	0.909	1.044	> 0.05
			Male	6	0.833	0.752	
	15	Monosyllabic	Female	11	2.272	1.420	> 0.05
			Male	6	1.000	1.095	
		Disyllabic	Female	11	3.000	2.280	> 0.05
			Male	6	1.833	2.136	
Hard	0	Monosyllabic	Female	11	0.181	0.603	> 0.05
			Male	6	0.166	0.408	
		Disyllabic	Female	11	0.727	1.009	> 0.05
			Male	6	0.166	0.408	
	4	Monosyllabic	Female	11	0.727	0.904	< 0.05
			Male	6	0.000	0.000	
		Disyllabic	Female	11	1.909	1.758	< 0.05
			Male	6	0.500	0.547	
	15	Monosyllabic	Female	11	1.454	1.293	> 0.05
			Male	6	1.166	1.471	
		Disyllabic	Female	11	3.727	2.572	< 0.05
			Male	6	1.833	0.752	

3.1.5 Effect of amplification device type on spoken word recognition

As shown in Table 6, the children's mean scores of the PLNTs-PV subscales were compared between the children using CIs and their peers with HAs in all the SNRs by the Independent-Samples T-Test. Although the scores of the children using HAs were higher than their peers using CIs, no significant difference was found between the two groups in SWR performance using the PLNTs-PV subscales in most of the experiments, except the PDLNT-hard in 0 dB SNR; That is, the type of amplification device was not a determining factor of the children's SWR performance under spectrally degraded conditions.

Table 6: Comparison of the scores means of children with hearing loss between the subscales based on amplification device

Word length	SNR (dB)	Lexical difficulty	Amplification device	N	Mean	Standard deviation	P
Easy	0	Monosyllabic	HAs	5	0.200	0.447	> 0.05
			CIs	12	0.166	0.389	
		Disyllabic	HAs	5	1.200	1.643	> 0.05
			CIs	12	0.333	0.651	
	4	Monosyllabic	HAs	5	1.000	1.000	> 0.05
			CIs	12	0.666	0.778	
		Disyllabic	HAs	5	1.200	1.303	> 0.05
			CIs	12	0.750	0.753	
	15	Monosyllabic	HAs	5	1.800	1.643	> 0.05
			CIs	12	1.833	1.403	
		Disyllabic	HAs	5	3.600	1.949	> 0.05
			CIs	12	2.166	2.289	
Hard	0	Monosyllabic	HAs	5	0.000	0.000	> 0.05
			CIs	12	0.250	0.621	
		Disyllabic	HAs	5	1.400	0.894	< 0.01
			CIs	12	0.166	0.577	
	4	Monosyllabic	HAs	5	1.000	1.224	> 0.05
			CIs	12	0.250	0.452	
		Disyllabic	HAs	5	2.400	1.516	> 0.05
			CIs	12	1.000	1.477	
	15	Monosyllabic	HAs	5	1.400	1.516	> 0.05
			CIs	12	1.333	1.302	
		Disyllabic	HAs	5	4.600	2.408	> 0.05
			CIs	12	2.416	1.975	

3.2 Comparison of mean scores on the PLNTs-PV between children with and without hearing loss

3.2.1 Comparison of the mean scores of the PLNTs-PV subscales

To investigate the SWR performance of the children with HL compared with the children with NH, the children's mean scores of PLNTs-PV subscales were compared between the two groups throughout the experiments in the test and the retest phases by the Independent-Samples T-Test (Table 7). Accordingly, a significant difference was found between the two groups' SWR performance throughout the experiments in both the test and the retest phases; That is, the SWR performance of the children with HL was significantly lower than the children with NH under spectrally degraded conditions (Figure 3).

Table 7: Comparison of the scores means between children with hearing loss and those with normal hearing

