Research Article

The Validity and Reliability of the Speech Prosody Comprehension Test for Children with Normal Hearing and Cochlear Implants

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Short running title: The Validity and Reliability of the Speech…

Highlights:
- The SPCT is a valid tool for assessing children's speech prosody comprehension
- The SPCT for children had high internal consistency (Cronbach's alpha=0.89)
- The SPCT for children had high test-retest reliability (ICC=0.99)

ABSTRACT
Background and Aim: The comprehension of speech prosody, the nonlinguistic elements of speech that convey emotions, is crucial for social interactions and speech comprehension. This study aimed to investigate the validity and reliability of the Speech Prosody Comprehension Test (SPCT) for Persian-speaking children aged 7–10.
Methods: In this study, face validity, construct validity, discriminant validity, test-retest reliability by calculating the Intraclass Correlation Coefficient (ICC), and internal consistency using Cronbach's alpha coefficient of the

SPCT were examined on 32 children aged 7–10 years, including 22 with normal hearing (mean age=8.63±1.04 years) and 10 with unilateral Cochlear Implant (CI) (mean age=9.20±0.78 years)
Results: The result demonstrated good face validity (face validity index=88.75). Construct validity was confirmed due to the existence of strong correlations within the subscale items and between the subscale items and the total score. A significant difference in mean scores was found between the normal-hearing and CI groups ($p<0.001$), indicating discriminant validity. High test-retest reliability was demonstrated for the overall scale (ICC=0.99) and for all subscales (ICC=0.91–0.97). The test also had high internal consistency, with a Cronbach's alpha of 0.89 for the overall scale.
Conclusion: The SPCT is a valid and reliable clinical tool for assessing speech prosody comprehension in children aged 7–10 with normal hearing and unilateral CI. Further research with larger samples is recommended to confirm the generalizability of the findings to children with other hearing conditions and age groups.
Keywords: Speech prosody comprehension test; children; validity; reliability; cochlear implant; speech prosody

Introduction

Emotional communication is a complex process of mutual influence between the emotions of communication partners [1]. It plays a crucial role in social interactions, providing information about the emotional states of others and guiding behavioral responses. Emotional speech prosody refers to the nonlinguistic aspects of speech that convey emotions. It plays a crucial role in decoding social interactions and adapting to contextual cues [2]. Research has shown that prosody and semantics are separate but intertwined channels in emotional speech perception, with prosody often dominating [3]. Emotional speech is characterized by variations in acoustic features, such as fundamental frequency (F0), intensity, and duration. Emotions such as happiness and anger are often associated with higher F0 and increased intensity, while sadness may exhibit lower F0 and reduced intensity. Duration changes also significantly contribute to the emotional expression of speech. [4]. Emotional speech prosody assessment is crucial for hearing-impaired children. Studies on emotional speech prosody in hearing-impaired children reveal that Cochlear Implant (CI) users face challenges in perceiving and producing emotional and linguistic prosody due to inadequate transmission of F0 cues and rely on semantic information [5-8]. Factors such as chronological age, duration of speech-language-auditory training, and language age are positively correlated to prosody perception scores [9]. Hearing age is also a predictor of prosody-based response accuracy [10].

Efforts have been made to develop valid and reliable tests for emotional speech prosody assessment. One of the proposed tests is the Emotional Prosody Measurement (EPM) method. The EPM has been used to evaluate the effectiveness of psychological therapies [11]. Another tool is the Speech Prosody Comprehension Test (SPCT), specifically designed for Persian speakers [12]. The validity and reliability of this test were examined for the 32 Persian-speaking adults aged 18-60 years [12]. Considering the importance of investigating the role of speech prosody in children, especially for those with CI, this study aimed to assess the validity and reliability of the SPCT for Persian-speaking children with normal hearing and CI aged 7–10 years.

Methods

The study was approved by the Human Research Ethics Committee of Tehran University of Medical Sciences (No: IR.TUMS.FNM.REC.1402.148).

