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Articulation Profiles of Children with Autism and Cochlear Implants: Exploring Acoustic Characteristics

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Abstract

Children with autism spectrum disorder and children with cochlear implants can experience phonological deficits. This study examines the acoustic profiles of the speech of ten Bangla-speaking children with either cochlear implant or autism spectrum disorder. A Bengali phonological picture test set as well as a narrative picture test were used as stimuli to elicit responses. Both groups exhibited significant articulation and/or phonological deficits in syllable, word, and sentence utterances. More specifically, to pronounce the different words, phrases, and sentences they frequently encountered phonological problems like stress, pitch, tone, intonation, and loudness. In the current study, PRAAT software was used by the researchers to analyze acoustic data. The analysis resulted in ten individual profiles of the speech of children with speech sound disorder. The children with a cochlear implant exhibited more phonological deficits than autistic children.

Keywords: Autism, Hearing Impaired, Cochlear Implant, Spectrogram, PRAAT

1. Introduction

Speech language pathologists provide assessment and intervention to children and adults with a variety of diagnoses including autism spectrum disorder and hearing impairment. Intervention can include both speech and language therapy. The present study has been conducted to explore the acoustic speech profiles of two groups- Bengali children with autism spectrum disorder and Bengali children with cochlear implant.

According to the World Health Organisation (2023a), autism spectrum disorder is a "neurodevelopmental disorder characterized by deficits in social communication, social interaction, and the presence of restricted repetitive behaviors". The current literature presents conflicting views on whether children on the autism spectrum are more likely than their neurotypical peers to have a phonological disorder (Wolk, Edwards, & Brennan, 2016).

Hearing impairment is the inability to hear and may be partial or complete (Zeng & Djalilian, 2010; World Health Organization, 2023b). The cochlear implant is an electronic medical device that restores the auditory function of the inner ear (Zeng et al., 2008). Children with cochlea implant are likely to have significant difficulty in developing phonology (Blamey, Barry, & Jacq, 2001).

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2. Acoustic Perspectives on Phonological Deficits

Phonological disorders are those speech sound disorders that contain "rule-based errors" (American Speech-Language-Hearing Association (n.d.). Phonological disorder is unique as it is categorized as both a speech sound disorder as well as a language disorder (Bishop et al., 2017). Children with phonological disorders may present with entirely unintelligible speech, even to a child's immediate family members. Those with children with phonological disorders of milder severity may present with speech that in generally intelligible but in which some sounds are somewhat mispronounced. Acoustic analysis is a method used to determine the properties of acoustic signals and generally this method is used in the field of linguistics. In the present study, acoustic analysis was carried out using PRAAT software.

3. Review of Literature

Hearing-impaired children present with a range of speech difficulties. These difficulties include consonant deletion and substitutions, consonant cluster reduction, voicing and devoicing, nasality errors, consonant substitutions, as well as vowel distortions (Hudgins and Numbers, 1942; Smith, 1982; Dunn & Newton, 1986; Culbertson & Kricos, 2002). As hearing loss becomes more complete, difficulties in phonological processing and speech intelligibility generally become more severe.

However for autistic children, there is conflicting information as to whether or not phonological development is noticeably affected (Wolk, Edwards, & Brennan, 2016). Early case studies indicated that autistic children were likely to have phonological difficulties (Eisenberg and Kanner, 1956) and early researchers also noted that echolalic and extemporaneously formed speech may develop differently (Ricks & Wing, 1981). Ricks and Wing (1981) point out that spontaneous speech may be less well articulated than echoed utterances. Wing (1988) suggested that autistic children have a similar phonological profile to children with hearing impairment. However an earlier study by Rutter, Greenfield, & Lockyer, (1967) indicated that autistic children with phonological disorder do not as as a group demonstrate the types of marked or persistent as phonological deficits which occur in developmental dysphasia and hearing-impaired children. Bartak., Rutter, & Cox, (1975) compared the phonological development of autistic children to language-matched peers and found the phonological development of autistic children to be slower than those without autism. A study by Chenausky (2015) reported that, one-third of adults with high-functioning autism presented with mild speech sound errors (for example on /r/, /l/, and /s/sounds) whereas in the general population, these errors are much rarer. Bartolucci, Pierce, Streiner, and Tolkin-Eppel (1976) proposed that the development of speech for children in autism generally follows the same trajectory as in typically-developing children; with the exception of "residual" phonological processes remaining in adulthood. Both children with autism and children with cochlear implant are generally understood to have difficulties in developing language skills; what is less clear is understanding is the intersection between language disorder and development of phonoloy.

