CAN THE HEARING HANDICAP INVENTORY FOR ADULTS BE USED AS A SCREEN FOR PERCEPTION EXPERIMENTS?

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ABSTRACT

When screening participants for speech perception experiments, formal audiometric screens are often not an option, especially when studies are conducted over the Internet. We investigated whether a brief standardized self-report questionnaire, the screening version of the Hearing Handicap Inventory for Adults (HHIA-S), could be used to approximate the results of audiometric screening. Our results suggest that while the HHIA-S is useful, it needs to be used with extremely strict cut-off values that could exclude around 25% of people with no hearing impairment who are interested in participating. Well constructed, standardized single questions might be a good alternative for web experiments.

Keywords: screening, audiometry, hearing handicap inventory

1. INTRODUCTION

Typically, only participants with normal hearing are recruited for speech perception studies. People with a hearing impairment, i.e. a deterioration in physiological function that affects their hearing, may find it hard to detect fine spectral or temporal distinctions, require higher presentation levels, or have problems with understanding speech in noise [2]—all of these issues can skew the final analysis.

By far the easiest and most popular way of screening for impairment is to recruit students and young people with self-reported normal hearing. This is a somewhat precarious safeguard, however. For example, in a recent representative survey of US adolescents, one in five 18/19-year-olds had subnormal hearing on at least one ear [8].

A more thorough approach is to screen each participant's hearing using a standard procedure as recommended by professional societies such as the British Society of Audiology (BSA, [3]) or the American Speech, Language and Hearing Association (ASHA, [1]). Participants are presented with several pure tones (usually 0.5, 1, 2, and 4 kHz) at a set level, which may vary depending on the level of background noise. Participants who can perceive all of these tones pass the screen; if one or more tones cannot be heard, they fail.

Although a hearing screen is superficial compared to a full hearing assessment [2], it requires specialized equipment, such as a screening audiometer; the person administering the screen needs to be trained; and, most importantly, the screen cannot be used for web-based perception studies.

In this study, we investigated whether a brief, clinically validated questionnaire, the screening version of the Hearing Handicap Inventory for Adults (HHIA-S) [6, 7], can be used in studies where a hearing test cannot be administered in person to detect participants who would fail the pure-tone screen.

The HHIA-S was adapted from a questionnaire developed to assess the perceived hearing problems of older people, the Hearing Handicap Inventory for the Elderly (HHIE, [11]). The screening version, HHIE-S, has been used extensively in audiological research (e.g. [5, 9]). The HHIA-S has very high test-retest reliability [7].

The HHIA-S consists of ten items. Each item covers a different situation where a hearing problem might cause difficulties or embarrassment. Two examples of items are 'Does a hearing problem cause you to feel embarrassed when you meet new people?' and 'Do you have difficulty hearing or understanding co-workers, clients, or customers?' There are three possible answers to each item, 'yes' (scored as 4), 'sometimes' (2) and 'no' (0). The total score is computed by adding the ten individual scores.

2. DESIGN

The main aim of the study was to test whether the HHIA-S could be used to screen participants in speech perception experiments for potential hearing impairments. We assessed its suitability using data from older people, because older adults are far more likely to have a hearing impairment than the young people typically recruited through the traditional student population. We used the HHIA-S instead of the HHIE-S with this age group because the HHIE-S contains a culture-specific item regarding church attendance that might not apply to a large part of our UK-based older sample.

We then examined the effect of different cut-off values in practice using two additional data sets, *Validation 1* and *Validation 2*. With *Validation 1*, we tested whether the cut-off values determined on the older sample were able to replicate the results of a stratified hearing screen, and on *Validation 2*, we assessed how many participants would be excluded by different cut-offs.

3. METHOD

3.1. Establishing cut-offs

The data used for establishing cut-offs for the HHIA-S were collected from 51 older participants who completed the HHIA-S (61% female, mean age 65, SD 10, range 50–84). As part of a more comprehensive assessment, a trained audiologist took a full history and administered pure-tone audiometry to each ear. Participants who had been fitted with a hearing aid were tested without it. All participants were native speakers of English.

Participants were considered to have passed a screen at 20 dB if their pure-tone thresholds for each of these four frequencies were 20 dB (HL) or better in both ears. If their pure-tone thresholds were 25 dB (HL) or better in both ears, they were considered to have passed at 25 dB. The 20 dB threshold follows BSA guidelines [3], while the 25 dB threshold follows the ASHA recommendations for screening adults [1].

