9-15-2023

# Development and initial evaluation of the Hearing Aid Attribute and Feature Importance Evaluation (HAFIE) questionnaire

Hasan Saleh
*Western University*, hsaleh3@uwo.ca

Paula Folkeard
*Western University*, pfolkea@uwo.ca

Selina Liao
*Western University*, sliao33@uwo.ca

Susan Scollie
*Western University*, scollie@nca.uwo.ca



Citation of this paper:
Hasan. K. Saleh, Paula Folkeard, Selina Liao & Susan Scollie (15 Sep 2023): Development and initial evaluation of the Hearing Aid Attribute and Feature Importance Evaluation (HAFIE) questionnaire, International Journal of Audiology, DOI: 10.1080/14992027.2023.2253498


International Journal of Audiology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/iija20

# Development and initial evaluation of the Hearing Aid Attribute and Feature Importance Evaluation (HAFIE) questionnaire

Hasan. K. Saleh, Paula Folkeard, Selina Liao & Susan Scollie

INTERNATIONAL JOURNAL OF AUDIOLOGY
https://doi.org/10.1080/14992027.2023.2253498

ORIGINAL ARTICLE

# Development and initial evaluation of the Hearing Aid Attribute and Feature Importance Evaluation (HAFIE) questionnaire

Hasan. K. Saleh[a,b], Paula Folkeard[b], Selina Liao[c] and Susan Scollie[b,d]

[a]Health & Rehabilitation Sciences, Western University, London, Canada; [b]National Centre for Audiology, Western University, London, Canada; [c]Health Studies, Faculty of Health Sciences, Western University, London, Canada; [d]Communication Sciences and Disorders, Faculty of Health Sciences, Western University, London, Canada

**ABSTRACT**

**Objectives:** To develop and validate a novel questionnaire aimed at providing a structured, evidence-based methodology for hearing aid recommendation and selection using self-reported importance ratings for different modern hearing aid features.

**Design:** The initial questionnaire items were created through a concept mapping approach that involved input from hearing aid users. Hearing care professional focus groups ($n = 10$) were conducted to assess questionnaire content and design, and to guide modifications. Validation of this initial 34-item version of the questionnaire was conducted using an anonymous online survey tool (Qualtrics). Exploratory factor analysis was used to assess the factor structure of the dataset, using principal axis factoring. Questionnaire reliability and inter-item correlation were assessed. Items with low factor loading and high cross-loading were removed.

**Study sample:** Two hundred and eighteen adult participants with a self-reported hearing loss (median age = 48 years, range = 18–95 years) completed the questionnaire.

**Results:** Analysis and item removal resulted in a 28-item questionnaire. Three factors were identified, dividing the hearing aid features into the subscales: “Advanced connectivity & streaming”, “Physical attributes & usability”, and “Sound quality & intelligibility”.

**Conclusion:** This study has resulted in a patient-oriented questionnaire that allows clinicians to gather patient input in a structured manner.

**ARTICLE HISTORY**
Received 11 February 2023
Revised 22 August 2023
Accepted 24 August 2023

**KEYWORDS**
Hearing aids; hearing aid selection; HAFIE; hearing aid technology; patient-oriented care

## Introduction

### Hearing aid selection

Hearing aid development has led to the evolution of a hearing aid from a simple amplification instrument to a complex device with product features including adaptive signal processing, connectivity (both between the hearing aids and to other devices via Bluetooth), and accessory compatibility. These differ in complexity between hearing aids at the upper and lower levels of the technology spectrum (Lansbergen and Dreschler 2020). Digital signal processing (DSP) features can differ between basic and advanced hearing aids: advanced aids are more likely to offer more complex directional microphone (DM), noise reduction (NR), and compression technologies, with environmental adaptation and a higher number of channels (Cox, Johnson, and Xu 2016; Lansbergen and Dreschler 2020; Wu et al., 2019). Product characteristics are not solely limited to DSP technology but also include non-DSP attributes such as device form factor (such as the behind-the-ear, receiver-in-canal, or in-the-canal forms), accessories, and smartphone compatibility (Saleh et al. 2022). Non-DSP product attributes have been shown to influence user preference, with previous literature showing that both DSP and non-DSP attributes may contribute to hearing aid user satisfaction (Meister et al. 2001; Picou 2020; Zhu et al., 2020), but also influence hearing aid cost.

This increase in hearing aid complexity may impact the hearing aid selection process. Hearing aid selection is the process of choosing and fitting an appropriate hearing aid to an individual, and is an important aspect of clinical practice (Audiology Practice Standards Organization 2021; Carhart 1950; Valente et al., 2006). In modern practice, the hearing aid selection process requires consideration of the increased complexity of hearing aid features and how they will interact with the hearing aid user's experience and abilities, in addition to the ability of the prospective hearing aid to provide an appropriate frequency response using a validated prescriptive formula (e.g. Keidser et al. 2011; Scollie et al. 2005). Having access to advanced attributes and features has been shown to influence user preference for hearing aid technology level (Saleh et al. 2022). This is in spite of recent findings reporting that higher levels of hearing aid technology do not significantly improve self-perceived auditory performance (Lansbergen, Versfeld, and Dreschler 2023). A previous study (Gioia et al. 2015) found that hearing aid professionals' technology level recommendations are influenced by patient speech perception scores (and thus, expected benefit). However, they found that recommendations were most influenced by clinician perception of the patient's lifestyle and activity levels. For this reason, systematic approaches to hearing aid selection are recommended (Audiology Practice Standards Organization 2021) but there is a scarcity of validated, patient-oriented hearing aid selection tools. Questionnaires may aid in

**CONTACT** Hasan. K. Saleh hsaleh3@uwo.ca Western University, London, Canada

the assessment of hearing aid candidacy and outcomes, which may in turn help to inform the selection of hearing aid features and characteristics.

### Questionnaire use in hearing candidacy and outcomes assessment

Questionnaires have been developed to assess patients by measuring a wide range of hearing aid constructs, such as expectations, subjective experiences, and benefit. Questionnaires can be used at different points of the patient journey (diagnosis, selection/candidacy, pre-fitting, or post-fitting). Many hearing aid questionnaires exist to measure hearing aid benefit, performance, and satisfaction. These include the Glasgow Hearing Aid Benefit Profile (GHABP, Gatehouse 1999), the Satisfaction with Amplification in Daily Life scale (SADL, Cox and Alexander 1999), the Client-Oriented Scale of Improvement (COSI, Dillon, Jamest, and Ginis 1997) the Hearing Aid Performance Questionnaire (HAPQ, Gatehouse, Naylor, and Elberling 2006), the International Outcome Inventory for Hearing Aids (IOI-HA, Cox and Alexander 2002), and the Abbreviated Profile of Hearing Aid Benefit (APHAB, Cox 1997). These hearing aid questionnaires (and others), however, are focused on aspects of the hearing aid experience outside of hearing aid selection, such as user satisfaction or benefit from hearing aids. These may indirectly inform hearing aid selection by providing some information on the patient's lifestyle or listening priorities (such as the COSI and GHABP). However, they have not been purpose-developed as selection tools.

