Short Article

Gap Detection Threshold in Children with Down Syndrome: A Brief Report

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Citation: Sayyahi F. Gap Detection Threshold in Children with Down Syndrome: A Brief Report. Aud Vestib Res. 2025;34(1):?-?.

Article info:
Received: 28 May 2024
Revised: 17 Jul 2024
Accepted: 07 Aug 2024

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Short running title: Gap Detection Threshold in Children with…

Highlights:

- People with Down syndrome discriminate speech sounds with temporal delay
- Gap detection range in Down syndrome is higher than in those with speech disorder
- Children with Down syndrome have difficulty in detecting prevocalic nasal consonants

ABSTRACT

Background and Aim: Auditory discrimination is one of reasons for low performance of phonological processing in people with Down syndrome. This study aims to evaluate the auditory discrimination performance of children with Down syndrome to explore a reason for deficit in phonological processing in these children.

Methods: In this descriptive cross-sectional study, 16 Persian-speaking elementary school male students with Down syndrome participated. Phonetic gap detection test was used to evaluate their auditory temporal threshold. They were asked to discriminate the sounds of six syllables at 20, 50, 100, 200 and 300 ms temporal gaps.

Results: The mean of phonetic gap detection threshold was 246.8 ms, ranged 183.3–300 ms. There was no significant correlation between auditory temporal thresholds and the factors of age or intelligence quotient.

Conclusion: Children with Down syndrome discriminate the sounds of syllables at higher thresholds compared to normal peers examined in previous studies. Increased gap detection threshold may be an underlying cause for low performance of these children in phonological processing.

Keywords: Auditory temporal processing; phonological processing; intellectual disability; working memory; auditory discrimination; auditory acuity

Introduction

People with Down syndrome has significantly lower performance in phonological processing compared to their peers [1]. Phonological processing involves screening sounds to identify each phoneme and reconstruct phonetic structure of the target word. One critical part of phonological processing is auditory discrimination [2]. Identification of each speech sound as a specified phoneme depends on auditory discrimination between heard

sounds. People with Down syndrome have difficulty to discriminate phonemes in the word context [3]. The reason may be temporal delay in auditory discrimination. Heschl's gyrus has less than 200 ms to identify each sound to reconstruct phoneme structure of the word [4, 5]. Pekkonen et al. [6] studied pre-attentive auditory processing in people with Down syndrome using auditory evoked field. Participants showed significant delayed detection of auditory stimulus. Latency range was 75–130 ms which was similar to the range of 80–160 ms reported by Wolpaw and Penry [7]. In other words, people with Down syndrome are missing time for precise auditory discrimination.

Sayyahi et al. [8] designed and validated phonetic gap detection test and examined it in children with and without phonological disorder. The outcomes revealed that those with high difficulties in phonological processing were not able to discriminate speech sounds in a same time period compared to normally developed children. These results have also been reported in other studies [9, 11]. Therefore, there is a relationship between gap detection threshold and phonological processing.

To the best of our knowledge, gap detection threshold has not been examined in people with Down syndrome. The present study aims to evaluate phonetic gap detection threshold in people with Down syndrome. The results can be help in exploring underlying deficits in phonological processing in children with Down syndrome for managing their speech difficulties.

Methods

In this descriptive cross-sectional study, 22 Persian-speaking elementary school male children with Down syndrome aged 8–12 years with Intelligence Quotient (IQ) of 62–68 participated. The parents of children received information about the study process and signed an informed consent form. Verbal performance at sentence level was the inclusion criterion while comorbidities or failure in vowel auditory discrimination were the exclusion criteria. Six children were dropped off the study and 16 children included in the study.

Phonetic gap detection test was used for auditory temporal discrimination [8]. This test is consisted of singleton sounds and six syllables including /bi/, /mi/, /zi/, /ʧi/, /li/ and /ji/ with 20, 50, 100, 200 and 300 ms temporal gap for each syllable. To conduct the test, the consonants of /b/, /m/, /z/, /ʧ/, /l/ and /j/ were blended with vowels /i/ and /e/ and presented to the participants. The evaluation was done perceptually. The examiner said a pair of syllables like /li/ and /le/ and asked children to identify that the pair was similar syllables or were different. A 80% accuracy in 10 trials for each consonant was the criterion of success. The children who met the success criterion entered a two-week training for segmentation and blending sounds in syllables. They learned to identify the number of sounds they hear by pointing to one or two Legos. After achieving 80% accuracy in 50 trials, phonetic gap detection test was conducted. Children were asked to listen to the stimuli and determine the number of sounds they hear. The temporal gap at which a child identified two sounds in a syllable was recorded as his phonetic gap detection threshold for the sound. The average of auditory thresholds in all stimuli was estimated as temporal thresholds for discriminating sounds.

