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Research Article

Effect of response method in participants with sensorineural hearing loss

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ABSTRACT

Background: Aim of the study was to compare the speed of response, false-alarm rate, and subject preference of different response methods i.e. raising a hand, using response switch, and oral response mode for measuring pure-tone thresholds.
Methods: Forty five participants (female-21 and 24 male) were included in the study with sensorineural hearing loss of various degree. Response method order was randomly assigned to 3 different sessions. Air-conduction thresholds were measured thrice for each participant in octave intervals between 250 Hz and 8000 Hz. The 2nd and 3rd session were performed for different response method on a different day but within 2 weeks of the 1st session.
Results: Difference in the time was noted when compared with the extent of time required to complete the test for each response method. On an average, using the pushbutton method took 3.02 to 3.42 minutes less than 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 (P = 0.15) was found.
Conclusion: This study supports the use of the response button when measuring auditory thresholds for sensorineural hearing loss.

Keywords: Pure tone threshold, Oral response, False alarm rate, Response method

INTRODUCTION

Threshold measurement is the most fundamental aspect of audiological assessment. Air and bone conduction measurement involves determination of pure tone threshold at 250- 8000 Hz. The threshold of hearing is the threshold of audibility. This threshold is defined as the minimum effective of sound pressure level of signal i.e. capable of evoking an auditory sensation in a specified fraction of the trials.[1] Accuracy of threshold measurement can be affected by many variables. These variables include (a) how clinician instruct to the client for the task, (b) interpretation of the response, (c) stimulus related parameters, and (d) the standardized procedure for threshold determination.[2] Most of the clinical research work was focused on measurement procedures, stimuli parameters, effect of different kind of headphone and client preference measure to ensure reliable results.[3-9]

Borton, Nolen, Luks and Meline[10] reported consistent and high test retest reliability for both normal and hearing-impaired subjects (>0.95). When compared for four frequencies for three earphone arrangements (supra-aural TDH-39 and an insert ER-3A coupled to each of a foam insert and an immittance probe cuff) with 2 adult subjects in each of a group of normal hearing, conductive hearing loss and sensorineural hearing loss.

Lindgren[11] reported the difference in intra-individual variability between the supra-aural (TDH-49P) and insert earphones (ER-3A) could not be verified as being statistically significant and was at all test frequencies within 1.3 dB variability in threshold, in the frequency range of 250-8000 Hz using a Bekesy technique on thirteen normal-hearing adult subjects when tested within five test-retest sessions.

Tyler and Wood[12] found no significant difference in terms of threshold measurement, false positive rate, participant preference when compared three procedures proposed by the education committee of the British society of audiology, the procedure proposed by Carhart and Jerger[5] that was later adopted by the American Speech and Hearing Association[13] and a modified version of the American speech and hearing association's recommended procedure. When comparing stimulus types, Burk and Wiley[4] recommend using pulsed pure tones to measure thresholds in clinical audiology. Mineau and Schlauch[8] reported more false positives in the continuous presentation than in the pulsed presentation. From these findings, Mineau and Schlauch[8] have recommended using pulsed tones to measure thresholds in patients with tinnitus. 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". Most of the studies suggested the specific procedures for screenings and measuring thresholds but they did not mention the method of participant response used to measure thresholds for specific case such as tinnitus cases and case with hearing loss.[14,15]

DiGiovanni and Repka[16] 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) on thirty participant with normal hearing, result revealed that a significant difference when comparing the amount of time necessary to complete the test for each response method. Push button took about 1 min less compared to 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.

To date, to the best of our knowledge, no studies have examined variability in participant response methods on threshold measurements, false positives, or number of presentations needed to determine threshold in cases with sensorineural hearing loss served to motivate the current study.

METHODS

Forty five participants, female-21 and male-24 (mean age = 35.2 years; age range = 18 to 40 years) were included in the study with sensorineural hearing loss of various degrees. The each participant had pure-tone thresholds >15 dB HL for octave frequencies from 250 Hz to 8000 Hz and a type-A tympanogram. Onset of hearing loss was post-lingual for all participants, thus having adequate speech and language.

All the participants were oriented about the study and written consent was taken regarding their willingness to participate in the study.

Inclusion criteria

Sensorineural hearing loss in either ear (>15 dB HL) at the average of 4 frequencies in audiogram.

- First language/native language being Hindi language (Language that has been spoken majorly in one of the province in northern part of India).
- No indication of middle ear pathology in both ears on immittance evaluation at the time of evaluation and study.
- No illness on the day of testing.
- No history of neurologic/cognitive/psychological problems.

