Effective management of auditory differences in people with autism

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The Research Team are unable to ensure that the information listed below provides an accurate & up-to-date snapshot of these matters

Research questions:

1. For people with autism and normal hearing who experience decreased sound tolerance:
   - Does use of sound reduction or exclusion devices or strategies result in permanent, long term improvements in sound tolerance or functional listening skills? And how do improvements compare to:
     i. improvements as a result of normal development
     ii. sound desensitization or other psychotherapy?
   - What is the risk of use of sound reduction or exclusion devices or strategies leading to increased sensitization and worsening of DST?
   - What therapies for DST are available in Australia?
2. For people with autism and normal hearing who experience deficits in functional listening skills or auditory processing:
   - Does use of sound reduction or exclusion devices or strategies result in permanent, long term improvements in functional listening or auditory processing skills? And how do improvements compare to:
     i. no treatment for adults

ii. normal development for children and young adults

iii. auditory processing development software programs?

- What is the risk of use of sound reduction or exclusion devices or strategies leading to increase impairment in functional listening or auditory processing skills?

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1. Contents

2. Summary

This paper is concerned with treatment and management of auditory differences in people with autism. For the purpose of this paper, auditory differences cover sensitivities and atypical reactions to sound and difficulties associated with auditory processing in people with typical hearing.

In the case of decreased sound tolerance (DST) conditions, clinicians generally prefer treatment approaches compared to the use of sound reduction or exclusion strategies. Some studies show that patients and parents of patients often prefer management strategies such as ear worn devices and environmental modifications over treatment strategies. There is more evidence that therapeutic approaches are effective at achieving long term outcomes for people with autism and for the general population compared with sound reduction management

strategies. The evidence base focussing on people with autism is minimal for most interventions. Clinicians warn against the overuse of ear protection devices and avoidance strategies as this may exacerbate symptoms of sound intolerance. However, sound exclusion or reduction strategies may still be used if they form part of a gradual desensitisation program.

In the case of auditory processing difficulties, there is some evidence that FM systems are effective for children with autism in improving listening in the classroom, though results are mixed. There is also evidence for an increase in listening effort while using the device. For further detail refer to TRT research papers RES 153 and RES 153a. Treatment approaches for auditory processing difficulties include auditory training and music therapy, though the evidence for an autism population is limited by study quality and amount of research.

For both DST and auditory processing difficulties, the long term outcome if no treatment is received is unclear. Some evidence suggests symptoms may reduce with age.

3. Terminology

There is some inconsistency in the literature in the use of terminology referring to sensory processing and the associated symptoms and conditions (for further detail, refer to discussion in section **3.1 Theoretical terminology** in RES 276 Sensory-based therapy). This is also true more specifically for auditory processing and auditory sensitivities (Henry et al, 2022; de Wit et al, 2018). Sound intolerance is understood using different terms and frameworks. For example, the terms 'hyperacusis' and 'decreased sound tolerance' are sometimes used synonymously (Williams et al, 2021a) and sometimes hyperacusis is treated as a specific type of DST (Timms et al, 2022).

For the purposes of this paper:

- **Decreased sound tolerance** refers to a group of conditions related to reduced tolerance to sound in people with normal hearing. These conditions are hyperacusis, misophonia and phonophobia (Timms et al, 2022).
- **Auditory processing difficulties** are behaviours or functional concerns which result from differences in the central auditory processing system and not from damage or impairment to the peripheral auditory system. Difficulties can include slow or inappropriate responses, difficulties hearing in noisy environments, difficulties with attention, following instructions, learning, reading, spelling, or localising sound (Aristidou & Hohman, 2022; American Academy of Audiology, 2010).
- **Auditory hypersensitivity** refers to symptoms of heightened sensitivity to sounds. Symptoms may or may not lead to a specific diagnosis.

Other key terms and definitions are:

- **Hyperacusis** is the experience of pain or discomfort at everyday sounds at volumes that would not trouble most people (Williams et al, 2021a).
- **Misophonia** is a strong negative emotional, physiological or behavioural response to specific sounds regardless of loudness. Trigger sounds are often, but not always, repetitive bodily sounds like chewing, slurping, sniffing, or breathing (Swedo et al, 2022).
- **Phonophobia** is a fear of specific sounds, usually associated with an anticipation that the sound will cause pain or discomfort or exacerbate an existing condition (Henry et al, 2022).
- **Auditory processing** refers to the contribution of the central auditory nervous system in receiving auditory stimuli and mediating physiological and behavioural responses (Mansour et al, 2021; Aristidou & Hohman, 2022).
- **Auditory processing disorder** (APD) is a condition in which auditory processing difficulties reach some determined clinical threshold (Aristidou & Hohman, 2022; Audiology Australia, 2022).

