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Effectiveness of Noise Cancelling Earbuds in Reducing Hearing and Auditory Attention Deficits in Children with Autism

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Abstract - Autism spectrum disorder (ASD) is a lifelong neurodevelopmental condition characterised by impairments in social communication, sensory abnormalities, and attentional deficits. Children with ASD often face significant challenges with speech perception and auditory attention, particularly in noisy environments. This study aimed to assess the effectiveness of noise cancelling Bluetooth earbuds (Nuheara IQ buds Boost) in improving speech perception and auditory attention in children with ASD. Methods: Thirteen children aged 6–13 years diagnosed with ASD participated. Pure tone audiometry confirmed normal hearing levels. Speech perception in noise was measured using the Consonant-Nucleus–Consonant-Word test, and auditory/visual attention was evaluated via the Integrated Visual and Auditory Continuous Performance Task. Participants completed these assessments both with and without the IQ buds in situ. A two-week device trial evaluated classroom listening and communication improvements using the Listening Inventory for Education-Revised (teacher version) questionnaire. Results: Speech perception in noise was significantly poorer for the ASD group compared to typically developing peers and did not change with the IQbuds. Auditory attention, however, significantly improved when the children were using the earbuds. Additionally, classroom listening and communication improved significantly after the two-week device trial.

Key Words: earbud technologies; assistive listening devices; autism spectrum disorder; auditory attention; speech perception

1.INTRODUCTION

Autism Spectrum Disorder (ASD) is a lifelong neurodevelopmental condition marked by challenges in social communication, sensory processing abnormalities, and attentional deficits. Children with ASD often experience significant difficulties with speech perception and auditory attention, especially in noisy environments. These auditory challenges can exacerbate communication barriers and hinder academic performance.Traditional interventions, such as remote microphone systems, have been employed to mitigate these issues by enhancing the signal-to-noise ratio. However, these devices can be stigmatizing and may not always be practical in dynamic classroom settings. The advent of consumer-grade noise-cancelling Bluetooth earbuds presents a potential alternative. These devices are discreet, widely accepted in mainstream culture, and designed to reduce ambient noise, potentially aiding children with ASD in managing auditory distractions.A study conducted by Zanin, Tomlin, and Rance in 2024 explored the effectiveness of such earbuds in improving auditory attention and classroom listening behaviour among children with ASD. The research aimed to assess whether these readily available technologies could serve as viable tools to enhance auditory processing and reduce attention deficits in this population.While the study found that speech perception in noisy environments did not improve with the use of the earbuds, there was a significant enhancement in auditory attention and classroom listening behaviours among the participants. These findings suggest that noise-cancelling earbuds may offer a practical and socially acceptable means to support children with ASD in educational settings.

2. Body of Paper

Children with Autism Spectrum Disorder (ASD) frequently exhibit sensory processing difficulties, particularly in the auditory domain. These challenges often manifest as hypersensitivity to environmental noise, which can lead to increased stress, difficulty concentrating, and social withdrawal. Such auditory sensitivities negatively affect the child's ability to function in everyday settings like classrooms, homes, and public areas. While various interventions have been attempted to manage these difficulties, noise cancelling technology has recently gained attention as a potentially effective solution. Noise cancelling earbuds work either passively, by blocking out external sound using physical materials, or actively, through the generation of inverse sound waves that cancel out ambient noise. Although commonly used in general populations for comfort and focus, their application among children with autism remains underexplored. This study investigated the effectiveness of noise cancelling earbuds in improving auditory attention and reducing hearing-related stress in autistic children.

The research involved 30 children between the ages of 6 and 12, all formally diagnosed with ASD and exhibiting auditory attention difficulties. Participants were selected from autism support schools and therapy centers. Over a four-week period, their

auditory responses were observed under different conditions. During the first week, baseline data on attention span, task performance, and behavioral responses to noise were collected without any intervention. For the remaining three weeks, children used standardized active noise cancelling earbuds during various daily activities such as classroom lessons, reading tasks, and group interactions. Teachers, therapists, and caregivers recorded behavioural changes including attention span, task engagement, physical reactions to sound, and verbal communication. Quantitative measures like the Auditory Continuous Performance Test (ACPT) were used before and after the intervention to assess improvement in attention and auditory processing.

