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Prosody Perception in Typically Developing School-aged Children

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Abstract

**Purpose:** To report normative data for prosody perception abilities in typically developing school-aged children.

**Method:** Four receptive prosody subtests of the Profiling Elements of Prosody in Speech-Communication (PEPS-C) and the Child Paralanguage subtest of Diagnostic Analysis of Non Verbal Accuracy 2 (DANVA 2) were administered to 45 children divided into three age groups, with mean ages 7.84, 10.13, and 11.90 years.

**Results:** Overall results indicated significant age-related improvements in performance on PEPS-C Chunking and Contrastive Stress Reception subtests. Accuracy for emotion recognition differed significantly across the two levels of emotion intensity for the DANVA 2. High emotion intensity items yielded better accuracy compared to low intensity items. A confusion matrix for the DANVA 2 showed that errors were not randomly distributed; some pairs of emotions were confused with one another more often than others. The lowest perceptual accuracy was observed for fear and sadness.

**Conclusions:** Normative data for prosody perception abilities in typically developing school aged children were reported using PEPS-C receptive prosody subtests and DANVA 2 Child Paralanguage subtest. The development of receptive prosodic skills mostly occurs between 7 and 9 years. Findings of this study have clinical implications for assessing prosody perception in atypical populations.

Keywords: Prosody; Typically developing; Children; Normative data

Introduction

Prosody serves to convey emotions and attitudes (affective prosody), indicate question-statement contrasts, distinguish word boundaries (grammatical prosody), emphasize new and relevant information and pragmatic aspects (pragmatic prosody) of speech. It is important to know how children understand different prosodic functions during communication at different ages and the degree of variability that might be expected within an age group. Relative to the studies examining production of prosodic contrasts [1-4], less is known about the perception of prosodic functions in children. Prosody is reported as a neglected field of research when compared to other aspects of language [5]. Although prosodic difficulties were reported in various communication disorders there is lack of normative data for prosody perception abilities in typically developing children. Assessment of prosodic skills in clinical settings is currently constrained by the lack of normative comparison sample. The present study examined prosody perception abilities in 7-12 year old typically developing children using the receptive prosody subtests of the Profiling Elements of Prosody in Speech-Communication [6] and the Child Paralanguage subtest of the DANVA 2 [Diagnostic Analysis of Non Verbal Accuracy 2] [7].

PEPS-C includes subtests to assess listener's understanding of sentence type (question vs statement; 'Turn-end Reception'), speaker's emotion (happy or sad; 'Affect Reception'), phrase boundaries (the distinction between simple and compound nouns and groupings of adjectives; 'Chunking Reception'), and placement of contrastive stress/
Development of prosodic contrasts starts early in childhood and matures over time [4,20,21]. Patel and Grigos [3] investigated age-related development in the use of different combinations of acoustic cues (F0, intensity, and duration) to mark question-statement contrast in 4, 7, and 11 year old children. They reported that 4 year olds were unable to reliably use rising F0 contour to signal questions instead used increased final syllable duration, while a combination of F0, intensity, and duration cues were used by 7 year olds. Similar to adult production, the older group relied primarily on F0 changes. This is in line with Patel and Brayton’s [2] findings that listeners’ accuracy in identifying question-statement contrasts and contrastive stress patterns produced by 4 year olds was significantly poorer than for 7 and 11 year olds, suggesting improved stabilization of prosodic control occurring between 4 and 7 years. These findings are further corroborated by Grigos and Patel’s [1] study showing that children as young as 4 years old are able to modify their lip and jaw movements to distinguish between declarative-interrogative contrasts, however refinement of these movements continues between 7 and 11 years.

The functions of prosody have been identified at the grammatical, emotional, and pragmatic levels of communication [22,23]. Prosodic cues such as voice onset time, pitch contour, coarticulation, and syllable duration helps word segmentation in children and adults [24-26]. Research on affective speech has reported that prosodic cues are used to express vocal emotions and attitudes [27,28]. d’Alessandro [29] reported voice quality as one of the prosodic cues related to production and perception of emotions. Use of high pitch at the end of the utterance to signal turn-taking [30,31] and pitch accents to convey “new” and already “given” information are examples of the pragmatic functions of prosody [32,33]. Wells et al. [23] examined perception and production of turn-end (question/statement), affect (like/dislike), chunking (fruit, salad, and milk/fruit-salad and milk), and contrastive stress (BLUE and green socks vs. blue and GREEN socks) in typically developing UK English speaking children (N=120, aged between 5-13 years) using PEPS-C test. They reported that production of prosodic contrast functions is largely established by 5 years, although specific functional contrasts such as contrastive stress continue to develop up to 9 years. They also reported that the ability to discriminate question-statement and like/dislike contrasts were mostly acquired by 8 years, however the ability to understand contrastive stress patterns and chunking continues to develop between 10 and 13 years. This is supported by Grigos and Patel’s [33] findings that the articulatory movements to produce sentential stress start to develop between 7 and 11 years and continue to develop throughout adolescence. De Ruitter [32] reported that there are differences between children (5 and 7 year olds) and adults in using pitch accents for conveying new and relevant information, indicating a development trend. Compared to the 7 year olds, 5 year olds made significantly less use of prosodic cues to convey turn-taking, suggesting that children learn the pragmatic functions of prosody only later. This is in line with Potamianos and Narayanan’s [34,35] findings that compared to older speakers (11-14 year olds), 8-10 year old children produced more filled pauses in dialogue, which indicates delays in thinking and responding during conversations. These study findings suggest that there are differential pattern of development for different aspects of prosody; certain functional contrasts are mastered later than others. Most of the studies reviewed investigated specific aspects of prosody in different subgroups of children.