There is a lack of evidence-based methodology in hearing aid selection. However, there exists an abundance of modern features, and challenges caused by the ambiguity of the features contained by each brand (and the differences between them). This highlights the necessity for a tool to assist professionals and patients in selecting appropriate hearing aids in a patient-centered, non-proprietary manner. A patient-centered approach has been shown to play an important role in healthcare, reducing post-treatment regret and improving patient satisfaction (Mulley, Trimble, and Elwyn 2012) and, in a hearing healthcare context, has been shown to improve hearing aid uptake rates (Poost-Foroosh et al. 2011).

There are questionnaires designed specifically to address hearing aid selection: The Hearing Aid Selection Profile (HASP; Jacobson et al. 2001) and the Characteristics of Amplification Tool (COAT; Sandridge and Newman 2006). Both include ratings of subjective factors such as patient motivations, opinions, and attitudes regarding different aspects of hearing aid use including perceived communication needs, cosmetics, cost, and technological sophistication. These questionnaires are intended to elicit patient perspectives in pre-fitting candidacy and selection. However, the questions regarding technology focus more heavily on patient attitude towards technology rather than on specific hearing aid features or attributes, and therefore may have limited use in identifying specific appropriate hearing aids based on their attributes. Furthermore, the questions do not represent current hearing aid characteristics because of technology changes since the development of the questionnaires. In summary, these questionnaires may provide hearing professionals with information on overall patient attitude information to inform hearing aid selection, but may not measure patient preferences for specific, modern hearing aid characteristics that drive cost and function, which may relate to overall preference of technology level in modern hearing aids.

More recently, online hearing aid selection tools have been made available which are aimed at helping potential hearing aid users choose devices appropriate to them. One such example is the Help Me Choose tool offered by HearingTracker (https://www.hearingtracker.com/hearing-aids/personalized-match-survey), which addresses some of the issues found in using the HASP and COAT by including modern, specific examples of technologies in its assessment of what the respondent finds important to have in their hearing aid. It has also proved to be a valuable research tool, allowing collection of information regarding hearing aid user preferences and attitudes. The large number of respondents has allowed studies of user preferences, behavioural trends, and expressed opinions (Heselton et al. 2022; Manchaiah et al. 2020; Manchaiah et al. 2021a; Manchaiah et al. 2021b).

To the author's knowledge, however, of these tools, only the developers of the HASP have published the process of item development and questionnaire evaluation. Therefore, the aim of the current study was to develop a feature and attribute-driven preference assessment tool, following well-established test construction methodologies.

### Current study

In this study, a novel questionnaire called the Hearing Aid Attribute and Feature Importance Evaluation (HAFIE) was developed. The aim of this self-administered questionnaire was to gather patient attitude and self-reported importance ratings for specific modern hearing aid features/attributes that are currently available, to assist with hearing aid selection by identifying the hearing aid characteristics important to the patient. The concepts driving hearing aid preference (Saleh et al. 2022) were used as the conceptual foundation for the constructs in the HAFIE.

## Methods

### Study steps

The steps in the development of the questionnaire were as follows:

1. Construction of a first version based on a published concept map.
2. Conducting a series of focus groups and interviews with clinicians to review the clinical purpose of the questionnaire and the first version items.
3. To revise the first version based on focus group input, with the aim of developing a self-administered, online, pre-fitting questionnaire for assessing feature and attribute-specific preferences.
4. Distribution of the reviewed version using online distribution.
5. Analysis of the questionnaire results from the online distribution: item evaluation, internal factor structure, and internal consistency.
6. Revision of the questionnaire based on the analysis results.

### Initial questionnaire design

#### Item design and questionnaire format

As a framework for the initial version of the questionnaire, the thematic dimensions (clusters) identified by Saleh et al. (2022) were analysed and used as thematic subscales. Statements within these clusters, and the features/attributes which they represent, were reworded to produce a list of questions within each of these subscales. Duplicates and statements referring to the same hearing aid characteristics were excluded.

It is important to acknowledge that the findings of Saleh et al. (2022) were derived from a study involving one pair of premium hearing aids and one pair of entry-level hearing aids. Both hearing aid models belonged were commercially available at the time of the study and belonged to the same brand and product family, with the premium model released in 2019 and the entry-level model in 2014. As such, this study should be regarded as a starting point framework to be built upon and cannot be presumed to encompass all available hearing aid characteristics. Indeed, some current hearing aid attributes and features were not present in the hearing aids used in the preference study and were thus not identified in the resulting concept map (such as the step-counter, fall detection, power bank charger). For the questionnaire to have a comprehensive list of features/characteristics within each subscale, an environmental scan of currently available hearing aid attributes and features was conducted by assessing contemporary hearing aid datasheets and recent hearing aid research. Questions based on these (i.e. step counting, fall detection) were added to the questionnaire item pool.

The questionnaire items were worded to ensure a similar format, clarity, and suitability for a Likert scale, according to the suggestions by Dillman, Smyth, and Christian (2014). Each question contained the prompt "How important is this to you if deciding on a new hearing aid to use?", with a 5-point unipolar Likert scale including the responses "Not important at all", "Slightly important", "Moderately important", "Very important", and "Extremely important". The use of a 5-point scale and the decision to allow a neutral response is debated (Garland 1991). However, Krosnick and Presser (2009) recommend 5 to 7-point scales over 3-point scales to produce reliable results.

A subsection for the collection of demographic information was included at the start of the questionnaire. This allowed the analysis of demographic variables including respondent age, and hearing aid experience.

The order of items in a questionnaire is an important factor to consider (Simon et al., 2003). We grouped the questions into their subscales, based on underlying meaning (e.g. items related to comfort in the same section), according to the suggestion by Wilson & McClean (1994). Walker (1996) suggests placing more sensitive items in the middle of the questionnaire to increase compliance; however, due to the non-sensitive nature of this questionnaire's items, the subscales, and items within them were placed in a random order.

### *Focus group(s) and focused interviews*

The aim of this stage of the study was to assess clinician attitudes about the need for a pre-fitting hearing aid selection questionnaire, and to gather suggestions about what should be included in such a questionnaire. The focus groups were conducted virtually, with two researchers present as moderators. Recommended focus group best practices were followed (Krueger and Casey, 2002), with a semi-structured group interview style, where all participants were given the opportunity to share their opinions by opening the focus group with inclusive ground rules, and using follow-up prompts throughout the session to elicit a wide range of responses. Recruitment was conducted via email and word of mouth.

Interview questions related to questionnaire use in practice, ("In your experience, what are your thoughts on pre-fitting questionnaires or questionnaires in general in practical clinical use?"), the feasibility of a hearing aid selection questionnaire, a desirable length/number of questions, ("What length of time would you say is reasonable for a clinical questionnaire?"), and what hearing aid technologies and attributes should be included. Focus group participants were also shown the first version of the questionnaire containing a list of possible questions for their review. Items suggested by the hearing care professionals were considered for addition. All sessions were recorded and transcribed. The focus group study was approved by Western University's Research Ethics Board (project # 119016).

## *Questionnaire evaluation: factor structure, validity, and reliability*

### *Sampling*

The questionnaire was distributed in an online administration tool (Qualtrics). Participant inclusion criteria included individuals aged above 18 years with a self-reported hearing loss. Participation was anonymous, and participants were allowed to skip any questions after consenting to take part in the survey. Participant recruitment for the validation of this questionnaire was primarily conducted via internet recruitment, including social media (LinkedIn, Twitter, and Facebook) and by posting invitations to online hearing aid user forums. Recruitment emails were also sent to hearing care professionals within the researchers' professional network to circulate to patients and colleagues, and through word of mouth. This study was approved by Western University's Research Ethics Board (project #119444).

