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Pitch Pattern Analysis in Speech of Children with Autism Spectrum Disorder

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Abstract*: Autism Spectrum Disorder (ASD) is a multifaceted neurodevelopmental condition. Atypical communication mostly occurs in tandem with ASD. We compared voice pitch of 16 Marathi children and adolescents with ASD of age of 7 to 18 with 27 Typically Developing (TD). Speech samples have been recorded and stored in .wav format with sampling frequency of 48000 Hz. For analysis we used PRAAT, a program for speech analysis, manipulation and synthesis. We divided the ASD and TD group into total 4 groups on basis of age and gender for comparison. We found that differences in voice pitch are present in these comparison groups, and male ASD group have more pitch variation than respective comparison groups. In future we look forward to include more ASD participants in study to increase the Marathi speech database for ASD.

Keywords : Autism Spectrum Disorder, Marathi, Pitch, Prosody , Speech.

I. INTRODUCTION

Speech is by far the most reliable and advanced biological way of conveying emotions, views and opinions via interpersonal verbal communication used among human beings [1]. The speech includes an accurate acoustic, linguistic and pathological description, composed of data that is not only limited verbal information. Fluent speech production requires the combination of cognitive, linguistic and motor operations in humans. Speech isn't always fluent, caused by a number of problems in cognitive, linguistic and motor processes, where we can say that an individual may have some speech disorder. Disordered speech may become unintelligible and this discrepancy in speech may negatively impact both personal and social communication as well as it may affect the performance of automatic speech recognition systems [2]. Autism Spectrum Disorder (ASD) is a multifaceted neurodevelopmental condition. Peculiar prosodic tones have been coupled with ASD. Speech of children as well as adolescents with ASD tends to exhibit an unconventional speech pattern [3].

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Due to atypical brain development, ASD is defined by cognitive, communicative, motor and/or behavioral impairments. NeuroDevelopmental Disorder (NDD) umbrella contains Intellectual Disability, Communication Disorder, Asperger's Syndrome (AS), Attention Deficit / Hyperactivity Disorder (ADHD), Specific Learning Disorder, and ASD [4]. However, due to various resemblances, DSM-5 substituted Autism, Asperger's Disorder and other pervasive developmental disorders with parallel term Autism Spectrum Disorder in 2013. Symptoms of all these disorders represent a similar range of mild to severe deficiencies in social communications and inflexible repetitive behaviors, rather than distinct disorders [5].

Prosody includes an overwhelming quantity of non-verbal high-level data, which is socially used and is negatively influenced by a number of neurological conditions. Pitch is a prosodic feature which defines high or low tone perceived by the ear, depending on the amount of vibrations per second generated by the vocal cord [6] [7].

II. METHODS AND MATERIAL

A. Participants

1) *Autism Spectrum Disorder:* Participants in this group includes 16 children and adolescents with ASD between the ages of 7 to 18 consisting 11 males and 5 females. Participants have Marathi Language as mother tongue. Participants were recruited for this study from a school Aarambh Autism Center, Aurangabad, Maharashtra. Participants were diagnosed with Autism Spectrum. A qualified clinician has independently confirmed the diagnosis.

2) *Typically Developing:* The TD group includes 27 children and adolescents aged 7 to 18 consisting 16 males and 11 females who were recruited from Balgram Orphanage in Georai, Maharashtra. Participants have Marathi Language as mother tongue. All participants in this group had typical development as reported. Participants in this group had no previous history of clinical diagnosis or special educational services, and for their age they were in the required school grade.

B. Procedures

1) *Setup:* For ASD participants we used a classroom from the school and for TD group at Balgram Orphanage in Georai, participants sat on a bench and we used Zoom H1 Handy Recorder with a pop filter. We used built-in microphones available on Zoom H1. Recorder was held close to a distance of 10 cm from participant.

Speech samples have been recorded and stored in .wav format with sampling frequency of 48000 Hz as per the guidelines by Linguistic Data Consortium for Indian Languages (LDC-IL) [8].

Table - I: Marathi vowels Alphabets with IPA

Devnagri (Marathi)	IPA
अ	/ə/
आ	/a/
इ	/i/
ई	/i:/
उ	/u/
ऊ	/u:/
ऋ	/ru/
ए	/e/
ऐ	/əi/
ओ	/o/
औ	/əu/
अं	/əm/
अः	/əɦə/

2) *Data:* Considering the pictorial Marathi alphabet's sheet for reference, speakers had general communication with author. We asked participants to identify the alphabets and words. Database contains Marathi vowels, consonants and words mentioned in Table I, II, III but not limited to the mentioned data. The ASD speech database contains total of 1434 utterances; and for TD it includes 1585 utterances.

Table II. Marathi consonant Alphabets with IPA

Devnagri Marathi	क	ख	ग	घ	ङ	च	छ	ज	झ
IPA	/kə/	/kʰə/	/gə/	/gɦə/	/ŋə/	/tɕə/ or /tsə/	/tɕʰə/	/dʑə/ or /dzə/	/dʑɦə/ or /dzɦə/
Devnagri Marathi	ञ	ट	ठ	ड	ढ	ण	त	थ	द
IPA	/jə̃/	/ʈə/	/ʈʰə/	/ɖə/	/ɖɦə/	/ɳə/	/tə/	/tʰə/	/də/
Devnagri Marathi	ध	न	प	फ	ब	भ	म	य	र
IPA	/dɦə/	/nə/	/pə/	/pʰə/ or /fə/	/bə/	/bɦə/	/mə/	/jə/	/rə/
Devnagri Marathi	ल	व	श	ष	स	ह	ळ	क्ष	ज्ञ
IPA	/lə/	/ʋə/	/ʃə/	/ʂə/	/sə/	/ɦə/	/ɭə/	/kɕə/	/gɲə/

