ANALYSIS OF VOICE IN CHILDREN AMONG ASD & ADHD -A COMPARATIVE CASE STUDY

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ABSTRACT

The study aims at analyzing and comparing voice parameters like fundamental frequency, jitter %, shimmer % and Harmonic to Noise Ratio (HNR) in children with Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactive Disorder (ADHD). Two male children with ASD and ADHD of ages 7 and 4.5 years respectively were selected. Dr. Speech software was used to record and analyse the voice by the experienced Speech & Language Therapist in Speech and Hearing unit at Composite Regional Centre for PwDs, Lucknow, UP, India. Recording was done by using a professional microphone placed at a 90° angle from the mouth and keeping a 5cm distance for the utterance of vowel /a/. Recorded sample was analyzed and it was observed that, the fundamental frequency was higher in ASD subject than ADHD subject. The jitter and shimmer % and HNR value was higher in ADHD subject than ASD subject. Voice quality of ASD subject was moderately affected and of ADHD subject was severely affected. The result of the study may be used for modification of voice during therapy for children with ASD and ADHD. And it can be reference for the therapist, teachers and other allied professionals.

Key Words- ***ASD, ADHD, Dr Speech, Voice, Children, Analysis.***

INTRODUCTION

Normal human voice may be characterized by five aspects, each related to function. First, the voice must be loud enough to be heard. Second, the voice must be produced in a manner that is hygienic and safe, that is, without vocal trauma and resulting laryngeal lesions. Third, the voice should have a pleasant quality. Fourth, the normal voice should be flexible enough to accurately express emotions. Last, the voice should represent the speaker well in terms of age and gender.[1]

Voice in Children with ASD: Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder in which characteristics mainly seen is deficits in social communication and social interaction and presence of restricted and repetitive behavior.[2] The voice of many ASD (Autism Spectrum Disorder) children appears abnormal and often appears machine-like**, "monotonic," or "sing-song."** These voice and speech abnormalities were noted in early descriptions of ASD.[3] But their exact characteristics and the underlying mechanisms, as well as their consistency and diagnostic power are currently unclear.[4]

Voice in Children with ADHD: Attention deficit Hyperactive Disorder (ADHD) is a brain disorder that is lifelong. In this disorder it is hard for a person to pay attention. Some people with ADHD have trouble sitting still or controlling their behavior.[2] More hoarseness, breathiness, and straining in voice was seen in children with ADHD.

They were also louder compared to controls. There were no significant changes in the acoustic parameters except for the Fundamental frequency, which was lower in the ADHD group.[5]

PARAMETERS OF VOICE IN CHILDREN (NORMAL GROUP): Fundamental frequency, denoted by F0 or $F_{0,}$ of a speech signal, refers to the approximate frequency of the quasi-periodic structure of voiced speech signals. The range of SFFs used in connected speech is known as **Frequency Variability**. Some frequency variability is seen in normal voices, perceived by the listener as acceptable changes in prosody. Functional, organic, or neurological basis can be present in Abnormal frequency variability. Frequency variability is measured in terms of the standard deviation (SD) from the average F0. It can be measured two ways: either the standard deviation of F0 in Hz (F0SD), or in semitones (pitch sigma).[6] The Voice Committee of the International Association of Logopedics and Phoniatrics proposed an official term **The Voice Range Profile (Phonetogram)** in 1992. It describes an individual's minimum and maximum intensity levels across his or her vocal range. They are graphical representations of the VRP. The patient is asked to phonate the vowel /i/ or /a/ at select frequencies across his or her frequency range, both as softly and loudly as possible. [7] The cycle-to-cycle variability in the vocal signal is known as **Vocal Perturbation Measures**. The normal voice may show a small amount of cycle-to-cycle variability. Sustained vowels or steady-state portions of vowels extracted from connected speech are typically used to determine vocal perturbation. Two vocal perturbation measures commonly obtained are **jitter** and **shimmer**. Jitter is the short-term variability in fundamental frequency. While shimmer is the short-term variability in the amplitude. Generally, jitter of less than 1.0% and shimmer of less than 0.5 dB are considered normal [8]. Children demonstrate higher jitter and shimmer than adults.

