Neurological state manifestation in infants' and children's voice features

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Abstract

This study has the aim to find out the data about the reflection of the neurological state in the voice features of infants and children. Two types of experiments were conducted: comparing of vocalizations of 0-3 months old infants having neurological disorders (n = 45) and typically developed (TD) infants (n = 50); comparison of speech features of TD children (n=30) with vocalization and speech features of 5-16 years old children with autism spectrum disorders (ASD) (n=30). The results of the study showed that the infant's vocalizations contain features important for determination of the risks of development. Differences between children with ASD and TD on the basis of higher values of pitch, pitch variability and formant characteristics were revealed.

Key words: voice features, children, RAS, neurological state.

Introduction

The human voice contains the characteristics important for different states and developmental risk determination. Since 50 years of the last century the study of infants cry and pain vocalizations for purpose to diagnose neurological conditions were beginning (e.g. Wasz-Hockert, et al., 1996; Xie, et al., 1996). More recent studies have focused on the acoustic properties of speech production in autism spectrum disorders (ASD). Abnormal prosody has been identified as a core feature for ASD (Bonneh, et al., 2011), however in respect of pitch values and pitch variation, the data are contradictory (Nakai, et al., 2014). The goal of this study is to find out the acoustic features specific for developmental risk and ASD children vocalizations and speech.

Method

Data collection

Participants in the study were -3 months old infants with neurological disorders (ICD -10, 91.8, 91.9) (n = 45) and typically developed (TD) infants (n = 50), 5-14 years old TD children and children with ASD (F84.0; n=30). ASD children have varying degrees of neurological disorder severity. They were divided into two groups: presence of

development reversals at the age 1.5 - 3.0 years (group-1- ASD -1) and developmental risk diagnosed at the infant birth (group-2 – ASD -2).

Two types of experiments were conducted: comparing of vocalizations of infants with neurological disorders and TD infants; and speech features of TD children with vocalization and speech features of ASD children. Different emotional states were used for comparing TD children and ASD children that allowed finding the variable characteristics of the voice.

Data analysis

The recording of vocalizations and speech was executed. Perceptive analysis of vocalizations and speech was made (200 adults). Spectrographic analysis of speech was carried out in the Cool Edit (Syntrillium Soft. Corp. USA) sound editor. The duration of vocalizations and pauses were measured. Pitch values, spectral maximums, their amplitude, and spectrum types were determined. Pitch values (F0), min and max pitch values, pitch range (F0 max - F0 min), formant frequencies and their amplitudes of vowels were measured in speech. All procedures were approved by the Health and Human Research Ethics Committee (HHS, IRB 00003875, St. Petersburg State University).

Result

Infant's vocalizations features

The "noise" spectrum frequently presents ($p<0.01$ –Mann- Whitney test) in the vocalizations of infants with neurological disorders than in vocalizations of TD infants (figure 1).

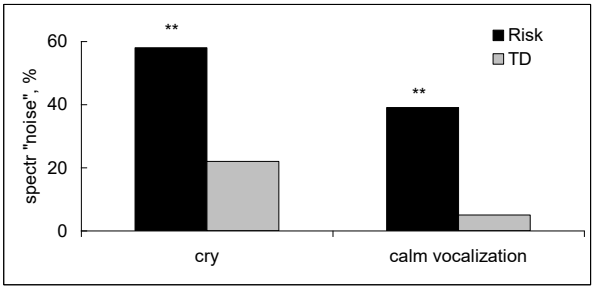

Figure 1. The duration of "noise" spectrum fragments in cry and calm vocalizations of TD infants and infants with neurological risk. ** $p<0.01$ – Mann - Whitney test.

The severity of the child's disease is reflected in the duration of vocalizations and the pauses between the phonation, the pitch values, and the predominance of vocalizations with "noise" spectrum.

Acoustic features of TD and ASD

Spectrographic analysis revealed that speech interpreted by listeners as discomfort, neutral and comfort is characterized by a set of acoustic features. Discomfort TD children's speech samples are characterized by highest maximum pitch values ($p<0.01$), average pitch values ($p<0.05$) and pitch variation values (F0max-F0min) ($p<0.05$) vs. neutral speech sample. Correctly recognized by adults discomfort and comfort speech do not differ in pitch variation values. Discomfort state is mostly characterized by falling pitch contour type, comfort state – by rising and neutral – by flat pitch contour.

For all children with ASD voice and speech is characterized by high values of the pitch, abnormal spectrum, and well-marked high-frequency. Discomfort state in the vocalizations and speech of ASD children, adults recognized better ($p<0.01$ Mann-Whitney test) than comfort and neutral state. Discomfort ASD children's speech samples are characterized by vowels' highest average pitch values, pitch range, and third formant frequency of vocalizations and words ($p<0.001$) than comfort and neutral speech samples.

Pitch average values (figure 2), pitch variation values (F0max-F0min) in ASD-1 child's discomfort, neutral and comfort speech significantly higher ($p<0.001$) than in ASD-2 child's speech. Pitch contour type does not change depending on the emotional state of ASD children. The F3 values in discomfort speech of ASD-1 children significantly higher than in corresponding voice features in ASD-2 children ($p<0.01$) and TD peers ($p<0.01$).

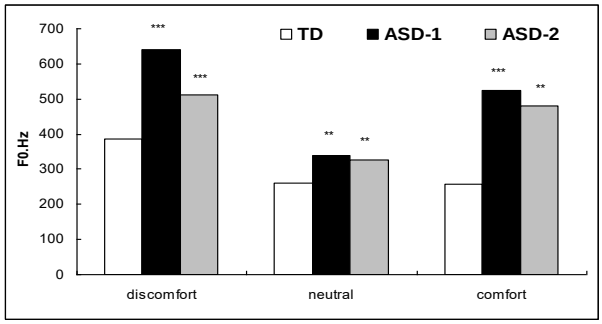

Figure 2. Vowel's pitch average value in discomfort, neutral and comfort state. **-$p<0.01$, *** - $p<0.001$ Mann-Whitney test.

The heaver child disease, the higher pitch values and third formant values, the lower speech level was revealed. Spearman correlation ($p<0.05$) was revealed between child's group and pitch values, third formant values.

Conclusion and discussion

We described the set of acoustical features that can be considered as one of the diagnostic sign of neurological disease and its severity. This result is amplifying with the findings of other studies on the early diagnosis of the infant's state on the voice features (Wasz-Hockert, et al., 1968). We present the first data for Russian ASD children of acoustic measures of participant's speech. Differences between children with ASD and TD on the basis of higher values of pitch, pitch variability and formant characteristics of ASD children were revealed. Our data confirm other studies with similar results [e.g. Paul, et al., 2005]. We believe that the acoustic features of speech of children with different neurological state are perspective for early diagnosis of developmental risk.

Acknowledgements

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