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Phonological processing skills and its relevance to receptive vocabulary development in children with early cochlear implantation

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Objectives: The purposes of this study were to investigate phonological processing skills for children with cochlear implants (CIs) in comparison with children with normal hearing (NH), and to assess whether phonological processing skills can explain variance in receptive vocabulary scores in children with CIs.
Methods: Twenty-five deaf children who received a CI before 2 years of age were included in this study, and they ranged from 4 years to 6 years 11 months. Twenty-five children with NH as a control group were matched to children with CIs on the basis of chronological age with 3 months. Phonological processing skills were measured by the phonological awareness (PA), nonword repetition (NWR), and rapid automatized naming (RAN) tasks. Receptive vocabulary skills were also tested by the Peabody Picture Vocabulary Test – Korean version.
Results: Children with CIs performed significantly lower than children with NH on PA ($p < .05$) and NWR ($p < .001$) tasks. Children with CIs showed slower naming speed than children with NH, which did not reach the significant level ($p > .05$). Among phonological processing skills, PA contributed significant amount to receptive vocabulary skills in children with CIs ($p < .001$).
Conclusions: Children with early implantation receive substantial benefits for developing lexical access skills. However, children with CIs showed delays in PA and NWR in comparison with age-matched children with NH. For children with CIs, PA among phonological processing skills plays an important role of developing receptive vocabulary skills.

1. Introduction

Cochlear implants (CIs) have been established as a safe and effective means of improving auditory performance for deaf children when benefit from a conventional hearing aid is limited [1]. A CI provides deaf children with increased access to spoken language, and greater early spoken language ability is associated with higher levels of speech perception, better speech intelligibility, and better vocabulary skills compared with deaf children who do not use a CI [2]. These findings are consistent with the growing body of research which suggests that children implanted at earlier ages may have more opportunities to develop lexical representations, develop better speech perception, and improve phonological processing skills than children implanted later [2,3].

Based on numerous studies [1–3], age at implantation accounted for much of the variance in outcomes of children with CIs. However, age at implantation alone does not account for a wide variability among children with early implantation in speech perception and language outcomes [4,5]. Although many deaf children are now being implanted at 2 years or younger, individual differences in children with early implantation are still an unsolved issue that needs to be answered [2,3]. Many researchers have investigated a number of demographic variables (e.g., age at implantation, amount of residual hearing, and duration of an implant use, etc.) affecting CI outcomes in deaf children [2,3,6]. However, demographic variables and traditionally measured outcomes are limited in explaining differences. Identifying and understanding other sources of variability and measuring underlying processes for these children will be useful in predicting CI outcomes, developing new habilitation program, and gaining a better understanding of how deaf children encode and process speech information using a CI.

In our study, we focused on phonological processing skills and receptive vocabulary skills in children with CIs. Phonological processing skills such as encoding phonological representations of spoken words, maintaining them in memory, and retrieving them efficiently are important skills that affect word learning and language development [7–9]. Phonological processing refers to the use of phonological information in processing written and oral information, requiring cognitive operations on the sound system of

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a language. The components of phonological processing include phonological awareness (PA), phonological memory (PM), and lexical access [7,8]. PA is defined as the ability to abstract and manipulate segments of spoken language, typically measured by tasks in which children have to match, blend, delete, or count sounds within words. PM is the coding of information in a sound-based representation system, commonly measured by digit span or nonword repetition (NWR) tasks. The NWR task requires a child to identify a string of heard phonemes, to retain them in a short-term memory, and to produce the same sequence as speech. Lastly, lexical access is the retrieval of lexical sound-based representations from long-term memory, which is measured by rapid automatized naming (RAN) tasks such as letters, digits, or color naming. These tasks tap several skills including phonological processing and executive functioning, and the performance of these tasks rely on speech output and language process [7,8].