Results

The mean age of children was 10.12±1.40 years. Table 1 presents phonetic gap detection thresholds of participants. The mean of temporal thresholds for syllables was as following: /bi/: 218.75±75 ms; /mi/: 281.25±40.3 ms; /ʧi/: 193.75±85.39 ms; /zi/: 187.50±80.62 ms; /li/: 300±0.00 ms; and /ji/: 300±0.00 ms.

The mean of total phonetic gap detection threshold for children was 246.87±32.89 ms, ranged 183.33–300 ms. The relationship of phonetic gap detection threshold with age and IQ was estimated by Wilcoxon test. The results showed no significant relationship.

Discussion

In the present study, phonetic gap detection threshold was evaluated in 16 participants with Down syndrome. The results revealed that phonetic gap detection threshold of children were higher compared to normally developed children reported in previous studies [8-10]. This finding is consistent with the findings of Pekkonen et al. [6] and Wolpaw and Penry [7] who found temporal delay in auditory stimulus detection of people with Down syndrome. The likelihood of identifying specified phonetic segments is less than 200 ms [4, 5]. High gap detection threshold has a role in disordered specification of speech sounds during phonological processing.

The results are also in agreement with the findings of Sayyahi et al. [8] in higher thresholds for detecting semi-vowels (/l/ and /j/) compared to sibilant consonants (/z/ and /ʧ/). Despite this consistency, the auditory temporal

threshold range for children with Down syndrome (117 ms) in our study was higher than in children with phonological disorder (61 ms) in Sayyahi et al.'s study. This indicates that the auditory detection performance of children with Down syndrome is not as concentrated as those with phonological disorder. As Kent and Vorperian [12] stated, speech patterns in Down syndrome should not be seen solely.

One outcome that confirms impaired auditory performance in children with Down syndrome is failure in the discrimination of consonants and vowels in the syllable /mi/. This may be related to impaired resonance in people with Down syndrome [13]. Rosyidah [14] studied speech errors in an individual with Down syndrome. Her participant assimilated nasals at the final position of the word for other sounds like stops, but not when nasals were at the initial position of the word. This can indicate that people with Down syndrome might perform better in detection of postvocalic consonants. According to the results of this study, children with Down syndrome has increased time in detecting consonant-vowel syllables especially those with liquids, glides and nasal consonants that are more similar to vowels in spectral and temporal cues.

One limitation of this study was the focus only on syllables of the stimuli in temporal gap detection test. There might be lexical factors involved in temporal delay in auditory detection of children with Down syndrome. Therefore, it is recommended to use words with different temporal gaps between sounds to compare prevocalic and postvocalic consonants detection in children with Down syndrome.

Conclusion

Phonetic gap detection threshold is higher in children with Down syndrome. One possible reason for lower performance of these children in phonological processing may be the lack of temporal window in the auditory processing of speech sounds. The results of this study can help clinicians and speech therapists to use new methods for improving the time of auditory detection in children with Down syndrome.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the Ethical Committee of Kermanshah University of Medical Sciences, Kermanshah, Iran, Code No: IR.KUMS.REC.1398.1058.

Funding

There was no funding source for this study.

Conflict of interest

There is no conflict of interest for this study.

Acknowledgments

Special thanks and gratitude to all participants, their parents and teachers who co-operated kindly in this study.

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Table 1. Frequency and mean of auditory temporal thresholds for participants with Down syndrome

Participants	Thresholds of syllables (ms)						Auditory temporal threshold (ms)
	[bi]	[mi]	[zi]	[ʧi]	[li]	[ji]	
1	200	-	200	300	-	-	300.00
2	200	300	200	200	-	-	233.33
3	100	300	100	100	300	300	266.67
4	-*	-	-	-	-	-	250.00
5	200	-	100	100	-	-	283.33
6	200	300	300	300	300	300	183.33
7	200	200	100	200	300	300	266.67
8	100	-	-	100	-	-	216.67
9	100	200	100	100	300	-	200.00
10	200	300	200	300	300	300	250.00
11	-	300	100	200	300	300	283.33
12	300	300	200	200	300	-	216.67
13	200	-	-	-	-	-	216.67
14	-	200	100	100	300	-	266.67
15	-	300	200	200	-	-	266.67
16	300	300	200	100	-	300	250.00

* Participants did not identify sounds of the target syllable at any temporal gap