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# A comparison of speech intonation production and perception abilities of Farsi speaking cochlear implanted and normal hearing children

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ABSTRACT

*Introduction:* Cochlear implant prosthesis facilitates spoken language development and speech comprehension in children with severe-profound hearing loss. However, this prosthesis is limited in encoding information about fundamental frequency and pitch that are essentially for recognition of speech prosody. The purpose of the present study is to investigate the perception and production of intonation in cochlear implant children and comparison with normal hearing children.
*Method:* This study carried out on 25 cochlear implanted children and 50 children with normal hearing. First, using 10 action pictures statements and questions sentences were extracted. Fundamental frequency and pitch changes were identified using Praat software. Then, these sentences were judged by 7 adult listeners. In second stage 20 sentences were played for child and he/she determined whether it was in a question form or statement one.
*Results:* Performance of cochlear implanted children in perception and production of intonation was significantly lower than children with normal hearing. The difference between fundamental frequency and pitch changes in cochlear implanted children and children with normal hearing was significant ($P < 0/05$). Cochlear implanted children performance in perception and production of intonation has significant correlation with child's age surgery and duration of prosthesis use ($P < 0/05$).
*Discussion:* The findings of the current study show that cochlear prostheses have limited application in facilitating the perception and production of intonation in cochlear implanted children. It should be noted that the child's age at the surgery and duration of prosthesis's use is important in reduction of this limitation. According to these findings, speech and language pathologists should consider intervention of intonation in treatment program of cochlear implanted children.


## 1. Introduction

One of the main features of all languages is prosody. Prosody is regimentation of pretty important factors producing the speech signal. It is mostly revealed in the rhythm of the speech and affects various aspects of the speech signal. To display what information in an utterance is important pragmatically, the speakers use the intonation. In addition, the speakers transmit their pragmatic intentions using intonation. The melody of voice at the larger levels of speech for example discourse and conversation can show intonation [1,2].

There are many important differences in the arrangement of prosodic structures and the organization of intonation events within various languages of the world. Generally, different languages have different intonation and pragmatic patterns. Some languages are tonal (for example Mandarin and Japanese) which have lexical tone and some of them are non-tonal or stress-timed language (such as English or Farsi) [3].

Indeed, the template of pitch changes in the speech is intonation and regularly called melody of language. These pitch changes can occur on words or phrases. Farsi is a stress language. In this language pitch variations on the words doesn't change their meanings, but does change, for example, an utterance from a statement to a question, or emphasize different words for pragmatic functions. Thus in Farsi as a stress-timed language, a statement can be converted to a question by tone (but the meaning of singular words does not change by tone lonely). Yet another use of intonation in Farsi is depicting some extra-linguistic attitudes such as surprise, impatience, sarcasm, etc [4,5].

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In Farsi like many other languages, the common intonation template of statement sentences is the decline of the pitch at the end of the sentence [6]. Also, in Farsi, the yes/no questions are created by adding the word "?âyâ" to the onset of sentences. The order of words in sentence remains unaffected after insertion of "?â yâ". In everyday speech, people only create such questions with using the rising intonation without inversion of subject-operator or subject-auxiliary. In fact, they increase the pitch on the last syllable of the phrase in yes/no question. This pattern signals a pause for audience's response and hence maintains a continuous flow of conversation between two interlocutors [5,6].

In severe to profound sensorineural hearing loss persons, an auditory prosthetic device, cochlear implant (CI), that implanted in the inner ear can stimulate primary auditory nerve fibers to evoke sound sense [7]. Researchers in many studies have reported that the development of speech and language can be facilitated by CI [8–10]. Most of these studies investigated segmental aspects of speech. Nevertheless, some researchers stated that persons with cochlear implant often experience difficulties in acquisition of suprasegmental characterizes. The fundamental frequency is one of the most important suprasegmental features of speech among intonation, lexical stress, rhythm, and tone, which has a significant function in the perception and production of intonation. The perceptual correlate of the fundamental frequency ($F_0$) is the pitch. When the $F_0$ is high in the speech, this speech is comprehended as "high pitch speech" [11]. The wider pitch range in normal hearing persons perceive as higher speech intelligibility by the listener and lack of pitch changes in the speech is associated with monotonous speech [12,13]. The persons with severe to profound hearing loss who use the current CI have difficulty to the recognition of prosodic characteristics of speech that based on the pitch (e.g. fundamental frequency) [14]. To perception of prosodic components of speech such as intonation, persons need to the perception of such pitch changes [15]. However, the recognition of the prosodic portions of speech relies on the encoding voice pitch information, so it is probable that CI devices have limited advantages to simplify the acquisition of the prosodic portions of speech in deafened children [16].