4. Methods

This research is descriptive in nature. The approach of qualitative data collection and analysis was utilized. Data-gathering instruments were created and then used to collect information. This study reports on the primary data gathered from the respondents.

4.1 Participants

Children with autism and those with cochlear implants were the study's target demographic. Five Bengali children with cochlear implants and five children with autism were selected via convenience sampling. Both groups spanned an age range of six to twelve years. The Auditory Verbal Therapy therapy unit, Bangabandhu Sheikh Mujib Medical University, and the Society for Welfare of Autistic Children hosted this cross-sectional study from August 2017 to April 2018.

4.2 The Study Stimuli

The Bengali Phonological Test Pictures (BPTP) set and a Narrative Picture Test (NPT) were developed for the present study. The aim for these tools was to elicit responses for both groups which would provide information on (i) word level acoustic anomaly, (ii) sentence level acoustic anomaly, and (iii) prosodic features of speech. All of the items were modified in response to participant feedback given by SLPs and teachers prior to final development of the test tools.

4.3 Data collection procedure

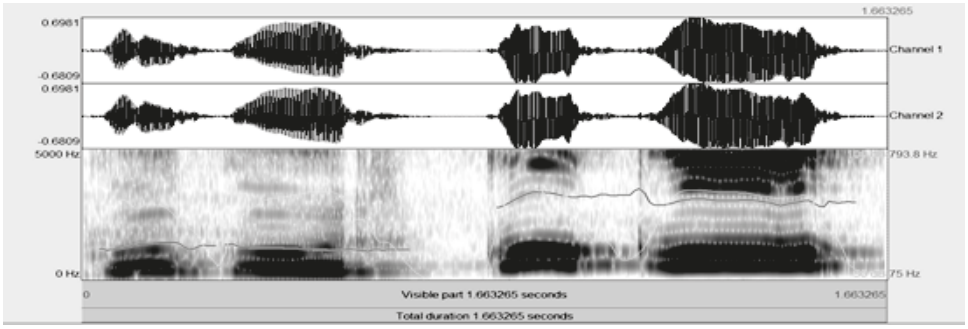
Employing the NPT and the BPTP set, the researcher presented each child participant with a set of related questions. All of the responses were coded by the researcher in the acoustic analysis record sheet.

4.4 Data Analysis

Data was coded using both extended and normal IPA during the observation and test sessions. Using PRAAT software (version 2018), the speech of the participants were captured and turned into a spectrogram. For comparison, an adult model of speech was also captured via PRAAT. PRAAT software was used to distinguish the acoustic nature of the phonological error. The researcher attempted to identify word level and sentence level acoustic anomaly of phonological patterns in target groups. In PRAAT analysis amplitude, frequency, pitch, loudness, f1 (formant 1), and f2 (formant 2) of participants' voice was included in the spectrogram.

5. Results

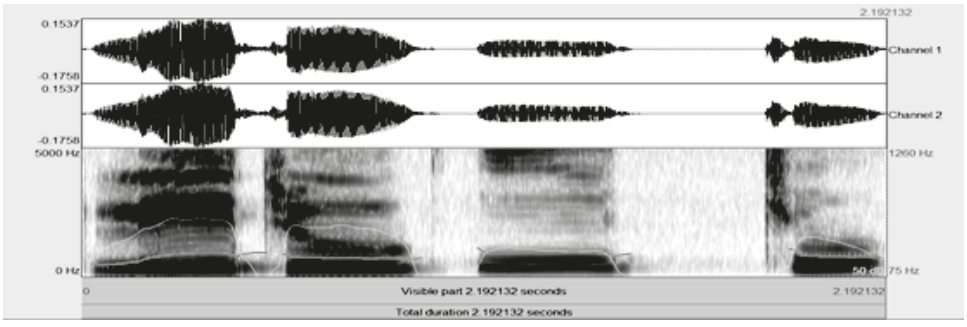
Spectrogram analysis showed several differences between the acoustic properties of the children with autism and the adult model. Figures 1, 2, 3, and 4 provide several examples of spectrograms that were produced during the study.