Vocal Noise Measures The human is made up of harmonic (periodic) and inharmonic (aperiodic) components. This is because vocal fold vibration is naturally aperiodic (irregular). In a voice with normal voice quality, the harmonic components should dominate, that is, have more energy (as measured in dB). In attempting to quantify the relationship between the harmonic and inharmonic components, researchers have proposed three ratios: the harmonics-to-noise ratio (HNR), the noise- to-harmonics ratio (NHR) and the signal-to-noise ratio (SNR). The voice with normal quality is characterized by a high HNR or SNR and low NHR, Whereas the dysphonic voice is characterized by a low HNR or SNR and a high NHR. [1][8]

AIM AND METHODS

This study aims to offer a contribution in the description of voice parameters in children with ASD and ADHD of ages 7 and 4.5 years respectively and their comparison. Both the children were males. The testing method selected was Dr. Speech software. The study was done at Composite Regional Centre, Lucknow, India. The vocal analysis was carried out by the Speech and Language Therapist. We used a professional microphone, placed at a 90° angle from the mouth, keeping a 5cm distance for the utterance of vowel /a/.

DR. SPEECH SOFTWARE- In this a wide range of parameters (jitter, shimmer, NNE, etc.) and graphic displays (spectrogram, F0, intensity, etc.) are offered. It is used to guide diagnostic assessments for voice disorders by measuring hoarse, harsh, and breathy voice. It provides diagnosis and rehabilitation data about laryngeal function signals (voice signals, laryngeal acoustics signals) and speech signals. It uses precise signal detection and processing. Advanced multidimensional voice parameter detection and analysis can be done by this software. It provides a comprehensive report for voice quality assessment using acoustic parameters – jitter, shimmer, fundamental frequency tremor, amplitude tremor, normalized noise energy (NNE), harmonic-to-noise ratio (HNR), signal-to-noise ratio (SNR). It is useful for patients with moderate hoarseness, mild roughness, and severe breathiness. [9]

CASE STUDY – ASD:

Case Name- N Age/Sex- 7 Years /Male
P. Diagnosis- Autism Spectrum Disorder (?)
Complaint- Child has inability to speak age appropriately. He shows echolalic behavior.

BIRTH HISTORY

Pre-Natal: No anormal pre-natal history reported by mother.

Peri-Natal: Delivery was full term (9 months) and caesarean at hospital. Weight of the child at birth was 2.5 kg as reported by mother. Birth cry was feeble as reported by mother.

Pre-Natal: Child suffered seizures at the age of 1 year.

MEDICAL HISTORY

Interpretation- Partial Seizures.

The child suffered seizures at the age of 1 year. Treatment was done from King George's Medical University, Lucknow. Seizures were controlled after which medication was stopped by self. Another episode of seizure took place at the age of 2 years. Currently the condition is maintained and the child is adherent to treatment.

EEG- borderline; abnormal sleep EEG recorded latest in 2019.

IQ Assessment was done at KGMU, Lucknow on 28th December,2020. Social Age was found to be 4 years 5 months. Reports indicated borderline level of Socio-Adaptive Functioning.

The score on Indian Scale for Assessment of Autism came out to be 130. Hence, indicating Moderate Autism.

Parents do not suspect hearing loss.

DEVELOPMENTAL HISTORY

Child had age-appropriate differential cry and babbling. The first meaningful word (mamma) came at the age of 13 months. The child communicates in phrases that are not grammatically correct. The child shows immediate echolalic behavior. Parents do not suspect hearing loss. Child's motor development is age appropriate. Child talks to himself and prefers to stay alone. Child exhibits aggressive behavior.

LANGUAGE STATUS

Child currently has good understanding of objects around him and can name them correctly. Child identifies and names all his family members. The child communicates in short phrases which are grammatically incorrect. The child does not have concept of yes/no type questions, opposites and colours. The child cannot initiate the topic or ask questions.

Language Age- Receptive Expressive Emergent Language Scale
Receptive Language Age~ 4-4.5 Years.
Expressive Language Age~ 3-3.5 Years.

VOICE ANALYSIS: Voice Analysis to be done using Dr Speech Software.

CASE STUDY – ADHD

Case Name- B Age/Sex- 4.5 Years/ Male
P. Diagnosis- Attention Deficit Hyperactive Disorder (?)
Complaint- Child is unable to speak according to his age. Child has hyperactive behavior.