Phase	Lexical difficulty	Word length	SNR (dB)	Group	N	Mean	Standard deviation	P
Test	Easy	Monosyllabic	0	Hearing loss	17	0.735	1.109	< 0.01
				Normal hearing	62	5.830	2.484	
			4	Hearing loss	17	1.411	1.351	< 0.01
				Normal hearing	62	7.532	2.286	
			15	Hearing loss	17	2.529	1.862	< 0.01
				Normal hearing	62	8.879	1.859	
		Disyllabic	0	Hearing loss	17	1.294	1.801	< 0.01
				Normal hearing	62	8.137	2.249	
			4	Hearing loss	17	2.088	2.234	< 0.01
				Normal hearing	62	9.411	1.925	
			15	Hearing loss	17	3.235	2.283	< 0.01
				Normal hearing	62	9.838	1.823	
	Hard	Monosyllabic	0	Hearing loss	17	0.617	1.044	< 0.01
				Normal hearing	62	5.491	2.239	
			4	Hearing loss	17	1.441	1.726	< 0.01
				Normal hearing	62	6.661	1.784	
			15	Hearing loss	17	2.205	1.871	< 0.01
				Normal hearing	62	8.258	1.642	
		Disyllabic	0	Hearing loss	17	1.441	1.330	< 0.01
				Normal hearing	62	6.427	2.142	
			4	Hearing loss	17	2.529	2.033	< 0.01
				Normal hearing	62	7.322	1.796	
			15	Hearing loss	17	4.029	2.610	< 0.01
				Normal hearing	62	8.588	1.628	
Retest	Easy	Monosyllabic	0	Hearing loss	17	1.558	1.599	< 0.01
				Normal hearing	62	5.830	2.484	
			4	Hearing loss	17	2.088	1.658	< 0.01
				Normal hearing	62	7.532	2.286	
			15	Hearing loss	17	4.029	2.528	< 0.01
				Normal hearing	62	8.879	1.859	
		Disyllabic	0	Hearing loss	17	2.411	2.284	< 0.01
				Normal hearing	62	8.137	2.249	
			4	Hearing loss	17	3.176	2.492	< 0.01
				Normal hearing	62	9.411	1.925	
			15	Hearing loss	17	4.441	2.536	< 0.01
				Normal hearing	62	9.838	1.823	
	Hard	Monosyllabic	0	Hearing loss	17	1.117	1.365	< 0.01

		Normal hearing	62	5.491	2.239	
	4	Hearing loss	17	2.000	1.984	< 0.01
		Normal hearing	62	6.661	1.784	
	15	Hearing loss	17	3.705	2.111	< 0.01
		Normal hearing	62	8.258	1.642	
Disyllabic	0	Hearing loss	17	2.676	1.934	< 0.01
		Normal hearing	62	6.427	2.142	
	4	Hearing loss	17	3.617	1.922	< 0.01
		Normal hearing	62	7.322	1.796	
	15	Hearing loss	17	4.823	1.641	< 0.01
		Normal hearing	62	8.588	1.628	

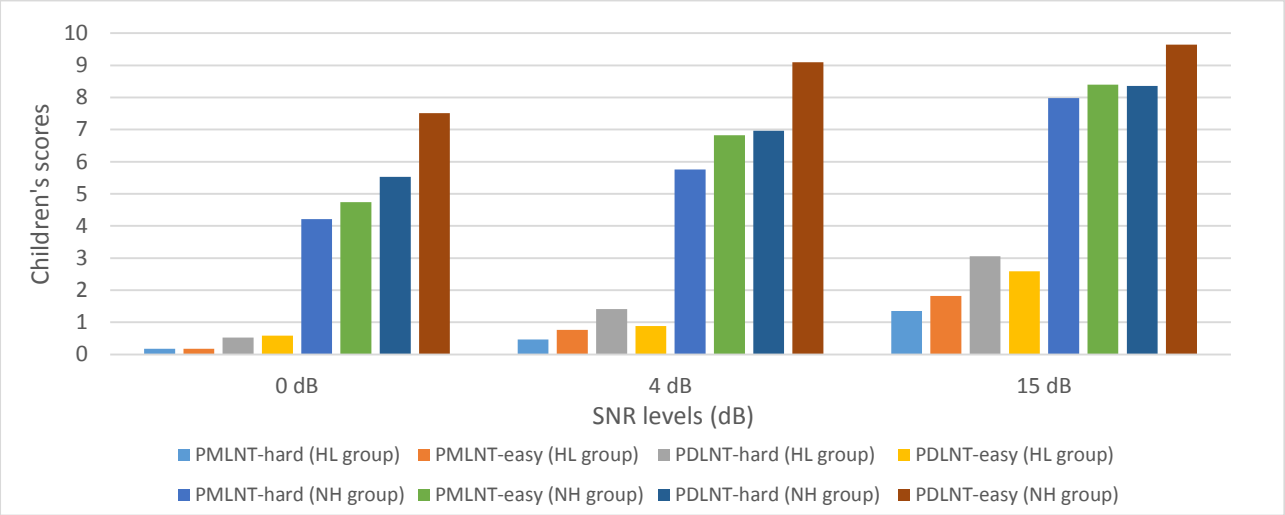

Figure 3: Comparison of mean scores on the PLNTs-PV between children with and without hearing loss

