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A comparison of Speech Duration in Cochlear Implant and Normal Hearing Elementary School Students in the Imitation and Reading Tasks

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ABSTRACT

Background and Objectives: Excessive duration is one of the suprasegmental features in cochlear implant children. Regarding the importance of the normal rate of speech in transferring the intonation and clarity of speech, the present study aims at comparing word and sentence duration in cochlear implant and normal hearing children in imitation and reading tasks.

Methods: The present descriptive-analytical study was performed on 30 elementary school cochlear implant children versus 30 normal hearing children. Voice recording was done in a silent room. The Persian-speaking subject was asked to utter "/sælam/ (hello)" and "/ʔemruz nemiyad/ (He won't come today)" with the following moods and emotions: statement, question, exclamation, with happiness and with sadness. Then, they were asked to do the same task imitating the voice which had been recorded earlier. Data recording was done using Praat software and data analysis was done by SPSS software.

Results: The average duration in cochlear implant children in two modes of imitating and reading a word showed a significant difference with that of children with normal hearing ($P < 0.001$). Moreover, in both groups, the average duration of reading the word was less in comparison with imitating the word. Also, the average duration in cochlear implant children in two modes of imitating and reading a sentence showed a significant difference with that of children with normal hearing ($P< 0.001$). In the cochlear implant group, the average duration of imitating the sentence was less than the average duration of reading the sentence, whereas in the normal hearing group, the average duration of reading the sentence was less than the average duration of imitating the sentence.

Conclusion: The average duration in cochlear implant in all modes (word imitation, word reading, sentence imitation, sentence reading) was more than normal hearing children, which results in abnormal intonation in these children. According to the present study, imitation cannot cause a decrease in duration and consequently, does not result in more natural intonation. Hence, it is probably not a proper therapeutic method.

Keywords: Speech duration, Cochlear implant, Normal hearing, Imitation, Reading, Persian

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Introduction

One of the most important senses to acquire speech is hearing. Researchers believe that the infant is able to process sounds around him from birth, so that he will be able to acquire speech and learn the language by reliance on the sense of hearing (Werner, 2007). In children with hearing impairment, the deficiency in verification of audible information, particularly in pre-lingual period, leads to speech disorders. The reason is that in addition to neurotic-muscular control, hearing is essential for the appropriate performance in oral communication (Coelho, Brasolotto, Bevilacqua, Moret & Júnior, 2015). Therefore, the reinforcement of hearing has been emphasized in children with hearing impairment (Abbasian Nik, Hassanzadeh, & Ghobaribonab, 2013). In recent years, progress in technology and hearing-aid equipment has paved the way to enhance hearing performance.As a result, this also reinforced linguistic skills as well as speech (Ashoori, Hasanzadeh, & Pourmohamadreza Tajrishi, 2013). Cochlear implant is a kind of common surgery in the world which is used to reinforce the sense of hearing in people with intense or deep hearing impairment. The operation includes implanting an electronic device inside the inner ear that functions as hearing aid equipment for them (Shankar, 2015). This device enables many congenial or pre-lingual deaf children to hear and understand speech and acquire their mother language (Wang, Trehub, Volkova, & van Lieshout, 2013). Since cochlear implant is a hearing substitute whose most specific advantage is hearing and perceiving sounds and consequently leading to better and more natural production of speech sounds, it is best that this operation be done at an earlier ages (Roohparvar, Bijankhan, Hasanzadeh, & Jalaie, 2010). Cochlear implant facilitates perception of speech and gives a substantial help to the advancement of different aspects of speech production, including increasing speech clarity, consonant production, vowel production, and speech prosody (Jafary, 2012).

Prosody is defined as the suprasegmental feature of speech. Speech intonation is one of the most important components of speech prosody whose parameters include fundamental frequency, intensity, and duration (Chin, Bergeson, & Phan, 2012). Every moment, hearing feedback is important in controlling the suprasegmental features of speech such as fundamental frequency, intensity, and duration (Angelocci, Kopp, & Holbrook, 1964). Children with normal hearing acquire speech prosody features before they could utter two-word phrases and are able to produce falling intonation properly up to 80 percent (Snow, 2001). However, imperfect hearing feedback in children with hearing impairment hinders them from forming normal intonation (Chin, 2012). Despite the mentioned advantages of cochlear implant, children with cochlear implant display major defects in the production of prosody, particularly intonation (Nakata, Trehub, & Kanda, 2012) because such devices provide limited information concerning the temporal and categorical features of speech (Wang, Trehub, Volkova, & van Lieshout, 2013; Nakata, Trehub, & Kanda, 2012).

