



SAINT-PETERSBURG
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A comparison of acoustic features of speech of typically developing children and children with autism spectrum disorders

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The study aims

The goal of this study is to find out the acoustic features specific for autism spectrum disorders (**ASD**) children vocalizations and speech

Method

Participants of this study:

1. Typically developing children, aged 4 -14 years (n=60)
2. Children with ASD (ICD - F84.0), aged 5 - 14 years (n=25)

Childhood Autism Rating Scale - CARS

(Shopler et al., 1986)

15 indicators

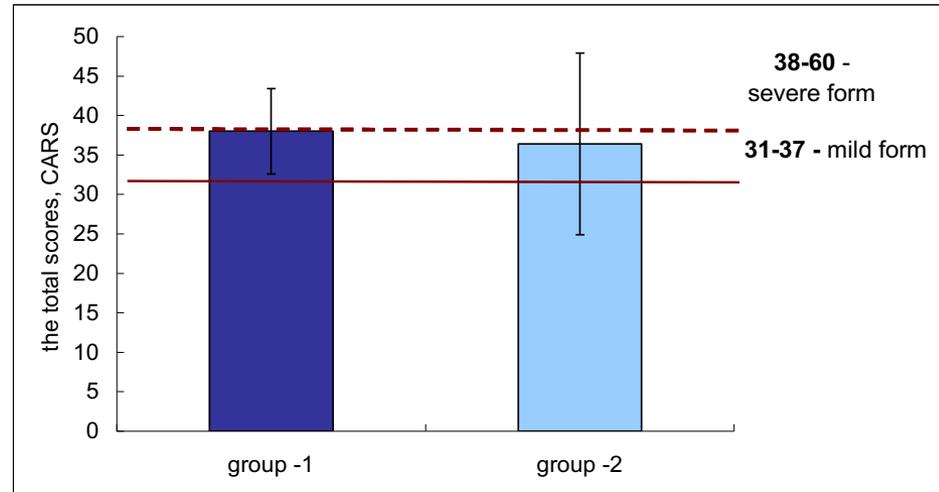
- 1 - social interaction;
- 2 – imitation;
- 3 - emotion;
- 4 – body possession;
- 5 - object manipulation;
- 6 – adaptation skills;
- 7 – visual responses;
- 8 – auditory responses;
- 9 – tactile & gustatory responses;
- 10 - fear or anxiety;
- 11 – verbal communication;
- 12 - non-verbal communication;
- 13 - activity level;
- 14 – intellectual level
- 15 – overall impression

31-37 – a mild form

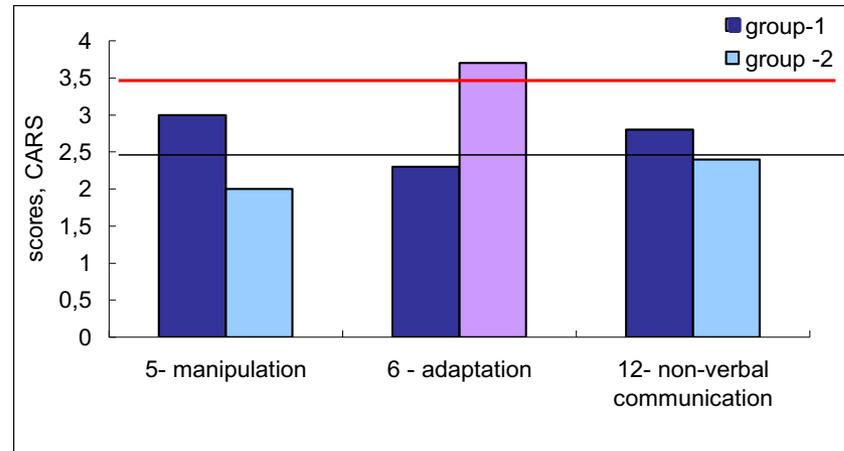
38-60 - a severe form of autism

Group-1 - development reversals;