### *Sample size estimation*

The target sample size in this study was to recruit the greater of 200 participants or a 5:1 participant to item ratio (corresponding to 170 participants in this questionnaire), a conservative cut-off recommended by Howard (2016), with follow-up assessment of data quality following published guidelines (Costello and Osborne 2005; Hinkin 1998; Howard 2016).

### *Factor structure evaluation*

Exploratory factor analysis (EFA) is a technique used to identify the factor structure of data, and is often used to determine questionnaire subscales (Howard 2016; Singh et al., 2019). In this study, the Principal Axis Factoring method (PAF) was used as the underlying method for the EFA (Costello and Osborne 2005). Prior to exploratory factor analysis (EFA), the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser 1970) and Bartlett's Test of Sphericity (Bartlett 1950) were conducted to assess data quality. The Bartlett's test of sphericity was significant ($\chi^2$ (561) = 3412.15, p<.001). The result of the KMO Measure of Sampling Adequacy was 0.87, a satisfactory value and well above the suggested 0.60 minimum before performing an EFA (Dziuban and Shirkey 1974; Kaiser 1970). These results support continuing with EFA by suggesting that key EFA assumptions had not been violated (Dziuban and Shirkey 1974; Howard 2016). All statistical analyses were conducted using the SPSS version 28 software.

## Analysis

### Data cleaning & missing data replacement

Typically, some items in a questionnaire will be skipped by participants, resulting in missing data., which may reduce the statistical power of the data and introduces bias. (Nakagawa and Freckleton 2008). Therefore, we addressed the missing responses before conducting factor analysis. Prior to this, the nature of the missing data was classified as missing completely at random (MCAR), missing at random (MAR) or missing not at random (MNAR) (Dray and Josse 2015; Graham 2009; Schafer & Graham, 2002) using Little's test (Little 1988), with follow-up planning to replace data using recommended methods if missingness was not MCAR (Downey and King 1998; Nakagawa and Freckleton 2008; Parent 2013).

### Factor analysis

A direct Oblimin oblique rotation (delta of zero) was used, allowing correlations between the rotated factors (Costello and Osborne 2005). This was selected as the appropriate rotation method for the questionnaire data, as preference factors for hearing aid characteristics were expected to be multidimensional (Manchaiah et al. 2021a; Saleh et al. 2022; Zhu et al., 2020) and likely to have some correlation.

The cluster solution was chosen using scree plot analysis and Velicer's Minimum Average Partial (MAP) test. Furthermore, inspection of the different factor solutions was conducted. The items within the factors and factor loadings in the resulting factor solutions were assessed to determine the appropriateness of item groupings and the clinical interpretability and relevance of the resulting subscales.

### Item retention & removal

To identify the items that do not represent any distinct factors well, thereby warranting review, the factor loadings of each item were assessed. Methods for retention criteria vary (Howard 2016), and the criteria used for item retention were: (1) a primary factor loading of 0.45 (Tabachnick and Fidell 2019); (2) no secondary factor loadings above 0.3 (Howard 2016); and (3) a minimum difference of 0.2 between primary and secondary factor loadings (Hinkin 1998). Items that met these criteria were retained, and items that did not meet these criteria were reviewed further to consider their removal (Costello and Osborne 2005).

### Internal reliability & consistency

Assessment of internal reliability of the questionnaire was conducted via inter-item correlation. According to Clark and Watson (1995), inter-item correlation between 0.15 and 0.50 is recommended, with anything above 0.50 indicating possibly redundant items.

Internal consistency was assessed by measuring Cronbach's alpha (Cronbach 1951). To identify items suitable for removal, the Cronbach's alpha following sequential item deletion in each factor was assessed ("Alpha if item deleted"; Gliem and Gliem 2003). Any items which improved alpha once removed were likely suitable for removal from the questionnaire and were subjected to review.

### Within-group analysis

The analysis of differences between various groups within the participant pool were conducted using independent t-tests, with the p-values adjusted using the False Discovery Rate (FDR) (Benjamini and Hochberg 1995). FDR corrections were selected to mitigate the risk of type II (false negative) errors (Matsunaga 2007), particularly relevant in exploratory analyses with potentially small effect strengths.

## Results

### Focus groups focused interviews

Ten experienced hearing care professionals (mean of 38.6 years old, range: 26 -53 y; 1 male, 9 females; clinical experience: mean of 16.7 years, range: 1 – 27 years) who were currently practicing primarily in adult hearing care were recruited via email recruitment and word of mouth. Three focus groups and one focused interview were conducted, with the sessions involving four, three, two, and one participant(s), respectively. These sessions were scheduled as such to accommodate participant availability.

Overall clinician feedback during the focus groups was overwhelmingly positive. The focus group participants clinicians supported the usefulness of a modern hearing aid questionnaire in practice, as this can "assist them in keeping track of what features to offer" and "allows the patient to understand what features are available. They also stated that this questionnaire can provide evidence of justification regarding the hearing aid suggestions made to the patient. Furthermore, it was suggested that having a pre-fitting questionnaire also may allow patients to consider their options, set realistic expectations, and involve their support system in the selection process.

The time required to complete the questionnaire was a commonly mentioned barrier by the focus group participants. Both in clinical and self-administration, a shorter questionnaire is necessary due to already limited appointment time and increased patient burden. Furthermore, there was a strong consensus to prioritise the use of simple language in the questionnaire. Many items were recommended to be rephrased to enhance clarity and ensure ease of understanding for patients. Clinicians suggested having online and paper versions of the questionnaire to facilitate its use for different participant demographics as well as in different clinical settings.

In addition to formatting suggestions, certain attributes and features common to modern premium hearing aids, such as having a step counter, were also recommended for addition to the questionnaire (and were thus added). Additionally, certain items were suggested for elimination, particularly those associated with feedback management, given the widespread nature of this requirement.

The opinions gathered in the focus group were used to modify the initial draft version of the questionnaire. New questions regarding features, such as the inclusion of a step counter, were added, while questions related to feedback and the weight of the hearing aid were removed.

This resulted in a questionnaire draft consisting of 34 items prior to distribution to individuals with hearing loss for evaluation.

### Questionnaire evaluation participants

A total of 345 individuals accessed and initiated the online questionnaire and agreed to the anonymous consent form. Due to the nature of the online questionnaire, any individual could open it to inspect the questionnaire, and this would be counted as a response. Therefore, this number of 345 included both those not self-reporting a hearing loss (not the target demographic) or those with no questions completed. We therefore removed the responses with no self-reported hearing loss ($N = 57$) or those with the questionnaire accessed but none of the 34 items in the questionnaire completed ($N = 114$). This resulted in 218 responses that were deemed appropriate for further analysis.

The 218 respondents included 114 females, 96 males, 3 non-binary, and 5 who did not complete the question regarding gender. Ages ranged from 18 to 93 years, with a median of 48 years and a standard deviation of 19.58 years. All participants self-reported a hearing difficulty. Of these, 84 participants reported currently using hearing aids, while 133 did not, and 1 did not respond. When asked about smartphone usage, 207 participants reported using a smartphone, 8 did not, and 3 did not respond. Participants took an average of 8.1 minutes to complete the survey.