[Ku Kur Ku Ku]

Adult Child

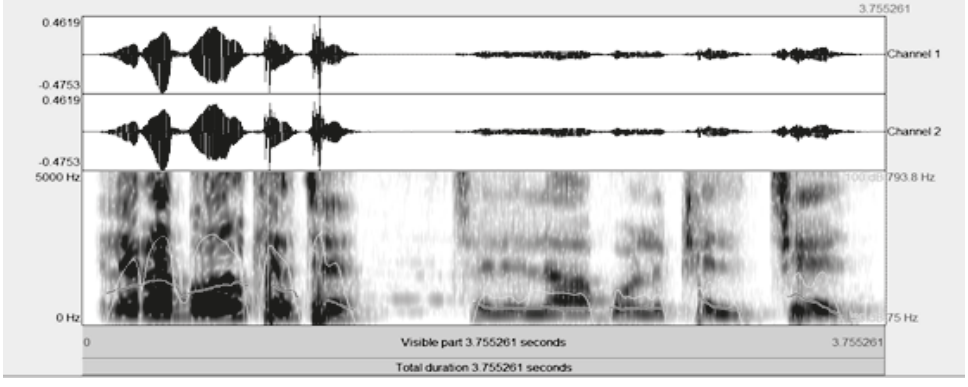
Figure 1. The adult model's utterance and atypical articulated speech of an autistic child – "kukur?" (Dog).



[li cu i cu]

Adult Child

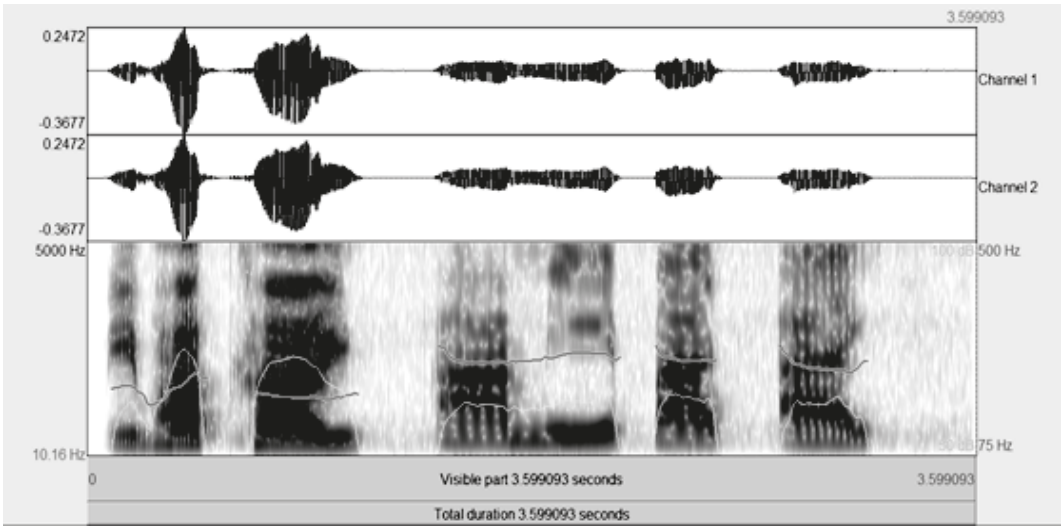
Figure 2. The adult model's utterance and atypical articulated speech of and CI child – "licu?" (Lychee).



[cʰelera bɔl kʰel cʰe cʰelela bɔl kʰel cʰe]

Adult Child

Figure 3. The adult model's utterance and atypical articulated speech of an autistic child – "cʰelera bɔl kʰelcʰe?" (The boys are playing football).



[ami bhat k^hai ami bhat ai]

Adult Child

Figure 4. The adult model's utterance and atypical articulated speech of a child with cochlear impant – "ami b^hat k^hai?" (I eat rice?).

Spectrogram analysis indicated that children with autism exhibited a higher prevalence of high-pitched sounds, formants, and pulses compared to the adult model. The analysis further revealed pronounced articulation deficits in words, phrases, and sentences, indicative of phonological disorders. In contrast, children with cochlear implants (CI) demonstrated an average pitch level in their spectrogram analysis, along with increased formants and pulses compared to the adult model. They displayed considerable phonological and articulation deficits across various linguistic contexts, surpassing those observed in autistic children. Both groups exhibited severe deficits in the suprasegmental prosody of speech, with autistic children demonstrating additional prosodic challenges compared to CI children. Notably, autistic children tended to lose prosodic features in their utterances, whereas CI children, despite emitting atonal high-pitched sounds, manifested more phonological errors. Autistic children were observed to discard more echolalic words, while CI children exhibited a higher frequency of filler words. Language abilities in CI children were marginally more developed than those in autistic children.