3.2.2 Comparison of the differences of the mean scores of the PLNTs-PV subscales

As shown in Table 8, the differences in the mean scores of PLNTs-PV subscales in the SNRs were compared between the children with HL and those with NH by the Independent-Samples T-Test. The differences (D) of the PLNTs' mean scores were significantly different between the two groups, including D1 = the PMLNT-easy minus the PDLNT-easy (0, 4 dB), D2 = the PMLNT-hard minus the PDLNT-hard (0 dB), and D4 = the PDLNT-easy minus the PDLNT-hard (0, 4, 15 dB); That is, the differences of SWR performance in monosyllabic versus disyllabic words and easy versus hard words in the children with HL were significantly lower than the children with NH.

Table 8: Comparison of the differences of the PLNTs-PV subscales between children with hearing loss and those with normal hearing

Lexical difficulty	Difference	SNR (dB)	Group	N	Mean	Standard deviation	P
Easy	D1 = Mono minus Di	0	Hearing loss	17	0.411	0.939	< 0.01
			Normal hearing	62	2.774	2.220	
		4	Hearing loss	17	0.117	0.696	< 0.01
			Normal hearing	62	2.274	2.470	
		15	Hearing loss	17	0.764	1.786	> 0.05
			Normal hearing	62	1.241	1.575	
Hard	D2 = Mono minus Di	0	Hearing loss	17	0.352	1.114	< 0.05
			Normal hearing	62	1.322	2.208	
		4	Hearing loss	17	0.941	1.748	> 0.05
			Normal hearing	62	1.209	1.968	
		15	Hearing loss	17	1.705	2.468	> 0.05
			Normal hearing	62	0.371	1.952	
Monosyllabic	D3 = Easy minus Hard	0	Hearing loss	17	0.000	0.707	> 0.05
			Normal hearing	62	0.532	2.474	
		4	Hearing loss	17	0.294	1.159	> 0.05
			Normal hearing	62	1.064	2.296	
		15	Hearing loss	17	0.470	1.504	> 0.05
			Normal hearing	62	0.419	2.131	
Disyllabic	D4 = Easy minus Hard	0	Hearing loss	17	0.058	0.747	< 0.01
			Normal hearing	62	1.983	2.479	
		4	Hearing loss	17	0.529	1.230	< 0.01
			Normal hearing	62	2.129	2.350	
		15	Hearing loss	17	0.470	2.124	< 0.01
			Normal hearing	62	1.290	2.067	

4. Discussion

It is essential to consider the SWR performance of the 5-to-6-year-old children with HL compared to the 4-to-6-year-old children with NH to explain the study's findings. The SWR performance of the children with HL did not change by using the spoken words with different lexical difficulties (easy, hard) under spectrally degraded conditions, unlike the children with NH who showed better SWR performance on the easy words than the hard ones (Oryadi Zanjani, [Under review]). In addition, the performance of the children with HL differed from the Persian-speaking school-aged children with HL (Mohammad Majid Oryadi-Zanjani & Vahab, 2021) and the children with NH (M. M. Oryadi-Zanjani & Zamani, 2020), who showed better SWR performance on the easy words than the hard ones.

The SWR performance of the children with HL was variable by using the words with different lengths (monosyllabic, disyllabic) depending on the words' lexical difficulty (easy, hard), as their performance did not vary by using the PMLNT-easy and the PDLNT-easy. At the same time, they recognized the items of the PDLNT-hard better than those of the PMLNT-hard. The performance of the preschool-aged children with HL was entirely different from the preschool-aged children with NH (Oryadi Zanjani, [Under review]) and the school-aged children with and without HL (Mohammad Majid Oryadi-Zanjani, 2022b; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020), who recognized the items of the PDLNT-easy better than those of the PMLNT-

easy. However, their performance on the PDLNT-hard and the PMLNT-hard was similar to them (Mohammad Majid Oryadi-Zanjani, 2022b; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020; Oryadi Zanjani, [Under review]).