4. Autism and auditory differences

The latest edition of the Diagnostic and Statistical Manual (DSM 5) includes sensory features to the diagnostic criteria for Autism Spectrum Disorder. It states that “restricted, repetitive patterns of behavior, interests, or activities” can manifest as:

> Hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement) (American Psychiatric Association, 2022, pp.57-58).

Increased sensory sensitivity or sensory processing issues are common in people with autism. Some studies suggest up to 95% of people with autism may show atypical reactions to sensory stimuli (Deng et al, 2021; Scheerer et al, 2021; Ocak et al, 2018; Robertson & Baron-Cohen, 2017).

Auditory differences associated with autism are characterised differently in the literature. Researchers and professional organisations disagree about whether APD can co-occur with autism or whether auditory processing difficulties are central symptoms of autism itself (Aristidou & Hohman, 2022; de Wit et al, 2018; Brout et al, 2018; Ocak et al, 2018; American Academy of Audiology, 2010). Furthermore, APD can produce an intolerance to sound (Ferrer-Torres & Giménez-Llort, 2022), blurring the lines between APD and DST conditions as distinct entities. Some researchers place the causes of DST in the auditory processing system, though specific sub-groups of DST (hyperacusis, misophonia, phonophobia) may have different causal factors including neurological or psychiatric factors (Ferrer-Torres & Giménez-Llort, 2022; Timms et al, 2022; Williams et al, 2021b; Brout et al, 2018).

In addition, some researchers focus on sound over-responsiveness or under-responsiveness. These auditory differences overlap with, but do not strictly map on to, the symptoms of either APD, hyperacusis, misophonia or phonophobia (Yuan et al, 2022). DSM 5 specifies that restrictive, repetitive patterns of behaviour can present as extreme or adverse responses to sounds (American Psychiatric Association, 2022). These responses may or may not meet diagnostic criteria for DST conditions or contribute to a diagnosis of APD.

Studies estimate the prevalence of hyperacusis in autism populations as anywhere between 18% and 69% (Williams et al, 2021a; Williams et al, 2021b; Scheerer et al, 2021; Danesh et al, 2021). One study found 3% of 275 people with autism were also diagnosed with misophonia (Jager et al, 2020). Regarding phonophobia, up to 55% of people with autism may have some fear or aversion to some sounds (Williams et al, 2021b), though it is unclear if these aversions would meet the diagnostic threshold for phonophobia. There are no available estimates for the coincidence of autism and DST more generally (combined hyperacusis, misophonia and phonophobia). Studies have also shown high frequency of auditory processing difficulties for people with autism (Ocak et al, 2018; Mansour et al, 2021; Jones et al, 2020).

Prevalence studies also indicate that hearing impairment may be more common in autism populations compared with the general population. Bougeard et al (2021) reviewed three prevalence studies and found estimates of 0% - 4.9%. The largest study reviewed, a Scottish study of over 25,000 people with autism, found hearing impairment is 9 times more prevalent in autism populations compared with the general population (Rydzewska et al, 2019).

5. Treatments and management strategies

5.1 Frequency Modulation systems

TRT research papers RES 153 and RES 153a review the literature on the use of FM systems for people with autism and APD. Please refer to these papers for more information. Our previous research found some evidence that the use of FM systems can improve listening, auditory performance, communication, speech recognition in noise, on-task behaviours, auditory filtering, effects of noise and reverberation, and aversiveness to sound. However, these effects are based on studies with significant issues of quality and low levels of evidence.

One further study related to the use of FM systems for people with autism was published since our last review. Feldman et al (2022) conducted a study on the use of a remote microphone system for 32 young people with autism. They found listening-in-noise accuracy improved for all participants while listening effort also increased for people with average or below average nonverbal cognitive ability, below average language ability and reduced audio-visual integration.

A connection proposed by Schafer et al (2020a) was not considered in TRT's previous reviews. The authors refer to previous studies showing that auditory processing differences present similarly in children with autism and other neurological or development concerns, such as ADHD and APD. From this they hypothesise that interventions which support people with APD may also address auditory processing concerns in children with autism. As such, it may be possible to support the use of FM systems for people with autism by appeal to the more robust evidence base for the use of FM systems for people with APD (without diagnosed autism). This includes a 2016 systematic review and a number of randomised controlled trials.