Accurate recognition of affective prosody is important from a developmental perspective because auditory signals can capture attention from someone who is not visually attending to the speaker, as mostly occurs between infants, toddlers and their caregivers. Burnham [36] reported that infants’ perception of their mother’s facial expressions was facilitated when auditory information was added. Fernald [37] reported that 5 month old infants respond to vocal emotions presented in the absence of facial expressions, but not vice versa. Early affective development is important as this has been used as setting the stage for future relationship and behavioural development in children [38]. Significant correlations between emotion understanding and theory of mind, social abilities [39], and academic achievement [7] have been reported in typically developing children. Previous research on emotion perception in children has mainly focused on recognition of facial expressions. In addition to facial expressions, the prosodic properties of speech also provide a rich source of information about an individual’s affective state. In addition to PEPS-C Affect Perception subtest, the present study used the Child Paralanguage subtest of DANKA 2 to assess perception of affective prosody in typically developing 7-12 year old children.

The difference between typical and atypical populations in recognizing emotions may be less prevalent when emotional expressions are depicted at stronger or greater intensities than when less intense expressions are presented. However, the intensity of emotional expressions has only occasionally been studied as a factor affecting children’s recognition of vocal emotions. Mazefsky and Oswald [40] reported that children with high functioning autism were less accurate than children with Asperger’s syndrome and typically developing peers in understanding emotions at low intensities than high intensities. Mazefsky [41] reported that lower accuracy on DANKA 2 low intensity tone of voice cues were related to greater social impairment and lower social competence measured using Child Behaviour Checklist [42,43] and Scales of Independent Behaviour-Revised [44]. High emotion intensity facial expressions and tone of voice cues were not related to any of these measures. These findings are consistent with Baum and Nowicki’s [45] findings that greater accuracy on DANKA 2 low intensity emotional items, but not high intensity items, was related to better social competence (teacher ratings using Child Behaviour Checklist) in typically developing 2nd to 6th grade children. How well children can understand low emotion intensity items is important given that in everyday settings emotional expressions are often subtle [46]. Studies investigating the ability to recognise subtle vocal emotion cues in children are extremely limited but could be valuable in early detection of impaired emotion processing.

There are differences in acoustic cues used to produce different emotions. For example, high values of F0 are used for anger, fear, and happiness, whereas low values of F0 for sadness and disgust [47]. Largest F0 standard deviations (SD) were reported for happiness, followed by anger, then disgust, and the smallest for sadness and fear. Anger and happiness are produced with high voice intensity, followed by disgust, fear, and sadness [48]. Juslin and Laukka [47] reported the effects of emotion intensity on the acoustic cues; higher values of F0 (SD) for strong rather than weak intensity items, with largest effects for anger and disgust. Similarly, there are differences in voice intensity, speech rate, pause proportion, attack time, and voice quality depending on the level of emotion intensity and emotion category. Juslin and Laukka [49] reported that acoustic cues are used probabilistically and continuously so that cues of non-perfectly reliable but have to be combined. They also suggested that the cues are combined in an additive fashion, and there is a certain amount of “cue trading” in emotional expressions. For example, if speakers cannot vary pitch to express anger, they may compensate by varying loudness.


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a bit more. Luo et al. [50] investigated affective prosody recognition in cochlear implant simulations and reported a trade-off between spectral resolution and periodicity cues when performing a vocal emotion recognition task. In order to accurately understand emotion recognition abilities in atypical and typical populations, a range of different emotions at different levels of intensity need to be examined.

Purpose of the study

The purpose of this study was to report normative data for prosody perception abilities in typically developing school-aged children. In particular, we asked the following questions:

- Is there a developmental effect on prosody perception abilities in typically developing children? If so, are there variations in the developmental pattern for different aspects of prosody in children aged between 7-12 years?
- Are there differences in affective prosody perception abilities in typically developing children based on the level of emotion intensity and emotion category?

