Prosody perception, reading accuracy, nonliteral language comprehension, and music and tonal pitch discrimination in school aged children

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Abstract
Twenty-five school aged children with normal hearing were tested on their perception of prosody using the receptive prosody subtests of the Profiling Elements of Prosody in Speech-Communication (PEPS-C) and Child Paralanguage subtest of Diagnostic Analysis of Non Verbal Accuracy 2 (DANVA 2). Performance of four children with hearing loss on the two prosody measures was compared with performance of normal hearing children. Children were also tested on their reading accuracy, comprehension of nonliteral language, and music and tonal pitch discrimination. Overall results showed that younger children aged 7;1 to 9;11 years had significantly poorer scores than 10;1 to 12;11 year olds on the Contrastive Stress Reception subtest of PEPS-C and the DANVA 2 Child Paralanguage subtest, indicating a developmental effect on speech prosody perception. Children with hearing loss had poorer scores and greater variability on PEPS-C and DANVA 2 assessments compared to normal hearing controls. Statistically significant correlations were observed between prosody perception scores and musical pitch perception and reading measures for the normal hearing group. This is consistent with previous studies showing links between reading and prosody perception [7,8]. Significant correlation between prosody perception and musical pitch discrimination indicates that pitch is an important cue for prosody perception.

Index Terms: prosody perception, PEPS-C, DANVA 2

1. Introduction
Prosody has a role in indexical, grammatical, emotional, and pragmatic levels of communication and it conveys a speaker’s emotional state (happy vs. sad), information on sentence type (question vs. statement), and word boundaries within phrases [1]. Most recent studies attribute a crucial role in understanding the prosodic component of the verbal message and show that accurate perception of prosodic features in speech is important for successful communication [2]. Children use prosodic features in speech to recover syntactic information and phrasal boundaries [3] and to segment the speech stream into words [4]. Young children use prosodic information to segment utterances and to derive the meaning of ambiguous sentences [5]. The potential role of prosody in understanding figurative language [6] and in reading development [7] has only been recently explored. Whalley and Hansen [8] reported that children’s prosodic skills have significant influence on word-reading accuracy and in reading comprehension. Children are sensitive to prosodic cues from a very early age and use this information for the acquisition of language. This study investigated whether there is a developmental effect on prosody perception in children with normal hearing and determined if there are any associations between prosody perception and non-literal language comprehension, music perception, F0 discrimination, and reading accuracy. Based on previous studies on UK English and Irish speaking children, it was hypothesized that age related changes in prosodic skills can be observed in New Zealand English speaking school aged children [9,10,11]. Preliminary prosody perception results for children with hearing loss are also reported.

2. Methodology

2.1. Participants
The normal hearing group consisted of 25 New Zealand English speaking children (7 boys and 18 girls) aged 7;1 to 12;11 years (mean 9.96, SD 1.61), with no speech, language, and hearing difficulties and who spoke English as their preferred language. Children were selected by age to form two groups: a younger group consisting of 11 children aged 7;1 to 9;11 years (mean 8;41, SD 0.83) and an older group comprising 14 children aged 10;1 to 12;11 years (mean 11;8, SD 0.81). Four children with hearing loss also participated in this pilot study (Table 2).

2.2. Test materials

2.2.1. Profiling Elements of Prosody in Speech-Communication (PEPS-C)
Four receptive prosody subtests of PEPS-C [12] that assess perception of sentence type (question versus statement; ‘Turn-End Reception’), speaker’s attitude (liking or disliking of food items; ‘Affect Reception’), phrase boundaries (the distinction between simple and compound nouns and groupings of adjectives; ‘Chunking Reception’), and placement of contrastive stress/accent (‘Contrastive Stress Reception’) were used in the current study. The PEPS-C uses a two alternative forced choice design; prerecorded auditory stimuli are presented and participants either point to the correct item on the screen (split-screen display of cartoon-type pictures) or give a verbal response. Pass criteria was set at 75% to avoid possibility of chance performance. Each subtest includes two example items, two practice items, and 16 test items. Only the test items count towards participants’ subtest and total scores. The language version used for the current study was British English. A raw score and percent correct score is obtained for each of the four receptive prosody subtests of the PEPS-C. PEPS-C total scores were calculated as the average of the scores from the four subtests.