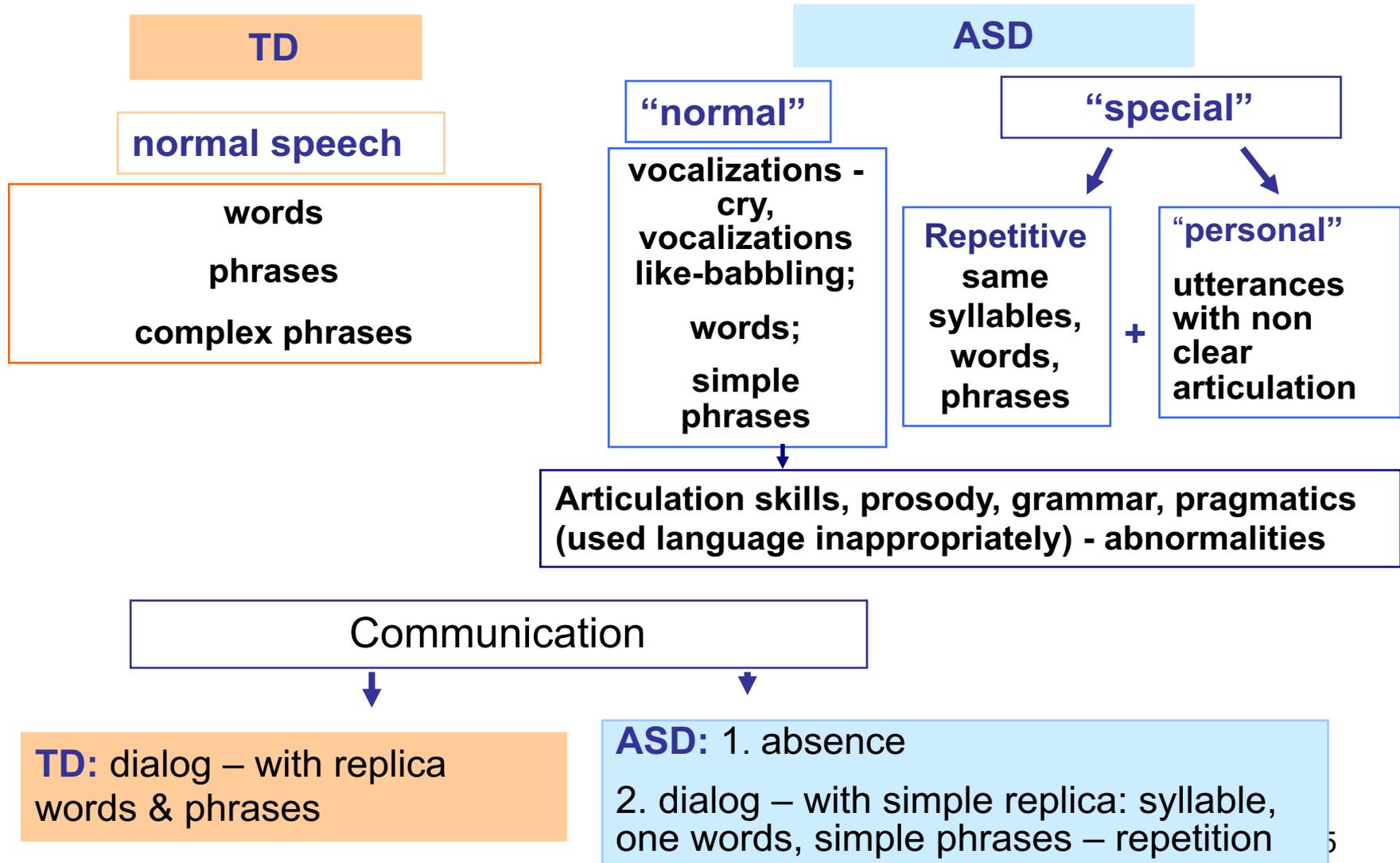
Group -2 - the risk diagnosed at birth: ASD – is a symptom of neurological diseases associated with brain disturbed



Differences between groups

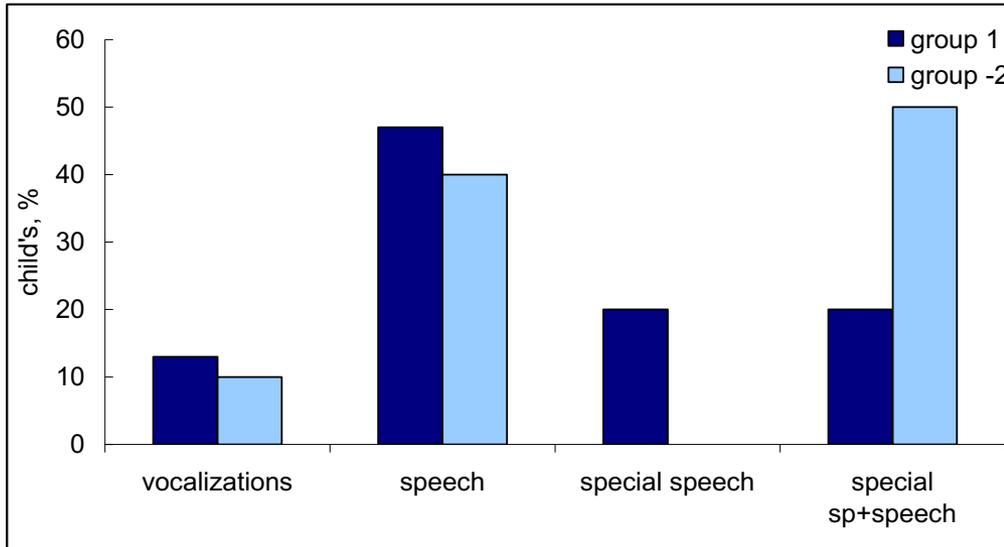


Speech & language

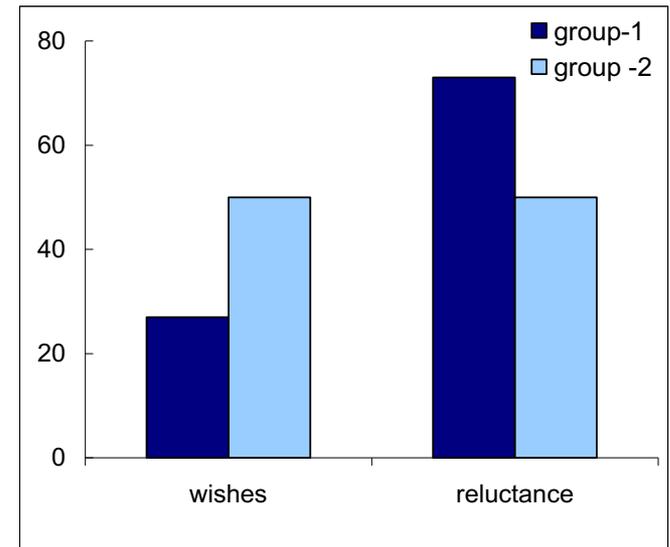


ASD: Characteristics of speech

A. Characteristics of speech level



B. Using the speech (wishes / reluctance)



Speech features: TD vs. ASD

3 experiments were conducted:

Experiment- 1: Emotional speech;

Experiment - 2: Spontaneous (spoken) speech;