Numerous studies [4,7,10–14] documented that children with CIs develop phonological systems that are stronger than those of deaf children without CIs, but weaker than those of children with normal hearing (NH). Children with CIs have an advantage over deaf children without CIs in terms of developing phonological processing skills [10]. Spencer and Tomblin [7] explored the phonological processing skills in children with CIs ($n = 29$) who used a CI over 4 years. Scores on PA and NWR tasks of children with CIs were significantly poorer than those of children with NH. Scores in RAN tasks were not significantly different between children with CIs and children with NH. They suggested that lexical access is more highly salient for children with CIs than PA and PM. Tse and So [14] found that Cantonese-speaking preschoolers with CIs and their NH peers had similar levels of syllable awareness, phoneme awareness, and rhyme awareness. However, children with CIs showed significantly poorer performance on tone awareness and phonological knowledge tasks than their NH peers. Children with CIs may not acquire sensitively to phonological structure on a typical timetable, and half the children with CIs continue to perform on language and reading tasks more than 1 SD below the mean of their NH peers [15].

Among children with CIs, earlier and greater access to spoken language provides greater opportunity to rapidly access the phonological structure and develop PA [10,12]. James et al. [10] reported that children implanted early (between 2 and 3.6 years) had significant growth on rhyme awareness, whereas late implanted children (between 5 and 7 years) showed no significant gains in PA over time. Similarly, Johnson and Goswami [12] also reported that early implanted children had better PA skills than those of late implanted children, although all children derived benefit from a CI in the development of the PA skills necessary for developing efficient word recognition skills. Moreover, several studies [16,17] documented that PA was significantly correlated with speech perception and language in children with CIs. These previous studies supported the view that deaf children had gains in PA skills after implantation, although not specifically addressing individual variations in CI outcomes.

Little is currently known about all three phonological processing components (i.e., PA, PM, and lexical access) especially in children with early implantation compared to NH controls. Additionally, investigating the predictors affecting receptive vocabulary skills is an urgent area of research in children who received a CI early. The present study hypothesized that deaf children who received a CI before the age of 2 years would have a fairly good performance in phonological processing tasks. Thus, it was expected that children with CIs and children with NH would show similarities and no difference in three phonological processing components. Furthermore, phonological processing skills would be strongly associated with receptive vocabulary skills in children with CIs and the valuable predictors of receptive vocabulary skills would be phonological processing abilities including PA, PM, and RAN. Therefore, the purposes of the current study were (1) to investigate phonological processing skills for children with CIs in comparison with children with NH, and (2) to assess whether phonological processing skills can explain variance in receptive vocabulary scores in children with CIs.

2. Methods

2.1. Subjects

Twenty-five children with CIs (11 females, 14 males) participated in this study. For every individual child with CIs, the child was selected based on four criteria. First, the children had to receive a CI before the age of 24 months. Second, at the time of testing, the children had to be between the age of 4 years and 6 years 11 months. Third, the children had no severe inner ear malformation and/or no additional disabilities (i.e., autism, visual impairment, and cognitive disabilities, etc). Fourth, scores of the open-set monosyllabic word test in children with CIs were over 85% at the phoneme level. Lastly, the children had to use oral-only communication (i.e., no use of any form of manual communication). Preoperatively, all children used conventional hearing aids and received auditory training in the auditory habilitation centers. All children with CIs showed no response at the preoperative auditory brainstem response (ABR). All of them underwent successful implantation with complete electrode insertion, and they used the Cochlear Corporation Nucleus multichannel cochlear implant. Aided thresholds of all children with cochlear implants were below 30 dB HL after implantation. The mean chronological age was 64.76 months ($SD = 9.48$). The average age at fitting hearing aids was 14 months ($SD = 7.27$), and the average at start of the habilitation program was also 14 months ($SD = 7.27$). The average age at implantation was 20.88 months ($SD = 3.88$). The mean duration of an implant use was 43.88 months ($SD = 10.28$).

Twenty-five children with NH (13 females, 12 males) participated as a control group. The children were matched individually to children with CIs on the basis of chronological age with 3 months (±3 months). The mean chronological age was 64.36 months ($SD = 8.53$). There was no age difference between groups ($t = 0.157$, $p > .05$). These children underwent a hearing screening using warble tone at frequencies 500, 1000, 2000, and

Table 1
Demographic data of the subjects.