Some suprasegmental errors that occur in children with hearing impairment include: excessive duration, low rate of speech, and abnormal changes of intonation (Hide, Gillis, & Govaerts, 2007; Bochner, Snell, & MacKenzie, 1988; Lenden & Flipsen, 2007). Duration means the time needed to produce each unit of language or a speech sample which is calculated by millisecond and is one of the major components of speech intonation that if damaged, the speech produced by impaired hearing becomes significantly unclear (Jafary, Yadegari, & Torabineghad, 2014; Cruttenden 1997; Mardani, Safaeyan, Tavakoli, Sobhani, & Ghaemi, 2014). By using duration, some paralinguistic information like confirmation and denial could be realized (Ishi, Ishiguro, & Hagita, 2008). In some languages such as Arabic, duration functions as a phoneme component which leads to semantic contrast, whereas in Persian the duration is only a phonetic feature which leads to changes in intonation (Nikravesh, Torabinezhad, Ghorbani, & Keyhani, 2012).

Despite the importance of duration in intonation and clarity of speech in children with hearing disorders, a few researches in this field have been carried out in recent years in IRAN. For instance, Kord et al. investigated the acoustic correlations of intonation

in sentences and statements in 50 elementary school students. According to the findings of their research, speech duration in cochlear implant children is significantly more than normal children (Kord, Shahbodaghi, Khodami, Nourbakhsh, & Jalaei, 2013). Jafary et al. compared vowel duration in Persian, in 20 pre-lingual cochlear children and 20 normal hearing children aged 5-9 years old. The words included /bid/, /bed/, /bud/, /bod/, /bad/ & /bæd/. The results showed that duration of 6 Persian vowels in cochlear implant children was longer than the duration of the same vowels in normal children (Jafary, Yadegari, & Torabineghad, 2014). In a study, Clark showed that the duration and pause in utterances of cochlear implant children is more than in normal children, particularly as the number of syllables increases (Clark, 2007). Vandam et al. showed that vowel duration in words in children with hearing aids and cochlear implant is longer than that of normal children, while children with hearing aids and cochlear implants did not perform differently from each other (Vandam, Ide-Helvie, & Moeller, 2011). Also, Uchanski and Geers realized that vowel duration in sentences in cochlear implant children is 132 milliseconds longer than vowel duration with normal hearing (Uchanski & Geers, 2003). In a study, O'Haplin showed that speech length in cochlear implant children is significantly longer than in normal children (O'Halpin, 2010). Levitt and Osberger showed that vowel duration in continuous speech in children with hearing problems is longer than vowel duration in normal children (Osberger & Levitt, 1979).

The present study aims at studying and comparing word and sentence duration in cochlear implant and normal hearing elementary school students in the tasks of reading and imitation. Two tasks were chosen so as to find an answer to the following question: does giving the right pattern in the form of imitation cause a change in speech duration of cochlear implant children?

Material and Methods

The current study is descriptive-analytic and it is applied through a cross-sectional and non-interventional investigation done on 30 cochlear implant (10.3 ± 0.39) and 30 normal hearing (10 ± 0.31) elementary school students. The samples were selected from children who referred to MAHASH clinic as well as the children who were studying in hearing impairment schools and children attending normal schools in the city of Tehran, Iran, along with considering the age parameter of the participants.

The provisions for including all the children in the study were the following: normal IQ, being monolingual, and being elementary school students. In addition to these, the provisions based on which cochlear implant children were included in the study were: congenital hearing problems or before learning language, one-sided cochlear implant, and having passed rehabilitation and speech therapy courses. The criteria to be excluded from the study for both groups were a record of having neurotic-muscular illnesses, having structural and movement disorders in speaking organs, physical or mental disabilities which cause malfunction in doing the tasks, diseases such as epilepsy and seizure, bilingualism, or having cold or respiratory diseases.

Sampling and voice recording was done in a silent room. Each subject was asked to sit on a chair in a way that they prevent the head or neck from turning to sides or upward/downward as much as possible. Voice recording was done by a condenser microphone connected to an ASUS X452L laptop and using Praat software (version 5.2.15). In order to decrease the noise, the microphone was set and fixed 5 to 10 centimeters from the subjects' mouths. To make sure that the subject is speaking in his routine constant voice, the sampling was done after at least two hours after waking up.

