

Citation: Bennett, R. J., Swanepoel, D. W., Ratinaud, P., Bailey, A., Pennebaker, J. W., & Manchaiah, V. (2021). Hearing aid acquisition and ownership: what can we learn from online consumer reviews?. *International Journal of Audiology*, 60(11), 917-926.

Hearing aid acquisition and ownership: What can we learn from online consumer reviews?

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ABSTRACT

Objective: To explore the publicized opinions of consumers actively participating in online hearing aid reviews.

Design: A retrospective design examining data generated from an online consumer review website (www.HearingTracker.com). Qualitative data (open text responses) were analyzed using the open source automated topic modeling software IRaMuTeQ (<http://www.iramuteq.org/>) to identify themes. Outputs were compared with quantitative data from the consumer reviews (short response questions exploring hearing aid performance and benefit, and some meta-data such as hearing aid brand and years of hearing aid ownership).

Study Sample: 1,378 online consumer hearing aid reviews.

Results: Six clusters within two domains were identified. The domain Device Acquisition included three clusters: *Finding the right provider, device and price-point*; *Selecting a hearing aid to suit the hearing loss*; and *Attaining physical fit and device management skills*.

The domain Device Use included three clusters: *Smartphone streaming to hearing aids*; *Hearing aid adjustment using smartphone*; and *Hearing in noise*.

Conclusions: Although online hearing aid consumers indicate positive performance on multiple choice questions relating to hearing aid performance and benefit, their online reviews describe a number of barriers limiting their success. Hearing healthcare clinicians must employ a personalized approach to audiological rehabilitation to ensure individual clients' needs are met.

Key words: Hearing aid, hearing aid acquisition, online consumer feedback, consumer reviews, satisfaction, performance, hearing aid management, device handling, phone streaming, bluetooth streaming

INTRODUCTION

Healthcare consumers are increasingly seeking health information and advice online. More than two thirds of people in the UK search for health information online (Dutton & Blank et al, 2013). In the US, one in three adults search online to identify a diagnosis or access information about a health complaint (Fox & Duggan, 2013). Historically, people searched for online health information seeking on business websites; however, social media sites are becoming increasingly utilised for health information access (Fox, 2011). Of 1745 US based adults surveyed in 2010, 41% consulted online review websites, 10% posted reviews, and 15% posted a comment, question or information relating to health (Thackeray, Crookston, & West, 2013). Respondents with a chronic disease were nearly twice as likely to consult online reviews. Social media provides an unparalleled platform for consumers to publicize their personal evaluations of healthcare services and products. These social media platforms include forums, review sites, social networks, blogs, microblogging (eg, Twitter), and media sharing (eg, YouTube). Review sites, such as Yelp, Yahoo or GoogleReviews, are gaining popularity in the healthcare industry and appear to influence healthcare consumer habits (Bujnowska-Fedak & Węgierek, 2020). Online reviews are often perceived as trustworthy and unbiased, and consumers appear to have inherent beliefs in the value of information provided by other consumers on account of their shared needs (Zhao & Zhang, 2017). However, online health information varies in quality, accuracy, and reliability (Laplante-Levesque & Thoren, 2015; Manchaiah et al., 2020; Simpson, Le, & Malicka, 2018). Furthermore, health consumers may lack the skills to evaluate information quality (Stvilia, Mon, & Yi, 2009), exacerbated by digital literacy inequalities (Chen, Lee, Straubhaar, & Spence, 2014).

Hearing loss is a common chronic health condition commonly managed with the use of hearing aids. Hearing aid performance, and the benefit obtained from using them vary widely (Lopez-Poveda et al, 2017). There is currently no universally agreed definition or measure of successful hearing aid use (Granberg et al, 2014). Typically the hearing

healthcare clinician will elicit information pertaining to an individual's hearing aid success and use it to inform modification to the individuals hearing rehabilitation program (including altering the physical or acoustical settings of the hearing aid), or use the information as recognition of the success of the program to third-party payers. Researchers monitor national and international trends in hearing healthcare and hearing aid acquisitions to inform policy, clinical care, research directions and product development. The US-based MarkeTrak survey has shown that satisfaction with hearing aids has increased from 74% in 2008, to 81% in 2014, to 83% in 2019 (Powers & Rogin, 2019). The EuroTrak data tells a similar story, with hearing aid satisfaction at 70% (Bisgaard & Ruf, 2017). While this publicly available hearing aid satisfaction data are motivating, it does not provide product or service specific information that might guide consumer decision making processes. More recently hearing aid owners have been self-evaluating their success with hearing aids and sharing their views and experiences through independent and anonymous feedback in various online consumer forums. One example of these forums is HearingTracker.com, a US-based site designed to help consumers to find hearing aids that best suit their needs. On this website hearing aids are rated and reviewed by members of the public, reflecting their personal opinions and experiences. It has been suggested that online reviews may provide unique insights into the hearing aid consumer experience since the data are generated by self-initiated patient reports as opposed to clinician/researcher elicited feedback as have been used by the majority of hearing aid research programs (Manchaiah et al, 2019; Manchaiah et al, 2021).