### *Data cleaning & missing data replacement*

Of the 7,412 items presented, 34 items to each of the 218 responses, 2.80% of respondents, 7,202 questions (98.20%) were completed, while only 210 questions (2.80%) received no response, which indicates a high completion rate. Item non-completion rates ranged from 0.92% to 6.42% (median 2.29%) on the most to least responded-to questions, respectively. Of the respondents, 37 did not respond to at least one question, and 181 completed the entire questionnaire.

Little's test of MCAR was not significant ($\chi2$ (888) = 955.56, $p > 0.05$), indicating that the missing data could be classified as MCAR. Therefore, the missing item values were replaced by the mean of that item across all respondents. For our dataset, mean substitution was found to produce nearly identical factor analysis results (discussed below) when compared to more complex missingness replacement methods, such as multiple imputation (MI).(Royston 2004). This is likely due to the very low rate of missingness across the items (Parent 2013) and the MCAR nature of the missing data.

### *Factor analysis*

Analysis of the scree plot and the Velicer's Minimum Average Partial (MAP) tests gave conflicting suggestions for the number of factors to be retained (3 and 4, respectively).

Upon inspection, the three-factor solution was selected as being the most interpretable, as the fourth factor in the four-factor solution loaded too few items and had no clear clinical interpretability and relevance.

This resulted in Factors 1 (Advanced connectivity & streaming), 2 (Physical attributes and usability), and 3 (Sound quality & intelligibility), which accounted for 29.5%, 9.3% and 7.5% of the variance, respectively, totalling 46.3%. The correlation between Factors 1 & 2, Factors 1 & 3, and Factors 2 & 3 were 0.39, 0.27, and 0.03, respectively.

### *Item retention & removal*

Some items failed to meet the factor-loading item retention criteria listed in the 'Methods' section and were assessed for removal, as follows.

Three statements ("The app allows me to contact the hearing professional directly."), ("The hearing aid settings can be changed remotely by my audiologist without needing to visit the clinic physically."), and ("The hearing aid can count the number of steps that I take throughout the day") did not have a minimum difference of 0.2 between primary and secondary factor loadings. However, the statements ("The hearing aid settings can be changed remotely by my audiologist without needing to visit the clinic physically.") and ("The hearing aid can count the number of steps that I take throughout the day") represent features that are relatively newly available in hearing aids, and which should be included in a questionnaire focused on current available attributes & features. This is supported by positive feedback during the focus group; inclusion of the remote fittings item was expressed, and a step-counter item was suggested by multiple participants. The difference between primary and secondary factor loadings, despite not meeting the 0.2 criteria, was close at 0.18 and 0.16 respectively. Furthermore, exemplifying the variability in item removal guidelines, these items would not be removed based on other alternative factor loading cut-off recommendations (less than 0.32; Costello and Osborne 2005). Therefore, these items were retained in the final questionnaire.

One item ("The hearing aids are linked so program or volume changes only need to be made on one hearing aid for both sides to change.") did not load on any factors and was thus removed.

This was also the case with the three items ("having this style of hearing aid") for ITE, RIC, and BTE hearing aids. However, removing three of the items related to form factor choices while retaining the last would not result in a clinical tool that can comprehensively assess patient preference for form factor. Furthermore, introspection revealed the underlying reason for lack of loading of these items: splitting the form factor inquiry between four items caused a situation not seen in other items in the questionnaire; the form factor items were mutually exclusive. That is, if the user preferred only one form factor, this caused a relation between the variance patterns across these four items. Therefore, all four form factor items were removed and replaced with a merged item containing all form factor choices with a non-Likert, ranking based, qualitative preference rating. This modified question was included in the revised questionnaire version (i.e. "rank these different hearing aid types based on your preference").

The extracted communalities of the 28 items ranged from 0.003 to 0.632, with a median of 0.452 and a standard deviation of 0.14. The only items differing more than two standard deviations from the median were three of the four form factor items, with communalities of 0.117, 0.003, and 0.022, further supporting their removal.

In total, six items were removed: Four statements related to form factor, as well as ("The app allows me to contact the hearing professional directly."), and ("The hearing aids are linked so program or volume changes only need to be made on one hearing aid for both sides to change."). This resulted in a final questionnaire of 28 items in three subscales (Table 1).

### *Internal reliability & consistency*

The HAFIE was found to have average inter-item correlation coefficients of 0.43, 0.40, and 0.48 for factors one, two, and three, respectively. Upon inspection of factor three, the item ("the hearing aid sound quality sounds natural") had a higher than intended inter-item correlation (>0.60). The ambiguity in the wording of this item may have contributed to this higher correlation, specifically the similarity to other items in factor three

**Table 1.** Questionnaire items in the Hearing Aid Feature Importance Evaluation subscales, and factor loading values.

| Item | Factor Loading |
|---|---|
| **Factor 1:** Advanced connectivity & streaming (α = 0.897) | |
| 1. The hearing aid can connect to my smartphone or tablet through a specialised phone/tablet application. | 0.691 |
| 2. The app which connects my phone to my hearing aid is clear and easy to use. | 0.639 |
| 3. Using my smartphone, I can make the hearing aid focus on speech from a certain direction (e.g. to my side if someone is sitting beside me). | 0.617 |
| 4. Using my smartphone, I can adjust the hearing aids volume and sound clarity through my phone. | 0.712 |
| 5. The hearing aid has a special program to use when I am outside (e.g. for natural wind sounds). | 0.532 |
| 6. The hearing aid has a special program to use when I am listening to live music. | 0.628 |
| 7. The hearing aid has a wide choice of programs which are specialised for different surrounding sounds. | 0.610 |
| 8. The hearing aid can connect to a remote microphone which sends sounds directly to your hearing aid. This makes it easier to hear people at a distance or in a noisy place. | 0.670 |
| 9. The hearing aid settings can be changed remotely by my audiologist without needing to visit the clinic physically. | 0.506 |
| 10. My hearing aid can connect to a TV streaming device that sends my TV sound directly into my hearing aid. | 0.730 |
| 11. The hearing aid can connect wirelessly to a remote control which allows you to change hearing aid volume. | 0.673 |
| 12. The hearing aid allows me to stream phone calls directly into my ear, including in the car. | 0.632 |
| 13. The hearing aid allows direct music streaming from my phone into my ears. | 0.634 |
| 14. The hearing aid can count the number of steps that I take throughout the day. | 0.481 |
| **Factor 2:** Physical attributes & usability (α = 0.848) | |
| 15. The hearing aid does not have many accessories to use and maintain. | 0.551 |
| 16. The hearing aid's volume and program buttons are easy to find and use. | 0.496 |
| 17. The hearing aid is comfortable to wear with eyeglasses. | 0.521 |
| 18. The hearing aid is easy to put into my ear. | 0.683 |
| 19. The hearing aid looks good aesthetically. | 0.646 |
| 20. The hearing aid is small in size and width. | 0.771 |
| 21. The hearing aid is rechargeable. | 0.541 |
| 22. Having a power bank to charge a rechargeable hearing aid. | 0.532 |
| 23. If using batteries, having a small sized battery. | 0.588 |
| **Factor 3:** Sound quality & intelligibility (α = 0.815) | |
| 24. The hearing aid makes my own voice sound natural. | 0.510 |
| 25. The hearing aid has a feature to reduce the noise from wind. | 0.584 |
| 26. The hearing aid can reduce background noise. | 0.644 |
| 27. The hearing aid makes external sounds have a natural sound quality | 0.738 |
| 28. The hearing aid makes speech sound clear and of high quality. | 0.648 |

such as ("the hearing aid makes my own voice sound natural"). To alleviate this issue without removing the item, the item was reworded to ("the hearing aid makes external sounds have a natural sound quality").