BIRTH HISTORY

Pre-Natal: No abnormal pre-natal history as reported by mother

Still birth of a baby prior to this case

Peri-Natal: Delivery was full term (9 months) and caesarean at hospital. Weight of the child at birth was 3.5 kg and birth cry were normal as reported by mother.

Post-Natal: Seizures after one year of birth

MEDICAL HISTORY

Seizures after one year of age. Undergone treatment at King George's Medical University, Lucknow.

The clinical observation suggested of Attention Deficit Hyperactive Disorder.

The score on Indian Scale for Assessment of Autism came out to be 65. Hence, Autism not diagnosed through ISAA.

Parents do not suspect hearing loss.

DEVELOPEMENTAL HISTORY:

Child has age-appropriate motor development but delayed language development. Child started babbling at the age of 1.5 years. His first babbling sound was /b/. Child's first meaningful word was /baba/ at the age of 2.5 years. Child acquired phrases at the age of 3.5 years but has not yet acquired sentences in speech. Child's social development was delayed. He is aggressive and stubborn.

LANGUAGE STATUS:

Child currently has fair understanding of people and objects around him. He identifies all family members, body parts, objects such as glass, spoon, remote, mobile, ball, toy car. Child can follow two step simple related command like sit down or stand up but refuses to follow when he is in aggressive. Child understands 'yes' & 'no'. Child does not understand complex commands. Child can name almost all the objects, fruits, vegetables, toys and people around him. Child shows misarticulation in palatal and retroflex sounds. Child can speak in phrases but cannot form accurate sentences. Child is able to initiate topic but is unable to maintain it and shows repetitive behavior.

Language Age as on 22nd January 2021

Receptive Expressive Emergent Language Scale
Receptive Language Age~ 22-24 Months
Expressive Language Age~ 12-14 Months

VOICE ANALYSIS: Voice Analysis to be done using Dr Speech Software.

RESULTS

Voice Analysis was done using Dr Speech software for both ASD and ADHD subject.

Voice Data
(Start: 0.0s End: 0.7s)

Habitual F0 (Hz)	312.94	NNE (dB)	-9.26
Jitter (%)	0.33	HNR (dB)	25.44
Shimmer (%)	2.64	SNR (dB)	22.48
F0 Tremor (Hz)	1.70	Amp Tremor (Hz)	1.43
Mean F0 (Hz)	305.38		
SD F0 (Hz)	7.38		
Max F0 (Hz)	319.57		
Min F0 (Hz)	290.13		