Research shows that social networks can influence a persons' motivation to obtain a hearing aid (Kochkin, 2012). It is thus likely that online reviews also have the power to sway hearing aid purchase decisions. Yet little is known regarding the experiences described within online hearing aid reviews. It would be helpful for clinical audiologists to have an understanding of the information being sourced by their clients from online review platforms, and the aspects of hearing aid ownership and use that receive the greatest focus. Armed with this knowledge, audiologists would be more adept at correcting common misunderstanding and ensuring that their services align with the general desires of consumers. The recent development of consumer driven hearing healthcare rating websites, the possible influence these review sites may be having on hearing healthcare consumers decision making processes, and the dearth of knowledge regarding the content posted on these review sites motivated the current study. The purpose of this study was to explore the publicized opinions of consumers actively participating in online hearing aid reviews to identify those aspects of hearing aid ownership and use that received the greatest focus. Three sub-aims of this study included to explore whether online review content was related to (i) client satisfaction ratings (i.e. to better understand what aspects of the hearing aid experience are publicised by satisfied hearing aid owners versus dissatisfied owners); (ii) hearing aid technology level (i.e. to better understand whether particular topics are more often described by consumers who own certain levels of hearing aid technology); and (iii) hearing

aid brand (i.e. whether certain hearing aid brands may more greatly contribute to certain review themes).

This study takes a topic modeling approach to understanding the publicized views of consumers actively participating in hearing aid reviews on the HearingTracker.com online platform. Specifically, data entered on the HearingTracker.com website by members of the public who indicated that they had recently obtained hearing aids via an in-clinic service with an audiologist, were extracted and analyzed. Analysis of publically and freely available data (such as from Google, Amazon, Social media, etc.) can be achieved through a relatively new and rapidly growing area of research, Consumer Health Informatics (CHI) (Demiris, 2016; Ho, 2010). CHI is devoted to informatics from multiple consumer or patient views and attempts to statistically draw out underlying themes of text (for review see Gibbons et al, 2011). Applying the CHI approach in examining self-reported hearing aid experience publicized in online review websites may provide unique perspective when compared to clinical studies and help contribute to theoretical triangulation knowledge in this area.

METHOD

Study Design and Ethical Considerations

The study involved a retrospective analysis of data extracted from the Hearing Tracker (<https://www.hearingtracker.com/>) website. The study did not require ethical approval as the data (a) were generated from a publicly available source, and (b) did not include any individual user details, thus posing minimal or no potential risk to individuals who provided the reviews (Ainscough et al, 2018; Eysenbach & Till, 2001). The reviews from the consumers were voluntary and there was no solicitation from the website. Consumers were not made aware that their reviews may be used for research purposes.

Data Extraction

2,352 individual consumer reviews during the years 2013 to 2019 and their hearing aid meta-data were downloaded from the from HearingTracker.com website. Of these, 974 reviews did not include a text response and/or the response was not a hearing aid review, and they were thus excluded from this study. The remaining 1,378 reviews were included in the analysis.

The data extracted included metadata (i.e., hearing aid brand, hearing aid technology level, duration of hearing aid use, and unilateral vs bilateral hearing aid use), a ten-item closed-response questionnaire, and the consumer review provided as an open-text response item. All 10 closed-response items were rated on a 5-point scale, and asked how the hearing aid performed in relation to: hearing speech in quiet; hearing speech in noise; hearing on the phone; sound clarity; music listening; comfort; reliability; presence of feedback (buzzing/whistling); general improvement in hearing; and value. The open-ended question

prompted the consumer to provide a description of their hearing aid experience using the open-ended question “How are things going with your hearing aid(s)?”