Instrument

The SPCT was developed by Torke Ladani et al. by utilizing the Florida Affect Battery (FAB). The FAB has three different components: speech prosody, facial expressions, and the interaction between facial expressions and prosody. Troke Ladani et al. focused on the prosody component [12]. The SPCT consists of four subtests. The first one is the non-emotional prosody discrimination with 16 tasks, each consisting of two sentences spoken by a single speaker. The sentences are presented two seconds apart. The prosody (intonation and stress) of each sentence is either identical or different. In this subtest, the child is asked to listen to each pair of sentences and indicate whether the prosody of the sentences is the same or different. The second subtest is the emotional prosody discrimination with 36 tasks, each consisting of two sentences spoken by a single speaker. The emotional prosody of each pair of sentences is either the same or different. In this subtest, the listener is asked to listen to each pair of sentences (each sentence separated by a two-second interval) and to determine whether the emotional prosody is the same or different. The third subtest is the naming of prosody with 32 tasks, each including one sentence that is spoken in eight different tones. The time interval between each sentence is four seconds. In this subtest, a list of target tones is provided to the listener, and they are asked to listen to each sentence and identify their tone based on the provided list. The final subtest is the naming conflicts" with 36 tasks, each including one sentence. The sentences are expressed similarly and differently in terms of their semantic load. In this subtest, the individual is asked to name the tone of the sentence without paying attention to the content of the sentence.

Participants

The participants were 32 children aged 7–10 years, including 22 children with normal hearing (pure tone threshold <25 dB for octaves at 250–8000 Hz frequency [13], normal speech recognition threshold <25 dB HL), and 10 children with CI (MED-EL prosthesis) on the right side. These children had undergone surgery before the age of three and had profound sensorineural hearing loss in the opposite ear. All participants had normal intelligence (IQ≥85) based on the Wechsler Intelligence test, were monolingual Persian speakers, and their parents had declared their written informed consent. The unwillingness to continue participation was the exclusion criterion.

Psychometric evaluation

Face validity was determined through a qualitative assessment. Six experts in audiology independently evaluated the SPCT in terms of clarity, appropriateness for the target age (7–10 years), and cultural relevance. Construct validity was examined by analyzing the correlations within and between subscales and the correlations between items and the total score. Discriminant validity was assessed by comparing the mean scores of the SPCT between children with normal hearing and those with CI. Test-retest reliability was assessed by administering the test to all participants twice with a two-week interval and calculating the Intraclass Correlation Coefficients (ICC). An ICC greater than 0.75 indicates excellent reliability, ICC 0.6–0.75 indicates good reliability, and ICC 0.4–0.59 indicates fair reliability [14]. Test-retest differences were also calculated and analyzed to further evaluate the consistency of scores over time. Internal consistency was assessed using Cronbach's alpha coefficient. The Cronbach's alpha values between 0.7 and 0.95 indicate a high reliability [15].

Statistical analysis

Data were analyzed in SPSS v.17 (SPSS Inc., Chicago, IL, USA). The normality of the data was assessed using the Kolmogorov-Smirnov test. The results indicated that the data were normally distributed ($p>0.05$). The correlations for assessing construct validity were tested using the Spearman correlation test. In determining discriminative validity, we used the t-test to compare the mean scores between the two groups of children.

Results

Among 32 children, 19 were male (59.3%) and 13 were female (40.6%). Their mean age was 8.81±0.99 years (ranged 7–10 years). The children with normal hearing had a mean age of 8.63±1.04 years and the children with CI had a mean age of 9.20±0.78 years.

All experts confirmed the clarity of items and reported the good face validity of the SPCT (face validity index=88.75). Experts suggested minor modifications, such as modifying the intensity balance and item arrangement, to ensure random assignment. These suggestions were implemented.

Spearman correlation test results revealed strong correlations within the items of subscales ($r=0.72$–0.76, $p<0.001$) and between the subscale items and the total score ($r=0.85$–0.92, $p<0.001$). The t-test results showed significant differences in total score and the subscale scores between two groups of normal hearing and CI (Table 1).

High ICC were reported for the overall scale (ICC=0.99, 95% CI=0.98-0.99, $p<0.001$) and for the subscales of non-emotional discrimination (ICC=0.91, 95% CI=0.83–0.95, $p<0.001$), emotional discrimination (ICC=0.97, 95% CI=0.95–0.98, $p<0.001$), naming (ICC=0.97, 95% CI=0.95–0.98, $p<0.001$), and naming conflicts (ICC=0.95, 95% CI=0.91–0.97, $p<0.001$). The paired t-test results revealed no statistically significant difference between the test and retest scores for the overall scale ($p=0.078$), non-emotional discrimination ($p=0.206$), emotional ($p=0.067$), naming ($p=0.420$), and naming conflicts ($p=0.465$).

The SPCT demonstrated high internal consistency, with a Cronbach's alpha value of 0.89 for the overall scale and Cronbach's alpha values of 0.83, 0.78, 0.75, and 0.77 for the subscales of non-emotional discrimination, emotional discrimination, naming, and naming conflicts, respectively.