Figure 1.1- Voice Data - ASD Subject

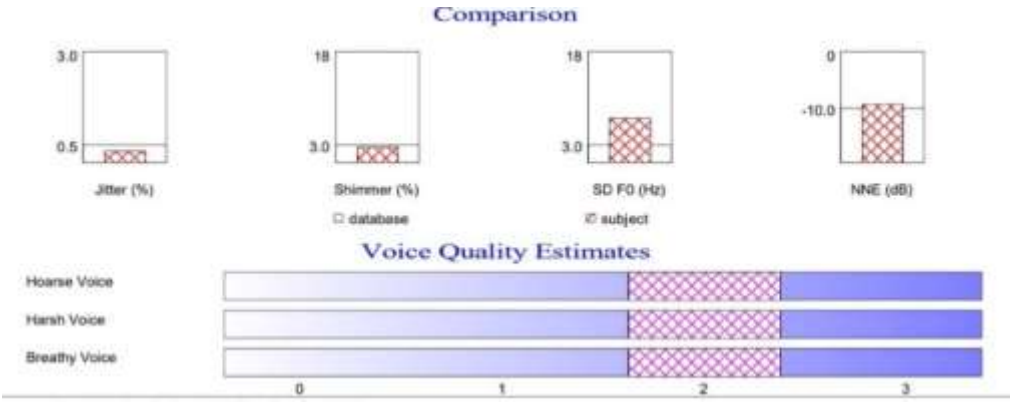

Figure 1.2- Voice Quality - ASD Subject

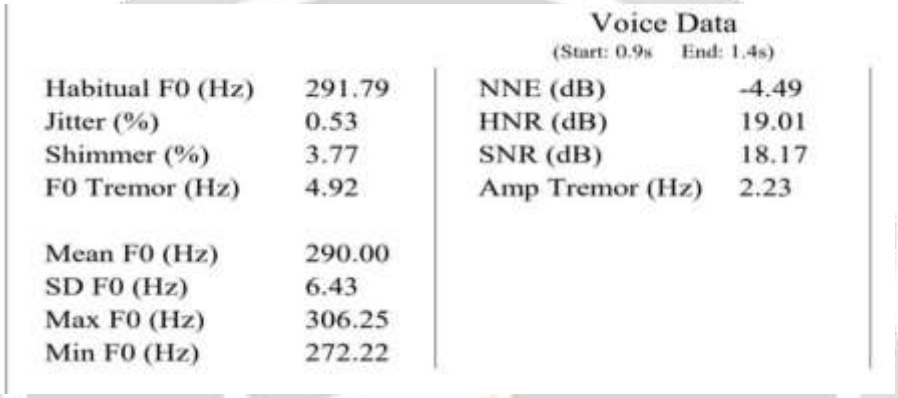

Figure 2.1- Voice Data – ADHD Subject

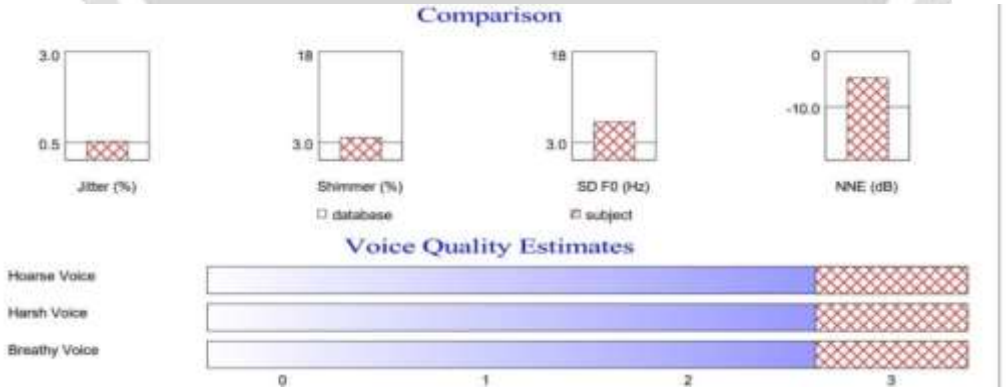

Figure 2.2- Voice Quality- ADHD Subject

As per voice analysis, it indicates that, the findings of both ASD and ADHD subjects vary from the normatives. Fundamental frequency, mean frequency, jitter, shimmer and HNR values are higher than the normal group. Comparison discussed in Table 1.0. Findings indicate high pitched voice in both the cases.

It also indicates that the voice quality of ASD subject is moderately affected and the voice quality of ADHD subject is severely affected which need to be corrected or modified.

Table 1.0 Comparison of Voice Parameters.

PARAMETERS	**NORMATIVE Children 4-8 yrs. boys**	**SUBJECT 1 ASD**	**SUBJECT 2 ADHD**
Habitual F0(Hz)	262	312.94	291.79
Jitter (%)	1.55-1.609	0.33	0.53
Shimmer (%)	0.52	2.64	3.77
Mean F0(Hz)	243	305.38	290
HNR (dB)	7-12	25.44	19.01

DISCUSSION:

Vocal analysis in children with ASD or ADHD have particularities which differ from those in children of normal group such as changes in F0, jitter, shimmer or HNR values and Voice Quality. The study done by D.N. Sorenson, April, 1990,[10] indicate that average fundamental frequency across tasks for the boys is approximately 262 Hz, and for girls approximately 281 Hz for age group 4 to 8 years. However, in this study, the F0 was 312 Hz for ASD subject and 291.79 Hz for ADHD subject, i.e., none of the two match the normal values. Both the cases show High pitched voice.

Wertzner et al (2005) [11] analysed the vocal characteristics of a group of 20 children, in the age range between 4 and 10 years. In the results, the mean values of vocal parameters for the /a/ vowel were, respectively: jitter % between 1.55% and 1.609%; Whereas, the jitter % for our cases came out to be- 0.33 % in ASD subject and 0.53% in ADHD subject. Anjali Kant (November 2015) [12] mentioned in a study that the shimmer % in age group 4-7 years of male children is 0.52%. However, the shimmer % of our cases are- 2.64% in ASD subject and 3.77% in ADHD subject.