Experiment - 3: Words repetition

Experiment -1: Emotional speech

TD: Modeling emotional state

1. Dialogue with the experimenter;
2. Playing with a standard set of toys
3. Repetition of words from a toy-parrot in a game store setting, and watching a cartoon - "Masha and bear" from iPad and the retelling of the story, respectively



places of recording were: at home, in laboratory and kindergarten

Experiment -1: Emotional speech

ASD: Modeling emotional state

1. Swimming in the pool – removal of stress
2. Show a standard set of the pictures and questions on the picture – pictures description
3. playing with toys



places of recording were: swimming pool & laboratory

Emotional state manifestation in child's speech:

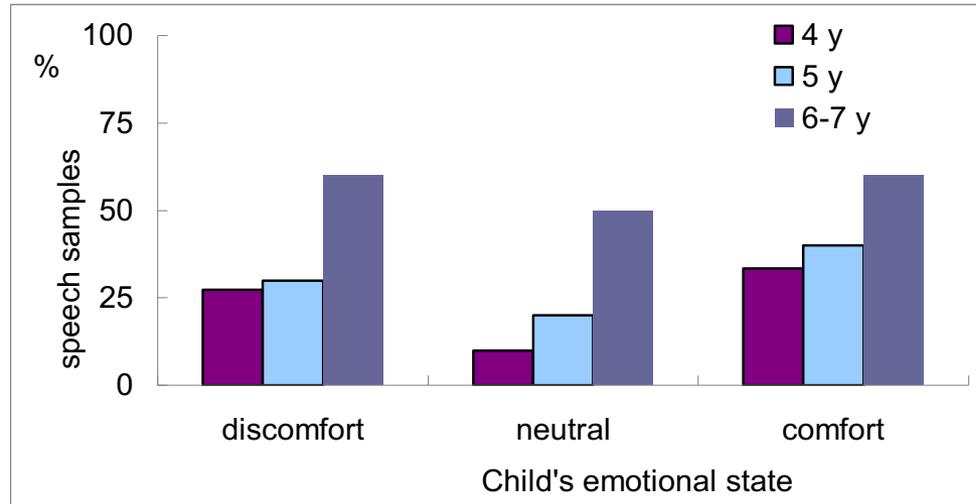
A. - recognition by adults

Task -1:

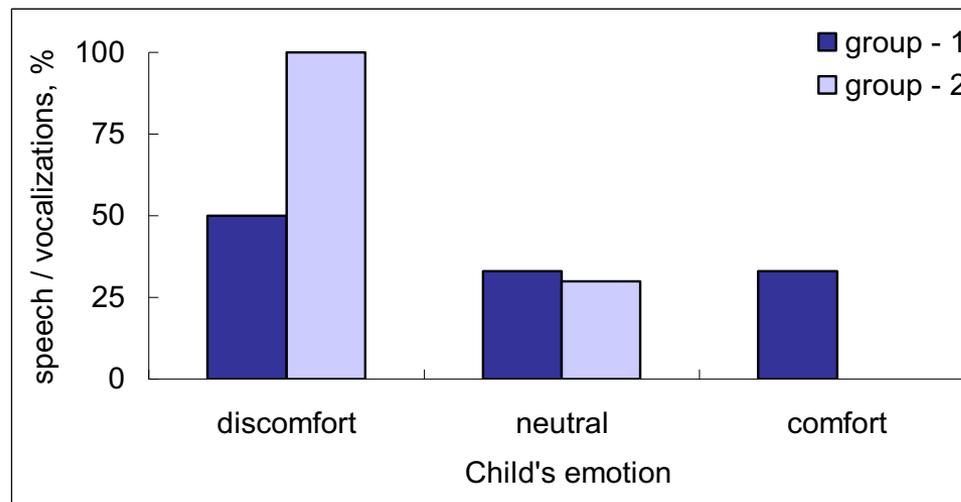
Discomfort

Neutral

Comfort



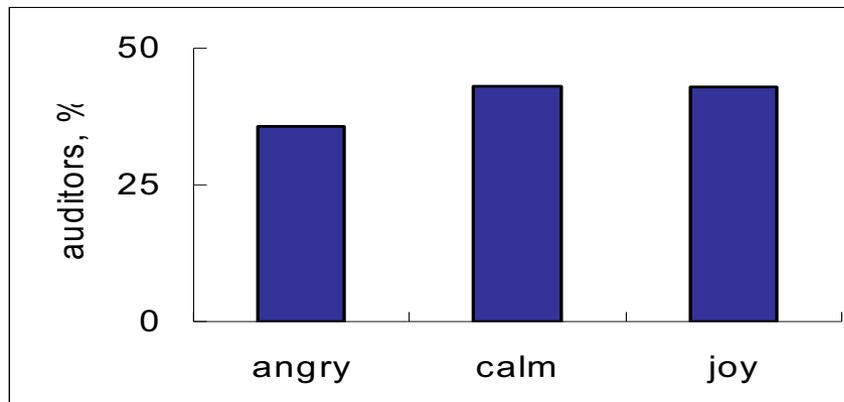
A. TD



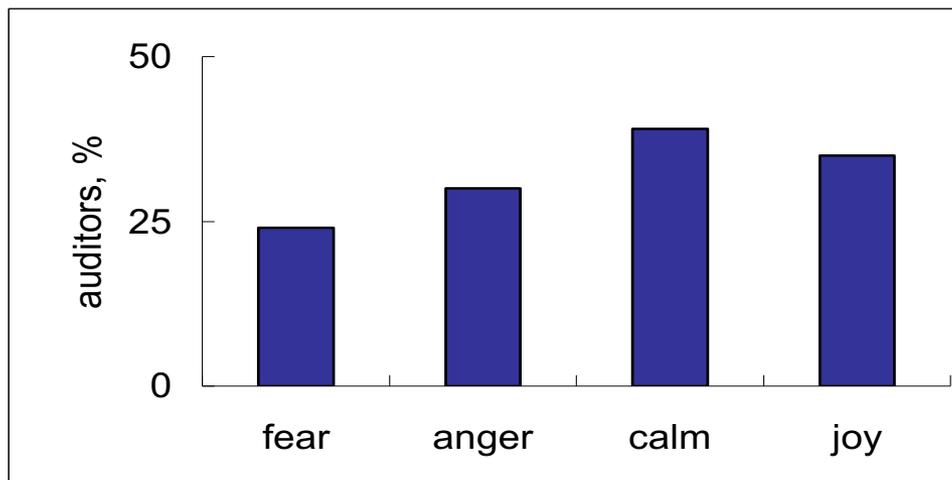
B. ASD

Correct recognition ASD children emotional state

A. words



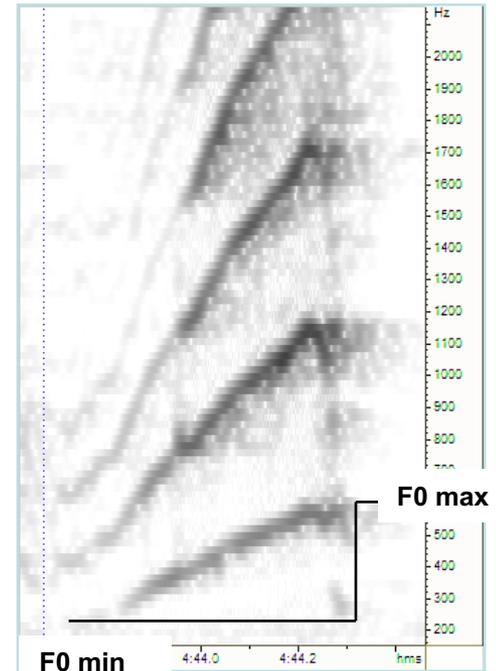
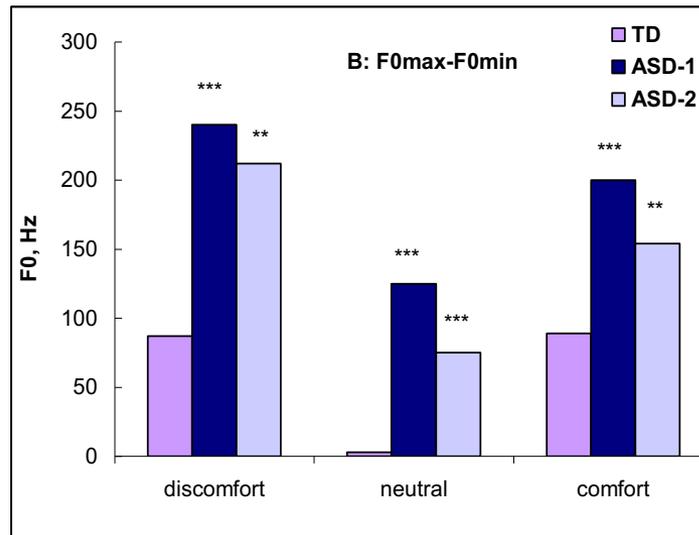
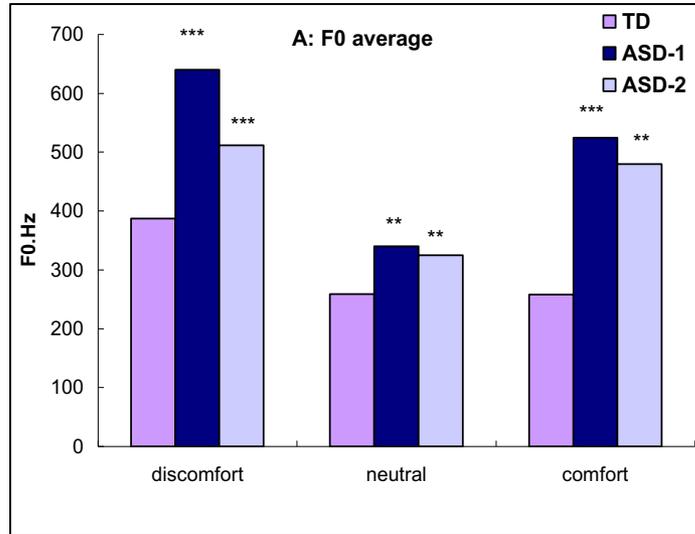
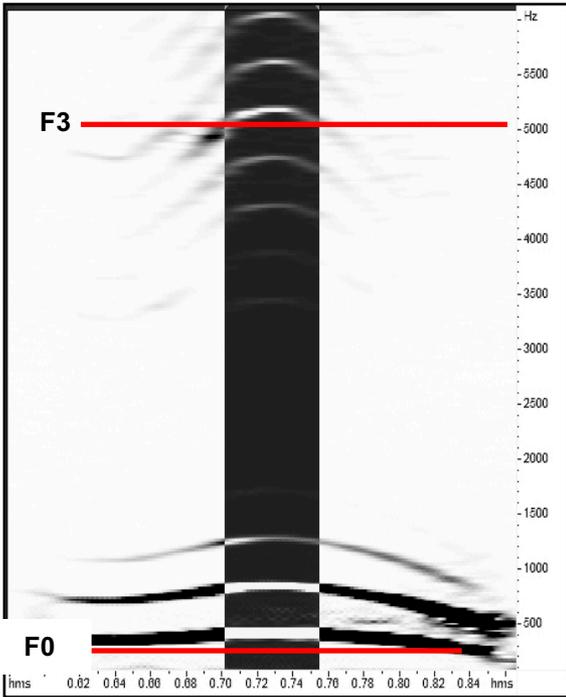
B. vocalizations