For factors 1–3, Cronbach's alpha was 0.90, 0.85, and 0.815, respectively. This is within the acceptable range of values, indicating high internal consistency between the items in each factor scale (Tavakol & Dennick, 2011). It was found that the Cronbach's alpha of each factor only decreased if any items were removed ('Alpha if deleted'), ruling out the need for any further item removal. The overall Cronbach's alpha for the 28-items was 0.92.

### *Within-group analysis*

It was found that Factor 2 (Physical attributes and usability) was the only factor that differed significantly in importance scores ($t(215) = 2.519$, $p = 0.01$) between participants who had hearing aid experience and those who did not, with participants without hearing aid experience scoring more highly on this factor.

## Discussion

Patient-oriented hearing aid selection requires consideration of patient preference for a complex set of attributes and features that span hearing aid DSP, form factor, accessories, and connectivity. Although patient involvement in the decision-making process is considered preferred practice (Bratzke et al. 2015; Brennan and Strombom 1998), few tools have been available to support the assessment of patient preference at the selection stage. One complicated factor in the development and sustained use of such tools is the evolution of new hearing aid features over time, which may contribute to well-developed tools becoming outdated.

This study aimed to develop a questionnaire designed to assess hearing aid attribute-specific preference from potential hearing aid users at the selection stage. The initial theoretical framework for this questionnaire was based on an end-user concept map of attributes and features that influence choice for one hearing aid over another, that was based on relatively current technology (Saleh et al. 2022), along with consideration of current evidence on features across brands (Lansbergen and

Dreschler 2020). This tool is called the Hearing Aid Attribute and Feature Importance Evaluation (HAFIE),) and was implemented as a self-directed questionnaire.

The theoretical framework for this questionnaire was derived from a concept mapping study involving one pair of premium hearing aids and one pair of entry-level hearing aids from the same product family and released in 2019 and 2014, respectively (Saleh et al. 2022). Therefore, the initial items derived from the concept mapping study did not encompass all available hearing aid characteristics. To address this, a comprehensive analysis of the market and relevant literature was also conducted to add relevant modern attributes and features to the questionnaire.

To follow an integrated knowledge approach to the development of this questionnaire, a series of hearing care professional focus groups were conducted prior to developing the initial draft of the HAFIE. Overall feedback was overwhelmingly positive during the focus groups, with support for the practical usefulness of a modern hearing aid questionnaire. Clinicians highlighted the HAFIE's potential role in helping them track relevant attributes & features to offer and informing patients of the available options, and to serve as evidence to justify hearing aid suggestions. Additionally, clinicians suggested that such a questionnaire may help patients to consider options, set realistic expectations, and involve their support system in the selection process. Furthermore, they made formatting and design recommendations, such as keeping it as short as possible (less than 10 minutes), as well as item inclusion/exclusion suggestions. These were considered and implemented in the initial draft of the questionnaire prior to distribution and validation.

Initial distribution and validation of the HAFIE was completed by 218 respondents who self- reported as having hearing loss. The questionnaire was determined to have appropriate internal reliability and internal consistency, as well as a stable internal factor structure. Furthermore, the questionnaire achieved face validity and construct validity.

Assessment of the item factor loadings in parallel with inspection of their content led to the removal of seven items, resulting in a 28-item questionnaire, called the Hearing Aid Attribute and Feature Importance Evaluation (HAFIE). The HAFIE includes three subscales (derived from the factors) which correspond well to the cluster themes identified in our prior concept mapping study: (Saleh et al. 2022): "Advanced connectivity & streaming", "Physical attributes & usability", "Sound quality & intelligibility". Specifically, statements contained within the same factor were more likely to be found in neighbouring, related clusters in the published concept map. For example, Factor 1 ('Advanced connectivity & streaming') contained items derived from statements in the clusters "app-based DSP", "streaming", and "convenience & connectivity" (Saleh et al. 2022). In the previous study, these features differentiated hearing aids at different ends of the technology spectrum and are therefore relevant to selection of hearing aids at different cost levels. Similarly, Factor 2 ('Physical attributes & usability') contained items derived from statements in the adjacent "Comfort & appearance" and "Ease of use" clusters. Factor 3 ("Sound quality & intelligibility") contained items from a single identically named cluster in the concept map.

Survey respondents who reported not having any previous hearing aid experience found Factor 2 (Physical attributes and usability) to be more important, on average. This may be due to apprehension experienced by individuals without HA experience towards the prospect of wearing an unfamiliar device on their body, thereby causing them to highlight the importance of physical comfort and aesthetics in their decision-making process.

Factors 1, 2, and 3 explain 29.5%, 9.3%, and 7.5% of the total response variance, respectively. This is clinically sensible as items related to physical comfort (factor 2) and speech intelligibility (factor 3) are unlikely to be rated as unimportant, as supported by the findings of Saleh et al. (2022). This suggests that the inclusion of subscales 2 and 3 may not be efficient. This could potentially allow the creation of an abbreviated questionnaire consisting of items solely from Factor 1, containing the 14 items encompassing high technology attributes & features, improving efficiency. Clinician feedback, however, emphasised the significance of the questionnaire in educating patients about hearing aid attributes, and the factors to consider when selecting a hearing aid (beyond technological feature availability). Although the questionnaire's primary aim is facilitating hearing aid selection, we also acknowledge its potential as an additional coaching and informational tool. Therefore, we opted to retain these factors in the current version of the HAFIE.

## *Implications for clinical practice*

Questionnaires are used to assess the attitudes and opinions of hearing aid users. While hearing aid questionnaires are widespread in use, they vary both in terms of the specific aspect of the hearing aid user experience as well as the stage in the patient journey (assessment/selection/pre- fitting/post-use) being assessed. While there is a wide range of validated questionnaires that measure hearing aid benefit, performance, and overall user satisfaction, there are few published questionnaires developed for use at the hearing aid selection stage. This stage of the patient journey is characterised as a "needs assessment" within recently-developed clinical practice guidelines (Audiology Practice Standards Organization 2021).

The Hearing Aid Selection Profile (HASP; Jacobson et al. 2001) and the Characteristics of Amplification Tool (COAT; Sandridge and Newman 2006) questionnaires were designed to fill the gap in hearing aid selection tools. However, these questionnaires were not focused on specific hearing aid feature characteristics selection, instead gathering data on user attitudes towards technology in general, as well as other factors such as cosmetics and communication needs. Moreover, these were created prior to the development of many current hearing aid technologies, which may limit their utility with today's hearing aid technological landscape.