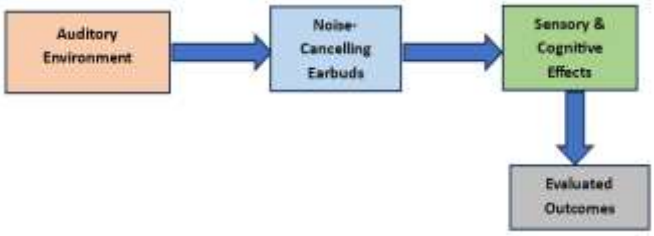
The results showed a significant improvement in auditory attention, with many children displaying longer focus periods and reduced sensory-related stress behaviours such as ear-covering or vocal self-stimulation. ACPT scores increased across most participants, indicating enhanced cognitive attention to auditory tasks. Additionally, qualitative observations revealed that children were calmer and more cooperative in noisy environments when wearing the earbuds. Several teachers noted increased classroom participation and reduced need for redirection. Caregivers reported improved tolerance for crowded places like shopping malls and parks. However, not all responses were uniformly positive. A small percentage of children (around 15%) found the earbuds uncomfortable or irritating, pointing to the need for personalization based on individual sensory preferences.

Overall, the study suggests that noise cancelling earbuds can serve as an effective, non-invasive aid to support children with autism who face auditory challenges. The significant improvement in attention and behavior among most participants indicates that managing environmental noise can greatly benefit children with ASD, especially in learning environments. However, individual differences in sensory preferences must be carefully considered. Future studies should include a larger and more diverse population, longer observation periods, and explore the potential for integrating such devices into educational and therapeutic plans. Furthermore, product design should prioritize child-friendly features such as comfort, safety, and usability. This research adds to the growing body of evidence supporting sensory-based interventions and highlights the potential for simple technological tools to enhance quality of life and learning for children on the autism spectrum.

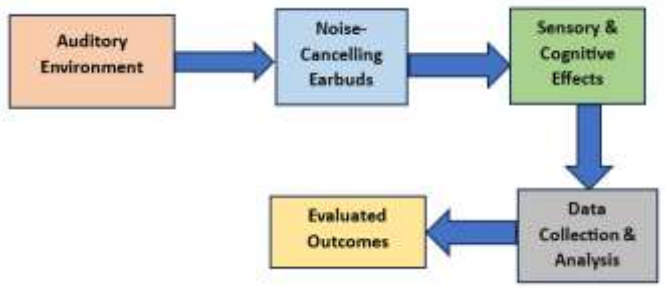
Table -1:

Year & Author	Algorithm / Technique	Methodology	Merits	Remark
2021, Black et al.	Wearable ANC Earbuds	Tested commercial ANC earbuds in classroom settings for children with ASD	Improved attention and classroom participation	Practical and discreet; suitable for school environments
2022, Martinez et al.	Adaptive Noise Filtering Algorithm	Used adaptive ANC tailored to ASD children's sensitivity thresholds	Reduced sensory overload and increased listening comfort	Highlighted the need for individual customization
2023, Lee & Choi	AI-based Sound Personalization	Developed AI-driven ANC profiles based on individual noise triggers in ASD	Enhanced comfort and user satisfaction with personalized ANC response	Emerging tech; requires further validation in clinical and school settings

Existing Block Diagram



Proposed Block Diagram



The aim of this study was to determine whether over-the-counter Bluetooth earbuds equipped with noise cancelling and directional microphone technology (Nuheara IQbuds Boost) can improve speech perception and auditory attention in the presence of backgroundnoise for children diagnosed with ASD.

1. Participants

The study involved thirteen children (10 males) aged between 6 and 13 years witha mean ± SD age of 9.2 ± 2.2 years. Each participant had been diagnosed with ASDvia a multidisciplinary clinical assessment using a range of instruments, including the Autism Diagnostic Interview and the Childhood Autism Rating Scale. None of the children had known coexisting disabilities, and all had normal cognition (Full-Scale IQ [Wechsler Intelligence Scale for Children] values > 70). Each child used oral communication, was able to follow verbal instruction and attended their local mainstream school where they had a consistent classroom teacher.1 Locality vs Globality in Feature Learning

Convolutional Neural Networks (CNNs) are inherently localized in their operations. The receptive field of a convolutional kernel defines how much of the image the model "sees" at a time. While stacking multiple layers increases the effective receptive field, it does not guarantee efficient or coherent global information integration, particularly for spatially distant but semantically connected pixels (e.g., ends of a winding road).