2.2.2. Diagnostic Analysis of Non Verbal Accuracy 2 (DANVA 2)
The Child Paralanguage subtest of DANVA 2 [13] was used to assess affect recognition using voice only. This 24-item subtest involves a semantically neutral sentence “I am going out of the room now but I’ll be back later” presented in happy, sad, angry, and fearful tones at two levels of emotional intensity (12 items per intensity level) by male and
female participants (in random sequence). Participants respond to say if the person sounds happy, sad, angry or fearful. The number of correct responses out of 24 test items is determined.

2.2.3. Montreal Battery of Evaluation of Amusia (MBEA)

Contour and Interval subtests of the MBEA [14] were used in the current study. The contour subtest consists of contour-violated melodies created by changing one note of the melody such that its pitch height relative to its neighbouring notes is reversed, but the key is not altered. The interval subtest includes contour-preserved, interval violated melodies that are created by modifying the musical interval between two notes, while maintaining the original contour and key. Each subtest consists of 31 trials (including one catch trial), where a trial comprises of two short musical tones that are either identical or different at a single point. The participant hears the two melodies and indicates on an answer sheet if they are same or different. Participants should correctly respond to a catch trial (which has a very obvious difference between stimuli) in order for their responses to be considered valid. The number of correct responses out of 30 test items is obtained for the two subtests of the MBEA.

2.2.4. Comprehensive Assessment of Spoken Language (CASL)

The Nonliteral Language subtest of the CASL [15] which evaluates the ability to understand figurative speech, indirect requests, and sarcasm was used for this study (Form 2 for children aged between 7-21 years). Raw scores and standard scores for the CASL Nonliteral Language subtest standard scores were computed for each participant.

2.2.5. Wheldall Assessment of Reading Passages (WARP)

The WARP [16] is a curriculum-based measure of reading comprising 21 short passage reading tests of 200 words each. Scores indicate the number of words read correctly in one minute averaged, in this case, over the three WARP passages administered.

2.2.6. F0 discrimination task

In the two-interval two-alternative forced choice adaptive F0 discrimination task participants had to indicate whether the first or the second sound had a higher pitch. A complex harmonic tone, 500 ms long, with a gap of 500 ms between the two intervals in a trial, and an inter trial interval of 2000 ms was used as stimulus. F0 frequencies of the stimulus set range between 213 Hz and 232 Hz. The frequency difference between the stimuli reduces after a correct response and increases after an incorrect response. The initial step size is 9.0508 Hz; this reduces after two reversals. Trial-by-trial feedback was provided. The adaptive tracking procedure stops automatically (no time limit) after a total of 10 reversals. The F0 DL was defined as the ΔF that gives 100% accuracy on at least four trials, calculated from the program output.

2.3. Procedure

Testing was carried out in a quiet room with the participant seated approximately 1 m from the loudspeaker placed at 0° azimuth. PEPS-C, DANVA 2 Child Paralanguage subtest, F0 discrimination tasks, and MBEA Contour and Interval subtests items were presented through a GENELEC 6010A active portable loudspeaker at a comfortable level in the normal conversational range (65-75 dB SPL) measured using a sound level meter at the position of the participant’s seat. Before each test, the examiner explained each task and introduced a few practice items to ensure participant understanding of the tasks. The order of presentation of different tests was randomized across participants.

3. Results

3.1. Performance of normal hearing children on PEPS-C subtests and DANVA 2 Child Paralanguage subtest

Figures 1 and 2 depict the results of the normal hearing groups on four subtests of PEPS-C and the DANVA 2 Child Paralanguage subtest. All the normal hearing participants scored above 75% pass criteria set on all the PEPS-C tasks (Figure 1), except one participant (7;2 year old) who scored 69% on the Contrastive Stress Reception task. Percent correct scores obtained by 7;1 to 9;11 year olds on the Contrastive Stress Reception task (mean 86.54, SD 9.25) were significantly poorer than the scores obtained by the 10;1 to 12;11 year olds (mean 94.28, SD 6.73, Mann-Whitney U=2.26, p=.024). No significant differences in scores between age groups were observed for the Turn-End, Affect, and Chunking Reception tasks. Ceiling performance was seen in both groups, however greater variability in the performance of younger children than the older children was observed across the PEPS-C subtests. A Mann-Whitney U test showed significantly poorer performance of the younger group (mean 18.81, SD 2.40) compared to the older group (mean 20.50, SD 1.50, U = 2.10, p=.035) on the DANVA 2 subtest (Figure 2). Descriptive statistics for each of the four receptive subtests of the PEPS-C are presented in Table 1 for the groups of normal hearing children and for the individual children with hearing loss. All scores are presented as percentages.