	CI group ($n = 25$)	NH group ($n = 25$)
Sex (F:M)	11:14	13:12
Age at testing (MO)	64.76 (9.48)	64.36 (8.55)
Age at fitting HAs (MO)	14 (7.27)	
Age at start of the habilitation program (MO)	14 (7.27)	
Age at implantation (MO)	20.88 (3.88)	
Duration of an implant use (MO)	43.88 (10.28)	
Phoneme scores of monosyllabic word test (%)	92.4 (6.13)	

Note. CI = cochlear implant; NH = normal hearing; F = female; M = male; MO = months; HAs = hearing aids.
Numbers in parentheses indicate standard deviation.
All children with cochlear implants showed no response at preoperative auditory brainstem response.
All children with CI group underwent successful implantation with complete electrode insertion, and they have used the Cochlear Corporation Nucleus multichannel cochlear implant.
Aided thresholds of all children with cochlear implants were below 30 dB HL after implantation.

4000 Hz at 20 dB to ensure no undiagnosed hearing loss was present. Parental reports indicated no history of a speech-language impairment or cognitive disorder. The demographic data of the children are presented in Table 1.

2.2. Materials and procedures

Children with CIs and children with NH were tested on phonological processing tasks individually in a quiet room. These children completed 3 phonological processing tasks; PA, NWR, and RAN tasks within a day. The stimuli of the PA and NWR tasks were presented verbally only, so children with CIs accessed and perceived the stimuli using only auditory input. Appendix A contains a summary table of the phonological processing tasks used. The children's receptive vocabulary was assessed by the Peabody Picture Vocabulary Test – Korean version (PPVT-K) [18].

2.2.1. Phonological awareness (PA)

The Assessment of Korean Preliteracy (AKP) [19] was adopted and administered both to children with CIs and children with NH. PA skills were tested by elision subtest, blending subtest, and segmenting subtests. Each of the subtests included at least 2 practice trials that were followed by correction, explanation, and readministration if the child gave an incorrect answer. There was no feedback on any test trials after practice trials.

The elision subtest required the child to listen to the examiner and to delete a target sound from the words. It had 2 practice items and 18 test items. An examiner asked the child to listen and say a word, and then to say the word with either a syllable or phoneme missing. The blending subtest required the child to listen to stimuli and to combine word elements to form a word. There were 2 practice items and 12 test items in the blending subtest. An examiner spoke isolated word elements, and then the child was asked to "tell me what word I am trying to say". The segmenting subtest required the child to segment a word into syllables or phonemes. The segmenting subtest consisted of 2 practice items and 8 test items. An examiner spoke a real word or pseudo word, and then the child was asked to divide a word into syllables or phonemes. Specific examples of these tests are included in Appendix A. Responses were scored as a binary correct/incorrect scoring procedure, in which correct repetitions were scored as 1 and incorrect repetitions as 0. Raw score of each child was the total sum score of the three subtests, and the scores of all children were converted to their percentage ranging from 0% to 100%.

2.2.2. Phonological memory (PM)

PM was assessed by a nonword repetition task adapted version of Lee's study [20]. The NWR task was developed from Korean phonology that was within the developmental level of the majority of preschoolers. The task includes 20 nonwords, which were made progressively more difficult by increasing numbers of syllables in the nonwords. This task was modified for considering Korean phonetic balance and phonotactic probability. Each child was asked to listen to each nonword without visual cues (i.e., lipreading), presented one at a time, and them to attempt to repeat the nonword aloud back to an examiner. Responses were scored as a binary correct/incorrect scoring procedure, in which correct repetitions were scored as 1 and incorrect repetitions as 0. Raw scores of all children were used to derive a percentage ranged from 0% to 100%.

Table 2
Descriptive statistics for children with cochlear implants and children with normal hearing on measures of phonological processing skills and receptive vocabulary skills.