Results are summarized as a Receiver Operating Characteristics (ROC) curve that plots sensitivity versus 1-specificity for all possible cut-off values for the HHIA-S. Sensitivity refers to the percentage of people with hearing impairment who fail the screen, while specificity is the percentage of people without impairment who pass the screen and are thus correctly screened out. The area under the ROC curve summarizes to what extent the HHIA-S can distinguish people with hearing impairment from non-impaired people—the larger the area, the more stable and robust the screen.

3.2. Validation 1: HHIA-S, with screen

24 adult participants (50% female, 22 (92%) aged 20-29, 1 younger than 20, and 1 in their thirties) completed the HHIA-S and were assessed using a stratified hearing screen. All participants were native speakers of British English. Participants were considered to have passed the screen if they were able to perceive the four pure tones 0.5, 1, 2, and 4 kHz at 20 dB (HL) in both ears. We assessed whether the HHIA-S cut-off score established earlier would screen out the participants who failed this screen.

3.3. Validation 2: HHIA-S, no screen

Using data from 189 participants who had completed the HHIA-S, but no additional hearing screen, we determined how many would be excluded from analysis depending on the chosen cut-off. All participants were adult native speakers of American English, recruited through the Internet. 63% were aged 18-30, 19% were aged between 30 and 39, and 16% were aged 40-59.

4. RESULTS

4.1. Establishing cut-offs

When using the BSA threshold of 20 dB (HL), 33 of the participants in the calibration sample have a hearing impairment (65%). While 75% of all participants in their fifties pass the screen, 67% of all people in their sixties and almost all people older than 70 fail it. Using the ASHA criterion, the number of people who fail the screen falls to 28 (55%). Most of this decrease is due to three participants aged 50–59 who now pass the screen.

Table 1 shows that the median HHIA-S scores of people with hearing impairment are much higher than those of people with no impairment, regardless of classification. However, the interquartile range of scores for people with impairment is still quite high.

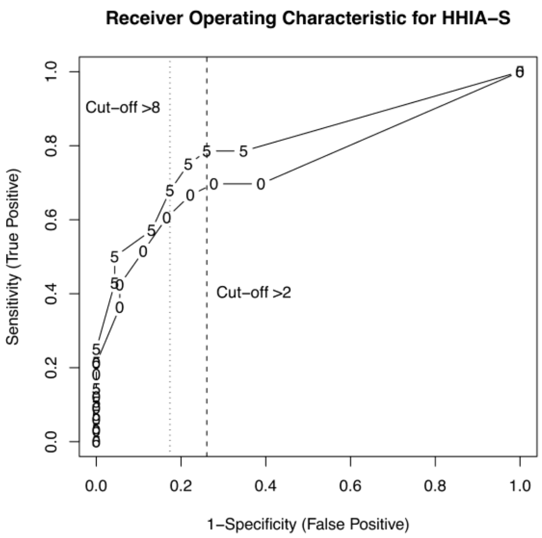
Table 1: HHIA-S scores in the calibration sample. Med. = median, Q. = Quartile.

Participant groups	Med.	1st Q.	3rd Q.
All	6.0	0.0	13.0
Threshold 20 dB (HL)			
Impaired	10.0	0.0	14.0
Not impaired	0.0	0.0	3.5
Threshold 25 dB (HL)			
Impaired	11.0	5.5	14.5
Not impaired	0.0	0.0	3.0

Figure 1 shows ROC curves for both the BSA and the ASHA thresholds. For both curves, the last data point before (1, 1) corresponds to a cut-off of > 0 (i.e., only people who score 0 pass), with thresholds increasing as we move to the left. The area under the curve is 0.74 for the 20 dB threshold, and 0.80 for 25 dB.

Judging from Figure 1, the best compromise between sensitivity and specificity appears to be a cut-off criterion of > 2, which corresponds to individuals who report (almost) no hearing problems. Applying a cut-off of > 8, as in [9], greatly decreases sensitivity.

Figure 1: Receiver Operating Characteristic for screening thresholds 20 dB ('0' line) and 25 dB ('5' line). Vertical lines indicate cut-offs of > 2 and > 8.



4.2. Validation

In the *Validation 1* data set, only two of the younger participants did not pass the screen. Both of those participants failed the screen only for their worse ear. Since their HHIA-S scores were 0 and 2, the suggested cut-off of > 2 would not have excluded them, but instead eliminated three people who passed the stratified screen.