Table III. Marathi Words with IPA

Devnagri Marathi Word	अननस	आई	इमारत	ईडलिंबू	उंदीर	ऊस	एडका	ऐरण	ओठ
IPA	/ənənəsə/	/əi:/	/imɐərətə/	/i:ɖələi:məbəu/	/unədəirə/	/u:sə/	/eɖəkəa/	/əirəɳə/	/oʈʰə/
Devnagri Marathi	औषध	अंजीर	अः						
IPA	/əuʂədɦə/	/əmdʑəi:rə/	/əɦə/						
Devnagri Marathi	कमळ	खजिना	गणपती	घरटे	ङ	चहा	छत्री	जहाज	झबले
IPA	/kəməɭə/	/kʰədʑəi:nəə/	/gəɳəpətəi:/	/gɦərəʈəəi/	/ŋə/	/tɕəɦəə/	/tɕʰəjə̃i:/	/dʑəɦəədʑə/	/dʑɦə bələəi
Devnagri Marathi	ञ	टपालपेटी	ठसा	डबा	ढग	बाण	तलवार	थवा	दरवाजा
IPA	/jə̃/	/ʈəpəələpəəiʈəi:/	/ʈʰəsəə/	/ɖəbəə/	/ɖɦəgə/	/ɳəəɳə/	/tələʋəərə/	/tʰəʋəə/	/dərəʋəədʑəə/
Devnagri Marathi	धनुष्य	नळ	पतंग	फळे	बदक	भटजी	मगर	यकृत	रस
IPA	/dɦənəu:ʂəjə/	/nəɭə/	/pətəəmgə/	/pʰəɭəəi/	/bədəkə/	/bɦəʈədʑəi:/	/məgərə/	/jəkərəutə/	/rəsə/
Devnagri Marathi	लसूण	वड	शहामृग	षटकोन	ससा	हरीण	बाळ	क्षत्रिय	ज्ञानेश्वर
IPA	/ləsəu:ɳə/	/ʋəɖə/	/ʃəɦəmərəugə/	/ʂəʈəkəonə/	/səsəə/	/ɦərəi:ɳə/	/ bəəɭə/	/kɕəjə̃i: jə/	/gɲənəəiʃə ʋərə/

3) *Analysis*: For acoustic analysis we used PRAAT, a program for speech analysis, manipulation and synthesis [9]. All replies were audio recorded and the following acoustic characteristics of prosody were tested for vocalizations: mean pitch across the complete utterance, pitch range, and the standard deviation (SD) of pitch. Mean pitch determines how high or deep a person's voice is. The pitch range and SD of

pitch are standard measures of the pitch range of speech, and these data indicate if the prosodic variations are more or less than anticipated. We used 'To Pitch…' function in PRAAT and script was written to extract pitch characteristics and results were exported into csv file for comparison, using 100 Hz to 600 Hz as pitch range.

III. RESULT AND DISCUSSION

We divided the recorded data mainly into 4 categories for comparison. ASD Male, ASD Female, TD Male, TD Female. Generally puberty changes are seen at the average age of 13 years [10], and these changes affects acoustic features of male voice much more than that of females [11]. Hence we further classified each of these four groups into two more classes i.e. Below 13 Years, and Above 13 Years. We found significant differences in pitch of comparison groups. TD females of 13 years and below found to have shown alike mean pitch (TD = 304.74, ASD = 311.85), pitch range (TD = 160.36, ASD = 176.25) as well as SD (TD = 44.07, ASD 48.56). TD females of 13 years and above found to have slight higher mean pitch (TD = 290.85, ASD = 274.79), but lower pitch range (TD = 125.22, ASD = 154.74) and SD (TD = 36.58, ASD = 42.37). In TD group male of 13 years and below it is found that TD have very similar mean pitch (TD = 297.93, ASD = 296.90), but much lower pitch range (TD = 126.80, ASD = 191.62) and SD (TD = 35.11, ASD = 47.29). For TD males 13 years and above we found that TD group have lower mean pitch (TD = 156.31, ASD = 174.33), pitch range (TD = 74.69, ASD = 125.73) as well as SD (TD = 20.65, ASD = 34.70) than ASD group.

Table IV. Pitch Values For TD & ASD Female Group Below 13 Years

Data	Mean	Range	SD
TD Below Female	304.74	160.36	44.07
ASD Below Female	311.85	176.25	48.56

Table V. Pitch Values For TD & ASD Female Group Above13 Years

Data	Mean	Range	SD
TD Above Female	290.85	125.22	36.58
ASD Above Female	274.79	154.74	42.37

Table VI. Pitch Values For TD & ASD Male Group Below 13 Years

Data	Mean	Range	SD
TD Below Male	297.93	126.81	35.11
ASD Below Male	296.90	191.62	47.29

Table VII. Pitch Values For TD & ASD Male Group Above 13 Years

Data	Mean	Range	SD
TD Above Male	156.3	74.69	20.65
ASD Above Male	174.33	125.73	34.70

IV. CONCLUSION

In this research work we used Pitch to analyze the difference between ASD group and TD group speech for Marathi Language. Our findings say that there is no any significant difference in case of mean pitch except the case for TD & ASD male group above 13 years (156.31 < 174.33). But in case of pitch range and SD, TD group is having considerable lower values than that of the ASD group expect for TD & ASD group for females, as there is no major difference in pitch SD. The result shows that the speech in ASD has more pitch variation except females below 13 years. In future we look forward to include more ASD participants in study to increase the Marathi speech database for ASD.

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