Measure	CI group ($n = 25$)		NH group ($n = 25$)	
	Mean	SD	Mean	SD
PA scores (%)	33.06	23.41	43.98	19.76
NWR scores (%)	60.00	20.87	78.60	11.14
RAN scores (s)	213.76	64.57	212.96	63.24
PPVT-K scores	50.16	19.68	68.04	17.71

Note. CI = cochlear implant; NH = normal hearing; PA = phonological awareness; NWR = nonword repetition; RAN = rapid automatized naming; PPVT-K = Peabody Picture Vocabulary Test – Korean version.

2.2.3. Lexical access

Although lexical access tasks typically use RAN of letters or numbers, many preschoolers are unable to name letters or numbers. Thus, RAN tasks including color, shape, and color–shape naming were used in our study. For each of these subtests, the child was shown an array of six rows that had six items (i.e., color, shape, color-shape) in each row and was instructed to name them sequentially across the rows as fast as possible. The time for the child to name the whole series of colors, shapes, and colors–shapes was measured. The score of each child was the total time (s) it took to name three subtests; 1 series of colors, 1 series of shapes, and 1 series of colors and shapes.

2.2.4. Receptive vocabulary

The PPVT-K [18] was used to assess spoken vocabulary by measuring the receptive vocabulary skills. It is a norm-referenced assessment of receptive vocabulary for children between 2 years and 7 years 11 months of age. During test administration, the child is shown a series of picture plates, each containing four pictures. The child is asked to look at the speaker, listen to a spoken word, and then select one of four black-and-white line drawings that correspond with the spoken word. The test is carried out in the auditory and visual (i.e., lip-reading) modality. Responses were correct or incorrect and scored as 1 and 0.

2.3. Statistical analysis

An analysis of covariance (ANCOVA) was performed to assess the group difference on 3 phonological processing task scores while controlling for their chronological age. A stepwise multiple regression analysis was also used to determine how much of the variance in receptive vocabulary skills are explained by chronological age, age at implantation, duration of an implant use, and three phonological processing components in children with CIs. Statistical analysis was conducted using the PASW statics version 18.0 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at a *p* value less than 0.05.

3. Results

Table 2 summarizes the means and standard deviations on PA, NWR, RAN, and receptive vocabulary scores obtained from the CI

Table 3
Correlations coefficients of PPVT-K with child variables and phonological processing measures in children with cochlear implants.

	Scores on PPVT-K
Chronological age	$.653^{***}$
Age at implantation	−.127
Duration of an implant use	$.650^{***}$
PA	$.735^{***}$
NWR	$.378^{*}$
RAN	$-.641^{***}$

Note. PPVT-K = Peabody Picture Vocabulary Test – Korean version; PA = phonological awareness; NWR = nonword repetition; RAN = rapid automatized naming. Receptive vocabulary scores were significantly correlated with chronological age, duration of an implant use, PA, NWR, and RAN.

* $p < .05$

*** $p < .001$

group and NH group. Mean scores of PA task were 33.06% ($SD = 23.41$) for CI group and 43.98% ($SD = 19.76$) for NH group. For the NWR task, the mean score of CI group was 60.00% ($SD = 20.87$) and the mean of NH group was 78.60% ($SD = 11.14$). For the RAN task, the mean of CI group was 213.76 s ($SD = 64.57$), and the mean of NH group was 212.96 s ($SD = 63.24$). On the PPVT-K [13], CI group ($M = 50.16$, $SD = 19.69$) scored significantly lower than NH group ($M = 68.04$, $SD = 17.71$) ($t = -3.376$, $p < .01$). The following results section is arranged by stated study objectives.

3.1. Comparison of phonological processing skills between children with CIs and children with NH

ANCOVA was used to assess group (CI vs. NH) difference on three phonological processing task scores while adjusting for chronological age. Means and standard deviations on the phonological processing tasks are shown in Fig. 1. The results reveal that scores for CI group were lower than those for NH group on all the phonological processing tasks. CI group performed significantly lower on the PA task [$F(1, 47) = 6.692$, $p < .05$, $\eta^2_{\text{partial}} = .125$] and on the NWR task [$F(1, 47) = 18.957$, $p < .001$, $\eta^2_{\text{partial}} = .287$]. For the RAN task, however, the difference between CI group and NH group was not statistically significant [$F(1, 47) = .059$, $p > .05$, $\eta^2_{\text{partial}} = .001$].