When looking at the impact of different cut-offs on the participant pool of large web experiments (*Validation 2*), we found that our suggested threshold, > 2, excluded data from 23% of all participants. Using the threshold recommended for hearing handicap screening [1], > 8, reduces this percentage to 13%.

The impact of the strict cut-off varies by age. While a cut-off of > 2 would exclude 28% of participants in their thirties and 24% of people aged below 30, the rate drops steeply to 10% for people aged between 40 and 59.

5. DISCUSSION

While the HHIA-S can be used to distinguish between people with and without a hearing impairment, strict cut-off values are needed to ensure that as few people with a hearing impairment as possible remain in the participant pool. The cut-off of > 2 suggested by our data is considerably lower than the value suggested by ASHA when screening for significant self-reported hearing handicap (> 8). Unfortunately, using such a strict cut-off means that around 20% of the participant pool may need to be excluded from analysis.

The sensitivity and specificity we found for the HHIA-S are roughly in the range reported by Sindhusake, et al. [9] for the HHIE-S. They found a sensitivity of 58%, and specificity of 85% for mild hearing loss when using a cut-off of > 8, which is equivalent to our 25 dB screen. The corresponding area under the ROC curve is 0.79, which is similar to our results. Sensitivity and specificity were considerably better for moderate and severe hearing loss than for mild hearing loss.

A potential problem with our study is that the cut-offs were established on an older population. When comparing scores on the HHIA/HHIE (the full version of the HHIA-S and HHIE-S, respectively) for younger and older participants with and without hearing impairments, Gordon-Salant, *et al.* [4] found that younger participants with an impairment tended to have higher scores than older people with impaired hearing. They suggest that younger people may be more keenly aware of any issues with their hearing. If a similar result could be established for the screening version of the HHIA, then the appropriate cut-off value might need to be varied by age.

This highlights a fundamental problem with measures such as the HHIA-S—they reflect the perceived effect of hearing problems on people's lives, not the actual impairment, which is defined as the physiological reduction in function. An impairment is only perceived as a problem if people feel that it restricts what they can hear, and it is only perceived as a handicap if it limits what people can do [1].

A simple alternative to the HHIA-S might be a single well-phrased question that asks people whether they feel they have hearing problems. For example, Hidalgo, et al. [5] report a very low sensitivity for the HHIE-S of 23%. A carefully worded multiple-choice question substantially outperformed the HHIE-S with a sensitivity of 62% and a specificity of 82%. This is similar to the values we found for a HHIA-S cut-off of > 0. Sindhusake, et al. [9] also found a single question to be a very effective screen for perceived hearing handicap.

While we do not have data on a single self-report question for our calibration sample, 61% of all 51 participants reported hearing difficulties in at least one ear during the audiological history. Table 2 shows that the sensitivity and specificity of this information as an indicator for hearing impairment is comparable to the HHIA-S with a strict cut-off. It remains to be seen whether a single self-report question, administered in a questionnaire, not through interview, would perform as well in a younger sample.

Table 2: Sensitivity and specificity of information on hearing difficulty.

	Threshold	
Participant groups	**20 dB (HL)**	**25 dB (HL)**
Difficulty hearing		
Sensitivity	73%	82%
Specificity	61%	65%
HHIA-S, cut-off > 2		
Sensitivity	70%	79%
Specificity	72%	74%

Another alternative might be a short standardized listening test that has been optimized for screening, such as the digit triplets test [10], which was developed for administration over the telephone. In this well-validated test, several series of three digits are presented in background noise with while systematically varying signal-to-noise (SNR) ratios. While this well-validated test is available online for self-testing, the present version can only be used in a laboratory setting, where the experimenter notes down the result obtained by the participant.

6. CONCLUSION

When screening participants for inclusion in perception experiments, the best option might be to ask participants a brief, standardized question about their hearing during recruitment. This recommendation is supported both by the literature and the HHIA-S cut-offs yielded by the analysis of our calibration sample. The suggested cut-off value of > 2 essentially reduces to no self-reported hearing problems.

Further research should investigate the effect of the wording used for this single question on the accuracy of self-reporting. The phrasing of single questions varies substantially from study to study [5, 9]. Existing questions are often clearly targeted at older people and ask about ‘hearing loss’ or ‘hearing handicap’. Younger people might not feel that these terms apply to them and instead be more likely to admit to ‘difficulty hearing’.

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