Generally, an HNR of approximately 12 dB or greater is indicative of a voice with normal quality (Yumoto and colleagues, 1982) [13]. Ferrand (2000, 2002) has reported that HNRs for children are lower than HNRs for young and middle-age adults i.e., HNR are lower than 12d B in children.[1] However, Joao Paulo Teixeira, Carla Oliveira, Carla Lopes (2013) clarified that HNR value of less than 7db is indicative of Pathology.[1] However, in the present study, HNR values in our cases are higher, i.e., 25.44 dB in ASD subject and 19.01 dB in ADHD subject which is higher than normative value of 7-12 dB in children.

The present study also indicates that both the cases have seizure disorders.

Both ASD and ADHD subject's voice quality is affected. ADHD subject had more harsh, hoarse and breathy voice than ASD subject i.e., the voice quality of ASD subject is moderately affected and the voice quality of ADHD subject is severely affected which need to be corrected or modified. Hence Voice Therapy will be carried to improve the quality of voice.

The receptive language age for 7-year-old ASD subject is 4-4.5 years and his expressive language age is 3-3.5 years. Whereas, the receptive language age for 4.5-year-old ADHD subject is 22-24 months and his expressive language age is 12-14 months. This finding indicates that both the cases have delayed language. Hence, Speech Language Therapy will be carried out to improve the receptive and expressive language as well as to correct associated problems like misarticulation and echolalic speech.

CONCLUSION:

The voice of many children with autism spectrum disorder (ASD) appears abnormal and is often described as machine-like**,** "monotonic," or "sing-song" and Children with ADHD were perceived to have significantly more hoarseness, breathiness, and straining in their voice. They were also louder compared to controls. In this study a ASD subject & a ADHD subject was selected to determine voice parameters through Dr Speech software. Analyzing the voice output of the subjects it was found that both cases have high pitched voice. Voice quality is moderately affected in ASD subject and severely affected in ADHD subject. The result of the study may be used for modification of voice during therapy for children with ASD and ADHD. And it can be reference for the therapist, teachers and other allied professionals.

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REFERENCE

1. Boone, D. R., McFarlane, S. C, Von Berg, S. L. & Zraick, R, I. (2013): The Voice and Voice Therapy. (9th Ed.). Englewood Cliffs, Prentice-Hall, Inc. New Jersy
2. American Speech-Language Hearing Association. (2003); retrieved on 20-01-22.
3. Kanner et al, (1943) ; The Voice and Voice Therapy. (9th Ed.). Englewood Cliffs, Prentice-Hall, Inc. New Jersy
4. McCann and Peppe, 2003; Paul et al. 2005 Clinical Voice Disorders. (4th Ed.). New York: Thieme, Inc
5. Hamdan AL, Deeb R, Sibai A, Rameh C, Rifai H, Fayyad J. Vocal characteristics in children with attention deficit hyperactivity disorder. *J Voice*. 2009 Mar;23(2):190-4. Doi: 2007 Dec 21.
6. Awan et al., (2001),): The Voice and Voice Therapy. (9th Ed.). Englewood Cliffs, Prentice-Hall, Inc. New Jersy
7. LeBorgne; (2007); Titze, (1994); Ferrand (2000, 2002) The Voice and Voice Therapy. (9th Ed.). Englewood Cliffs, Prentice-Hall, Inc. New Jersy
8. Aronson, A.E. & Bless, D. M. (2009). Clinical Voice Disorders. (4th Ed.). New York: Thieme, Inc
9. www.drspeech.com; retrieved on 10-01-22.
10. D.N. Sorenson, April, (1990); Clinical Voice Disorders. (4th Ed.). New York: Thieme, Inc
11. Wertzner, H. F., Schreiber, S., & Amaro, L. (2005). Analysis of fundamental frequency, jitter, shimmer, and vocal intensity in children with phonological disorders. *Brazilian Journal of Otorhinolaryngology*, 71(5), 582-588
12. Kant, A., (2015). Vocal Parameters in Children. *International Journal of Scientific and Research Publications, Volume 5* (Issue 11) November 2015
13. Yumoto, E., and Gould, W., 1982. Harmonics-to-noise ratio as an index of the degree of hoarseness, *The Journal Acoustic Society of America*. (2009)