The effectiveness of the Real Ear Sound (RES) hearing aid algorithm for front/back localisation by hearing-impaired children

Josephine Marriage, Sarah Gardner*, Michael Stone, Brian CJ Moore
Department of Experimental Psychology, University of Cambridge, Downing Street, CAMBRIDGE CB2 3EB
and *Donald Winnicott Centre, Coate St, Hackney, London E2, UK.

Background:
Localisation ability is important in allowing babies and children to identify sound sources, and thereby recognise and differentiate auditory objects. Localisation relies on interaural level and timing differences and pinna-effects. The pinnae alter the spectra of sounds reaching the eardrums depending on the direction the sound comes from; the largest effects occur at high frequencies. For normally hearing people, pinna-cues are especially important for distinguishing up from down and front from back (Blauert, 1997).

Behind-the-ear (BTE) hearing aids normally prevent the use of such cues, as the mics are located above the pinnae, causing direction-dependent pinna cues to be lost (Moore, 2007).

Real ear sound (RES) is a hearing aid signal-processing algorithm that involves filtering the sound to simulate the acoustical characteristics of the pinna. The RES algorithm has been found to improve judgements of front/back orientation for hearing-impaired adults, relative to a condition using an omni-directional microphone (ref 1). The RES algorithm was designed for adults, and it is not clear how well it may work with children, since the direction-dependent filtering depends strongly on the size of the head and pinnae, and it is likely to differ between adults and children. Also children who have had hearing loss from early life and worn hearing aids, have had little opportunity to experience pinna-cues,

Aim of the study: to assess localisation ability for signals presented from right/left and front/back positions, in children with RES compared to omni-directional hearing aids.

Subjects:
N=15
5 and 8 years
Mild to severe hearing loss
Hearing aid users for > 1 year

Hearing Aid Conditions:
Fitted with Phonak Savia hearing aids with
(A) RES or
(B) omni-directional microphone fittings. Each worn for two weeks in ABA, or BAB sequence.

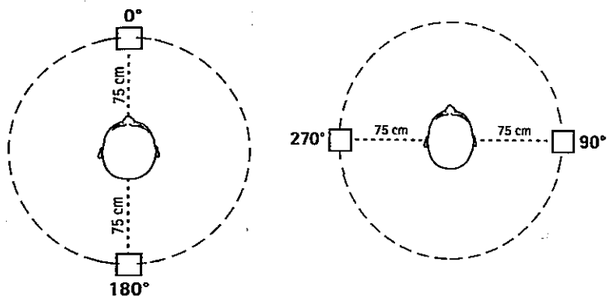
Test conditions:
Localisation of right from left (90°/270) and front from back (0°/180°)
Assessor was blind to the test condition.

The right/left condition was not predicted to be challenging for most hearing aid wearers and was included as a control condition for the task.

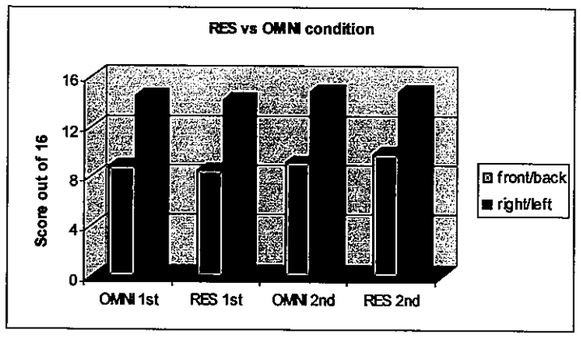
Test Equipment:
Signals were presented from an HP laptop through an Indigo dj sound card, connected to a two channel GSI 61 audiometer, with output from two Mordaunt Short speakers with matched frequency responses across the speech spectrum, to reduce the likelihood of intensity cues. Signals were randomly presented at levels of between 55 and 70 dB SPL with 5-dB step size.

Test sequence:
4 blocks of 8 presentations randomly presented from each of 2 loud speakers.
The child was seated so that the speakers were: 1) right/left, 2) front/back, 3) right/left, 4) front/back.
Colourful stickers were placed above the speaker to maintain the child's gaze and head-position during signal-presentation.

Signal is 1-second duration of modulated pink-noise, high-pass filtered at 100 Hz, with a fade in/out time of 10 msec with raised cosine ramps.



Results:
The graph below shows mean scores for RES and Omni-directional (OMNI) conditions across two test sessions.



Overall mean scores were 9.0 for OMNI and 9.2 for RES condition. There was no significant improvement in front/back localisation ability in RES over the OMNI condition, or between the first and second test episodes. The small trend for improved performance in the second session is seen for both RES and OMNI conditions. Most subjects were at ceiling for right/left but 3 were below ceiling, hence the reduced mean score for right/left performance.

Analysis
A within-subjects ANOVA with factors microphone condition (RES/OMNI) and session number (first/second) showed no significant effect of microphone condition ($F(1,14) = 0.21$; $p = 0.655$) or session number ($F(1,14) = 3.50$; $p = 0.082$).

Training effects No training on the task was given initially. After the second appointment for each child a training session of 32 signal presentations in the front/back plane was given with feedback on the true direction of the signal.

There is no significant improvement in performance across subjects following the training session.

Unaided condition In view of the inability to identify the front/back direction of signals with RES hearing aids, testing in the **unaided** condition was done. Again subjects were not able to demonstrate ability to use pinna cues even without hearing aids, though the signals were audible (70-85 dB presentation levels). It is noted that severely hearing impaired subjects would not have been able to detect high frequency cues without their hearing aids.

Discussion
Thirteen of the 15 children had late identification of hearing loss with unaided listening in early life giving potential familiarity for pinna cues. However they did not show ability to use these cues either with or without hearing aids.

Although this study indicates that our subjects were not able to demonstrate benefit from RES over the course of this short study, it would be reasonable to include RES into hearing aid settings for young children, to allow potential learning from pinna effects for localisation from early life.

Acknowlegements
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References
Bl *Blauert, J. 1997. Spatial Hearing: The Psychophysics of Human Sound Localization. Cambridge, Mass: MIT Press*

Mooore, BCJ. 2007. Cochlear Hearing Loss: Physiological, Psychological and Technical Issues. Chichester: Wiley.