Reynolds et al (2016) reviewed 7 publications investigating the role of FM systems in the classroom. They found moderate evidence that FM system use improves listening and attention in the classroom. The evidence was mixed in relation to the improvement of specific academic areas. More recently, Stavrinos et al (2022) conducted an RCT with 26 children with APD and no other developmental or neurological condition. The studies focus on possible benefits of regular use of the FM system on unaided listening and attention skills. The authors found no significant improvements to unaided listening and attention skills. They did find improvements in classroom listening based on children's responses to a shortened version of the LIFE-R questionnaire. No behavioural or audiological tests were performed to assess listening or attention skills while using the FM device.

While existing studies show positive results, the most robust findings are for populations without autism. There is some evidence that FM systems are effective for children with autism in improving listening in the classroom, though results are mixed and there is also evidence for an increase in listening effort while using the device.

Individual factors may determine the efficacy of an FM system. For example, some autistic participants in the reviewed studies were not able to tolerate the device due to discomfort or sensory issues. This suggests strategies that do not involve ear worn devices may be more accepted. For example, a recent systematic review into the use of soundfield amplification systems in a primary school setting show benefits for speech perception, listening comprehension and auditory analysis, language outcomes, academic outcomes, and behaviour (Mealings, 2022). Considering sensory processing may affect all students in the classroom (Mallory & Keehn, 2021), soundfield amplification systems may be desirable as they can benefit the entire classroom without singling out an individual with a disability.

5.2 Sound exclusion or reduction

A common strategy to manage DST is avoidance of the offending sound. This might mean a person removes themselves from noisy environments or avoids environments they expect to be noisy. It can also mean the use of assistive technology or modifications to reduce or exclude the offending sounds. Such assistive technology might include: noise cancelling headphones, earmuffs, ear plugs, sound absorbing material on walls, curtains or carpets.

In a survey of 255 speech therapists, audiologists, teachers and graduate students, Neave-diToro et al (2021) found that almost half of respondents had recommended ear worn devices to their clients with autism. Scheer et al (2022) found around half of parents surveyed had used ear worn devices to reduce sound exposure, while half of those parents were satisfied with the strategy. Pfeiffer et al (2019a) report that parents and teachers were generally supportive of the use of headphones during class. Smith et al (2022) show that patients with misophonia are generally more accepting of ear worn devices or environmental modifications compared to active treatment approaches. Some guidelines for classroom design recommend sound/noise reduction materials in order to facilitate learning for all students (Kulawiak, 2021; Mallory & Keehn, 2021). Potential advantages of noise reduction devices or modifications include:

- improved comfort
- improved focus
- reduction in aversive sound
- reduction in behaviours of concern
- improved participation in social and community activities
- minimal cost (in the case of ear worn devices) (Neave-diToro et al, 2021; Kulawiak, 2021; Mallory & Keehn, 2021).

There is a body of literature pointing to the benefits of noise cancelling headphones for reducing behaviours of concern, stress and anxiety and improving attention and participation in activities for children with autism (Kulawiak, 2021; Pfeiffer et al, 2019a; Pfeiffer et al, 2019b; Ikuta et al, 2016). One study found that sound absorbing walls led to students with autism initiating more social interactions with their peers (Mallory & Keehn, 2021). However, this evidence is generally based on single-case designs and small samples. Kulawiak (2021) concludes their survey of literature by suggesting that use of noise cancelling headphones in the classroom is understudied and currently does not meet the standards of evidence-based practice.

Studies also regularly address potential risks of sound exclusion or reduction. Avoidance of offensive stimuli could prevent the person from learning self-regulation skills and threaten to exacerbate their symptoms or reinforce unsustainable behaviours (Mednicoff et al, 2022; Lewin et al, 2021). Other potential disadvantages of sound exclusion or reduction include:

- discomfort of ear worn devices
- difficulty hearing
- limiting language input
- slowing language development
- limiting social interaction
- stigma or singling out of the student with autism
- cost, especially of home modifications

- dependence on device / increased sensitisation (Danesh et al, 2021; Neave-diToro et al, 2021; Kulawiak, 2021; Mallory & Keehn, 2021).