![Figure 1: Percent correct scores obtained by two groups of normal hearing children on four subtests of the PEPS-C. The median scores are indicated by the thick horizontal line. Boxes indicate the data falling between the 25 and 75 percentile and the whiskers indicate the 95% confidence intervals. Outliers are indicated as circles (value is less than or equal to the first quartile minus 1.5 times the interquartile range) and asterisks (value is less than or equal to the first quartile minus 3 times the interquartile range or greater than the third quartile plus 3 times the interquartile range).](image-url)
### 3.2. Comparison between children with hearing loss and age matched control group on prosody measures

Four receptive prosody subtests of PEPS-C and the DANVA 2 Child Paralanguage subtest were administered to children with hearing loss (N=4). These children differed in terms of age, degree of hearing loss, age at amplification, and devices used (Table 2). Two children were bilateral hearing aid users and two were unilateral cochlear implant (CI) users. Preliminary data are reported for the hearing loss group; statistical analyses were not performed on this small sample. The scores obtained by the children with hearing loss were compared with their age matched normal hearing peers. Table 1 shows that participants H-2, CI-1, and CI-2 performed close to chance level (<75%) on the Affect Reception task. CI-2 also performed near chance level on the Chunking Reception task. Generally, it seems that within the hearing loss group, the CI users performed more poorly than the hearing aid users. Figure 3 shows that hearing loss group performed more poorly overall than an age matched subset of the normal hearing group and there was greater variability in their performance on the DANVA 2 Child Paralanguage subtest.

#### 3.3. Correlation between PEPS-C scores and other measures

Multiple Pearson correlations were carried out to check whether there is any relationship between scores obtained for different tests. Due to multiple comparisons, a Bonferroni correction was used and significance level was set at 0.05/6=0.008. PEPS-C total scores showed significant positive correlations with WARP (r=.642, p=.001) and MBEA Contour (r=.667, p=.001) scores. PEPS-C Chunking Reception scores showed a significant positive correlation with MBEA Contour (r=.543, p=.005) and Interval scores (r=.519, p=.008). There was also a statistical trend for lower F0 DLs to be associated with better PEPS-C total scores (r=-.463, p=.020).

<table>
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<tr>
<th>Age group</th>
<th>N</th>
<th>TER</th>
<th>AR</th>
<th>CR</th>
<th>CSR</th>
<th>PEPS-C Total</th>
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<tr>
<td>7;1-9;11</td>
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<td>(6.07)</td>
<td>(9.5)</td>
<td>(9.25)</td>
<td>(4.48)</td>
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<td>75-100</td>
<td>81-100</td>
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<td>69-100</td>
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<td>(5.15)</td>
<td>(3.87)</td>
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<td>69</td>
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### Table 1: Means, SDs, and ranges for two groups of normal hearing children on four subtests of the PEPS-C. The shaded portion shows the individual test scores obtained by children with hearing loss; TER: Turn-End Reception, AR: Affect Reception, CR: Chunking Reception, CSR: Contrastive Stress Reception. H-1 & H-2: Hearing aid users, CI-1 & CI-2: Cochlear Implant users.

#### 4. Discussion

In this study we investigated whether there is a developmental effect on prosody perception in children with normal hearing. The perception of grammatical, emotional, and pragmatic aspects of prosody was assessed using four receptive prosody subtests of PEPS-C and the DANVA 2 Child Paralanguage subtest. Overall results showed that the normal hearing children aged 7;1 to 9;11 years had poorer scores than the 10;1 to 12;11 year olds on PEPS-C tasks and the DANVA 2 subtest, indicating a developmental effect. Age group differences were significant for Contrastive Stress and the DANVA 2 measure of affective prosody perception. These results are in line with a small number of previous studies that have reported developmental effects on prosodic skills [9,11]. Gibbon and Smyth [11] used the Irish version of PEPS-C and demonstrated that 4 year olds performed significantly more poorly than 5 to 6 year olds on PEPS-C Affect, Chunking, and Contrastive Stress Reception tasks. Wells et al. [9] investigated receptive prosodic abilities in UK English speaking children aged 5 to 13 years using PEPS-C and reported significant age related changes for the Contrastive Stress and Chunking Reception receptive prosody tasks.
The data obtained for New Zealand English speaking children using PEPS-C in the present study are comparable to the norms reported by Wells et al. [9]. The age related changes in prosodic skills demonstrated for New Zealand English speaking children using PEPS-C provides support for the use of this test for New Zealand children. A developmental effect on affective prosody skills was evident from the DANVA 2 subtest results. The DANVA 2 Child Paralanguage subtest assesses perception of affective prosody using four different emotions (happy, sad, angry, and fearful) while the Affect Reception subtest of PEPS-C uses only two emotions (like/dislike). Similar to the PEPS-C data, the DANVA 2 Child Paralanguage subtest results for the normal hearing group in the present study are comparable to the normative data reported by Nowicki [17] for North American children.