Most and Peled (2007) reported that severe to profound hearing loss children wearing hearing aids carried out significantly better in intonation and stress perception than CI children [3]. Peng, Tomblin, and Turner (2008) investigated production and perception of intonation in CI and NH children and found that CI group had poorer performance in both tasks than their NH peers [7]. Peng et al. (2004) illustrated that CI children's ability in production of rising intonation in yes-no questioning sentences was significantly lower than NH children [12]. Klieve and Jeans (2001) reported that in CI children production of intonation contours was more difficult than the production of lexical stress or accent [17].

One year children can discriminate words according to prosodic cues [18]. At a very young age, using of intonation can be seen in infants' vocalization and utterances universally [19]. Unlike intonation patterns, diverse intonation contours (e.g., falling at the terminal place of a statement) do not appear at a very young age. For children, mastering in use of rising intonation contours is harder than falling. In fact, rising intonation doesn't produce masterly until preschool years [20].

Whereas cochlear implantation can facilitate the acquisition of communication skills in severe to profound hearing loss children, but it has some limitations in the development of intonation perception and production [21].

The number of studies that have examined the suprasegmental features of speech in CI children is few, and the most of them have been done in segmental characteristics of speech. Thus, the aims of this study are to investigate the production and perception of speech intonation in Farsi cochlear implant children, to compare these skills with those of normal hearing peers, and to evaluate the potential effects of age of implantation and duration of implant use on perception and production of intonation in Farsi cochlear implant children.

## 2. Method

### 2.1. Participants

The participants were divided into three groups: cochlear implant group (CI), normal hearing group (NH) and adult listeners.

**Table 1**
Demographics data and device detail.

| subject | Gender | Age at test time (years) | Age at implantation (month) | Duration of implant use (years) | Device type | Speech coding strategy |
|---|---|---|---|---|---|---|
| 1 | Male | 11 | 42 | 7.6 | N 22 | SPEAK |
| 2 | Female | 9 | 12 | 8 | N 22 | SPEAK |
| 3 | Male | 11 | 18 | 9.6 | N 22 | SPEAK |
| 4 | Female | 7 | 72 | 1 | N 22 | SPEAK |
| 5 | Male | 9 | 24 | 7 | N 22 | ACE |
| 6 | Male | 7 | 18 | 5.6 | N 24 | SPEAK |
| 7 | Female | 11 | 20 | 9.4 | N 24 | SPEAK |
| 8 | Female | 7 | 60 | 2 | N 22 | ACE |
| 9 | Male | 8 | 36 | 5 | N 22 | ACE |
| 10 | Female | 8 | 48 | 4 | N 24 | ACE |
| 11 | Female | 10 | 12 | 9 | N 22 | SPEAK |
| 12 | Male | 10 | 24 | 8 | N 22 | SPEAK |
| 13 | Female | 8 | 7 | 7.5 | N 22 | ACE |
| 14 | Male | 8 | 8 | 7.4 | N 22 | ACE |
| 15 | Male | 11 | 12 | 10 | N 24 | SPEAK |
| 16 | Male | 7 | 72 | 1 | N 24 | SPEAK |
| 17 | Female | 9 | 18 | 7.6 | N 24 | SPEAK |
| 18 | Female | 11 | 42 | 7.6 | N 22 | SPEAK |
| 19 | Male | 7 | 30 | 4.6 | N 22 | ACE |
| 20 | Male | 10 | 13 | 8.11 | N 22 | ACE |
| 21 | Male | 7 | 39 | 3.9 | N 22 | ACE |
| 22 | Male | 10 | 36 | 7 | N 22 | ACE |
| 23 | Female | 9 | 17 | 7.7 | N 22 | SPEAK |
| 24 | Female | 10 | 24 | 8 | N 22 | SPEAK |
| 25 | Male | 8 | 72 | 2 | N 22 | SPEAK |
| Mean | | 8.92 | 31.4 | 6.34 | | |