Data from the ten closed-response items were averaged to derive a global rating for each consumer; which was then rounded to a whole number to allow for analysis of categorical data (1-5). A lower global score indicates poor performance/benefit, and a higher global score indicates good performance/benefit. Hearing aid brands identified from the demographic data were categorized to enable analyses, classified into eight categories: Phonak=1, Oticon=2, Starkey=3, Widex=4, Siemens=5, Unitron=6, ReSound=7, All Other=8. Within the website consumers indicate the exact brand and model of hearing aid that they have purchased. The website then classifies the device into one of six technology levels inferred from information obtained directly from the manufacturer websites; with 6 = highest level of technology and 1 = lowest level of technology. Consumers contributing to this study indicated owning hearing aids only from technology levels 6 to 2, i.e. none of the consumer reviews included in this study indicated that they owned a hearing aid from the lowest level of technology according to the HearingTracker classification system. It is important to note that as this data was collected over a seven year timespan, it is possible that features contained within high levels of technology in the earlier years may have become accessible in lower levels of technology in more recent years. Interpretation of data relating to technology levels should be considered with this in mind.

Consumer Characteristics

The study included a total of 1,378 online hearing aid reviews. Of these, 1,274 (92.5%) indicated owning bilateral hearing aids, and the remaining 104 (7.5%) unilateral. Consumers indicated having between 0 to 10 years of experience using hearing aids (mean 4.8; SD 4.1). The two most prevalent hearing aid brands documented were Phonak and Oticon (Table 1). Over two-thirds of consumers indicated that they owned hearing aid models classified as the highest level of technology. The majority of consumers appeared satisfied with their hearing aids, with 36.5% and 43.1% self-reporting Very Good and Good on the global performance rating, respectively.

Data Analysis

The data were analyzed using the open source automated text analysis software, IRaMuTeQ (<http://www.iramuteq.org/>). First, a cluster analysis was conducted on the text corpus to examine the main themes reported by hearing aid owners (1,378 unique reviews). The cluster analysis used a Reinert method for the textual data analysis (Ratinaud & Marchand, 2012; Reinert, 1983). The Reinert method uses a divisive hierarchical clustering known to improve the text data analysis (Sbalchiero & Tuzzi, 2017). The cluster analysis groups the text segments based on co-occurrence of lemmas (i.e., group of words in a single form). The cluster analysis aims to produce each cluster, which is as homogeneous (i.e., having text segments with the common pattern of lemmas) as possible within the cluster and as

heterogeneous as possible between the clusters. The software produces results in a dendrogram that characterizes the clustering (see Figure 1) and also provides text excerpts that are typical representation of the clusters. This automated text analysis approach is demonstrated to generate similar themes to traditional qualitative content analyses, and is thus a reliable method in analyzing a text corpus (Manchaiah et al, 2019). The font size of words within each cluster is proportional to the chi-square value in that cluster (i.e., larger font size indicating larger chi-square value); however this comparison is only reliable for comparison with a cluster, i.e. comparisons cannot be made between clusters. The research team generated names and descriptions of the clusters based on the words and text excerpts, based on consensus (RJB, DWS & VM).

To explore whether online review content was related to (i) client satisfaction ratings; (ii) hearing aid technology level; or (iii) hearing aid brand, we used Chi-square analyses examining the relationship between clusters and meta-data (consumers global performance ratings, technology level, and hearing aid brand. The chi-square analysis was intended to examine if particular types of consumer reviews are over (or under) represented in any clusters. A chi-square value of 3.84 or more has a p-value of $< .05$ in these images suggesting a significant association. The graphs are interpreted by considering the overrepresentation or underrepresentation of variables (e.g., consumer rating, technology level, hearing aid brand) in each of the clusters. The bars going up indicate a statistical overrepresentation (a higher proportion), and the bars going down indicate a statistical underrepresentation (a lower proportion) of each variable in relation to each cluster. The length of the bars indicates the strength of overrepresentation or underrepresentation. For a detailed description of these approaches see Manchaiah et al. (2019).

RESULTS

Main Themes in Consumer Reviews Based on Cluster Analysis

The cluster analysis yielded six clusters within two domains: (i) Device Acquisition and (ii) Device Use. The domain Device Acquisition includes the three themes: *Finding the right provider, device and price-point, Selecting a hearing aid to suit the hearing loss, and Attaining physical fit and device management skills*. They describe the three step process of finding a clinician or provider that offers products (hearing aids) and services that meets the individual's needs and financial expectations; selecting a hearing aid that addresses the individual's hearing needs; and setting up the physical and acoustical parameters of the hearing aid, including learning how to use and manage the device. The domain Device Use included the three themes: *Hearing in noise, Smartphone streaming to hearing aids, and Hearing aid adjustment using smartphone*. They describe the experience of using the hearing aid in a real-world situation, including managing one's own hearing aid settings (adjusting the volume or programs) primarily via a smart phone application; using connectivity functionalities to stream audio signals through the hearing aid; and ongoing difficulties experienced when trying to communicate in noisy environments.