Before sampling, the subject was given a list of the intended tasks so that he could read them as a practice and also get familiar with these tasks. To make the subject ready for voice recording, he/she was asked to produce the vowel /a/ continuously for some seconds. Then the subject was given "/sælam/ (Hello)" and "/ʔemruz nemiyad/ (He won't come today)" [taken from a study done by Nikravesh et al. (Nikravesh, Aghajanzade, 2011)] and was asked to read them with the following moods and emotions: exclamation, sad-

ness, happiness, question, and statement. To guide the subject through different ways of articulation, the following emotions and sign were used: surprised, sad, happy, and question mark (?). In the next step, the subject was given a break and reward and was asked to do the same tasks by imitating the voices which had been recorded before.

Upon completion, the audio samples were TextGrided using Praat software. Then, by use of the proper script, the duration related to each sample was extracted. Statistical data analysis was done using SPSS (version 22).

Results

The repeated measurement analysis indicated that the mean duration to produce "/sælam/" in different modes of imitation and reading had significant difference between the two groups (P-Value < 0.001). As it can be seen in figure 1, the mean duration to produce "/sælam/" in all modes of imitation and reading in the cochlear implant group was longer than that of the normal group. Also, in the two groups as studied separately, the mean duration of "/sælam/" in different modes showed a significant difference (P-Value < 0.001). According to tables 2 and 3, the longest duration time in the two groups was that of exclamation imitation, the shortest duration time in the cochlear implant group was that of reading in exclamation emotion, and the shortest duration time in normal hearing group was that of reading in statement mood. Also, it was observed that in both groups, mean duration in reading mode was less than that of imitation mode.

Mean duration of the sentence "/ʔemruz nemiyad/" in different modes of imitation and reading showed a significant difference between the two groups (P-Value < 0.001). As it can be observed in figure 2, mean duration of "/ʔemruz nemiyad/" in imitation as well as reading mode in the cochlear implant group was longer than that of the normal hearing group. Moreover, in the two groups as studied separately, the mean duration of "/ʔemruz nemiyad/" in different modes showed a significant difference (P-Value < 0.001). According to tables 2 and 3, the longest duration time in the cochlear implant group was that of reading in sad emotion, and the shortest duration time was that of imitation in statement mood. On the other hand, the longest duration time in the normal group was that of imitation in happiness emotion, and the shortest duration time was that of reading in statement mood. The comparison of mean duration of the sentence in reading and imitation showed that in the cochlear implant group, mean duration of the sentence in imitation was less than reading, while in the normal hearing group sentence duration in reading was less than imitation.

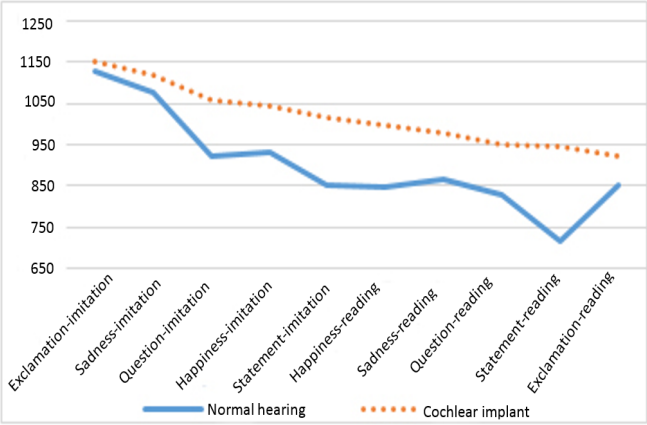

Diagram 1. The comparison of mean duration of "/sælam/" in the two groups in different moods and emotions of imitation and reading by millisecond

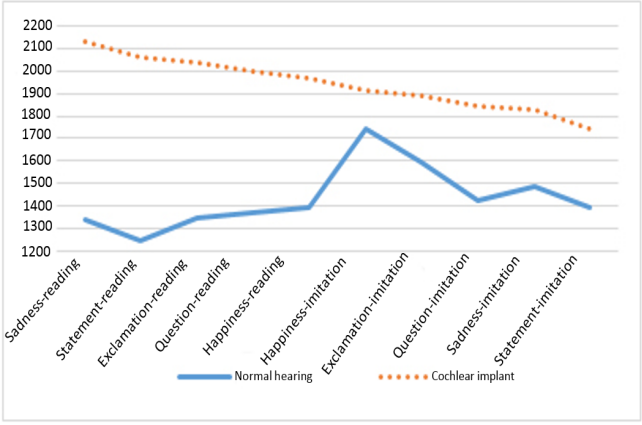

Diagram 2. The comparison of mean duration of "/emruz nemiyad/" in the two groups in different moods and emotions of imitation and reading by millisecond