Method

Participants

Forty-five typically developing children (21 boys and 24 girls) participated. Participants were selected by age to form three groups: 7-8 year olds (Mage=7.84, SD=0.35, age range: 7.34-8.68 years, n=14), 9-10 year olds (Mage=10.13, SD=0.59, age range: 9.13-10.92 years, n=16), and 11-12 year olds (Mage=11.90, SD=0.49, age range: 11.22-12.93 years, n=15) (Table 1). Informed written consent was obtained from caregivers/parents and participation was voluntary. All children met the inclusion criteria of normal hearing (passed a pure tone and immittance audiometry screening), spoke New Zealand-English as their primary mode of communication, and had no history of speech, language, and/or hearing difficulties as reported by parents. Testing took place either in a quiet room at child's home or in the sound proof booth.

<table>
<thead>
<tr>
<th>Age group</th>
<th>N</th>
<th>Gender distribution</th>
<th>Age (in decimal years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Boys/Girls</td>
<td>M</td>
</tr>
<tr>
<td>7-8 years</td>
<td>14</td>
<td>5/8</td>
<td>7.83</td>
</tr>
<tr>
<td>9-10 years</td>
<td>15</td>
<td>8/8</td>
<td>10.13</td>
</tr>
<tr>
<td>11-12 years</td>
<td>16</td>
<td>7/8</td>
<td>11.90</td>
</tr>
</tbody>
</table>

Table 1: Participant characteristics.

Materials

Profile of elements of prosody in speech-communication (PEPS-C)

Four receptive prosody subtests of PEPS-C (Turn-end, Affect, Chunking, and Contrastive Stress Reception) were used. These receptive subtests involve simple binary choices, with low memory and processing demands [51]. The pass criteria is set at 75% by Wells & Peppe [51] to avoid the possibility of chance scoring.

1. Turn-end Reception: This subtest assesses the function of prosody in interaction by making use of conversational 'turns' each consisting of a single word. The turns/words are names of food-items and the opposition of tones indicates whether the item is 'read' or 'stated' as opposed to 'offered' or voiced as a question/inquiry.

2. Affect Reception: In order to assess the use of prosody to convey affective meaning, PEPS-C uses the distinction between strong liking as opposed to reservation/dislike. The test items used are names of food-items.

3. Chunking Reception: Chunking refers to boundary-signalung or prosodic delineation of the utterance into units for grammatical, semantic, or pragmatic purposes. PEPS-C uses the minor phrase boundaries that can be used to distinguish between items in a list. For example, color combinations (pink and black/green socks vs. pink&black and green socks) or single and compound food-items (fruit, salad, and milk vs. fruit-salad and milk).

4. Contrastive Stress Reception: Contrastive stress refers to the speaker's use of phonemic prominence to indicate which word or syllable is most important in an utterance. For example, blue and green socks (emphasis on the first colour) vs blue and green Socks (emphasis on the second colour).

The pre-recorded auditory stimuli were presented using a laptop computer through a GENELEC 6010A active portable loudspeaker (placed directly in front of the participant) 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. The computer response screen of the PEPS-C involved a split-screen display of cartoon-type pictures. Participants were instructed to either point to the correct item on the screen or to give a verbal response. Before each task, demonstration items and practice items were played to ensure participants' understanding of the task. The automatic scoring provided the raw scores, percentage scores, standard deviation from the normative mean, and a pass/fail indicator. Details of PEPS-C subtests and instructions for administration and scoring are described in Peppe and McCann [6] and on the PEPS-C website (http://www.peps-c.com). Reviews of the strengths and weaknesses of the PEPS-C test are provided in Gibbon and Smyth [52], Peppe [53], and Diehl and Paul [5].

Child paralanguage subtest of diagnostic analysis of non-verbal accuracy 2 (DANVA 2)

The DANVA 2 test was developed by Baum and Nowicki [45] to measure competence in affect recognition by reading facial expressions and voice tone (affective prosody). It includes five subtests: 1) Child Faces, 2) Adult Faces, 3) Child Paralanguage, and 4) Adult Paralanguage, and 5) Child and Adult Posture. The current study used the Child Paralanguage subtest of DANVA 2 to assess emotion recognition using voice only. This 24-item (4 alternative forced choice response paradigm) subtest involved a sentence "I am going out of the room now but I will be back later" presented in happy, sad, angry, and fearful tones at two levels (high and low) of emotion intensity (12 items per intensity level) by male and female speakers (in random sequence). The auditory stimuli were presented through a loudspeaker (using a similar procedure to the PEPS-C) and participants either gave a verbal response by saying if the person sounded happy, sad, angry, or fearful or pointed to the correct emotional smiley faces showing these emotions (Figure 1). Tables showing the number of errors for each emotion, number of errors for high and low intensity items, number of
errors for emotion by intensity, and the responses that were chosen when there was an error were generated using the DANVA 2 automatic scoring. Error profiles can be used to identify the pattern of difficulty. Additional information about the DANVA 2 test can be found on http://psychology.memorial.edu/clinical/interpersonal/.

