Validation of browser-based Arabic Digits-In-Noise tests, including comparisons of diotic and antiphasic versions

A. Shehabi\textsuperscript{1}, M. Zuriekat\textsuperscript{2}, O. Aboudi\textsuperscript{2}, C. Plack\textsuperscript{3,4}, & H. Guest\textsuperscript{3}  
\textsuperscript{1}Birzeit University, Palestine; \textsuperscript{2}University of Jordan, Jordan; \textsuperscript{3}The University of Manchester, UK; \textsuperscript{4}Lancaster University, UK

\section*{Background}

- The need for accessible, valid and reliable hearing screening tools in the Arab region is largely unmet.
- Digits-in-noise (DIN) tests are used in many world languages to screen for hearing loss and assess functional hearing ability (Van et al., 2021).
- Standard DIN tests involve diotic digits in diotic noise. Antiphasic stimuli, in which the digits are phase-reversed between the ears, are suggested to be more predictive of pure-tone audiometric (PTA) thresholds (Smits et al., 2004; De Sousa et al., 2022).

This study aims to:

(a) Determine whether Arabic DIN thresholds are linearly related to the worse ear PTA threshold average, after controlling for age.

(b) Determine whether antiphasic DIN thresholds are superior to diotic DIN thresholds in predicting worse ear PTA.

(c) Determine the test-retest reliability of both versions of the DIN test.

\section*{Methods}

\subsection*{Participants}

A total of 128 native-Arabic Jordanian participants (57 males) aged 18 – 80 with a wide variety of audiometric profiles completed Session 1 of the study.

A subset of 30 participants completed Session 2 of the study (assessing reliability).

\subsection*{Procedures}

In Session 1, participants were tested using PTA, tympanometry, and diotic and antiphasic Arabic DIN tests.

Session-2 of the study involved re-testing participants using tympanometry, and diotic and antiphasic Arabic DIN tests.

Partial correlations and linear regressions were calculated to assess relations between the DIN tests and worse-ear PTA.

ROC curves were obtained to determine sensitivity and specificity of the DIN tests in predicting a PTA average > 25 dB HL.

Test-retest reliability was assessed using the one-way, random-effects, single-rater intraclass correlation coefficient (ICC\textsuperscript{1,1}).

\section*{Results}

\subsection*{Diotic DIN}

\begin{figure}[h]
  \centering
  \includegraphics[width=\textwidth]{diotic_din_plot.png}
  \caption{Relations between DIN thresholds and PTA}
  \label{fig:diotic_din}
\end{figure}

\subsection*{Antiphasic DIN}

\begin{figure}[h]
  \centering
  \includegraphics[width=\textwidth]{antiphasic_din_plot.png}
  \caption{Antiphasic DIN}
  \label{fig:antiphasic_din}
\end{figure}

\subsection*{Antiphasic DIN}

\begin{figure}[h]
  \centering
  \includegraphics[width=\textwidth]{antiphasic_din_plot.png}
  \caption{ROC curve for the antiphasic DIN in predicting HL > 25 dB HL}
  \label{fig:antiphasic_roc}
\end{figure}

- Partial correlation between worse-ear PTA and diotic DIN, controlling for age: \( r = 0.20 \) (\( p = 0.03 \)).
- Partial correlation between worse-ear PTA and antiphasic DIN, controlling for age: \( r = 0.54 \) (\( p < 0.001 \)).
- Diotic DIN as a predictor of PTA > 25 dB HL has a sensitivity of 80% and a specificity of 64% at a cut-off of -9 dB (AUC = 0.74).
- Antiphasic DIN as a predictor of PTA > 25 dB HL has a sensitivity of 74% and a specificity of 77% at a cut-off of -13.5 dB (AUC = 0.84).
- Antiphasic DIN thresholds (ICC = 0.83, 95% CI = 0.68–0.92) are more reliable than diotic DIN thresholds (ICC = 0.46, 95% CI = 0.12–0.70).

\section*{Summary}

- Findings support the browser-based Arabic DIN as a valid and reliable screening tool.
- The antiphasic DIN appears more strongly related to worse-ear PTA and more reliable than the diotic DIN.
- Given limited access to in-person hearing healthcare in many parts of the Arabic-speaking world, findings could support beneficial hearing-related public-health measures.

\section*{References}

