

The Influence of Emotional Prosody on Mandarin Tone Perception by Children with Cochlear Implants

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Mandarin Chinese is a tonal language using four lexical tones with different pitch contours to differentiate word meanings [1]. However, for children with cochlear implants (CIs), accurate tonal perception is still a great challenge since CI devices cannot transmit pitch information effectively [2]. Furthermore, their tonal perception is even challenging in sentences, where tonal realizations are altered by intonation patterns, such as emotional prosody [3,4,5]. Despite this, daily speech often involves face-to-face communication, where the production of Mandarin tones is also accompanied by specific visual-articulatory movements, which have been proved to facilitate tonal perception, especially in noisy environment [6]. For example, it has been found that, relative to auditory-only condition, children with CIs showed more accurate tonal perception in audio-visual condition (where children can see speakers' articulatory movements) under noise [7,8]. However, it remains unclear whether children with CIs also use visual cues to facilitate tone perception in sentences with different emotion prosody. Therefore, this study aims to investigate the impacts of emotional prosody (angry and happy) on Mandarin tone perception of children with CIs and to examine whether visual-articulatory cues can facilitate their perception.

Forty-four Mandarin-speaking children (22 CIs and 22 NHs) aged 4-6 participated in this study. Stimuli consisted of 144 monosyllabic words forming 72 tonal minimal pairs across six tonal contrasts, embedded in a disyllabic carrier sentence (“zhao3 dao4 X”, Find the X) produced by a professional female speaker in happy, neutral, and angry prosody. Two presentation conditions were created with babble noise added (SNR = -6 dB): audiovisual (AV), where participants both heard and saw the speaker, and audio-only (AO), where participants heard only the acoustic signal without visual information. Participants were tested individually in quiet rooms and completed two blocks (AO and AV), each including 36 trials (6 tonal contrasts $\times$ 3 emotions $\times$ 2 environments). In each trial, participants performed a two-alternative picture identification task, and responses were recorded.

The perception accuracy was analyzed with linear mixed-effects models (Tables 1 and 2). The results showed that NH children's performance remained comparably high in both AO and AV conditions, across emotion types and environments (Fig. 1.). However, relative to neutral prosody, children with CIs showed lower tone perception accuracy for angry prosody in noisy environment. Despite this, tonal perception of children with CIs in noisy condition demonstrate clear visual benefits, where their perception accuracy is much higher in AV condition as compared to that in AO condition, albeit for neutral and angry emotions only (Fig. 2.).

Our results demonstrated tonal perception with CIs were influenced by emotional prosody, especially angry prosody. Importantly, children with CIs can use additional visual cues to improve their tonal perception particularly in noise. These findings highlight the role of visual cues in tone perception for children with CIs in complex conditions and have implications for rehabilitation strategies of children with CIs.

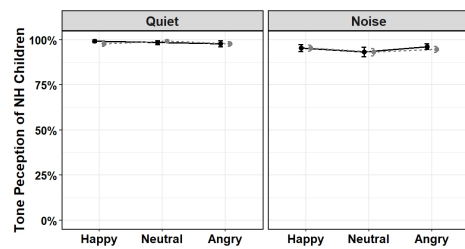


Fig. 1. Tone perception accuracy of Normal-Hearing Children.

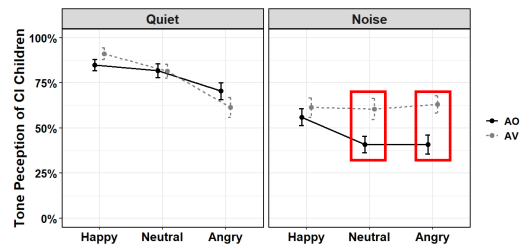


Fig. 2. Tone perception accuracy of Children with CIs.

Table 1. Effects of Emotion, Environment, and Modality on Tone Identification in NH Children.

Effect	df	χ^2	p
Emotion	2	0.764	0.683
Environment	1	16.90	< 0.001
Modality	1	0.181	0.671
Emotion*Environment	2	2.693	0.26
Environment*Modality	1	0.02	0.887
Emotion*Modality	2	0.362	0.835
Emotion*Environment*Modality	2	0.523	0.77

Table 2. Effects of Emotion, Environment, and Modality on Tone Identification in Children with CIs.

Effect	df	χ^2	p
Emotion	2	0.764	< 0.001
Environment	1	16.90	< 0.001
Modality	1	0.181	0.003
Emotion*Environment	2	2.693	0.006
Environment*Modality	1	0.02	< 0.001
Emotion*Modality	2	0.362	0.775
Emotion*Environment*Modality	2	0.523	0.016

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