Regarding the last point, there appears to be consensus that the goal for the clinician should be desensitisation of the patient's auditory system and that overprotection due to the use of noise reducing or excluding technology may eventually cause harm (Henry et al, 2022). However, this does not mean that any use of ear worn devices or sound reducing environmental modifications should be avoided. For example, noise cancelling headphones may be part of a gradual process of desensitisation. For people with autism, Danesh et al (2021) recommend that:

> ... it is important to desensitize an autistic child with hyperacusis to sounds by reducing use of unnecessary ear protection, as use of protection only helps to reduce symptoms of hyperacusis rather than tackling the cause of the sensitivity. However, this desensitization should be done with more tact and in a more gradual timeline. Autistic children may need initially to have the option to protect themselves against the hyperacusis with noise cancelling headphones, and later on working closely with their parent, clinicians can start to implement desensitization (p.551).

For a general population, Henry et al (2022) recommend:

> Patients should be aware that loud sound can cause damage and exacerbate [the patient's] sound tolerance condition—thus necessitating the appropriate use of hearing protection. They also need to understand, however, that "inappropriate" use of hearing protection can exacerbate their sound tolerance condition. Some patients use earplugs or earmuffs because of their belief that certain sounds or sound, in general, will cause their tinnitus or sound tolerance condition to become worse. They need to be educated that overuse of hearing protection can result in heightened sensitivity to sound, as well as the perception that the tinnitus is louder due to the occlusion effect … If such overuse has already occurred, then it is important that the patient take steps to reverse any heightened sensitivity by gradually reducing the use of hearing protection. These patients must progress to the point that they only use hearing protection when exposed to sounds that can cause damage to the auditory system (Henry et al, 2022, p.518).

5.3 Therapies

Recommendations for the treatment of DST include habituation training, cognitive behavioural therapy, dialectical behavioural therapy, and tinnitus retraining therapy. Danesh et al (2021) suggest cognitive behavioural therapy and habituation therapy are proven effective in the treatment of hyperacusis. Henry et al (2022) note that treatment for hyperacusis usually involves an element of exposure and an element of counselling to address anxiety and avoidant symptoms. The exposure element can be implemented via ear worn devices such as headphones or hearing aids in which a gradual increase in increase in loudness aims at desensitisation. Nolan et al (2020) conducted a retrospective study of 268 patients with tinnitus, 50 of whom also had hyperacusis. They found that CBT with components of musical therapy, different relaxation techniques, and directed attention could significantly reduce symptoms of tinnitus, hyperacusis and associated psychological symptoms such as depression. They suggest that further research is needed to demonstrate the efficacy for patients with hyperacusis alone.

Misophonia can also be treated with cognitive behavioural therapy, though there is less evidence of its efficacy (Henry et al, 2022). In the first randomised controlled trial for the treatment of misophonia, Jager et al (2020) found 10 of the 27 subjects in the treatment group improved significantly with cognitive behavioural therapy and the results were maintained after one-year follow up. Other psychotherapies that target associated symptoms of misophonia such as anxiety or obsessive-compulsive symptoms may also be effective (Henry et al, 2022; Ferrer-Torres & Giménez-Llort, 2022). As fear is the main component of phonophobia, counselling such as the therapies already mentioned may assist to decouple sounds and negative associations (Henry et al, 2022).

Evidence is less reliable for the use of these therapies for people with autism with co-occuring sound tolerance conditions (Zai et al, 2022; Ferrer-Torres & Giménez-Llort, 2022; Williams et al, 2021b; Danesh et al, 2021; Brout et al, 2018). Yuan et al (2022) suggest that cognitive behavioural therapy is effective for general sensory sensitivities in people with autism but does not address specific issues with sound intolerance.

Treatment for central auditory processing problems can include music therapy, auditory training and cognitive behavioural therapy. However the evidence of effectiveness in an autism population is minimal, with studies using small sample sizes and non-controlled designs (Moossavi & Moalemi, 2021). In a controlled trial, Ramezani et al (2021) found improvements in speech perception in a group of 14 young people with autism after auditory processing training for six weeks. For a general population, Audiology Australia's clinical practice guide (2022) recommends music therapy and auditory training for the treatment of central APD. Early evidence show some support for the efficacy of auditory training in the general population, though the quality and level of evidence is a significant limitation (Murphy & Schochat, 2013). A 2021 systematic review found positive correlation between auditory processing skills and musical ability. More specifically, the authors found that 6 months to 2 years of musical training can improve behaviour and speech-in-noise perception in children Braz et al, 2021). One study suggests that the severity of auditory processing symptoms decreases with age (Schafer et al, 2020b).

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