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Title: Identification of conductive hearing loss using air-conduction tests alone: reliability and validity of an automatic test battery

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Abstract: 

Objectives: The primary objective of this study was to determine whether a combination of automatically administered pure-tone audiometry and a tone-in-noise detection task, both delivered via an air-conduction pathway, could reliably and validly predict the presence of a conductive component to the hearing loss. Our hypothesis was that performance on the battery of tests would vary according to hearing loss type. A secondary objective was to evaluate the reliability and validity of a novel automatic audiometry algorithm to assess its suitability for inclusion in the test battery.

Design: Participants underwent a series of hearing assessments that were conducted in a randomized order: manual pure-tone air- and bone-conduction audiometry; automatic pure-tone air-conduction audiometry; and an automatic tone-in-noise detection task. The automatic tests were each administered twice. The ability of the automatic test battery to: (a) predict the presence of an air-bone gap; and (b) accurately measure air-conduction hearing thresholds, was assessed against the results of manual audiometry. Test-retest conditions were compared to determine the reliability of each component of the automatic test battery. Data were collected on 120 ears that included normal hearing and conductive, sensorineural, and mixed hearing loss subgroups.

Results: Performance differences between different types of hearing loss were observed. Ears with a conductive component (conductive and mixed ears) tended to have normal signal-to-noise ratios (SNRs) despite impaired thresholds in quiet, while ears without a conductive component (normal and sensorineural ears) demonstrated, on average, an increasing relationship between their thresholds in quiet and their achieved SNRs. Using the relationship between these two measures among ears with no conductive component as a benchmark, the likelihood that an ear has a conductive component can be estimated based on the deviation from this benchmark. The sensitivity and specificity of the test battery vary depending on the size of this deviation, but increase with increasing air-bone gap size, with decreasing test frequency, and when results from multiple test frequencies are taken into account. The individual automatic tests comprising the battery were found to be reliable and valid, with strong, significant correlations between the test and retest results ($r = 0.81-0.99, p < 0.0001$) and between automatic and manual audiometry procedures ($r = 0.98-0.99, p < 0.0001$).

Conclusions: The presence of an air-bone gap can be predicted with a reasonably high degree of accuracy using air-conduction tests alone. Applications of such a test battery include any clinical context in which bone-conduction audiometry and/or specialized diagnostic equipment is unavailable or impractical. Examples of these include self-fitting hearing aids, whose efficacy relies on the ability of the device to automatically administer an in situ hearing test; self-administered adult hearing screenings in both clinical and home environments; large-scale industrial hearing conservation programs; and test environments in which ambient noise levels exceed the maximum permissible levels for unoccluded ears.