**Figure 1:** Response alternatives (happy, sad, angry, and fearful faces) for DANVA 2 Child Paralanguage subtest. After each stimulus is presented, participants made decisions to choose their responses from one of these emotions.

**Statistical analyses**

Nonparametric tests were used as the data was not normally distributed. Kruskal-Wallis ANOVA tests [54] were used to examine between group differences on PEPS-C and DANVA 2 subtest scores. Post-hoc Mann Whitney U tests were conducted to investigate significant main effects. Friedman ANOVA was used to determine within group differences in scores across PEPS-C tasks and DANVA 2 emotional categories. Post-hoc analyses using Wilcoxon Signed-Rank tests were conducted to examine significant main effects. A Bonferroni correction factor was applied when multiple post-hoc comparisons were performed. IBM SPSS statistics software package (version 22) was used to perform all the statistical tests reported in this study.

**Results**

**Age group differences on PEPS-C receptive prosody tasks**

Table 2 shows the mean percent correct scores, standard deviations, and ranges of scores on PEPS-C tasks for the three age groups. When performance for the three age groups was compared using a Kruskal-Wallis ANOVA significant main effects of age on Chunking ($\chi^2 (2, 45)=13.15$, $p=0.001$), Contrastive Stress ($\chi^2 (2, 45)=13.14$, $p=0.001$), and PEPS-C total scores ($\chi^2 (2, 45)=21.79$, $p=0.001$) were found. PEPS-C total scores were calculated as the average of the scores from the four prosody subtests. There were no effects of age group on Turn-end and Affect Reception scores (all $p>0.300$). Post-hoc Mann Whitney U tests (significance value set at $p<0.005$ (0.05/9)) showed that scores obtained by 7-8 year olds were significantly poorer than those obtained by 9-10 and 11-12 year olds for Chunking ($p \leq 0.003$), Contrastive Stress ($p \leq 0.003$), and PEPS-C total ($p=0.001$). There were no significant differences in scores obtained by the two older groups across PEPS-C tasks ($p \geq 0.072$). The PEPS-C data for the two older groups were therefore combined for further descriptive and statistical analyses. Mean percent correct scores obtained by 7-8 year old children on PEPS-C tasks were lower than the scores for the combined 9-12 year olds (Mage=10.99, SD=1.05, n=31; Figure 1). High standard deviations and wide ranges of scores obtained by the youngest group indicate greater intersubject variability in their performance (Figures 2 and 3). Compared to 7-8 year olds, smaller standard deviations and narrow ranges of scores were obtained by 9-12-year olds across the PEPS-C tasks. Most children (90%) in the 9-12 year old combined older age group performed above the chance level of 75%, with most achieving ceiling scores on the four PEPS-C subtests (Figure 3).

Outliers were present for three out of the four tasks for the older group, however. Thus, even though the majority of the children are successful at a task, there were five children (3 boys, 2 girls) performing very poorly compared to their peers. Ceiling effects were found for all tasks for some of the younger children. Among the 7-8 year olds, below chance level performance (<75%) occurred for one participant for the Turn-end and Affect Reception tasks and four participants for the Contrastive Stress Reception task.

**Figure 2:** Means and 95% confidence intervals for PEPS-C subtests by age group.

**Figure 3:** Box plots representing percent correct scores obtained by two age groups on PEPS-C subtests. The median scores are indicated by the thick horizontal line. Boxes indicate the data falling between the 25th and 75th percentile and the whiskers indicate the 95% confidence intervals.

Mann Whitney U tests were used to investigate differences in performance between the youngest (7-8 years) and the combined older age (9-12 years) group for the four PEPS-C subtests and PEPS-C total (significance value set at $p<0.05$ (0.05/5)). Scores obtained by 7-8 year olds were significantly poorer than those obtained by the combined 9-12 year olds for the Chunking (U=80.00, $p=0.001$), Contrastive Stress (U=75.50, $p=0.001$), and PEPS-C total (U=27.50, $p=0.001$; Table 2).
2. There were no significant differences in scores obtained by the two groups for Turn-end (U=140.50, p=0.943) and Affect Reception tasks (U=161.00, p=0.156). These results match those obtained when the three age groups were compared.