The six clusters included:

- *Finding the right provider, device and price-point* (Cluster 2; 17.3% of the texts). These statements described the importance of “shopping around” for hearing aid brands, models, features or price points that meet the individual’s needs. Participants also described how services delivered by various hearing clinics differ, and the importance of finding a clinic that provides a full service.
- *Selecting a hearing aid to suit the hearing loss* (Cluster 3; 14.3% of the texts). These statements were mostly put forward by experienced hearing aid owners, providing a product comparison and recommendation. For the most part, they described changing brands, and being happier with their newer devices. These participants often also described their hearing loss severity and/or configuration.
- *Attaining physical fit and device management skills* (Cluster 1; 21% of the text). Statements within this cluster described the process of trial and error with selecting the appropriate physical components for the hearing aid; such as dome/mould comfort and retention, tubing length, battery size, managing perspiration issues. Participants described both positive and negative experience regarding the physical fit, problem resolution, and management requirements for their new devices.
- *Hearing in noise* (Cluster 6; 23.3% of texts). Statements within this cluster described the experience of using hearing aids in noisy environments. The majority of these comments related to unmet expectations regarding hearing aid performance in noise, with a few participants noting how the noise reduction technology had improved over the years.
- *Smartphone streaming to hearing aids* (Cluster 4; 13.8% of the texts). Statements within this cluster described participants’ experiences with audio-streaming (such as music, TV, phone signal) to their hearing aids via a smartphone. These statements often included both positive expressions relating to the enjoyment of the streaming function and negative statements relating to technical problems or sound distortion when streaming; often both positive and negative statements were provided together in the same participant entry.
- *Hearing aid adjustment using smartphone* (Cluster 5; 10.2% of the texts). This cluster described the use of the smartphone to make acoustic modifications to the hearing aid settings. These statements often included recommendations for which phone brands work best with the hearing aid, delight in being able to make their own adjustments, and disappointment with some of the problems that arise with the system.

Responses were fairly well distributed across clusters (Figure 1), with the cluster *Hearing in noise* containing the highest percentage of consumer review content (23.3%) and the cluster *Hearing aid adjustment using smartphone* containing the lowest percentage of content (10.2%). The names of each cluster and example text segments are provided in Appendix 1.

Note that the cluster/domain numbers do not signify ranking; they provide only a means of identification.

Association Between Clusters and Device-Related Variables

Associations between the cluster and the consumer's overall ratings revealed an over representation of user ratings 1-3 (poor experiences) for the cluster *Finding the right provider, device and price point* (Figure 2, also provided as a black and white image in Supplementary 1). That is, consumers self-reporting poorer general outcomes provided more text responses relating to this cluster.

Associations between the cluster and the consumers' hearing aid's technology level (6 = highest technology level, to 2 = lowest technology level reported) revealed an over representation of level 6 (highest technology) in the cluster describing *Hearing aid adjustment using smartphone*, with all other technology levels underrepresented in this cluster (Figure 3, also provided as a black and white image in Supplementary 2). These results likely suggest the availability of functions to control the hearing aid via smartphone in hearing aids of higher level technology. Also, the technology level 2 (lowest technology) was overrepresented in the cluster *Selecting a hearing aid to suit the hearing loss*, suggesting that hearing aid owners with lower technology level devices are more likely to talk about shopping around for the right device when providing online reviews.

Associations between the cluster output and the consumers' hearing aid brand (1=Phonak, 2=Oticon, 3=Starkey, 4=Widex, 5=Siemens/Signia, 6=Unitron, 7=ReSound, 8=All Others) revealed varying levels of involvement. That is, consumers with certain brands were more likely to provide text that described key words from some clusters more than others (Figure 4, also provided as a black and white image in Supplementary 3). For example, the Phonak and Unitron brands were both overrepresented in the cluster describing *Attaining physical fit and device management skills*, whereas the Oticon brand was overrepresented in the cluster describing *Selecting a hearing aid to suit their hearing loss*. Although these associations suggest that some brands may elicit different user experiences, whether or how these experience influence hearing aid satisfaction or repurchase decisions is beyond the scope of this study.

DISCUSSION

The purpose of this study was to explore the publicized opinions of consumers actively participating in online hearing aid reviews to identify those aspects of hearing aid ownership and use that received the greatest focus. When asked the question "How are things going with your hearing aid(s)?" consumers described a myriad of different responses, including those positive, negative and neutral in tone. Responses were classified into six clusters using automated cluster analysis software, and were fairly well distributed across clusters, suggesting that all six concepts are important to hearing aid owners.

