Assistive and therapeutic effects of remote microphone hearing aid systems for children with auditory processing disorders

W J Keith

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One of the most exciting research findings in the treatment of auditory processing disorder (APD) is the neuroplastic benefit of amplification. Whereas hearing aid benefits are purely assistive in the case of peripheral hearing losses, it is now well established that, in the case of APD, amplification with remote microphone hearing aid systems[1] (RMHAs) over time also results in therapeutic improvements in hearing skills due to beneficial neuroplastic changes in the brain. The two main acoustic features of RMHAs are; a significant improvement in signal to noise ratio, and mild amplification of the signal. It is difficult to separate the beneficial contributions of these two features, but in terms of the neuroplastic benefits seen over time from wearing RMHAs, the amplification factor may be most responsible. Amplification stimulates more neural elements which may facilitate synaptogenesis leading in turn to enhanced neural connections.

Assistive benefits of RMHAs

The more immediate assistive benefits of RMHAs for children with APD are well known and include improvements in:

- speech perception in noise
- classroom participation
- attention
- academic performance
- language
- reading
- phonological awareness
- self-confidence, self-esteem and other aspects of psychosocial adjustment
- after-school fatigue

(Friederichs & Friederichs, 2005; Hoen, Rogiers, & Mulder, 2010; Johnston, John, Kreisman, Hall, & Crandell, 2009; W. Keith & Purdy, 2014; Phonak, 2004; Reynolds, Kuhaneck, & Pfeiffer, 2016; Smart, Purdy, & Kelly, 2010, 2018; Umat, Mukari, Ezan, & Din, 2011).

In children with autism spectrum disorder (ASD) and associated APD, RMHAs have been shown to:

[1] This article follows the convention of referring to remote microphone assistive technology systems commonly used for APD as remote microphone hearing aid systems (RMHA systems or RMHAs). The term “RM” (remote microphone) encompasses both the older FM (frequency modulation) and newer DM (digital modulation) technologies. The term “hearing aid” is incorporated to signify the use of amplifying RM receivers (e.g., Roger Focus, Oticon Amigo). RMHA systems incorporating mild amplification are primary hearing devices for children with APD, as distinct from the “accessory” RM systems coupled to conventional hearing aids or cochlear implants.

- increase on-task behavior
- result in improved listening behavior ratings
- reduce listening difficulty
- reduce classroom stress (as inferred from saliva cortisol)
- improve oral comprehension in noise
- improve auditory working memory in noisy situations

(Rance et al., 2017, 2014; Schafer et al., 2019, 2016, 2013).

Studies in adults demonstrate the effectiveness of RMHAs in mitigating hearing difficulties in conditions which are known to cause central auditory temporal distortions (multiple sclerosis, Friederich Ataxia) (Lewis et al., 2006; Rance et al., 2010). Once again the amplification feature of RMHAs may contribute. Amplification may increase synchronicity of neural firing thus ameliorating temporal distortions. Hornickel et al (2012) showed improved synchronicity of auditory brainstem responses as a result of use of RMHAs in children with dyslexia and associated APD.

Therapeutic benefits indicative of neuroplastic change from RMHA use

Multiple therapeutic benefits, indicative of beneficial neuroplastic change, are observed after periods of several months of RMHA system use (compared to unaided control participants). Improvements in the following ability areas have been measured in the unaided condition following the period of RMHA system use:

- consistency of auditory brainstem responses to speech stimuli
- amplitude and latencies of cortical auditory evoked potentials
- interaural temporal resolution
- frequency discrimination
- frequency pattern recognition
- auditory working memory
- language
- speech perception in spatially separated noise
- self-perceived listening ability
- parent and teacher ratings of hearing ability

(Friederichs & Friederichs, 2005; Hoen et al., 2010; Hornickel et al., 2012; Johnston et al., 2009; Phonak, 2004; Sharma et al., 2012; Smart et al., 2010, 2018; Umat et al., 2011; Yip & Rickard, 2011). These studies (pre-2014) are reviewed in more detail in Keith and Purdy (2014).

A neuroplastic therapeutic benefit from RMHA system use has been observed also in adults. Adult stroke patients showed improved hearing ability in spatially separated noise, unaided, after 10 weeks' use of RMHA systems (Koohi et al., 2017).

Given that the ability to hear in noise can be improved by a period of RMHA system use, separate speech in noise auditory training may not be necessary in some children who are also being fitted with RMHAs for APD.

One area that is not, in our clinical experience, ameliorated by RMHA system experience is abnormal interaural asymmetry on dichotic testing (i.e., amblyaudia; Moncrieff et al., 2016). However we have pilot data suggesting that it may be possible to correct amblyaudia in children wearing RMHAs by gradual adjustment of interaural gain. We are studying this further.

Which children benefit from RMHA system use?

The limited research evidence available, supported by clinical experience, suggests that a high proportion of children with auditory processing disorders will benefit from use of RMHAs, and that there is no method of predicting those who will benefit. Certainly a blanket rule of only prescribing RMHAs for children who score poorly on a speech in noise test will deny many children potential benefit. Evidence inferring this can be derived from close scrutiny of published studies in which poor scores on speech in noise tests were not a prerequisite for participation (e.g., Johnston et al., 2009). In our view children should have the option of trying RMHAs if other less costly APD treatments (such as dichotic training e.g., for amblyaudia; specific auditory treatments such as Sound Storm for spatial perception deficit; other auditory training, phonological processing and/or language training etc) have not been or are not predicted to be sufficient. In our view a controlled trial is the only reliable decision tool. One of our multi-disciplinary team collaborates with the child, parent, teacher and learning support coordinator in school to set up and run a 6-10 week trial with pre-agreed measurable goals and classroom observation visits before a mutual decision informed by the trial outcomes is agreed. It also helps parents to weigh up benefit vs cost of the hearing system.

Classroom sound field systems and hearing aids without remote microphones cannot approach the performance of personal RM systems for improvement in signal to noise ratio (Schafer & Kleineck, 2009) and there is no (or very weak) evidence supporting either as an adequate alternative to personal RM systems. But from a pragmatic point of view there will be occasions when an alternative solution to RMHAs is better than no amplification (Wolfe et al., 2015). There is some evidence supporting the use of mild gain hearing aids alone for adults with APD (Roup et al., 2018).The ultimate versatility is provided by hearing aids with an accessory RM system, a solution often chosen by adults (Smart et al., 2007) and some adolescents with APD.

Duration of RMHA use

Since use of RMHAs leads to long term improvement of hearing skills, many children fitted with RMHAs may only need to use them for a limited time. We see children pass previously failed APD diagnostic tests at successive annual reviews after being fitted with RMHAs. In data we are currently analysing on reasons why children and young people with APD (n=42) stopped using RMHAs (e.g., no longer needed, increased self-consciousness at tween/teen years, inconvenience of taking microphone to multiple teachers) not one gave as a reason that the RMHAs had not been useful. Our data indicate that duration of use in our cohort is very variable, with age, change from single to multiple teachers, and psychosocial factors certainly playing a part. The mean duration of use is two years and five months [NB: amended on further analysis to two years and nine months][2].

Conclusion

In providing both assistive and therapeutic benefits to children with a broad range of auditory processing disorders, RMHAs are a highly effective treatment for most children with APD. Amplification with RMHAs appears to treat a wide range of auditory skills simultaneously, facilitating neuroplastic change while also providing improved access to the auditory world.

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