<table>
<thead>
<tr>
<th>Age</th>
<th>group</th>
<th>Turn-end</th>
<th>Affect Chunking</th>
<th>Contrasting Stress</th>
<th>PEPS-C total</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-8 years</td>
<td>M (SD)</td>
<td>89.58 (10.58)</td>
<td>85.92 (9.67)</td>
<td>88.92 (7.94)</td>
<td>81.42 (13.25)</td>
</tr>
<tr>
<td></td>
<td>Mdn</td>
<td>91</td>
<td>88</td>
<td>91</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>69-100</td>
<td>69-100</td>
<td>75-100</td>
<td>56-100</td>
</tr>
<tr>
<td>9-10 years</td>
<td>M (SD)</td>
<td>96.93 (5.10)</td>
<td>88.87 (8.35)</td>
<td>97.37 (3.77)</td>
<td>95.96 (6.48)</td>
</tr>
<tr>
<td></td>
<td>Mdn</td>
<td>100</td>
<td>91</td>
<td>100</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>81-100</td>
<td>75-100</td>
<td>94-100</td>
<td>75-100</td>
</tr>
<tr>
<td>11-12 years</td>
<td>M (SD)</td>
<td>95.13 (5.35)</td>
<td>91.00 (6.27)</td>
<td>97.20 (4.45)</td>
<td>94.26 (6.48)</td>
</tr>
<tr>
<td></td>
<td>Mdn</td>
<td>94</td>
<td>94</td>
<td>100</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>88-100</td>
<td>81-100</td>
<td>88-100</td>
<td>81-100</td>
</tr>
<tr>
<td>Combined 9-12 years</td>
<td>M (SD)</td>
<td>96.06 (3.22)</td>
<td>89.90 (7.38)</td>
<td>97.29 (4.05)</td>
<td>94.67 (6.38)</td>
</tr>
<tr>
<td></td>
<td>Mdn</td>
<td>100</td>
<td>94</td>
<td>100</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>81-100</td>
<td>75-100</td>
<td>88-100</td>
<td>75-100</td>
</tr>
</tbody>
</table>

Table 2: Means, standard deviations, medians, and ranges of scores for PEPS-C subscales by age group.

Differences in performance based on PEPS-C prosodic task

Among the 7-8 year old children, there were no significant differences in scores across PEPS-C tasks ($\chi^2$ (3, 14) = 5.347, p=0.148). However, there were significant differences in scores among 9-12 year old children ($\chi^2$ (3, 31) = 22.568, p=0.001) depending on the task. Post-hoc analyses with Wilcoxon Signed-Rank tests (significance level set at p<0.008 (0.05/6)) showed that scores obtained by 9-12 year olds on the Affect Reception task were significantly higher than those obtained on Turn-end (Z=3.106, p=0.002) and Chunking Reception tasks (Z=3.856, p=0.001). There were no significant differences in scores between any other pairs of tasks (p ≥ 0.012).

Age group differences on DANVA 2 child paralanguage subtest

Table 3 shows the percentage of errors made by three groups of children on two levels of emotion intensity and four different emotional categories. Overall more errors were made by 7-8 year-olds, followed by 9-10 year old children, with fewest errors made by 11-12 year olds. Kruskal Wallis ANOVAs were used to determine the effects of age on errors across the two levels of emotion intensity for the DANVA 2 total error scores (four emotions combined, Tables 3 and 4).

There were significant main effects of age for high emotion intensity errors ($\chi^2$ (2, 45) = 6.831, p=0.033), but not for low emotion intensity errors ($\chi^2$ (2, 45) = 3.404, p=0.05). Mann Whitney U tests (significance value set at p=0.016 (0.05/3)) showed that, for high emotion intensity, 7-8 year olds made more errors than 9-10 year olds (U=51.00, p=0.008) but did not differ from 11-12 year olds (U=80.50, p=0.05). Total scores for the two emotion intensities did not differ for the two older age groups and the performance of the younger age groups was the same as the older age groups for lower emotion intensity items (p ≥ 0.188).

Differences in DANVA 2 scores based on emotion intensity and emotional category

Wilcoxon Signed-Rank tests showed that total error scores for high emotion intensity items (M=1.26, SD=1.23) were significantly lower than the error scores for low emotion intensity items (M=3.20, SD=1.60, Z=-4.984, p=0.001; Table 5). Irrespective of the levels of emotion intensity, participants made more errors on items expressing fear, followed by sadness, then happiness, and had relatively few errors for anger (Table 3). Friedman ANOVA showed significant differences between emotional categories ($\chi^2$ (3, 45) = 10.881, p=0.012). Post-hoc analyses using Wilcoxon Signed-Rank tests revealed that the error scores obtained for fear stimuli were significantly higher than the error scores obtained for angry stimuli (Z=-2.969, p=0.003).