3.2. Factors contributing to receptive vocabulary skills in children with CIs

Table 3 summarizes correlation coefficients between receptive vocabulary scores on PPVT-K [13] and three child variables and three phonological processing scores in children with CIs. Receptive vocabulary scores were highly related with chronological age ($r = .653$, $p < .001$), duration of an implant use ($r = .650$, $p < .001$), also with PA ($r = .735$, $p < .001$), NWR ($r = .378$, $p < .05$), and RAN ($r = -.641$, $p < .001$) scores. We also found similar tendency in children with NH in which a child's internal variable (chronological age) and other phonological processing skills were significantly correlated with receptive vocabulary scores ($p < .01$).

Multiple regression analysis using stepwise selection identified variables associated with receptive vocabulary skills in children with CIs. Three child variables and three phonological processing variables were entered into a stepwise multiple regression analysis predicting receptive vocabulary skills: chronological age, age at implantation, duration of implant use; PA, NWR and RAN scores. PA was the only significant predictor from these variables, and the association was positive. PA accounted for 54.0% of the variance in receptive vocabulary scores for children with CIs ($\beta = .735$, $p < .001$). For children with NH, it was chronological age ($\beta = .606$, $p < .001$) and PA ($\beta = .369$, $p < .001$) which significantly explained the variance of receptive vocabulary scores, accounting for 77.7% ($p < .001$) of the variance in receptive vocabulary scores.

4. Discussion

This study was designed to investigate the phonological processing skills of children with CIs compared to children with NH, and to assess whether the phonological processing skills predict receptive vocabulary skills in children with CIs beyond chronological age, age at implantation, and duration of an implant use. First, our results showed that children with CIs scored significantly lower on PA and NWR than age-matched children with NH. However, there was no group difference on RAN scores. Second, among phonological processing skills, PA was a significant predictor for receptive vocabulary scores in children with CIs. Based on these results, we suggest that children with better PA skills have higher receptive vocabulary skills after implantation.

Our results confirmed previous studies [7,9] in which children with CIs have lower PA skills compared to children with NH. In Spencer and Tomblin's study [7], the process of learning PA for children with CIs was characterized by a longer, more protracted learning phrase than children with NH. We observed that even children with early implantation continue to have difficulty in acquiring PA skills in comparison with age-matched children with NH. Children with CIs might not develop PA and linguistic skills as well as children with NH because the period of early auditory deprivation prior to implantation may have led to a delay or deficit of PA skills [9]. We could infer that children who received CI at even