All Participants were counterbalanced that included all permutations of order of presentation to eliminate order effects.

Testing environment

All tests were carried out in a sound treated two room situation. Ambient noise levels in the test rooms were as per the standards of ANSI S3.1 (1999) with adequate illumination.

Instrumentation

Instrument used for pure tone thresholds measurement was diagnostic dual channel, clinical audiometer (AC-40 Interacoustics). Tones were presented through earphones (Telephonics, TDH-39) mounted in supra-aural cushions (MX-51/AR).

Calibration of the audiometer was performed according to the American National Standards Institute (ANSI) guidelines (ANSI, 2004b). Immittance Audiometry was carried out with GSI Tympstar (Grason-Stadler Inc. USA) middle ear analyser using 226 Hz probe frequency. Ipsilateral and Contralateral reflexes were measured for 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz.

Stimuli

Pulsed tones were presented with four presentations of a 200-ms tone.[2,4,8,16]

Procedure

Participants were selected based on the participant selection criteria and on willingness to participate. Cases were taken from the Department of audiology who were diagnosed as having sensorineural hearing loss in the either ear, type-A tympanogram[17] with elevated or absent acoustic reflex in either ear.

Participants were instructed as to respond using push-button in first session. This threshold is defined as the minimum effective of sound pressure level of signal i.e. capable of evoking an auditory sensation in a specified fraction of the trials. It was estimated as the softest level of intensity were participant gives at least two responses out of three presentations on bracketing method as recommended in ASHA, 2005; ANSI, 2004a standards. 23 participants were tested using right ear whereas 22 participants were tested with left ear (i.e. total = 45 ears). Participants were familiarized with a 10 dBSL pulsed presentation of each frequency before measurement of actual threshold. After familiarization, measurement of threshold began. The time interval between two successive presentations of tone was greater than 1 second. Hughson and Westlake's (1944) procedure of obtaining threshold was used on all participants with a down 10, up 5 dB rule.[5] The first presentation was started with 20 dB below the threshold. Thresholds at octave frequencies between the lowest and highest recommended frequencies were obtained (ASHA, 2005). Order of presentation of frequencies were 1000, 2000, 4000, 8000, 500, and 250 Hz, in. 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 20dB below threshold. False-positive responses were determined as any response given at least 1 s after any tone pre-sentation. Test time started with the first familiarization tone at 1000 Hz and ended with the final presentation at 250 Hz. Participants were then reinstructed for remaining two response methods, the order in which was threshold was determined was randomized. Threshold measurement with the remaining two response methods was carried out in the same manner as used for first response method in within 2 weeks. After completion of the measuring threshold at last session, participants were asked to give preference of response among three methods.

RESULTS

Study aimed to compare the speed of response, false-alarm rate, and subject preference of different response methods i.e. raising a hand, using response switch, and oral response mode for measuring pure-tone thresholds for each participant.

Descriptive statistic (average threshold and standard deviation) were calculated shown in Table 1 for each frequency and response method. Two way measures ANOVA was carried out to find significant difference between thresholds across three different response methods.

Table 1: Thresholds and standard deviations for the six test frequencies for each response method.

Measures	Threshold					
	250 Hz	500 Hz	1 Hz	2 Hz	4 Hz	8 Hz
PB	42.5 ± 5.2	48.9 ± 4.1	53.5 ± 7.2	58.6 ± 6.2	59.2 ± 11	65.6 ± 6.1
HR	42.9 ± 5.7	46.2 ± 4.5	52.4 ± 7.1	59.6 ± 6.4	61 ± 4	67.3 ± 6.3
OR	45.7 ± 5.1	47.5 ± 4.6	52.3 ± 7.1	58.1 ± 6.1	60.3 ± 4.4	64.1 ± 6.5

Note: PB-push button, HR-hand rising, OR-oral response

The result showed a no significant difference ($P = 0.55$) across three different conditions, means to say that response method did not affect the threshold level, $F(2, 1142) = 0.75$, $P = 0.55$.

There was no interaction found between the order in which response methods were tested and the results obtained by each response method, $F(2, 1142) = 0.04$, $P = 0.95$.

For statistical analysis for time taken for each response method average time and standard deviation of test time were obtained for different mode of response for all 45 participants as depicted in the Table 2.

Table 2: Average time and standard deviation of test time for different mode of response for each participant.

Measures	PB	HR	OR
Average time (min)	6.58	9.16	10
SD	0.94	1.00	1.32

Note: PB-push button, HR-hand rising, OR-oral response

From Figure 1 it can be observed that average time taken for the oral response is more compared to push button and hand rising in cases with sensorineural hearing loss. Lesser time was taken with push button as compared with two other method responses.