Table 1. Mean and standard deviation of duration of "/sælam/" and "/ʔemruz nemiyad/" in different moods and emotions in imitation and reading in the two groups by millisecond

			Cochlear Implant	Normal Hearing
mood/emotion	Task	Type	Mean (SD)	Mean (SD)
exclamation	/sælam/	imitation	1149.60 (54.47)	1127.06 (50.95)
		reading	921.10 (54.67)	852.37 (51.23)
	/ʔemruz nemiyad/	imitation	1885.85 (81.92)	1127.06 (50.95)
		reading	2040.64 (124.73)	852.37 (51.23)
sadness	/sælam/	imitation	1059.64 (46.30)	922.93 (43.31)
		reading	948.76 (50.88)	826.18 (47.60)
sadness	/ʔemruz nemiyad/	imitation	1829.64 (81.07)	922.93 (43.31)
		reading	2132.89 (110.86)	826.18 (47.60)
happiness	/sælam/	imitation	1120.10 (51.66)	1078.53 (48.32)
		reading	978.39 (53.06)	865.00 (49.63)
	/ʔemruz nemiyad/	imitation	1120.10 (51.66)	1078.53 (48.32)
		reading	978.39 (53.06)	865.00 (49.63)
question	/sælam/	imitation	1045.78 (42.21)	933.68 (39.47)
		reading	999.00 (51.96)	847.15 (48.61)
	/ʔemruz nemiyad/	imitation	1045.78 (42.21)	933.68 (39.48)
		reading	999.00 (51.96)	847.15 (48.61)
statement	/sælam/	imitation	1015.78 (47.17)	850.87 (44.12)
		reading	947.67 (45.65)	716.31 (42.70)
	/ʔemruz nemiyad/	imitation	1015.78 (47.17)	850.87 (44.12)
		reading	947.67 (45.65)	716.31 (42.70)

Table 2. Sentence duration of broadcasted sound in different moods and emotions by millisecond

Modes	Task	Duration
exclamation	/sælam/	1305
	/ʔemruz nemiyad/	1527
sadness	/sælam/	1038
	/ʔemruz nemiyad/	1473
happiness	/sælam/	932
	/ʔemruz nemiyad/	1799
question	/sælam/	972
	/ʔemruz nemiyad/	1370
statement	/sælam/	872
	/ʔemruz nemiyad/	1388

Table 3. Variation range of duration of "/sælam/" and "/ʔemruz nemiyad/" in the two groups in different moods and emotions

Task	Type	Hearing	Max – Min
/sælam/	Imitation	cochlear implant	exclamation – happiness
		normal	happiness – exclamation
	Reading	cochlear implant	exclamation – happiness
		normal	sadness – statement
/ʔemruz nemiyad/	Imitation	implant cochlear	happiness – statement
		normal	statement – happiness
	Reading	cochlear implant	happiness – sadness
		normal	happiness – sadness

Discussion

This study aims at comparing word and sentence duration in cochlear implant and normal elementary school students in imitation and reading. Hence, the word "/sælam/" and the sentence "/ʔemruz nemiyad/" were chosen because they are used in everyday speaking, they are not dependent on the subjects level of knowledge, they are short, and they can be measured quickly.

The results showed that mean duration of "/sælam/" in cochlear implant children in all moods and emotions (exclamation, sadness, happiness, question, and statement) is significantly longer than in normal hearing children both in imitation and reading.

It was observed that mean duration of "/sælam/" in both groups in all modes is shorter in reading as compared to imitation, which maybe because the test is a one-word that is considered as an everyday use with which the subjects are familiar. In other words, this result is because the participant reads the word in a short time in the process of reading the whole word while in imitation, the subject tries to imitate the speech pattern which s/he has heard and that causes the contestant to imitate the one-word slower than when s/he tries to read it.

The results also showed that the mean duration of "/ʔemruz nemiyad/" in cochlear implant children is longer than in normal hearing children in all modes of imitation and reading.