Other available online tools, such as HearingTracker's Help Me Choose tool (https://www.hearingtracker.com/hearing-aids/personalized-match-survey), are more aligned with current product-specific attributes and features. Yet, the theoretical framework behind the items and subscales in these tools and any steps taken to validate them are unknown. However, inspection of the items in the Help Me Choose tool reveals some similarities with the items developed in this study via concept mapping and the subsequent focus group process, which may be supportive of the construct validity of both Help Me Choose and the HAFIE. This also highlights the importance of these technology-specific questions in modern hearing aid selection.

The HAFIE measures hearing aid attribute and feature importance. This may address the need for a hearing aid selection tool for clinical use, by providing a structured process of incorporating patient input into the hearing aid selection process, allowing potential hearing aid users the ability to evaluate a wide range of hearing aid attributes that vary between hearing aid models and cost levels. A key aim of the HAFIE was to address the limitations of previous hearing aid selection questionnaires, namely their utility with modern hearing aids. This was facilitated by the inclusion and emphasis on current hearing aid attributes and features, via a comprehensive analysis of the market and relevant literature. As such, the HAFIE questionnaire aims to overcome previous shortcomings and provide a more effective tool for hearing aid selection.

We, the authors, suggest a practical approach for utilising this questionnaire: Providing the questionnaire to the patient either electronically or in person, perhaps in a waiting room, before their appointment with the audiologist. The clinician has the flexibility to guide the patient to either complete the entire questionnaire or specific sections of it, depending on their clinical needs, time constraints, and what information they wish to gather from the patient. By examining the questionnaire responses, the clinician can gain a preliminary understanding of the patient's views on broad topics such as technology level (via average factor score). Additionally, item level responses assess the patient's opinion on specific features or attributes. This approach serves as an initial step for initiating a discussion about the nature and availability of features, as well as setting realistic expectations. By using the questionnaire, the patient gains a clearer understanding of the attributes and features they can inquire about and express their preferences to the clinician. Simultaneously, the clinician gains insights into which hearing aid attributes require further explanation and those that necessitate realistic expectations regarding their suitability.

The HAFIE is, in some ways, comparable to other patient-oriented questionnaires, such as the COSI (Dillon, Jamest, and Ginis 1997). However, while the COSI and the HAFIE both involve patient-led importance assessments, they focus on different aspects of the hearing aid experience and selection criteria. The COSI identifies listening situations and communication goals that the patient wants to improve, determines their priorities, and assesses any self-perceived benefit after amplification. On the other hand, the HAFIE does not gather information about listening environments or communication goals; instead, it focuses more on specific hearing aid attributes and features that the patient may desire.

## Limitations

The focus group contained a male-to-female clinician ratio of 1:9 due to recruitment outcomes, potentially introducing gender-related variations in the focus group suggestions. Although the inclusion of one male clinician's input is hoped to have mitigated this impact, it is important to note that they cannot represent all male clinicians. Examination of the male participants' suggestions revealed no evident differences from the female participants, however, to fully address the ratio's potential impact, a follow-up study with a more gender-balanced composition would be necessary.

The number of participants who did not complete the questionnaire (those with no self-reported hearing loss, those who provided no responses) nearly matched the number of adequate responses. Given that the survey invitations were sent to professional communities, we speculate that many of these were hearing healthcare professionals or other interested parties who wished to see the questionnaire. However, this is not known at this time, so this could also flag low feasibility for some users.

The sample size was adequate for performing an exploratory factor analysis aimed at identifying the factor structure of the dataset. However, to verify and validate the factor structure, confirmatory factor analysis (CFA) is recommended (Harrington 2009) as a next step. CFA should be done on a different sample than the EFA to have accurate results, so this conformation could be a future direction. Similarly, while other forms of reliability were assessed, test-retest reliability for the questionnaire was not assessed in this study and remains to be evaluated.

Although the content of the questionnaire was judged as appropriate by the overall positive feedback from the hearing care professionals during the focus group, content validity has not been formally assessed. A content validity index calculation (Martuza 1977) should be conducted on the individual items and the subscales of the final version of the questionnaire.

The HAFIE was evaluated following a classical psychometric approach, employing traditional metric models such as t-tests and exploratory factor analysis. However, some research has suggested that utilising metric techniques on ordinal data, such as Likert data, may introduce Type I and II errors and may lead to the misinterpretation of item mean orders ("inversions of effects"). This is due to the nature of ordinal data, which lacks equal steps between response categories. The use of an ordered-probit approach, be it Bayesian or frequentist, is recommended to avoid such errors (Liddell and Kruschke 2018). Furthermore, analysis of existing ordinal questionnaire data using Bayesian Item Response Theory (IRT) suggested that this modern approach reduces measurement error, affecting individual result interpretation (Leijon et al. 2021). This study employed a classical psychometric approach due to our goal of obtaining an overview of the HAFIE's characteristics, such as factor sub-structure, reliability, and consistency. Our methodology may also allow a smaller sample size, depending on the number of parameters used during IRT modelling (Jiang, Wang, and Weiss 2016). However, the limitations of our approach must be considered.

How the self-administered format is optimal, and how the clinician would incorporate the results into clinical decision-making are not known at this time. Clinicians have the choice to utilise the questionnaire in different ways, depending on their experience and clinical needs. This way, their usage of the questionnaire will suit their specific requirements and maximise the benefit they gain from it.

Lastly, an understanding of the relationship between product price and overall attribute and feature importance is currently unknown and warrants further investigation.

## Conclusions and future works

This study resulted in the Hearing Aid Attribute and Feature Importance Evaluation (HAFIE): A 28-item, patient-oriented hearing aid selection questionnaire aimed at measuring patient importance ratings for different hearing aid attributes and features. The HAFIE has 3 well-defined subscales: "Advanced connectivity & streaming", "Physical attributes & usability", and "Sound quality & intelligibility".

To ensure the HAFIE remains up-to-date and modern, biennial updates will be conducted. These updates will involve thorough market and literature scans to incorporate the latest attributes and features within the questionnaire. The content validity of the questionnaire will be measured to assess clinician attitudes towards the HAFIE. Furthermore, an effort will be made to shorten the HAFIE to allow better clinical feasibility and efficiency.

## Acknowledgements

The authors express their gratitude to all participants in the study, including the hearing care professionals who generously shared their

expertise through the focus group interviews, and the individuals who contributed by completing the questionnaire anonymously.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

The project was supported by the Ontario Research Fund RE08-072 and by Western University via the Undergraduate Student Research Internship (USRI) award.

## References


Audiology Practice Standards Organization 2021. *Hearing Aid Fitting Standard For Adult & Geriatric Patients*. APSO Current Standards. May 2. Retrieved April 14, 2022, from https://www.audiologystandards.org/standards/display.php?id=102

Bartlett, M. S. 1950. "Tests of Significance in Factor Analysis." *British Journal of Psychology* 3:77–85.