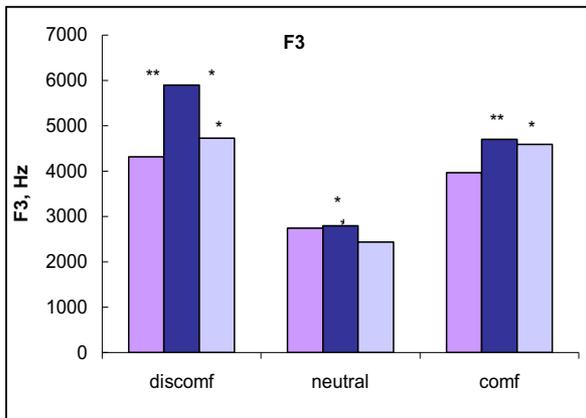
Task -2:

- Fear
- Anger
- Sadness
- Calm
- Joy
- Surprise

B - acoustical features – F0 - pitch values, F3



F0 range = F0max - F0min



* - $p < 0.05$; ** - $p < 0.01$; *** $p < 0.001$ - Mann-Whitney test

Intonation contour (prosody)

ASD

TD

!!!! For this samples of speech:



Falling -
discomfort

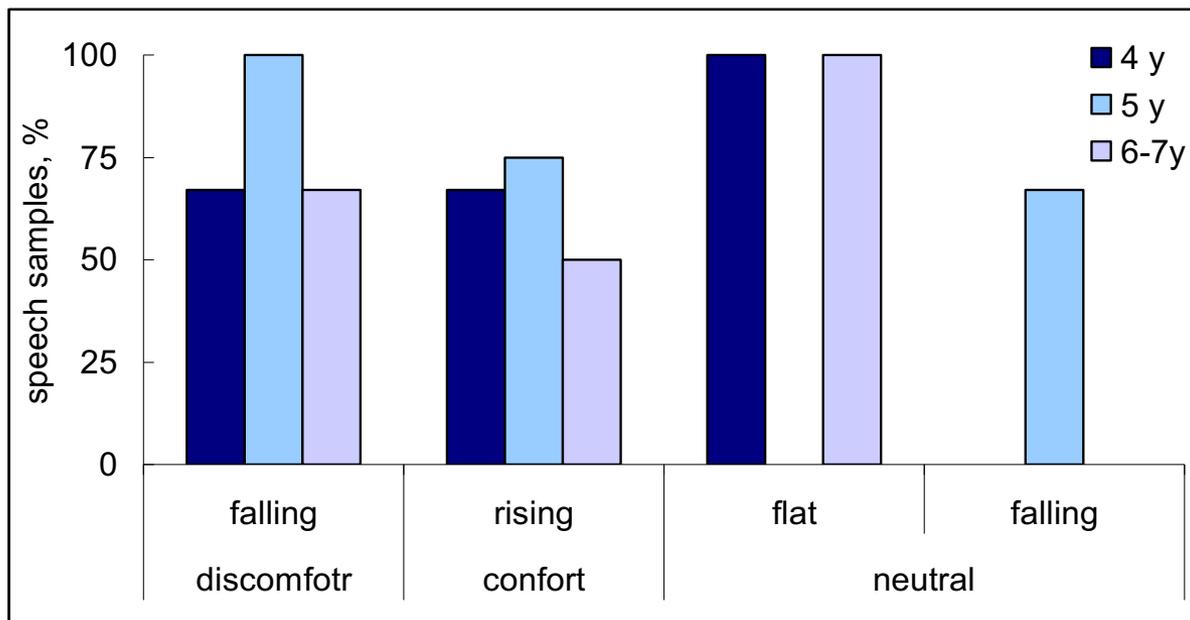


Rising -
comfort



Flat -