The mean duration of the sentence "/ʔemruz nemiyad/" in cochlear implant group is longer in reading as compared to imitation, contrary to the result of reading the word "/sælam/" where the distance between the reading curve of the two groups is low. In reading the sentence "/ʔemruz nemiyad/", the distance between the curve of the two groups has been much bigger – which shows that the cochlear implant group takes a much longer duration in reading the sentence than the normal hearing group. It can be deducted that since the sentence is composed of two words and there is a long pause between the two words, cochlear implant children take a much longer duration to finish reading the sentence. of . This is because one of the features of speech prosody in children with hearing impairment is long pauses (Clark, 2007), while in imitation, the subject imitates the pattern which is not much paused. Moreover, as discussed by Clark, as the number of the syllables increases, the duration needed by cochlear implant children becomes longer than that needed by normal children.. Thus, the increase in number of the syllables in the sentence "/ʔemruz nemiyad/" can be another reason for the duration difference between the two groups. (Clark, 2007).

The results of the present study show that the mean duration of cochlear implant children in all tasks is longer than in normal children. Kord et al. have also indicated that the mean duration of cochlear implant children in question and statement moods is significantly longer than normal hearing children (Kord, Shahbodaghi, Khodami, Nourbakhsh, & Jalaei, 2013). Jafary's study also indicated that cochlear implant children's duration of the Persian language vowels is longer than normal children (Jafary, Yadegari, & Torabineghad, 2014).

The present study as well as Clark's study indicated that the duration needed by cochlear implant children speech, particularly when the number of the syllables increases, is longer than that needed by normal children (Clark, 2007). The results of the study of Vandam et al. indicated that vowel duration in words pronounced by cochlear implant children is longer than that in normal children (Vandam, Ide-Helvie, & Moeller, 2011). Also, Uchanski and Geers indicated that vowel duration in sentences said by cochlear implant children is longer than normal hearing children (Uchanski & Geers, 2003). In a study, O'Halpin indicated that speech duration in cochlear implant children is significantly longer than in normal children (O'Halpin, 2010). Levitt and Obseger indicated that vowel duration in the group with severe hearing impairment is longer than in the normal hearing group (Osberger & Levitt, 1979).

Hence, the results of the present study are the same as previous studies and all indicate that mean duration of speech in cochlear implant children is longer than

in normal children. The analysis of mean duration in the cochlear implant group in different moods and emotions indicated that the mean duration is different in different modes of the word "/sælam/" and the sentence "/ʔemruz nemiyad/" in such a way that the longest duration in the word "/sælam/" was that of imitation with exclamation emotion, and the shortest was that of reading in exclamation emotion. Also, the longest duration in the sentence "/ʔemruz nemiyad/" was that of reading in sad emotion, and the lowest was that of imitating in statement mood. The mean duration of different modes of the aforementioned word and sentence in normal group also showed different values, such that the longest word duration in this group was that of imitation with exclamation emotion, and the lowest was that of reading in statement mood. Also, the longest sentence duration was that of imitation with happy emotion, and the lowest was that of reading in statement mood. Therefore, it can be deducted that a word or a sentence in different modes (exclamation, sadness, happiness, question, and statement) has different durations and one factor that affects speech duration is its emotional state. Nikravesh has also indicated that different moods of a sentence have different durations as well (Nikravesh, 2010).

In addition to studying the mean duration between the two groups, the present study also aims at finding an answer to the following question: Will the duration disorder in cochlear implant children be improved by giving an appropriate duration pattern in imitation mode?

The longest mean duration (tables 2 & 3) in the two groups in imitating "/sælam/" was that of exclamation emotion, and the longest mean duration of "/ʔemruz nemiyad/" was that of happy emotion – which is completely similar to the longest duration of the broadcasted sounds in the word and the sentence. Also, the lowest mean duration in the two groups in imitating both tasks (imitation and reading) was similar to one another and different from the broadcasted sound. The lowest duration of "/sælam/" in the two groups was that of happy emotion, and in broadcasted sound was that of statement tone. Also, the lowest duration of "/ʔemruz nemiyad/" in the two groups was that of statement mood, and in the broadcasted sound, it was that of question mood. The cochlear implant group had a relatively similar performance to that of the normal group in imitating the word and the sentence, in such a way that the longest and lowest duration in the two groups in the given tasks is similar and there is no meaningful difference between the variation ranges of the two groups. On this basis, it can be understood that when the duration of the given task is long, the cochlear implant group as well as the normal group is able to imitate it properly, while when the duration of the given task is short, neither of the two groups are able to imitate it. Therefore, it can be deducted that both groups have probably understood the notion of duration and were trying to imitate it, but they could not adjust its level.

