Response Method in Audiometry

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Purpose: This study compared the speed, false-alarm rate, and participant preference of different response methods (raising a hand, pushing a response button, and giving an oral response) for measuring pure-tone thresholds.

Method: Thirty female university students with normal hearing participated. Response method order was randomly assigned to 6 different groups. Air-conduction thresholds were measured twice for each response method for each participant in octave intervals between 250 Hz and 8000 Hz. The 2nd threshold measurements were performed on a different day but within 2 weeks of the initial measurement.

Results: A significant difference was found when comparing the amount of time necessary to complete the test for each response method. On average, it took about 1 min less when using the push-button response than when using hand-raise or verbal response methods. There was also a significant participant preference for using the response button. No significant difference between response method for threshold level and number of false positives was found.

Conclusion: This study supports the use of the response button when measuring auditory thresholds for young adults with normal hearing.

Key Words: audiometry, response method, threshold

Clinical threshold measurement is a fundamental diagnostic tool in audiology. Research on threshold measurement has largely focused on measurement procedures and stimuli parameters. Comparisons and analyses have been made to ensure reliable results in a timely manner and sometimes have included participant preference measures (e.g., Arlinger, 1979; Burk & Wiley, 2004; Carhart & Jerger, 1959; Harris, 1979; Hughson & Westlake, 1944; Mineau & Schlauch, 1997; Reger, 1950). This body of research has led to guidelines from the American Speech-Language-Hearing Association (ASHA, 2005). These guidelines include information on (a) how to instruct the participant to the task, (b) how to interpret the response behavior, (c) stimulus parameters, and (d) the recommended procedure for threshold determination (ASHA, 2005). The literature used to develop these recommendations has a long and rich history. It is not our intent to critically review this history but rather to test a hypothesis regarding the impact of common response methods on speed, false-alarm rate, and patient preference of air-conduction, audiometric-threshold measurements.

Tyler and Wood (1980) compared three procedures for measuring threshold. They compared the procedure proposed by the Education Committee of the British Society of Audiology, the procedure proposed by Carhart and Jerger (1959) that was later adopted by the American Speech and Hearing Association (1978), and a modified version of the American Speech and Hearing Association’s recommended procedure. Tyler and Wood found no significant difference in finding threshold among the three procedures, the number of false positives measured, or participant preference.

When comparing stimulus types, Burk and Wiley (2004) compared threshold measurements in listeners with normal hearing using continuous and pulsed pure tones. Comparing the two stimulus types, there was a small but significant difference in threshold but no significant difference in the number of false positives or the number of presentations required to achieve threshold. However, listeners preferred the pulsed tone presentation to the continuous tones. Burk and Wiley recommend using pulsed pure tones to measure thresholds in clinical audiology.

When using pulsed versus continuous tones for patients with tinnitus, differences in the number of presentations were found (Mineau & Schlauch, 1997). Patients required significantly fewer presentations at 4000 Hz when pulsed tones were used. They also recorded more false positives in the continuous presentation than in the pulsed presentation. From these findings, Mineau and Schlauch (1997) have recommended using pulsed tones to measure thresholds in patients with tinnitus.

Previous studies have not measured whether a participant’s response method influences thresholds. In ASHA’s (2005) guidelines, participant response tasks are listed as follows:
Overt responses are required from the participant to indicate when he or she hears the tone going on and off. Any response task meeting this criterion is acceptable. Examples of commonly used responses are (a) raising and lowering the finger, hand, or arm, (b) pressing and releasing a signal switch, and (c) verbalizing “yes.” (p. 3)

Some studies recommending specific procedures for screenings and measuring thresholds did not mention the method of participant response used to measure thresholds throughout the experiment (Bogardus, Yeuh, & Shekelle, 2003; Hamill & Haas, 1986). Therefore, these accepted and commonly used response methods described in ASHA’s (2005) guidelines were chosen for this study.