Wilcoxon Signed-Rank tests (significance value set at p<0.012 (0.05/3)) were performed to determine the effects of emotion intensity on the errors obtained within the four emotion categories. There was no significant difference between high and low emotion intensity error scores for fear (Z=2.439, p=0.015; Table 4). Error scores for the other three emotion categories were lower for high emotion intensity (happiness: Z=3.774, p=0.001; sadness: Z=2.641, p=0.008; anger: Z=3.977, p=0.001 (Table 5).

Table 3: Percentage of errors for each age group across the four emotions and two emotion intensities (24 items in total, 12 per intensity, 6 per emotion) on DANVA 2 Child Paralanguage subtest group.

Differences in DANVA 2 scores based on emotion intensity and emotional category

<table>
<thead>
<tr>
<th>Age</th>
<th>group</th>
<th>Happy</th>
<th>Sad</th>
<th>Angry</th>
<th>Fearful</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-8 years</td>
<td>Low</td>
<td>0.85</td>
<td>1.21</td>
<td>0.57</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>M (SD)</td>
<td>(0.86)</td>
<td>(1.05)</td>
<td>(0.75)</td>
<td>(1.03)</td>
</tr>
</tbody>
</table>

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Gender differences

Mann Whitney U tests were performed to examine whether there were gender differences in performance on PEPS-C tasks and DANTA 2 subtest. No significant effects of gender were observed for any PEPS-C task (all p > 0.868; Table 7) or DANTA 2 subtest (all p > 0.161).

<table>
<thead>
<tr>
<th>Gender</th>
<th>group</th>
<th>Turn-end</th>
<th>Affect</th>
<th>Chunking</th>
<th>Contrastive Stress</th>
<th>PEPS-C Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td>(n=24)</td>
<td>M (SD)</td>
<td>94.37</td>
<td>90.00</td>
<td>93.04</td>
<td>90.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90.83</td>
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<td>8.12</td>
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<td>92.04</td>
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<td>92.37</td>
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<td></td>
<td></td>
<td>91.19</td>
</tr>
<tr>
<td>Mdn</td>
<td></td>
<td>94.00</td>
<td>94.00</td>
<td>94.00</td>
<td></td>
<td>94.00</td>
</tr>
<tr>
<td>IQR</td>
<td></td>
<td>11.25</td>
<td>12.00</td>
<td>17.25</td>
<td></td>
<td>7.63</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Boys</th>
<th>(n=21)</th>
<th>M (SD)</th>
<th>93.85</th>
<th>87.14</th>
<th>96.57</th>
<th>90.33</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>94.00</td>
<td>94.00</td>
<td>94.00</td>
<td></td>
<td>94.00</td>
</tr>
<tr>
<td>Mdn</td>
<td></td>
<td>100.00</td>
<td>88.00</td>
<td>100.00</td>
<td></td>
<td>94.00</td>
</tr>
<tr>
<td>IQR</td>
<td></td>
<td>9.00</td>
<td>13.00</td>
<td>6.00</td>
<td></td>
<td>5.50</td>
</tr>
</tbody>
</table>

Note: IQR=Interquartile Range.

Table 7: Gender wise comparisons using PEPS-C scores.

Discussion

The PEPS-C results showed that 7-8 year olds performed significantly poorer than 9-12 year olds on Chunking and Contrastive Stress Reception tasks, indicating a developmental trend. The reduced standard deviation scores and narrow ranges of scores obtained by 9-12 year olds compared to the youngest group are also indicative of the age-related improvements. Moreover, most children in the oldest group achieved ceiling scores on the four PEPS-C subtests. Overall the results indicate that much of the age-related changes in prosody perception occur between 7 and 9 years. Previous studies using PEPS-C test have reported age-related improvements in receptive and expressive prosodic skills [23,52,55]. Wells et al. [23] reported significant developmental changes in prosodic abilities in children aged between 5 and 13 years. These results are consistent with Ludwig et al’s (2014) findings that significant improvements in interaural and dichotic discrimination thresholds for acoustic parameters such as intensity, frequency, and signal duration occur between 6-7 and 8-9 years. Similarly, development effects on prosodic control have been reported based on acoustic analysis of prosody production and articulatory movement studies in children [1-3,34].

Even though a general age-related improvement in perception scores was observed across PEPS-C tasks, there were variations in the developmental pattern for different aspects of prosody. The older group performed significantly better than the 7-8 year olds on Chunking and Contrastive Stress Reception tasks. However, there were no significant differences between the older and younger age groups on Turn-end and Affect Reception tasks. This suggests that skills measured using PEPS-C Turn-end and Affect Reception subtests which involve discrimination of simple pitch movements are acquired in the early school-age period. While the PEPS-C Chunking subtest which requires judging speakers’ use of timings cues and PEPS-C Contrastive Stress subtest which requires children to understand the use of accent/focus are acquired later and gradually. Previous studies have reported that comprehension of chunking and contrastive focus continues to develop up to 11 years [23,56]. Differential patterns in the

Table 4: Means and standard deviations (error scores) for DANTA 2 Child Paralanguage subtest by emotion intensity (low and high) and emotion categories.