Benjamini, Y., and Y. Hochberg. 1995. "Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing." *Journal of the Royal Statistical Society: series B (Methodological)* 57 (1):289–300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x

Bratzke, L. C., R. J. Muehrer, K. A. Kehl, K. S. Lee, E. C. Ward, and K. L. Kwekkeboom. 2015. "Self-Management Priority Setting and Decision-Making in Adults with Multimorbidity: A Narrative Review of Literature." *International Journal of Nursing Studies* 52 (3):744–755. https://doi.org/10.1016/j.ijnurstu.2014.10.010

Brennan, P. F., and I. Strombom. 1998. "Improving Health Care by Understanding Patient Preferences: The Role of Computer Technology." *Journal of the American Medical Informatics Association : JAMIA* 5 (3):257–262. https://doi.org/10.1136/jamia.1998.0050257

Carhart, R. 1950. "Hearing Aid Selection By University Clinics." *The Journal of Speech Disorders* 15 (2):106–113. https://doi.org/10.1044/jshd.1502.106

Clark, L. A., and D. Watson. 1995. "Constructing validity: Basic issues in objective scale development." *Psychological Assessment* 7 (3):309–319. https://doi.org/10.1037/1040-3590.7.3.309

Costello, A. B., and J. Osborne. 2005. "Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most from your Analysis." *Practical Assessment, Research, and Evaluation*, 10 (1):7. https://doi.org/10.7275/JYJ1-4868

Cox, R. M. 1997. "Administration and Application of the APHAB." *The Hearing Journal* 50 (4):32–35. https://doi.org/10.1097/00025572-199704000-00002

Cox, R. M., and G. C. Alexander. 1999. "Measuring Satisfaction with Amplification in Daily Life: The SADL Scale." *Ear and Hearing* 20 (4):306–320. https://doi.org/10.1097/00003446-199908000-00004

Cox, R. M., and G. C. Alexander. 2002. "The International Outcome Inventory for Hearing Aids (IOI-HA): Psychometric properties of the English version: El Inventario International de Resultados para Auxiliares Auditivos (IOI-HA): propiedades psicometricas de la version en ingles." *International Journal of Audiology* 41 (1):30–35. https://doi.org/10.3109/14992020209101309

Cox, R. M., J. A. Johnson, and J. Xu. 2016. "Impact of Hearing Aid Technology on Outcomes in Daily Life I: The Patients' *Perspective*." *Ear and Hearing* 37 (4):e224–e237. https://doi.org/10.1097/AUD.0000000000000277

Cronbach, L. J. 1951. "Coefficient Alpha and the Internal Structure of Tests." *Psychometrika* 16 (3):297–334. https://doi.org/10.1007/BF02310555

Downey, R. G., and C. V. King. 1998. "Missing Data in Likert Ratings: A Comparison of Replacement Methods." *The Journal of General Psychology* 125 (2):175–191. https://doi.org/10.1080/00221309809595542

Dillon, H., A. Jamest, and J. Ginis. 1997. "Client Oriented Scale of Improvement (COSI) and Its Relationship to Several Other Measures of Benefit and Satisfaction Provided by Hearing Aids." *Journal-American Academy of Audiology* 8:27–43.

Dillman, D. A., J. D. Smyth, and L. M. Christian. 2014. *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. Hoboken, NJ: John Wiley & Sons.

Dray, S., and J. Josse. 2015. "Principal Component Analysis with Missing Values: A Comparative Survey of Methods." *Plant Ecology* 216 (5):657–667. https://doi.org/10.1007/s11258-014-0406-z

Dziuban, C. D., and E. C. Shirkey. 1974. "When is a Correlation Matrix Appropriate for Factor Analysis? Some Decision Rules." *Psychological Bulletin* 81 (6):358–361. https://doi.org/10.1037/h0036316

Garland, R. 1991. "The Mid-Point on a Rating Scale: Is it desirable." *Marketing Bulletin* 2 (1):66–70.

Gatehouse, S. 1999. "Glasgow Hearing Aid Benefit Profile: Derivation and Validation of a Client-Centered Outcome Measure for Hearing Aid Services." *Journal of the American Academy of Audiology* 10 (02):80–103. https://doi.org/10.1055/s-0042-1748460

Gatehouse, S., G. Naylor, and C. Elberling. 2006. "Linear and Nonlinear Hearing Aid Fittings – 1. Patterns of Benefit: Adaptación De Auxiliares Auditivos Lineales y no Lineales – 1. Patrones de Beneficio." *International Journal of Audiology* 45 (3):130–152. https://doi.org/10.1080/14992020500429518

Gioia, C., M. Ben-Akiva, M. Kirkegaard, O. Jørgensen, K. Jensen, and D. Schum. 2015. "Case Factors Affecting Hearing Aid Recommendations by Hearing Care Professionals." *Journal of the American Academy of Audiology* 26 (3):229–246. https://doi.org/10.3766/jaaa.26.3.4

Gliem, J. A., and R. R. Gliem. 2003. "Calculating, Interpreting, and Reporting Cronbach's Alpha Reliability Coefficient for Likert-Type Scales." Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education. Columbus, OH: Ohio State University.

Graham, J. W. 2009. "Missing Data Analysis: Making It Work in the Real World." *Annual Review of Psychology* 60 (1):549–576. https://doi.org/10.1146/annurev.psych.58.110405.085530

Harrington, D. 2009. *Confirmatory Factor Analysis*. USA: Oxford University Press.

Heselton, T., R. J. Bennett, V. Manchaiah, and D. W. Swanepoel. 2022. "Online Reviews of Hearing Aid Acquisition and Use: A Qualitative Thematic Analysis." *American Journal of Audiology* 31 (2):284–298. https://doi.org/10.1044/2021_AJA-21-00172

Hinkin, T. R. 1998. "A Brief Tutorial on the Development of Measures for Use in Survey Questionnaires." *Organizational Research Methods* 1 (1):104–121. https://doi.org/10.1177/109442819800100106

Howard, M. C. 2016. "A Review of Exploratory Factor Analysis Decisions and Overview of Current Practices: What We Are Doing and How Can We Improve?" *International Journal of Human-Computer Interaction* 32 (1):51–62. https://doi.org/10.1080/10447318.2015.1087664

Jacobson, G. P., C. W. Newman, D. A. Fabry, and S. A. Sandridge. 2001. "Development of the Three-Clinic Hearing Aid Selection Profile (HASP)." *Journal of the American Academy of Audiology* 12 (03):128–141. https://doi.org/10.1055/s-0042-1745589

Jiang, S., C. Wang, and D. J. Weiss. 2016. "Sample Size Requirements for Estimation of Item Parameters in the Multidimensional Graded Response Model." *Frontiers in Psychology* 7:109. https://doi.org/10.3389/fpsyg.2016.00109

Kaiser, H. F. 1970. "A Second Generation Little Jiffy." *Psychometrika* 35 (4):401–415. https://doi.org/10.1007/BF02291817

Keidser, G., H. R. Dillon, M. Flax, T. Ching, and S. Brewer. 2011. "The NAL-NL2 Prescription Procedure." *Audiology Research* 1 (1):e24. https://doi.org/10.4081/audiores.2011.e24

Krosnick, J., and S. Presser. 2009. "Questionnaire and Questionnaire Design." In *Handbook of Survey Research*, 263–314. Elsevier.

Krueger, R. A., and M. A. Casey. 2002. *Designing and Conducting Focus Group Interviews*. (Vol. 18). St. Paul, MN.

Lansbergen, S. E., N. Versfeld, and W. A. Dreschler. 2023. "Exploring Factors That Contribute to the Success of Rehabilitation With Hearing Aids." *Ear & Hearing* 20:00–00.