A lack of data on the influence of participant response methods on threshold measurements, false positives, or number of presentations needed to determine threshold served to motivate the current study. The hypotheses include the following: Push-button response will (a) take fewer presentations, (b) require a shorter amount of time, and (c) result in fewer false alarms when compared with hand-raise and verbal response methods.

Method
Participants
Thirty females with normal hearing were recruited as participants (mean age = 21.5 years; range = 19–24 years). Each participant had pure-tone thresholds ≤ 15 dB HL for octave frequencies from 250 Hz to 8000 Hz and a Type-A tympanogram (Jerger, Jerger, & Mauldin, 1972). Participants were counterbalanced to one of six groups that included all permutations of order of presentation to eliminate order effects.

Instrumentation
Thresholds were measured with a diagnostic, clinical audiometer (Madsen, Itera II). Tones were presented through earphones (Telephonics, TDH-50P) mounted in supra-aural cushions (MX-51/AR). Pulsed tones were presented with four presentations of a 200-ms tone (ASHA, 2005; Burk & Wiley, 2004; Mineau & Schlauch, 1997). Participants were seated in a double-walled sound booth (Industrial Acoustics Company).

Annual calibration of the equipment was performed according to the American National Standards Institute (ANSI) guidelines (ANSI, 2004b). A listening check was performed daily on the equipment.

Procedure
Informed consent was obtained prior to data collection. Otoscopic examination and tympanometry were completed on the right ear to rule out any conductive pathology. Participants were then instructed as to the response required—either push-button, hand-raise, or verbal response to perceiving the tone. Threshold was determined as the softest level obtaining at least two responses out of three presentations on an ascending run as recommended in ASHA’s (2005) guidelines, which is also consistent with ANSI’s (2004a) standards.

All participants were tested using their right ear. Participants were familiarized with a 30-dB HL pulsed presentation of each frequency before measurement of threshold. If a response was obtained, measurement of threshold began. The interval between presentations of threshold measurement varied but was not shorter than the test tone. Hughson and Westlake’s (1944) procedure of obtaining threshold was used on all participants with a Down 10, Up 5 dB rule (Carhart & Jerger, 1959).

Once familiarization was completed, threshold measurement began. The first presentation was given 20 dB below the familiarization level. Thresholds at octave frequencies between the lowest and highest recommended frequencies were obtained (ASHA, 2005). Test frequencies included 1000, 2000, 4000, 8000, 500, and 250 Hz, in order of presentation. Total number of false alarms through testing, the presentations for the initial threshold measurements, and total test time were recorded for each response method. Each presentation of the tone was counted starting with the 30-dB HL familiarization tone. False-positive responses were determined as any response given at least 1 s after any tone presentation. Test time started with the first familiarization tone at 1000 Hz and ended with the final presentation at 250 Hz. Participants were then re instructed and tested using the remaining two response methods, the order of which was determined by the group to which each participant was assigned. Presentation measurement with the remaining response methods was carried out in the same fashion as described above.

Participants were asked to return within 2 weeks for a second session. The second session was used to show that the threshold measures were replicable. Therefore, the same

<p>| Table 1. Thresholds and standard deviations (in parentheses) for the six test frequencies and three response methods. |</p>
<table>
<thead>
<tr>
<th>Response method</th>
<th>250 Hz</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
<th>8000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Button push</td>
<td>8.3 (6.6)</td>
<td>5.3 (6.1)</td>
<td>1.5 (6.3)</td>
<td>1.0 (5.6)</td>
<td>0.5 (6.7)</td>
<td>5.0 (6.6)</td>
</tr>
<tr>
<td>Hand raise</td>
<td>8.3 (6.6)</td>
<td>5.0 (6.0)</td>
<td>2.5 (6.3)</td>
<td>0.2 (6.1)</td>
<td>0.5 (6.9)</td>
<td>5.5 (6.3)</td>
</tr>
<tr>
<td>Verbal response</td>
<td>8.3 (6.5)</td>
<td>5.0 (6.3)</td>
<td>3.0 (6.6)</td>
<td>1.3 (5.7)</td>
<td>1.0 (6.7)</td>
<td>5.3 (7.9)</td>
</tr>
</tbody>
</table>

Note. There were no significant differences in threshold across response methods.
procedure was used including instructions, threshold measurement procedure, and response method order. Following completion of the second session, participants were asked preference of response method.