Discussion

The present study aimed to investigate the psychometric properties of the SPCT for the pediatric population. It was administered to 32 children aged 7–10 years, including normal-hearing and CI children. The results demonstrated that the SPCT had high psychometric properties for this population. Face validity was confirmed by experts regarding the clarity and appropriateness of the test. Construct validity was reported by obtaining significant correlations within subscale items and between the subscale items and the total score. Discriminative validity was evident due to the significant differences between the SPCT scores of children with normal hearing and those with CI. Internal consistency was high, as indicated by Cronbach's alpha values greater than 0.8, and test-retest reliability was confirmed by obtaining high ICC values and the absence of significant differences between the test and retest scores. The mean SPCT scores in our study were lower than those reported in Torke Ladani et al.'s study [12]. High significant correlations were observed between the subscale items and the total score in our study (r=0.85–0.92) and in Torke Ladani et al.'s study (r=0.77–0.93) [12]. Our study demonstrated high ICC for the overall scale (ICC=0.99) and for all subscales (ICC=0.91–0.97), consistent with the ICCs reported by Torke Ladani et al. (ICC for the overall scale=0.94, ICC for subscales=0.73–0.89) [12].

Speech prosody comprehension ability develops significantly during childhood. Infants exhibit early sensitivity to prosodic cues, demonstrating preferences for emotional prosody over neutral tones. This early sensitivity forms the basis for later language development [16]. Neural entrainment also plays a crucial role, enabling infants to predict and process the rhythmic patterns of speech [17]. Toddlers begin to use phrasal prosody to segment the speech into syntactic units, demonstrating early sensitivity to prosodic patterns [18]. This ability continues to develop as children reach preschool age (3–5 years), when they start to decode emotional prosody in their native language, with skills gradually improving. By school age (6–8 years), children refine their ability to recognize and use prosody for pragmatic purposes, such as expressing emotions and intentions [19]. While children demonstrate early sensitivity to prosody, full proficiency in comprehending and utilizing prosody for various communicative functions (like adults) continues to develop during childhood and adolescence. Research has consistently demonstrated the significant role of prosody in reading comprehension and language processing. Text reading prosody and speech prosody independently contribute to children's reading comprehension, with phrasing emerging as a particularly crucial factor [20]. Prosody plays a vital role in various aspects of language processing, including word recognition, syntactic structure computation, and discourse processing [21].

The participants in this study were children with normal hearing or unilateral CI. Therefore, the generalizability of the findings to children with other hearing conditions, such as those with bilateral CI or those using hearing aids, may be not be possible. Furthermore, the study focused on a specific age range (7–10 years), and the findings may not be directly applicable to younger or older children. Further research with larger sample sizes can confirm the generalizability of these findings. Future studies should investigate the psychometric properties of the SPCT in other children with various hearing conditions, age ranges, and cultural and linguistic backgrounds. Additionally, longitudinal studies are needed to investigate the developmental trajectory of speech prosody comprehension in children with different hearing conditions and to examine the impact of early intervention and rehabilitation on their prosodic abilities. This research can also be replicated to explore the relationship between speech prosody comprehension and other language and cognitive skills in children with hearing loss.

Conclusion

The speech prosody comprehension test is a valid and reliable tool for assessing children's speech prosody comprehension. It can be used to identify children who may be struggling with speech prosody comprehension, allowing for early intervention. Its high psychometric properties and ability to differentiate between children with normal hearing and those with cochlear implant highlight its potential for clinical use and applicability in research. By identifying specific areas of difficulty, this test can help clinicians in Iran design tailored interventions to address deficits in children's speech prosody comprehension. Also, it can be used to track the progress of children who are receiving interventions, providing valuable feedback on the effectiveness of treatment.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by Tehran University of Medical Sciences (No: IR.TUMS.FNM.REC.1402.148). All participants gave their informed consent prior to the administration of the study.

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Authors' contributions

NS: Study design, acquisition of data, interpretation of the results, statistical analysis, and drafting the manuscript; SF: Study design, interpretation of the results, and drafting the manuscript; FF: Study design, interpretation of the results, and drafting the manuscript; VR: Study design, interpretation of the results, and drafting the manuscript; SJ: Statistical analysis; SMK: Study design.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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Table 1. Comparison of mean and standard deviation of speech prosody comprehension test scores between normal hearing and children with cochlear implant (n=32)

Subscale	Mean(SD)		Mean difference(p)
	Normal-hearing children	cochlear implant children	
Non-emotional discrimination	10.91(1.15)	7.80(2.15)	3.10(0.001)
Emotional discrimination	28.95(1.36)	21.19(3.90)	7.85(0.001)
Naming	24.59(1.59)	15.40(4.69)	9.19(0.001)
Naming conflicts	27.95(2.03)	20.20(1.61)	7.75(0.001)
Total	92.54(5.67)	64.50(6.75)	28.04(0.001)