Lansbergen, S., and W. A. Dreschler. 2020. "Classification of Hearing Aids Into Feature Profiles Using Hierarchical Latent Class Analysis Applied to a Large Dataset of Hearing Aids." *Ear and Hearing* 41 (6):1619. https://doi.org/10.1097/AUD.0000000000000877

Leijon, A., H. Dillon, L. Hickson, M. Kinkel, S. E. Kramer, and P. Nordqvist. 2021. "Analysis of data from the International Outcome Inventory for Hearing Aids (IOI-HA) using bayesian item response theory." *International Journal of Audiology* 60 (2):81–88. https://doi.org/10.1080/14992027.2020.1813338

Liddell, T. M., and J. K. Kruschke. 2018. "Analyzing Ordinal Data with Metric Models: What Could Possibly go Wrong?" *Journal of Experimental Social Psychology* 79:328–348. https://doi.org/10.1016/j.jesp.2018.08.009

Little, R. J. 1988. "A Test of Missing Completely at Random for Multivariate Data with Missing Values." *Journal of the American Statistical Association* 83 (404):1198–1202. https://doi.org/10.1080/01621459.1988.10478722

Manchaiah, V., M. L. Bellon-Harn, R. J. Kelly-Campbell, E. W. Beukes, A. Bailey, and I. Pyykkő. 2020. "Media Use by Older Adults With Hearing Loss: An Exploratory Survey." *American Journal of Audiology* 29 (2):218–225. https://doi.org/10.1044/2020_AJA-19-00039

Manchaiah, V., E. M. Picou, A. Bailey, and H. Rodrigo. 2021a. “Consumer Ratings of the Most Desirable Hearing Aid Attributes.” *Journal of the American Academy of Audiology* 32 (8):537–546. https://doi.org/10.1055/s-0041-1732442

Manchaiah, V., D. W. Swanepoel, A. Bailey, J. W. Pennebaker, and R. J. Bennett. 2021b. “Hearing Aid Consumer Reviews: A Linguistic Analysis in Relation to Benefit and Satisfaction Ratings.” *American Journal of Audiology* 30 (3):761–768. https://doi.org/10.1044/2021_AJA-21-00061

Martuza, V. R. 1977. *Applying norm-referenced and criterion-referenced measurement in education*. Allyn and Bacon.

Matsunaga, M. 2007. “Familywise Error in Multiple Comparisons: Disentangling a Knot Through A Critique of O’Keefe’s Arguments Against Alpha Adjustment.” *Communication Methods and Measures* 1 (4): 243–265. https://doi.org/10.1080/19312450701641409

Meister, H., I. Lausberg, M. Walger, and H. von Wedel. 2001. “Using Conjoint Analysis to Examine the Importance of Hearing Aid Attributes.” *Ear and Hearing* 22 (2):142–150. https://doi.org/10.1097/00003446-200104000-00007

Mulley, A. G., C. Trimble, and G. Elwyn. 2012. “Stop the Silent Misdiagnosis: Patients’ Preferences Matter.” *BMJ (Clinical Research ed.)* 345 (v07 6):e6572–e6572. https://doi.org/10.1136/bmj.e6572

Nakagawa, S., and R. P. Freckleton. 2008. “Missing inaction: The Dangers of Ignoring Missing Data.” *Trends in Ecology & Evolution* 23 (11):592–596. https://doi.org/10.1016/j.tree.2008.06.014

Parent, M. C. 2013. “Handling Item-Level Missing Data: Simpler is Just as Good.” *The Counseling Psychologist* 41 (4):568–600. https://doi.org/10.1177/0011000012445176

Picou, E. M. 2020. “MarkeTrak 10 (MT10) Survey Results Demonstrate High Satisfaction with and Benefits from Hearing Aids.” *Seminars in Hearing* 41 (1):21–36. https://doi.org/10.1055/s-0040-1701243

Poost-Foroosh, L., M. B. Jennings, L. Shaw, C. N. Meston, and M. F. Cheesman. 2011. “Factors in Client–Clinician Interaction that Influence Hearing aid Adoption.” *Trends in Amplification* 15 (3):127–139. https://doi.org/10.1177/1084713811430217

Royston, P. 2004. “Multiple Imputation of Missing Values.” *The Stata Journal: Promoting Communications on Statistics and Stata* 4 (3):227–241. https://doi.org/10.1177/1536867X0400400301

Saleh, H. K., P. Folkeard, M. Van Eeckhoutte, and S. Scollie. 2022. “Premium Versus Entry-Level Hearing Aids: Using Group Concept Mapping to Investigate the Drivers of Preference.” *International Journal of Audiology* 61 (12):1003–1017. https://doi.org/10.1080/14992027.2021.2009923

Sandridge, S. A., and C. W. Newman. 2006. “Improving the Efficiency and Accountability of the Hearing Aid Selection Process.” *The Hearing Journal* 59 (12):46–48.

Schafer, J. L., and J. W. Graham. 2002. “Missing data: Our View of the State of the Art.” *Psychological Methods* 7 (2): 147–77. https://doi.org/10.1037/1082-989X.7.2.147

Scollie, S., R. Seewald, L. Cornelisse, S. Moodie, M. Bagatto, D. Laurnagaray, S. Beaulac, and J. Pumford. 2005. “The Desired Sensation Level Multistage Input/Output Algorithm.” *Trends in Amplification* 9 (4):159–197. https://doi.org/10.1177/108471380500900403

Simon, C., P. Little, J. Birtwistle, and T. Kendrick. 2003. “A Questionnaire to Measure Satisfaction with Community Services for Informal Carers of Stroke Patients: Construction and Initial Piloting.” *Health & Social Care in the Community* 11 (2): 129–37. https://doi.org/10.1046/j.1365-2524.2003.00408.x

Singh, G., L. Liskovoi, S. Launer, and F. Russo. 2019. “The Emotional Communication in Hearing Questionnaire (EMO-CHeQ): Development and Evaluation.” *Ear and Hearing* 40 (2): 260–71. https://doi.org/10.1097/AUD.0000000000000611

Tabachnick, B. G., and L. S. Fidell. 2019. *Using Multivariate Statistics*. Boston, MA: Pearson.

Tavakol, M., and R. Dennick. 2011. “Making Sense of Cronbach’s Alpha.” *International Journal of Medical Education*, 2: 53–5. https://doi.org/10.5116/ijme.4dfb.8dfd

Valente, M., H. Abrams, D. Benson, T. Chisolm, D. Citron, D. Hampton, and R. Sweetow. 2006. *Guidelines for the Audiologic Management of Adult Hearing Impairment*. Reston, VA: American Academy of Audiology.

Wilson, N., and S. McClean. 1994. *Questionnaire Design*. Newtownabbey: University of Ulster.

Wu, Y. H., E. Stangl, O. Chipara, S. S. Hasan, S. DeVries, and J. Oleson. 2019. “Efficacy and Effectiveness of Advanced Hearing Aid Directional and Noise Reduction Technologies for Older Adults with Mild to Moderate Hearing Loss.” *Ear and hearing* 40 (4): 805. https://doi.org/10.1097/AUD.0000000000000672

Zhu, D., X. Shi, S. Nicholas, X. Ye, S. Chen, and P. He. 2020. “Preferences for Hearing Aid Attributes Among People with Moderate or Greater Hearing Loss in Rural China: A Discrete Choice Experiment.” *Patient Preference and Adherence* 14: 643. https://doi.org/10.2147/PPA.S248522