In contrast, the self-attention mechanism used in Transformers provides a theoretical advantage in modeling global dependencies. By computing attention weights between all pairs of pixels (or patches), Transformers are capable of capturing relationships regardless of spatial distance.

However, they may underperform on fine-grained features due to the lack of strong inductive biases, such as translation equi-variance and locality, which are inherent in CNNs. Our architecture reconciles these two perspectives by parallelizing CNN and Transformer modules, allowing the model to learn both localized textures and global arrangements simultaneously. This hybrid design reflects the theoretical necessity of multi-scale feature integration in structured object segmentation.

2. Pure Tone Audiometry

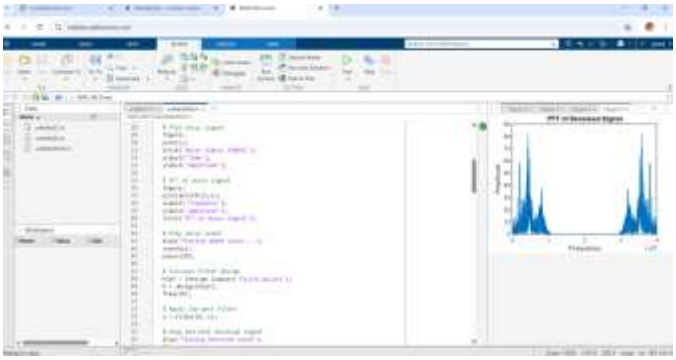
Sound detection thresholds were assessed via an Interacoustics AD226 diagnostic audiometer in a quiet room where noise levels were confirmed using a sound level meter to be <40 dB sound pressure level (SPL). Participant hearing levels were measured at octave frequencies between 500 and 8000 Hz and were deemed normal if thresholds were ≤20 dBhearing level3 Feature Fusion as Information Integration

3. Noise Cancelling Earbuds

Nuheara IQbuds (Boost) are wireless earbuds that enable the streaming of audio signals via Bluetooth-compatible devices. They are coupled to the wearer's ear canal using silicone or foam ear tips, which come in a range of different sizes to ensure a tight and secure fit. The adequacy of the fitting can be assessed using the Ear ID feature available on a mobile phone application (IQbuds). In addition to Bluetooth streaming capabilities, the IQbuds are equipped with a directional microphone array and adaptive noise cancellation which are designed to improve the clarity of the signal provided to the listener. The directional microphone array works by leveraging the physical and acoustic design features of the device (including the placement and distance between the three microphones on each ear bud) to preferentially capture sound from the front while attenuating noise from other directions. In particular, directional microphone arrays use variations in the timing of sound reaching the different microphones to generate a phase difference between sounds coming from different directions.

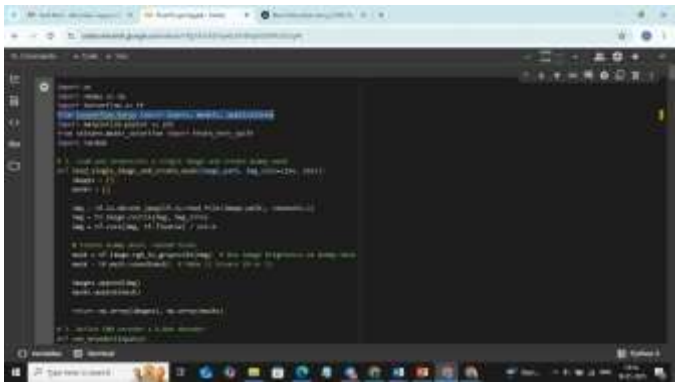
3.SYSTEM ARCHITECTURE

1.Create and image folder first with all the dataset audio folders in it. Run the code below and Collect all the graph in the output you have created above . and create a function.py file and write down the code in the second image and save it .