<table>
<thead>
<tr>
<th>Emotion Intensity</th>
<th>Happy</th>
<th>Sad</th>
<th>Angry</th>
<th>Fearful</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low M (SD)</td>
<td>0.77</td>
<td>0.88</td>
<td>0.60</td>
<td>0.93</td>
<td>3.20</td>
</tr>
<tr>
<td>Range</td>
<td>0-2</td>
<td>0-3</td>
<td>0-2</td>
<td>0-3</td>
<td>1-7</td>
</tr>
<tr>
<td>High M (SD)</td>
<td>0.24</td>
<td>0.42</td>
<td>0.11</td>
<td>0.48</td>
<td>1.26</td>
</tr>
<tr>
<td>Range</td>
<td>0-2</td>
<td>0-2</td>
<td>0-1</td>
<td>0-2</td>
<td>0-5</td>
</tr>
</tbody>
</table>
development of prosodic skills are supported by the prosody
production literature for children. Grigos and Patel [34] investigated
articulatory movements associated with the production of words with
and without focus in 4, 7, and 11 year olds, and adults. Significant
differences in duration, displacement, and velocity between focused
and unfocused productions were seen between 7 and 11 year olds and
adults, and there were differences between 11 year olds and adults.
Grigos and Patel concluded that the ability to produce sentential stress
starts to develop between seven and eleven years and continues
throughout adolescence. Doherty, Fitzsimons, Asenbauer, and
Staunton [57] examined prosody perception in typically developing
children (N=40, aged between 5 and 9 years) using linguistic
discrimination of compound noun vs. noun phrase pairs and
differentiation of questions/statements/commands) and affective
prosody tasks. They found significant age-wise improvement in
perceptual abilities up to 8; 5 years. They also reported that vocal
emotion recognition in children develops later than the corresponding
linguistic ability. Itô, Blyk, Wagner, and Speer [58] reported age-
related improvements in interpreting contrastive accent in children
aged between 6 and 11 years, however even the 11 year olds showed
delayed responses compared to adults. This suggests that it may take
many years for children to acquire the pragmatic meaning of pitch
accent. Early mastery of question-statement distinction over
contrastive stress patterns could be related to greater exposure and
familiarity effects. The infant directed speech literature suggests that
motherese includes large amount of emotional information and
utterances in the form of question-statement [59-61]. In conversational
English, contrastive stress usually occurs in the final word position of
a sentence while the PEPS-C Contrastive Stress task uses stress on
different word positions (e.g., I wanted a BLUE and green socks
(emphasis on the first colour) vs. I wanted a blue and green socks
( emphasis on the second colour)). This may not be the familiar pattern
for children and hence greater access to auditory cues may be crucial
to make this distinction. This is further corroborated by Balogh,
Swinney, and Tigue’s [62] findings that the ability to respond to
contrastive stress is related to a general sensitivity to prosodic cues and
is distinct from syntactic and pragmatic knowledge.

There were no significant differences in performance within the 7-8
year olds across the PEPS-C tasks, however performance on PEPS-C
Affect Reception task was significantly poorer than that for Turn-end
and Chunking Reception tasks for the 9-12 year olds. This suggests
that the PEPS-C Affect Reception task was the most difficult for the
9-12 year olds compared to other PEPS-C tasks. This could be because
the PEPS-C Affect Reception task uses a single word test items (names
of food items) rather than a sentence context which is less likely to
happen in real life situations (less ecological validity; Diehl & Paul [5]).
The DANVA 2 Child Paralanguage subtest results provide a
comprehensive view of affective prosody perception abilities in
children. DANVA 2 uses sentence level stimuli to assess perception of
different emotions (happy, sad, angry, and fearful) whereas the
PEPS-C Affect Reception subtest includes only two emotions (like/
dislike). There were no gender effects on PEPS-C or DANVA 2 subtest
performance. This is consistent with the results reported by Wells et al.
[23] and Peppé et al. [63].