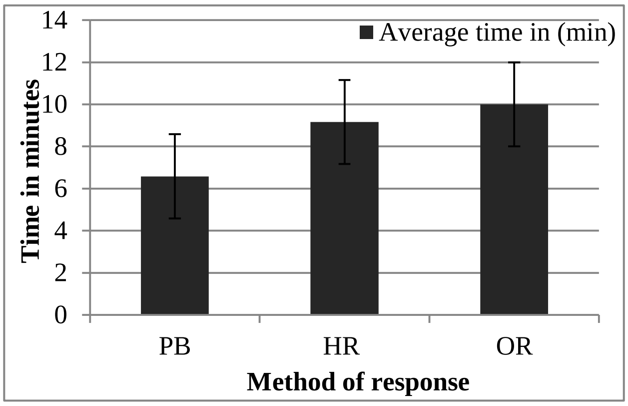

Figure 1: Mean and Standard deviation of test time obtained for different mode of response for all 45 participants.

Mean and standard deviation (Table 3) of false alarm and number of tone presentation were calculated across different response method results revealed that number of false alarm were more in case of when push button were used as compare to two other conditions. Results revealed that more number of false alarm rate was seen when push button were used, which apparently not uncommon.

Table 3: Mean and Standard deviation (SD) of false alarm rate and no. of presentation for different method of response.

	No. of false alarm rate	Number of presentation
Mean ± SD	1.10 ± 0.41	44.38 ± 1.40
	0.69 ± 0.26	44.27 ± 1.27
	0.70 ± 0.40	44.47 ± 1.44

Multivariate analysis of variance (MANOVA) was done in which response method was considered as a factor and false alarms, number of presentations, and time lapsed in testing was considered as a dependent variables. Results of MANOVA revealed that there was no significant difference in the number of false alarms, $F (2, 75) = 1.67$, $P = 0.15$ and also no significant difference were noted for number of presentations, $F (2, 81) = 1.35$, $P = 0.225$ but significant difference in time lapsed were seen across groups, $F (2, 81) = 8.95$, $P < 0.05$. Therefore post hoc comparisons was done and results revealed that the push-button method took about 1.2 min less per participant than the hand-raise method, which was significant ($P < 0.05$), and almost 1.74 min less than the verbal response method, which was also significant ($P < 0.05$). However, there was no significant difference in the hand-raise and verbal response ($P = 0.32$) were noted.

At last test session, each participant was asked to give the preference for each response method. Table 4 shows participant preference to response method. Thirty nine participants (86.6%) preferred the push-button method, 8.89% preferred hand-raise whereas 4.4% were preferred verbal response methods.

Table 4: Participant preferences and their percentages for each response method.

Measures	Preference (Number of participant)	Percentage (%)
Push button	39	86.6
Hand rising	4	8.89
Oral response	2	4.4

DISCUSSION

The present study showed a no significant difference across three different method of response when it was used for threshold estimation, means to say that regardless of the response method threshold did not changed much, which is consistent with DiGiovanni and Repka[16] findings in which reported that using the push-button method, hand-raise or verbal response methods in normal hearing individuals.

Among method, push-button method takes significantly less time when compared with the hand-raise and verbal response methods. On an average, Push-button method took about 3.02 to 3.42 min lesser than the hand-raise method and verbal response method. However, no difference in the hand-raise and verbal response, which consistent with DiGiovanni and Repka[16] findings where push button took lesser time compare to hand rising or oral response in normal hearing individual. Quick and motoric response can be reason for lesser time taking.

In this study more number of false alarm rate were seen with pushbutton, which is apparently not uncommon. These can be noted in cases with sensorineural hearing loss.[18] Strict instructional criteria may reduced the number of false alarm rate.

In response method participants reported that push button was easier, more natural, and/or more reflexive than the other two methods. It helps in time savings might be due to small motor function in pushbutton as a response rather than a more complex motor function like hand raising or a more complex motor-speech function like verbalizing. Therefore, participants willing to use push button rather than a hand-raise or a verbal response. Because the thresholds were the same regardless of response method, the only real sacrifice is the time required to make the measurements.

From these study, it is now clear that no significant difference threshold in cases with various degrees of sensorineural hearing loss using different response method but how these findings would extend to difficult to test population populations (e.g., paediatric cases, cases with cerebral palsy or other motor disorder cases). To generalize these findings, further research on these populations is needed.

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

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