Results

Average threshold levels with standard deviations are shown in Table 1 for each frequency and response method. To understand the effect of response method on threshold level, a two-way analysis of variance was performed using threshold as the dependent variable with response method and order as factors. Response method did not affect the threshold level, $F(2, 1044) = 0.65$, $p = .52$. Furthermore, the thresholds were the same for the first and second tests, suggesting that the threshold measures were replicable, $F(1, 1044) = 0.01$, $p = .92$. There was no interaction between the order in which response methods were tested and the results obtained by each response method, $F(2, 1044) = 0.03$, $p = .97$.

Figure 1 displays the average amount of time for each of the three response methods averaged for all 30 participants. The first two data columns of Table 2 show the average number of false alarms and number of presentations for each response method. A multivariate analysis of variance was performed using response method as a factor and false alarms, number of presentations, and time elapsed as dependent variables. There was no significant difference in the number of false alarms, $F(2, 87) = 1.71$, $p = .19$, or number of presentations, $F(2, 87) = 1.43$, $p = .244$. However, time differed significantly across groups, $F(2, 87) = 9.94$, $p < .05$. To better understand how response methods compared in the amount of time each required, Tukey's post hoc comparisons were performed. On average, the push-button method required about 1 min less per participant than the hand-raise method, which was significant ($p < .05$), and almost 1.50 min less than the verbal response method, which was also significant ($p < .05$). However, the hand-raise and verbal response did not take a significantly different amount of time ($p = .42$).

Immediately following the second test session, each participant's preferred response method was recorded. The right column of Table 2 shows participant preference to response method. Twenty five participants (83.3%) preferred the push-button method over the hand-raise and verbal response methods. No participant chose the verbal response method. A chi-square analysis of participant preference showed a significant result for participant preference of using the push-button as a response method, $\chi^2(1, N = 30) = 13.33$, $p < .05$.

Discussion

The data indicate that using the push-button method takes significantly less time when compared with the hand-raise and verbal response methods. On average, the push-button method took 58.2 s and 82.2 s less for one ear than using hand-raise or verbal response methods, respectively. This time savings of using a push-button response is 12.9% and 17.3% shorter than the hand-raise and verbal response methods, respectively.

Participants preferred the push-button response method over the other two response methods. Participants reported that it was easier, more natural, and/or more reflexive than the other two methods. Of the participants, 27 (90%) spontaneously reported dislike of the verbal response method; no participants preferred that method. It is not surprising that a time savings might occur by using a small motor function (thumb pressing a button) as a response rather than a more
complex motor function (raising one’s own arm) or a more complex motor-speech function (verbalizing an English word). Therefore, if a patient is unwilling or unable to use the button or if the button is unavailable, then a hand-raise or, less preferably, a verbal response may be used. Because the thresholds were the same regardless of response method, the only real sacrifice is the time required to make the measurements.

From these data, it is not clear how these findings would extend to other populations (e.g., elderly, pediatric) or various degrees of hearing loss. To generalize these findings, further research on other populations is required. In terms of hearing status, the impact of hearing loss and tinnitus would need to be assessed.

In summary, comparisons were made of measurements taken when participants responded to pulsed tones using a push-button, hand-raise, and verbal response. The push-button response was preferred by participants, required less time when compared with the hand-raise and verbal response methods, and resulted in the same threshold levels for young, normal-hearing adults. It is recommended that clinicians use the push-button as the response method for pulsed tones when testing this population.

References

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