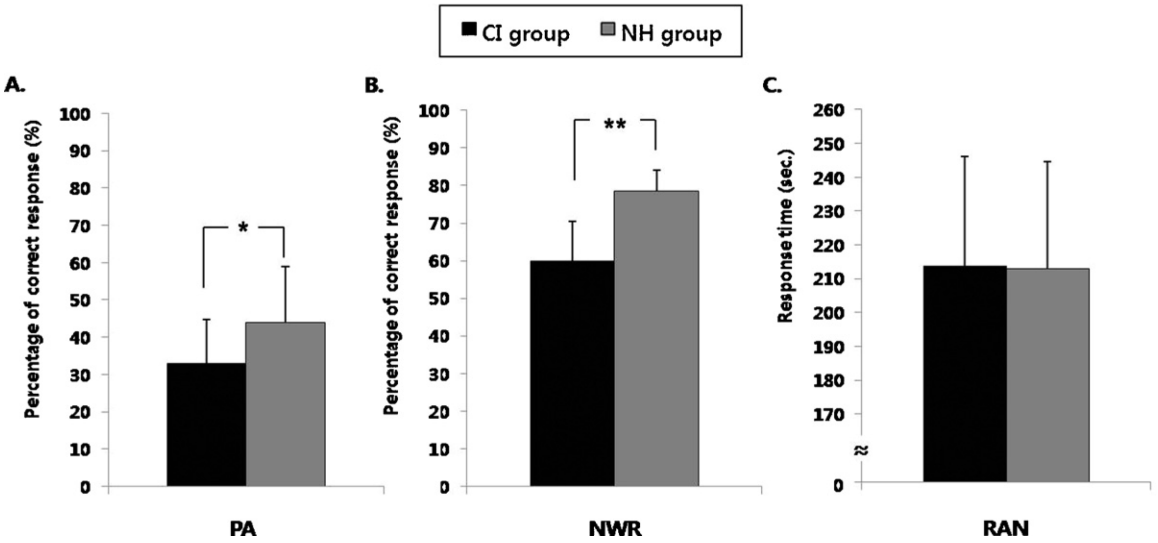

Fig. 1. Mean scores of phonological processing measures for children with cochlear implants and children with normal hearing. (A) CI and NH groups' mean performance on the phonological awareness task. (B) CI and NH groups' mean performance on the nonword repetition task. (C) CI and NH groups' mean performance on the rapid automatized naming task. Error bars represent standard error of the mean. *Note.* CI = cochlear implant; NH = normal hearing; PA = phonological awareness; NWR = nonword repetition; RAN = rapid automatized naming. CI group ($M = 33.06$, $SD = 23.41$) performed significantly lower than NH group ($M = 43.98$, $SD = 19.76$) on the PA task ($p < .05$), and CI group ($M = 60.0$, $SD = 20.87$) also performed significantly lower than NH group ($M = 78.6$, $SD = 11.14$) on the NWR task ($p < .01$). However, the difference between CI group ($M = 213.76$, $SD = 64.57$) and NH group ($M = 212.96$, $SD = 63.24$) was not significant ($p > .05$). * p is significant at .05 level. ** p is significant at .01 level.

earlier age may have problems in acquisition of PA skills because short-term auditory deprivation may inhibit their basic linguistic skill development related to PA.

Additionally, we also found that children with CIs scored significantly lower than age-matched hearing children on the NWR task. PM delay in children with CIs was also observed by Spencer and Tomblin [7]. They reported that children with CIs performed significantly poorer than children with NH on the NWR task in the auditory only condition [7]. These results are similar to other research [4,11] in that children with CIs tend to display shorter working memory for verbal and spatial patterns than children with NH.

PA and PM delay or deficit in children with CIs could be due to perceptual level of auditory limitation. Children with early implantation could not achieve speech perception equivalent to NH children. Auditory information provided by a CI is impoverished and highly degraded when compared to normal hearing. The frequency resolution of sound delivered by a CI is not as high as that the one provided by a normal cochlea. A CI is not able to preserve all acoustic details available in natural speech signals. The processing strategy divides the speech spectrum into some number of channels, and recovers amplitude structure from each of those channels [15,21]. As a result of these limitations, representations of speech sound patterns in children with CIs may be weaker due to degraded auditory input, resulting in underspecified phonological representations. Pisoni et al. also suggested that underspecified phonological representations may reduce the efficiency of PA and PM, which would affect speech perception, word recognition, and language processing [5].

An alternative explanation of poorer PA and PM in children with CIs is that the period of early auditory deprivation prior to implantation may lead to delayed or disordered course of speech perception, speech, and language development. Indeed, there is some evidence suggesting that any degree of hearing loss may cause problems in PM [22,23]. Briscoe et al. [22] found that children with mild to moderate hearing loss scored significantly poorer than children with NH on phonological discrimination and NWR tasks. Gilbertson and Kamhi [23] also noted that even a mild hearing loss was a significant risk factor for the development of phonological processing skills. We could infer that deaf children prior to implantation could not access segmental aspects of speech with conventional hearing aids to develop PA and PM related to speech perception, speech, and language.