Since duration is one of the main components of speech intonation and any damage to it results in defect(s) in intonation and decreases speech clarity of these children, in the present study, duration was studied as a prosodic element. The present study aimed at presenting an appropriate solution to decrease duration, and hence enhancing the intonation and speech clarity of cochlear implant children. For this purpose, the imitation therapeutic method was applied, but the results indicated that cochlear implant children's performance in imitation differs depending on the type of the task and its emotional state. Therefore, it can be said that the imitation method is probably not an appropriate method to improve duration in these children and hence more appropriate methods should be looked for.

Conclusion

In general, the duration of speech in cochlear implant children in various emotional states, in imitation and reading, is longer than normal hearing children. Although cochlear implant children's performance in imitation is relatively similar to normal hearing children, but their performance in reading is very different and their mean duration of speech, particularly as the number of the syllables increases, is much longer than normal group which could be probably

due to patterns being internal – which exposes itself more in reading. CI children's longer duration results in disruption of their speech intonation. Although the results showed that the imitation method does not cause cochlear implant children to follow speaker's duration as they should, but when the duration of the given tasks is long, cochlear implant children are able to imitate it. Hence, it is suggested that the therapists who deal with such children begin the treatment from the highest level of duration if they utilize imitation method for modifying duration.

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Conflict of Interest

Authors declared no conflict of interest.

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مقایسهٔ دیرش گفتار کودکان کاشت حلزون شده با کودکان طبیعی مقطع دبستان در تکالیف تقلید و خواندن

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چکیده

زمینه و هدف: یکی از ویژگی‌های زبرزنجیری گفتار در کودکان کاشت حلزون شده، دیرش زیاد است. با توجه به اهمیت دیرش در انتقال آهنگ و وضوح گفتار، هدف پژوهش حاضر مقایسهٔ دیرش کلمه و جمله در کودکان کاشت حلزون شده با کودکان طبیعی در تکالیف تقلید و خواندن بود.

روش کار: مطالعهٔ توصیفی ـ تحلیلی حاضر روی ۳۰ کودک کاشت حلزون شده و ۳۰ کودک با شنوایی طبیعی مقطع دبستان صورت گرفت. ضبط صدا در اتاقی آرام انجام شد. از آزمودنی‌ها خواسته شد کلمهٔ «سلام» و جملهٔ «امروز نمیاد» را با حالت‌های خبری، پرسشی، شادی و ناراحتی بخوانند. سپس از آنها خواسته شد همین تکالیف را این‌بار از صدایی تقلید کنند که از قبل ضبط شده بود. ضبط صدا با نرم‌افزار praat و تحلیل داده‌ها با SPSS انجام شد.

یافته‌ها: میانگین دیرش کودکان کاشت حلزون شده در خواندن و تقلید کلمه با کودکان طبیعی تفاوت معنادار داشت ($P>۰/۰۰۱$). علاوه بر این در هر دو گروه میزان دیرش خواندن کلمه نسبت به تقلید آن کمتر بود. همچنین میانگین دیرش کودکان کاشت حلزون شده در خواندن و تقلید جمله با کودکان طبیعی تفاوت معنادار داشت ($P>۰/۰۰۱$)؛ به‌طوری که در این گروه از کودکان میزان دیرش در تقلید جمله کمتر از میزان آن در خواندن بود، در حالی که در گروه کودکان طبیعی میزان دیرش در خواندن جمله کمتر از میزان آن در تقلید بود.

نتیجه‌گیری: میزان دیرش کودکان دارای کاشت حلزون در همه حالت‌های کلمه و جمله و در تقلید و خواندن بیشتر از کودکان دارای شنوایی طبیعی است که به آهنگ غیرطبیعی گفتار در این گروه از کودکان منجر می‌شود. بر اساس یافته‌های پژوهش حاضر، تقلید نمی‌تواند باعث کاهش دیرش و در نتیجه بهبود آهنگ گفتار شود که نشان می‌دهد احتمالاً روش درمانی مناسبی نیست.

واژه‌های کلیدی: دیرش گفتار، کودکان دارای کاشت حلزون، کودکان شنوای طبیعی، مهارت تقلید و خواندن