neutral

Correlation
between child
emotion state and
intonation – are
absent



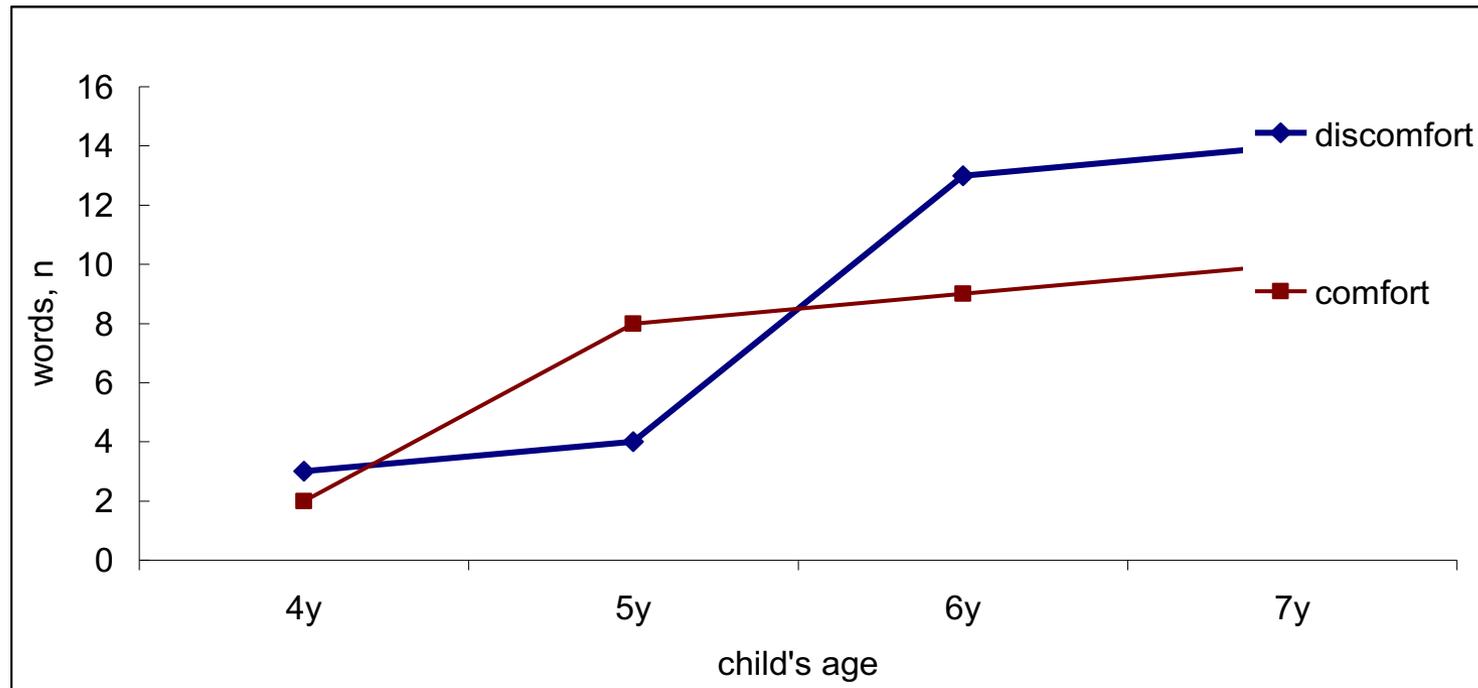
For vocalizations:



Discomfort:

falling,
rising +falling + rising

TD: The words of children, reflecting different emotional states



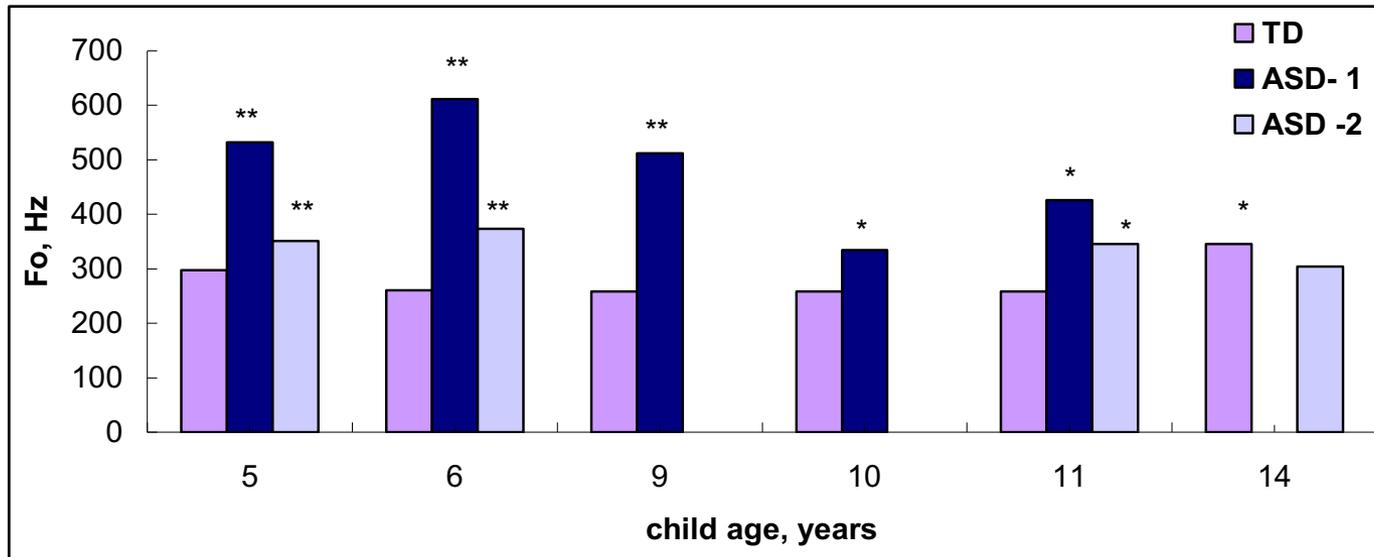
Verb + adjective

Experiment - 2: spontaneous speech

child dialogue with the experimenter
(neutral theme as possible as)