The SWR performance of the children with HL did not consistently get better using the PLNTs-PV subscales under spectrally degraded conditions from 0 to 15 dB SNR. Accordingly, they showed different performances compared to the children with NH (Oryadi Zanjani, [Under review]) and the older children with and without HL (Mohammad Majid Oryadi-Zanjani, 2022b; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020), whose SiN performance improved along with increasing SNR levels. The SWR performance of the girls with HL was better than the boys depending on lexical difficulty, word length, and SNR level, whereas no difference was seen between the girls and boys with NH (Oryadi Zanjani, [Under review]).

Therefore, the children with HL not only had different SWR processes compared to the children with NH, but also their speech recognition process was different from the school-aged children with and without HL; That is, the SWR process development of the children with HL was immature compared to the children with NH and the older children with HL. Because on the one hand, according to the Neighborhood Activation Model, lexical difficulty and word length are two determining factors of SiN performance (Luce, 1986). On the other hand, the findings of several studies on children with and without HL acknowledge that children's speech recognition system works based on the model (Kirk, Pisoni, et al., 1995; Krull et al., 2010; Mohammad Majid Oryadi-Zanjani, 2022b; Mohammad Majid Oryadi-Zanjani & Vahab, 2021; M. M. Oryadi-Zanjani & Zamani, 2020; Oryadi Zanjani, [Under review]; Wang et al., 2010). Moreover, this finding confirms that although lexical difficulty and word length affect SWR performance in children, the lexical difficulty has powerful effects (Kirk, Hay-McCutcheon, Sehgal, & Miyamoto, 2000) because the children could recognize the disyllabic hard words better than the monosyllabic ones. In contrast, their performance was equivalent for the disyllabic and monosyllabic easy words.

According to the findings, the preschool-aged children with HL showed much poorer SiN performance than those with NH using the PLNTs-PV, consistent with the school-aged children with HL compared to their peers with NH (Mohammad Majid Oryadi-Zanjani, 2022a). Furthermore, the differences in SWR performance in monosyllabic versus disyllabic words and easy versus hard words in the children with HL were significantly lower than in those with NH (Oryadi Zanjani, [Under review]). This finding is dissimilar to the results of the Persian-speaking older children with HL, whose SWR performance differences were higher than their peers with NH (Mohammad Majid Oryadi-Zanjani, 2022a). Therefore, the preschool-aged children with HL had a poor performance on SiN recognition regardless of the PLNTs-PV subscales because their SWR processes do not act based on the Neighborhood Activation Model (Luce, 1986).

Finally, no performance difference was seen between the preschool-aged children using CIs and HAs, similar to the findings on the school-aged children with HL (Mohammad Majid Oryadi-Zanjani & Vahab, 2021). Accordingly, cochlear implantation could not improve the SiN performance of the 5-to-6-year-old children with HL more than hearing aids; That is, pediatric CIs users experience critical difficulties in SiN perception, consistent with the findings of previous studies (Eisenberg et al., 2016; Eisenberg, Martinez, Holowecky, & Pogorelsky, 2002; Gifford, Olund, & DeJong, 2011; Kirk, Eisenberg, et al., 1998; Kirk, Hay-McCutcheon, Sehgal, & Miyamoto, 1998; Kirk & Hudgins, 2016; Kirk, Pisoni, et al., 1995; Lee & Sim, 2020; Liu et al., 2013; Mohammad Majid Oryadi-Zanjani, 2022a; Pisoni, 2009; Wang et al., 2010; Zaltz et al., 2020). As a result, background noise, as a fundamental factor, should be managed to improve the listening performance of preschool-aged children with HL. But, early intervention to train SiN skills may be the most effective solution in preschool-aged children with HL.

To sum up, the PLNTs-PV, as a lexically controlled assessment tool, could show that the speech recognition processes of the 5-to-6-year-old children with HL did not develop compared to the 4-to-6-year-old children with NH because of: (I) the SiN performance of children with HL was much poorer than the performance of those with NH, and (II) the process of word recognition in the children with HL was not influenced by lexical difficulty and word length under spectrally degraded conditions according to the Neighborhood Activation Model.

5. Conclusion

According to the findings of this study, the processes of word recognition in preschool-aged children with HL were not influenced by lexical difficulty and word length under spectrally degraded conditions. In addition, the speech recognition processes of preschool-aged children with HL did not develop compared to those with NH. Furthermore, the PLNTs-PV, as a lexically controlled assessment toolkit independent of vocabulary and language competency, can be used measuring SiN recognition in preschool-aged children with HL. Therefore, managing background noise and early intervention to train SiN skills may be two practical solutions to improve speech perception in preschool-aged children with HL.

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