6. Discussion

The study's findings align with prior research, including studies by Eisenberg and Kanner (1956), Wing (1981), and Kjelgaard and Tager-Flusberg (2001), supporting the presence of phonological challenges in autistic children. The critical period from birth to five years for speech and language acquisition, as highlighted by Stoel-Gammon and Otomo (1986), emphasizes the interconnectedness of phonology, speech perception, and speech

production. Additionally, studies such as Ibertsson (2009), Culbertson & Kricos (2002), and Uchanski & Geers (2003) underscore the complex nature of speech errors in hearing-impaired children and CI recipients. The study contributes to the existing body of knowledge on phonological difficulties in Bengali children with autism and CI, paving the way for future investigations despite certain limitations.

7. Limitations

Due to resource constraints, the number of participatnts was limited. Secondly, also due to resource availability, we compared the speech of the children to an adult model; future studes would benefit from the inclusion of age-matched neurotypical peers. In addition, our study targeted participants who were already accessing therapy services; perhaps we may have found different results had we accessed those children who either could not access or did not require therapy. Nevertheless, despite its limitations, this study has contributed to our understanding of phonological deficits, especially as there is currently very little research about the speech development of Bengali children. The current study adds to the body of knowledge about the phonological difficulty in autistic children as well as children with cochlear impant.

8. Conclusion

Current study demonstrates that some Bengali children with autism do also have phonological difficulties and these are evident in acoustic analysis, however in our study these difficulties were not as pronounced as the difficulties demonstrated by the children with cochlear impant. PRAAT analysis demonstrated the following:

- Children with autism exhibited more high-pitched sounds, formants, and pulses in their speech, while children with cochlear implants used an average level pitch along with formants and pulses.

- The differences in pitch and sound characteristics between the two groups were evident in the spectrogram analysis, highlighting distinct acoustic properties.

- Both groups demonstrated articulation deficits in words, phrases, and sentences, indicative of phonological disorder.

- Children with cochlear implants presented a higher incidence of phonological errors, such as consonant obliteration, substitution, and distortion, compared to autistic children. Autistic children, in turn, displayed more echolalic words and phrases.

- Both autistic children and children with cochlear implants exhibited severe deficits in the prosody of suprasegmental features.

- Autistic children showed supplementary deficits in prosody compared to children with cochlear implants. The misplacement of prosodic features and atonal high-pitched sounds were more pronounced in the autistic group.
- Despite both groups having severe deficits in prosody, articulation, and phonology, the nature and extent of these deficits varied.
- Both groups displayed segmental and suprasegmental errors in their speech, as identified through spectrogram analysis.
- The presence of inappropriate stress patterns, and poor resonance indicated suprasegmental errors.
- Phonological errors such as phoneme deletion and substitution were evident in both groups.

These comparative findings from PRAAT analysis underscore the nuanced differences and similarities in speech characteristics between Bengali children with autism and those with cochlear implants. The analysis provides insights into pitch, articulation, prosody, phonological patterns, and language development, contributing to a better understanding of the distinct challenges faced by each group.

To sum up, the spectrogram analysis revealed distinctive speech characteristics in both Autism and Cochlear implant (CI) children. Children with autism exhibited more high-pitched sounds, formants, and pulses, along with articulation deficits indicative of phonological disorders. In contrast, CI children displayed average pitch levels but showcased numerous phonological and articulation deficits across various linguistic contexts, along with an increased incidence of phonological errors and the rejection of filler words.

Despite the limitations, the study contributes to understanding phonological deficits in Bengali children, emphasizing the need for further investigations. The findings suggest that both groups exhibited severe deficits in the prosody of suprasegmental features, with autistic children showing additional deficits compared to CI children. The study highlights the nuanced nature of phonological challenges in both populations and provides insights into the speech development of Bengali children, particularly those with autism and cochlear implants. The hope is that this research will inspire future studies, incorporating a larger participant pool and age-matched neurotypical peers, to refine therapeutic interventions and support strategies.

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