We observed in our study that RAN scores did not differentiate between children with CIs and children with NH. This is consistent with the findings of Spencer and Tomblin [7]. They found no significant differences on the rapid letter and number naming between children with CIs and children with NH. This suggests that lexical access in children with CIs is more highly salient than other phonological processing skills. Alternatively, RAN task taps the efficiency with which visual symbols are recoded into children's phonological representations, and children must access long-term memory to retrieve this information (e.g., colors and shapes that children learned very early in their life). This may be why speed of processing was more stable for children with CIs than children with NH, since RAN was measuring the child's efficiency at accessing already known information stored long term. Moreover, Lonigan et al. [24] documented that a 2-factor model in which PA and PM were represented by the first factor and lexical access was represented by the second factor provided the best fit for both younger preschoolers ($n = 129$) and older preschoolers ($n = 304$). Lonigan et al. observed that PA and PM factor was more related to children's oral language skills, cognitive abilities, and early reading skills than was the lexical access.

Our regression analysis revealed that PA skills along with chronological age accounted for 77.7% of variance in receptive vocabulary scores in children with NH. However, only PA skills accounted for 54.0% of variance in receptive vocabulary skills beyond chronological age, age at implantation, and duration of an implant use in children with CIs. Thus, age was important in children with NH but was not as important as PA skills in children with CIs. This implies that chronological age in children with NH drives receptive vocabulary scores but not in children with CIs. However, in our study, children with CIs did not differ from children with NH on chronological age, and children with CIs had an implantation early on. Thus, our results are strictly applicable only to the type of population used in our study.

Additionally, PA skills of children with CIs predicted receptive vocabulary proficiency which suggests a strong link between the ability to map the phonological representations and word learning. In order to learn a word, children not only have to organize the phonological representations of spoken words but must also map phonological representations onto meanings [9]. Children with CIs who have difficulties with PA development may display difficulties in learning new words. The abilities with which children with CIs can learn new words reflect their abilities to organize phonological information into long-term memory. We could infer that PA skills play an important role in receptive vocabulary in children with CIs.

These findings support the previous studies [5,11] in which demographic variables (i.e., age at implantation and duration of an implant use, etc.) are only a small part of explaining CI outcomes in deaf children. To gain a better understanding of a wide range of CI outcomes in deaf children, it is necessary to identify fundamental factors that are responsible for the variability in speech and language outcomes in children with CIs, and to develop reliable predictors of CI outcomes above demographic variables and traditional routine clinical measures [25]. This could lead to new speech and language screenings that can identify children with CIs at high risk for poor language outcomes as early as possible. Lastly, new interventions targeting underlying processes such as phonological and language processing may help deaf children achieve optimal levels of performance and reach important speech and language milestones in development.

5. Conclusions

Children with early implantation performed fairly well compared to age-matched children with NH on RAN task. However, children with CIs showed delays on the PA and NWR tasks. Children with CIs showed lower levels of distinguishing and manipulating syllables or phonemes, and they tended to display shorter working memory for coding, retaining, and producing a string of heard phonemes. For predicting receptive vocabulary skills, it was PA which was the significant predictor in children with CIs whereas it was age and PA in children with NH. These findings support that PA is an important variable that needs to be taken into consideration for children with CIs even for those with early implanted children. Thus, intervention programs serving children with CIs should target these skills for their speech and language development. However, further study will have to document a direct contribution of PA to receptive vocabulary by using treatment paradigm in this population.

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Appendix A. Description of phonological processing tasks

Phonological processing	Subtests or task names	Brief description
Phonological awareness	Elision subtest	Listening to words and deleting a target sound from the words (i.e., say "kimchi," say "kimchi" without the "k").
	Blending subtest	Listening to stimuli and combing word elements to form a word; asking "tell me what word I am trying to say." Test item "kim chi." The child puts the word together and says "kimchi."
	Segmenting subtest	Listening to a word and segmenting a word (real word or pseudo word) into syllables or phonemes; asking "divide a word into syllables." Test item "kimchi." The child segments the word and says "kim chi."
Phonological memory	Nonword repetition task	Listening to nonwords without visual cues and repeating them. Test item "nube." The child repeats the nonword "nube."
Lexical access	Rapid automatized naming task	Child calls the names the whole series of color, shape, and color-shape each item from block of items on page. Child calls each item once and total time is recorded.

Note. The words used in the brief descriptions are examples and not the real test items used in the phonological awareness tasks.

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