Acoustic features of TD and ASD spontaneous child speech

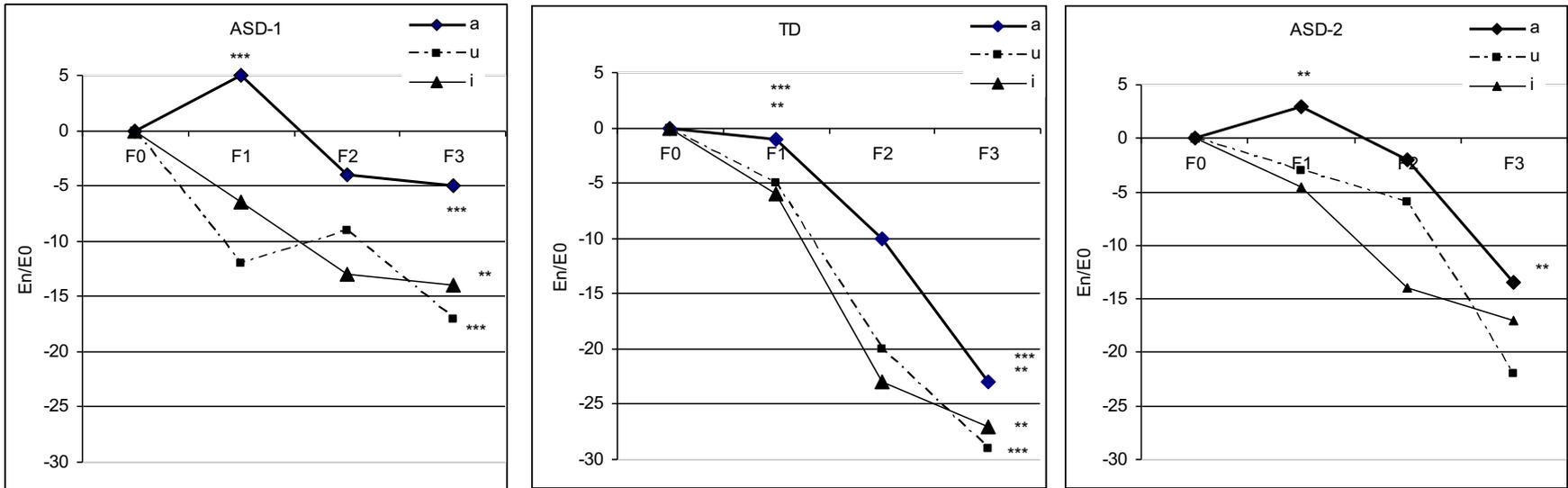
Pitch values



Pitch values of spontaneous speech of ASD children higher ($p < 0.001$) than pitch values of TD children, pitch values of ASD-1 children higher ($p < 0.01$) than in ASD-2.

For all children with ASD voice and speech is characterized by **high values of the pitch, abnormal spectrum, and well-marked high-frequency.** 16

The intensity of the third formant



The distribution of the three first format's amplitudes normalized to the amplitude of pitch for vowels /a/, /u/, /i/ in spontaneous speech.

Vertical axis – E_n/E_0 (normalized amplitude), horizontal axis – F0 and formants (F1, F2, F3).

A specific characteristic of the dynamic spectrum of the vowels of the ASD -1 child **is the intensity of the third formant.**

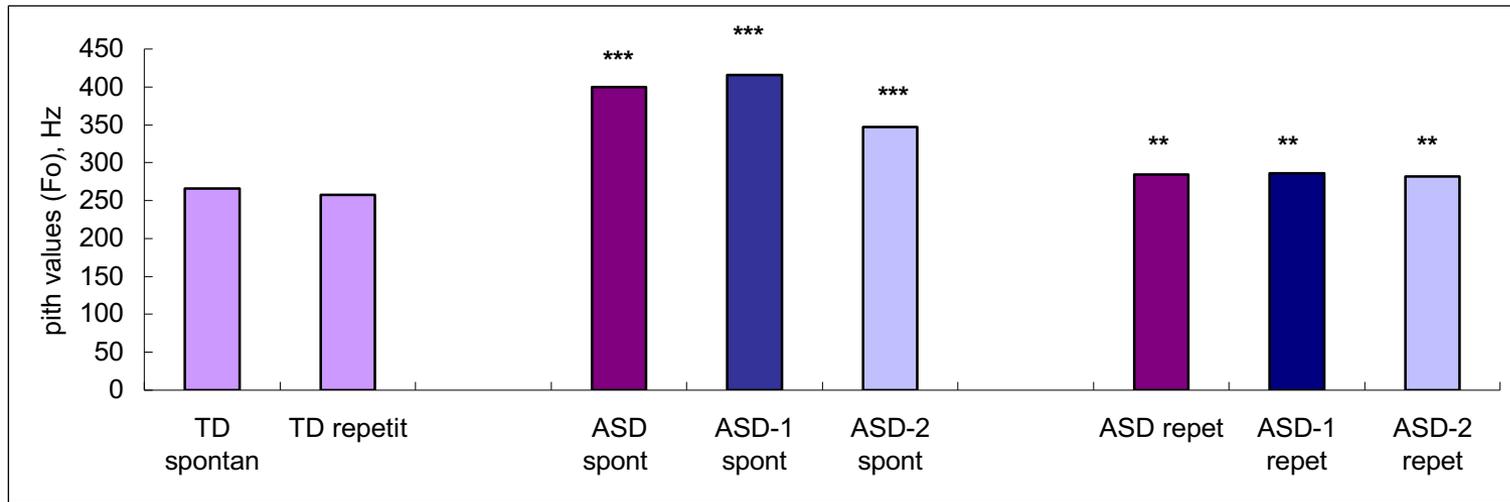
The intensity of the vowel formants ASD -2 children was not significantly different from the TD corresponding data, except for F3/E0 for vowel /a/.

Experiment - 3: the words repetition

- the child repeated the words of the experimenter or parent (for ASD children)

Experiment -3: Repetition

Repetition vs. spontaneous child speech



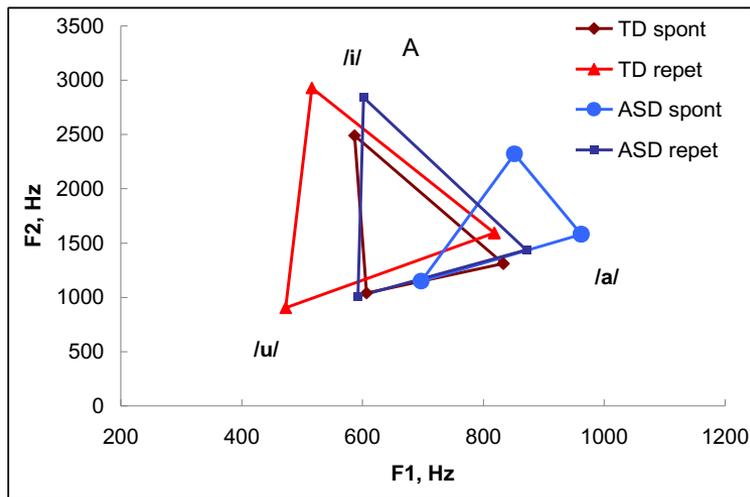
The pitch median values in the stress vowels of ASD and TD children in twice speech tasks (spontaneous and repetition)

Pitch values don't differ significantly in stress vowels from TD children's words in twice task. Pitch values of the ASD-1 children was significantly higher ($p < 0.001$) than in the ASD-2 child's spontaneous speech.