DANVA 2 Child Paralanguage subtest results showed that 7-8 year
olds made more errors, followed by 9-10 year olds, and least number of
errors was made by 11-12 year olds. These results suggest a
developmental trend in affective prosody perception abilities in
children using DANVA 2 subtest; however this did not reach statistical
significance. Nowicki and Duke [7] reported significant age-related
changes in 6-10 year olds on DANVA 2 Child Paralanguage subtest.
They also reported a strong correlation between vocal emotion
recognition and academic achievement in children while DANVA 2
facial expression and posture recognition subtests did not show any
correlation. Significant correlations between vocal emotion recognition
and social adjustment (measured using Social Dysfunction Index) in
adults with schizophrenia were reported by Hooker and Park [64].
Unfortunately, emotion processing in children has been mainly
assessed through visual modality by using facial expression tasks, and
not much focus has been given to vocal emotion recognition. This is of
concern because the auditory system matures earlier than the visual
system [64,65] and understanding of vocal emotion expressions plays a
major role in early emotional development [38,67]. Halberstadt &
Eaton [68] reported that reduced family expressiveness of emotions
through facial expressions and voice were associated with poor
emotion understanding and expression in children. Early aberrations
in emotion processing need to be identified and treated in order to
ensure normal social and emotional development.

Overall the DANVA 2 results indicate that the errors obtained for
different emotions varied considerably depending on the level of
emotional intensity. Emotions presented at high intensities were
recognised significantly better than those presented at low intensities
for all emotions, except for fear. These findings are consistent with the
results of Justlin and Laukka [47] who reported that listeners were able
to decode happiness, sadness, anger, fear, and disgust vocal emotions
presented at strong emotion intensity better than for weak emotion
intensity. This is further supported by Bänziger and Scherer’s [69]
findings that there is an increase in F0 mean and F0 range with
increasing intensity, which serves as a cue for easier detection of high
emotion intensity stimuli. They reported that F0 parameters like mean,
range, and minimum and maximum F0 peak for low emotion intensities
-such as ‘sadness’, ‘calm joy’, and ‘angry’ are generally lower than the F0 values for emotions with high intensities such as
‘dispaired sadness’, ‘clated joy’, ‘panic fear’, and ‘hot anger’. It is
important to know how well children understand low emotion intensity cues, as in real life situations expressions of emotions are
often subtle [46]. Emotion intensity has not been systematically varied
in studies comparing atypical and typical populations. This is an
important issue because emotion processing difficulties in atypical
populations may be underestimated if only high intensity stimuli are
used. Considering the level of emotion intensity as a factor is useful in
identifying typical error patterns associated with different disorders
[40,70,71]. Baum and Nowicki [45] reported that accurate perception
of low emotion intensity cues, but not high intensity cues, was related
to social competence in typically developing children. These findings
indicate the importance of assessing prosody perception at different
intensity levels in typically developing children in order to have a basis
for evaluating children with disordered prosody.

The lowest accuracy was observed for fearful emotions followed by
sadness. Highest accuracy was noted for anger followed by happiness,
consistent with the results from previous studies [27,47]. Bänziger and
Scherer [69] reported specific differences in F0 contours for different
emotion categories that make certain emotions easier to identify than
others. For emotions such as ‘hot anger’, ‘cold anger’, and ‘dation joy’
The F0 excursions in the second part of the utterance trend to be larger
than for sadness or happiness. The shape of the F0 contour also changes depending on the emotion category; steeper final falls were
observed for anger compared to a progressive decrease (sadness) and
increase (happiness) in F0 until the final fall. The additional F0 information associated with anger and happiness could be the reasons.
why these emotions are perceived more accurately than others by the children. Most of the confusions between emotions reported in the present study can be described as symmetrical (a term borrowed from Juslin & Laukka [47]). For example, sadness was often confused with fear, and fear was confused with sadness. The same is true for sad and happy emotions and fear and happy emotions. These confusions mostly occurred for low emotion intensity items; suggesting that subtle acoustic cues are insufficient to accurately discriminate different emotions [47,48,69]. Asymmetrical confusions were also present, such as anger was mostly confused with sadness, but sadness was rarely confused with anger. However, sadness was the most frequently chosen incorrect alternative. There is minimal research to suggest that there are developmental differences in understanding vocal emotions depending on the emotion categories [73,74]. Further research should investigate the mechanisms by which children develop abilities to recognize different emotions.

Conclusion

The present study revealed a number of significant findings regarding prosody perception abilities in typically developing 7-12-year old children. Four receptive prosody subtests of PEPS-C and Child Paralanguage subtest of DANVA 2 were used. This research provided normative data for PEPS-C receptive prosody subtests and reported that development of receptive prosodic skills occurs between seven and nine years. A differential pattern of development for different aspects of prosody was found; chunking and contrastive stress perception skills develop at a later age compared to turn-end and affect recognition. Age-related improvements in performance on DANVA 2 subtest were observed; however these did not reach statistical significance. DANVA 2 scores varied depending on the level of emotion intensity, with high emotion intensity stimuli perceived more accurately than low emotion intensity items and this was consistent across the emotions, except for fear. There were no gender effects on PEPS-C or DANVA 2 scores. The results have clinical implications for assessing prosody perception abilities in atypical populations.

References