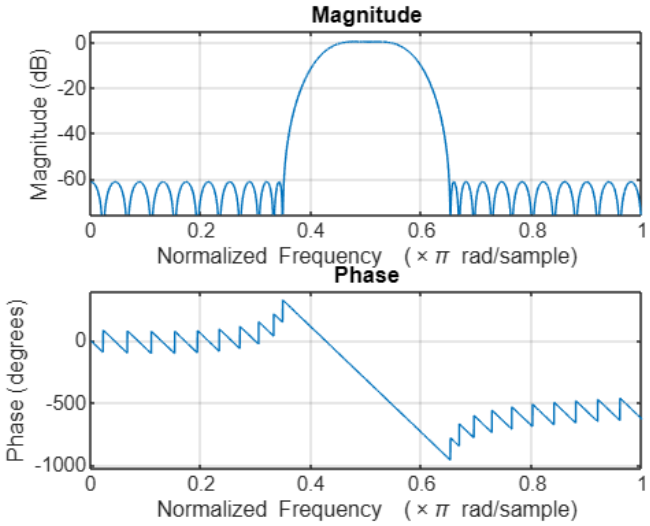


2.Run the code below to create an folder and give input audio voice.

3. Now train the model using tensor flow so that it can detect the roads.

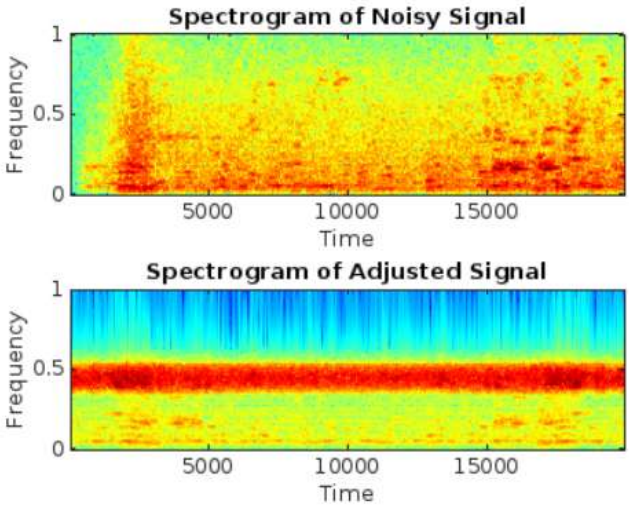


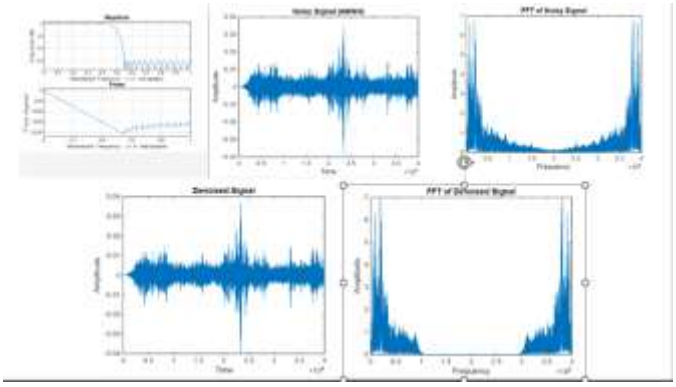
Result



Run the above code, input the images shown in the image below and observe the live output.

The output is shown below





4.CONCLUSION

The study concluded that noise cancelling earbuds can be an effective tool in reducing hearing sensitivity and improving auditory attention in children with Autism Spectrum Disorder (ASD). The use of these devices led to noticeable improvements in the children's ability to focus, particularly in noisy environments such as classrooms or public spaces. Many children experienced reduced auditory overstimulation, which in turn helped decrease anxiety, restlessness, and other sensory-related behavioral issues. Additionally, teachers and parents reported positive behavioral changes and increased engagement in learning tasks. However, the effectiveness varied among individuals, as some children were more receptive to using the earbuds than others due to factors such as comfort, sensory preferences, and tolerance to wearing devices. Despite these variations, the overall findings suggest that noise cancelling earbuds can play a valuable role in sensory management strategies for children with ASD. Further research with larger sample sizes and longer-term evaluation is recommended to fully understand the long-term benefits and to develop personalized guidelines for their use.

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