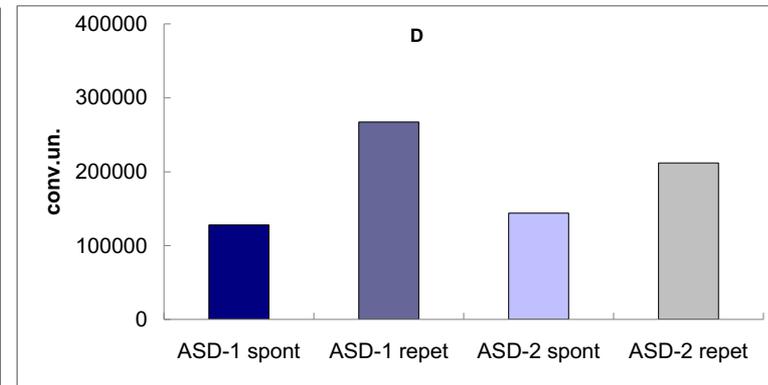
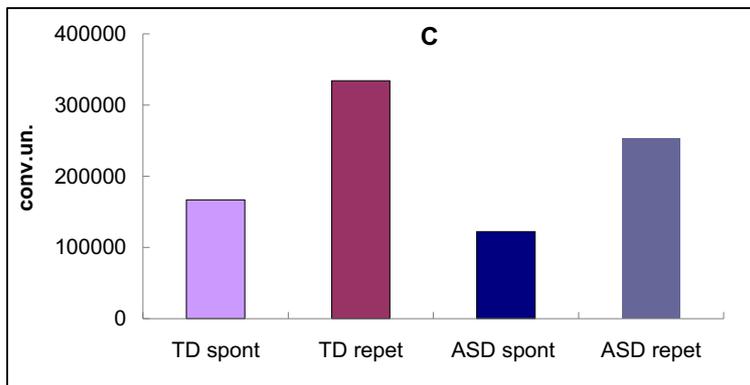
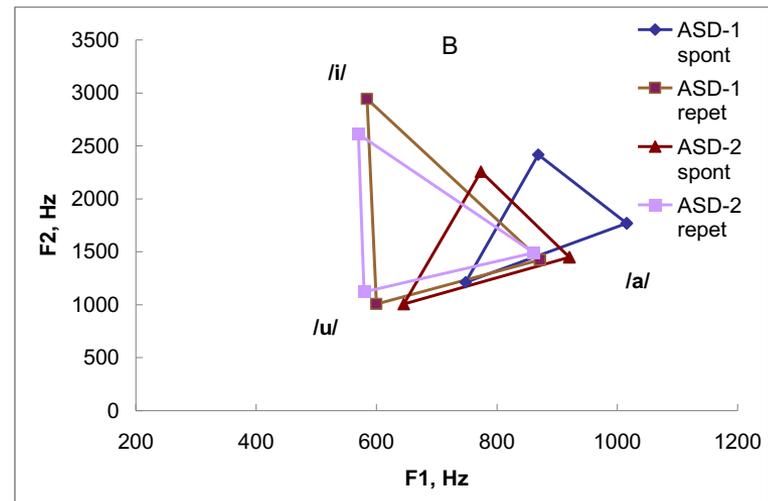
Pitch values variation ($F0_{max} - F0_{min}$) significantly higher in spontaneous speech of ASD-1 children than ASD-2 and TD children and in repetition words ASD-2 children were revealed.

The vowels formant triangles with apexes */a/*, */u/*, */i/*

TD & ASD



ASD-1 & ASD-2



Conclusion

- 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.
- In general, for all children with ASD voice and speech is characterized by high values of pitch and pitch variability. These acoustic features and well-marked high-frequency in spectrum were more clearly presented in the speech of the first group ASD children than the second group ASD children.

The current results are one of the first steps toward developing speech based bio-markers for diagnosis of ASD. We believe that the acoustic features of speech of children with different neurological state are perspective for early diagnosis of developmental risk.

Thank for yours attention!

Experiment -3: the words repetition

- the child repeated the words of the experimenter or parent (for ASD children)

Words to repeat:

1. Vowels /a/, /i/ and /u/ after the following consonants:

/k/ and /d/ for /a/,

/b/ and /g/ for /u/,

/t'/ for /i/

/ T'i / - тигр (tiger), ротик (mouth),

/ Ка / - кашка (clover), кар-кар (car-car), кап-кап (the drip-drip), кар (car),

/ Да / - дача (cottage), да (yes!), дай (give),

/ Бу / - буря (Storm), бух (wham!), буду (I will), могу (I can), арбуз (watermelon), бу-бу-бу (bu-bu-bu)

/ Гу / - губы (lips), в пургу (in a blizzard), гу-гу (gu-gu), гуси (geese)

2. Words with stressed vowels / a /, / i /, / u /

- The context (/a/, /i/ and /u/ after the following consonants) influence on the characteristics of vowels in speech repeated was not significant for ASD and TD children