



# Acoustics Paper Preparation 2024 - Evidence-Based Interventions for Auditory Processing Issues in Individuals Who are Neurodiverse

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**Abstract** - Many children and young adults diagnosed with autism spectrum disorder (ASD) experience substantial auditory processing issues despite the presence of normal, pure-tone hearing sensitivity. Relative to neurotypical peers, individuals with ASD report and experience poorer auditory filtering abilities, binaural integration (dichotic listening), speech recognition in noise, temporal processing, and spatial processing. This paper will begin with a review of auditory issues faced by this population, followed by a summary of four strategies and evidence-based interventions to mitigate auditory issues found in most individuals with ASD. These strategies include (1) the use of remote-microphone (RM) hearing technology, (2) computerized dichotic auditory training, (3) one-on-one speech-in-noise training, and (4) university social and peer support groups.

## 1 INTRODUCTION

Most individuals with normal, pure-tone hearing sensitivity and ASD experience significant difficulties with auditory processing as documented with parent/teacher surveys, self-assessments, and auditory testing assessing speech-in-noise (SIN) recognition, binaural integration, spatial stream segregation, temporal processing, auditory attention, and auditory filtering (Alcántara et al., 2004; Ashburner et al., 2008; DePape et al., 2012; Dunlop et al., 2016; Groen et al., 2009; James et al., 2022; Jussila et al., 2020; Kozou et al., 2018; Leekam et al., 2007; Rance et al., 2014, 2017; Schafer et al., 2013, 2016, 2019b, 2020b, 2022; Schelinski et al., 2020; Tomchek & Dunn, 2007). These documented auditory processing issues impact listening abilities in everyday situations, such as school classrooms and social gatherings. Thus, evidence-based strategies for assessing and addressing these auditory challenges are imperative to ensure optimal communication and listening experiences for this population.

## 2 METHODS AND RESULTS

In the Department of Audiology and Speech-Language Pathology and Audiology at the University of North Texas (UNT), we conducted a series of studies to examine the potential benefits of RM technology, computerized dichotic auditory training, and one-on-one speech-in-noise training as well as developed university social and peer support groups for students who are neurodiverse.

**RM Technology.** This technology, consisting of a transmitter for the primary talker and small receivers worn on listeners' ears, may be fit to individuals with ASD with normal, pure-tone hearing sensitivity using an objective fitting approach (Schafer et al., 2019a). During the fitting, a hearing aid test box is used to (1) measure the real-ear-to-coupler difference (RECD) and (2) ensure the receiver output meets Desired Sensation Level (DSL) v5 prescriptive targets (Scollie et al., 2005). Over the past 10+ years, our work and the work of others has documented the significant benefits of remote-microphone technology for improving auditory function in individuals with ASD (Keller et al., 2021; Rance et al., 2014, 2017; Schafer et al., 2013, 2014, 2016, 2019a; Wilson et al., 2021). Results of our studies showed that RM-system use resulted in significantly improved speech-in-

noise recognition, auditory filtering, observed on-task behaviours in the classroom, teacher- and parent-observed listening abilities, self-perceived listening abilities, noise acceptance, and listening comprehension.

**Auditory Training.** Multiple research studies support the use of two types of auditory training to improve auditory function in individuals with ASD, including speech-in-noise (SIN) and dichotic training (Denman et al., 2015; Kozou et al., 2018; Mathews et al., 2024; Schafer et al., 2019b, 2022, 2024). In a recent publication, we summarized the development and benefit of one-on-one SIN training that may be conducted in a clinic or by school-based professionals (Mathews et al., 2024). During 30-minute sessions, three times per week over 12 weeks, individuals with ASD trained on four tasks: (1) word repetition, (2) following directions, (3) sentence comprehension, and (4) sentence repetition. During training, participants repeated words or sentences in the presence of multi-classroom noise, responded to simple prompts, or answered questions about sentence stimuli. In our studies (Schafer et al., 2019b, 2022, 2024), computerized dichotic training was conducted with the commercially available, web-based Central Auditory Processing Disorder Online Therapy System (CAPDOTS-Integrated, 2018). This training also was conducted in a 30-minute session three times a week over 12 weeks. CAPDOTS-Integrated aims to improve binaural integration of fixed-intensity speech stimuli (i.e., words, consonants, vowels, and digits) in quiet that adapt and vary in lead-lag timing differences between ears. Participants repeat what they hear in each ear, and stimuli are adapted based on correct and incorrect responses recorded by the examiner.

Research in our laboratories documented the significant benefits of combining RM-system use, SIN training, and dichotic training for improving multiple areas of auditory processing. In Mathews et al. (2024), we report significantly improved minimum to maximum training levels for both the SIN and CAPDOTS-Integrated training in 20 participants with ASD, ages 7 to 17 years, who used RM systems and completed auditory training over 12 weeks. These participants also showed significantly improved spatial processing, binaural integration, phonological processing, auditory memory, auditory cohesion, and SIN recognition when using the RM system (Schafer et al., 2019b, 2024). Across participants, higher total training times in minutes and larger training improvements (i.e., maximum – minimum training level) were associated with better performance on the test battery (Schafer et al., 2024). In addition, analyses of performance across the various auditory processing test measures showed strong relationships. As a result, an abbreviated auditory processing test battery is recommended for individuals with ASD (James et al., 2022; Schafer et al., 2024). In addition to improvements on behavioural test measures, electrophysiological testing in 15 participants showed that training resulted in decreased latencies of the frequency following waves of complex auditory brain stem responses (cABR), a reduction in pitch error, and an increase in pitch strength and phase shift (Gopal et al., 2020). Following training, latencies of auditory late potentials (ALR; P1, N1, and P2) also decreased and amplitudes increased. These P1 and N1 amplitude increases were associated with results on the general auditory processing test used in our studies (Gopal et al., 2020; Schafer et al., 2019b).

**University Supports.** UNT is one of 92 universities in the United States with support services specifically for neurodiverse students. The UNT Neurodiversity Initiative includes student support through a neurodiversity network, faculty and staff training, an employee support program, and an autism-focused research group. The neurodiversity network includes a one-on-one support group, social outing group, peer support group, counselling and vocational training, dorm living community, learning center, Office of Disability and Accommodations, and a social communication skills group led by speech-language pathology graduate students.

### 3 CONCLUSIONS

Many individuals with ASD exhibit and report poor auditory processing abilities, particularly in noisy environments. A streamlined assessment protocol may be used by audiologists and speech-language pathologists to identify auditory processing deficits. Once identified, these deficits may be addressed with RM technology, SIN training, and dichotic training. These interventions have the potential to significantly improve performance on multiple tests of auditory processing as well as listening abilities in everyday environments. University programs focused on neurodiverse students also have the potential to improve academic, social, and communication abilities in this population.

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