Ceiling performance was observed across PEPS-C subtests for both age groups however, the younger group showed greater variability in performance. It is interesting that the median values on Affect Reception task for the groups are similar and outliers are seen within the older group, suggesting that performance on this task matures more slowly for some children. Comprehension of affective prosody may continue to develop beyond the age of 13 years and future studies including older children are recommended. Further research with larger number of participants is needed to establish normative cutoffs for performance on the PEPS-C subtests.

The statistical trend for lower F0 DLs to be associated with better PEPS-C total scores suggests that perception of subtle variations in pitch may help in perceiving different aspects of prosody (18,19,20). Pitch changes, preboundary lengthening, and pause duration are the acoustic cues for chunking incoming speech into syntactically relevant units [21]. Better sentence stress perception is associated with better F0 discrimination in 4-13 year old children with hearing loss using cochlear implants [23]. A significant association between Chunking Reception and PEPS-C total scores and musical pitch perception indicates that pitch is an important cue for prosody perception. This is consistent with the results of previous studies. Haasen et al. [22] reported the association between the perception of music measured using the MBEA and comprehension of word stress in adults aged 19-60 years. Studies of people with normal hearing have reported that prior musical experience and music lessons promote sensitivity to prosodic cues in speech, providing evidence for shared neural resources underlying prosody and music processing [24,19].

The significant association between PEPS-C prosody reception total scores and WARP reading scores is consistent with Daane et al.'s [25] report of a strong correlation between prosody production and overall reading achievement in fourth-grade students. Children in this study (N=1779) were examined on different elements of oral reading including grouping of words or phrasing, syntax and sentence structure, and expressiveness which are manifested through intonation, stress placements, and pause insertions. Schwanenflugel et al. [26] measured prosodic features of oral reading in 2nd and 3rd grade children (N=123) and 24 adults. Children with faster decoding speed made shorter and less variable intersentential pauses, larger sentence-final F0 declinations, and better matched the adult prosodic F0 profile.

The PEPS-C and the DANVA 2 Child Paralanguage subtest scores obtained for children with hearing loss were compared to their aged matched controls. The children with hearing loss performed more poorly than their normal hearing peers on Affect and Chunking Reception subtests of the PEPS-C and on the DANVA 2 Child Paralanguage subtest. The data are very preliminary but suggest a difference in performance based on the degree of hearing loss and the hearing device used, with hearing aid users performing better than the CI users. Of the four subtests of PEPS-C, the Affect Reception task was the most difficult for the children with hearing loss. This is consistent with the relatively poor performance of the children with hearing loss on the DANVA 2 Child Paralanguage subtest. These results need to be further verified on a large sample, however, these preliminary results are consistent with previous studies which have reported that children with hearing loss have difficulty perceiving different aspects of prosody [29,30,31]. Accurate perception and production of prosody is important for social and emotional wellbeing [27] and perceptual prosodic difficulties in children with hearing loss have been shown to be responsive to intervention [28].

5. Conclusion

To the best of our knowledge, the present study is the first of its kind to report receptive prosody skills in New Zealand English speaking children. The normative data on prosody perception in this population obtained using PEPS-C and DANVA 2 Child Paralanguage subtest are comparable to norms reported in literature. This suggests that these tests are useful for assessment of prosodic skills in New Zealand children. The associations between prosody perception and reading accuracy, and pitch perception have implications for future studies using a larger sample. Preliminary data on children with hearing loss suggests that these children have difficulties perceiving different aspects of prosody. The influence of variables such as age at amplification and degree/type of hearing loss on prosody perception abilities should be investigated in future studies.
6. References