The cluster *Finding the right provider, device and price-point* described the importance of finding the right hearing clinic from which to receive services and products, and how these decisions can be affected by cost-benefit considerations. Previous research involving adult hearing aid owners have highlighted the importance of the client-clinician relationship, specifically in regards to hearing aid adoption (Poost-Foroosh et al, 2011), acquisition of hearing aid handling skills (Bennett et al, 2018d; Bennett et al, 2018b), ongoing hearing aid use (Laplante-Lévesque et al, 2013; Linssen et al, 2013), and overcoming problems associated with hearing aid use (Bennett et al, 2019b). However, research relating to hearing service providers is sparse (Reeves et al, 2000).

Consumers who indicated poorer general outcomes with their hearing aids were more inclined to provide text contributing to the cluster *Selecting a hearing aid to suit the hearing loss*, suggesting that “shopping around” to find the right hearing aid brand, model, features or price to meet an individual’s needs was more important to those consumers purchasing lower level devices. This cluster included statements that appeared to be put forward by more experienced hearing aid owners; often providing a product comparison and recommendation. The concept of “shopping around” or intra-consumer product comparisons is not new. In a US-based national survey Kochkin (2003) identified about three out of four consumers to have been satisfied with the ability of their hearing aid to “improve their hearing,” yet roughly half of all consumers switched brands or attempted to switch brands with the hope of receiving better hearing aid outcomes with the new purchase. It appears that hearing aid consumers somewhat attribute their ongoing hearing aid problems to the brand or model of device that they own.

The cluster *Attaining physical fit and device management skills* described the process of trial and error with setting up the physical and acoustical parameters of the hearing aid, and also learning how to use and manage new devices. There has been a recent proliferation in evidence-based approaches to improve hearing aid orientation skills training in the clinical setting (Bennett et al, 2018a; Ferguson, 2017; Ferguson et al, 2015; Saunders et al, 2018). A recent participatory study involving hearing aid owners and clinicians identified 111 unique items describing the knowledge and skills required for hearing aid management; thus highlighting the magnitude of information and skill required to optimally manage hearing aids (Bennett et al, 2018d). Knowledge and skills identified were represented by six themes: 1) Daily Hearing Aid Use; 2) Hearing Aid Maintenance and Repairs; 3) Learning to Come to Terms with Hearing Aids; 4) Communication Strategies; 5) Working with Your Clinician and 6) Advanced Hearing Aid Knowledge. When asked to rate the importance of each, hearing aid owners indicated that all six concepts were of equal importance, whereas clinicians indicated the concept Advanced Hearing Aid Knowledge was significantly less important than the other five concepts, suggesting that clinicians are likely to make a judgment call and omit certain aspects of information and training despite clients wanting all of the available information so as to aid informed decision making. To address this, clinicians must

take a patient-centered approach to delivering audiological rehabilitation services, and ensure that each hearing aid owner has received sufficient training and support regarding hearing device use and maintenance.

The cluster *Hearing in noise* described the experience of using hearing aids in noisy environments, with a focus on unmet expectations regarding hearing aid performance in noise. It is well recognized that hearing aids do not solve all of one's hearing-related concerns; and as such there is much literature describing the common problems experienced by hearing aid owners (Bennett et al, 2018c; McCormack & Fortnum, 2013; Solheim et al, 2018). A recent multi-center clinical cohort study (n=413) found 98% of hearing aid owners to self-report current experience of at least one (of 26) hearing aid problems included on the survey (range 0 to 25; mean = 10; SD = 5) (Bennett et al, 2020). The three most commonly reported problems related to difficulty hearing in noisy environments, hearing in windy environments, and understanding certain voices. However, participants had reported less than half (46.33%) of their problems to their clinic. Importantly, participants who reported experiencing a greater number of hearing aid problems also reported lower levels of hearing aid benefit, and satisfaction with their hearing aids. The finding that hearing in noise was found to be a cluster in and of itself in the current study speaks volumes to the prevalence of this problem, and its importance in the eyes of adult hearing aid owners. Hearing aid manufacturers have developed features that help to improve signal processing in noise (Sarampalis, Kalluri, Edwards, & Hafter, 2009), yet adults with hearing loss require greater improvement in order to meet their expectations. Hearing healthcare clinicians have a role to play in educating and counselling adult hearing aid owners on the current limitations regarding hearing in noise.

Two clusters described the use of wireless capabilities to (i) stream audio to the hearing aids, and (ii) adjust the hearing aid using a smartphone. Wireless streaming has been an important feature in hearing aids for decades; specifically for enabling telecoil and FM functionalities. The evolution of Bluetooth streaming brought an expansion of hearing aid wireless connectivity facilitating not only convenient access to recreational use, but also improved hearing capabilities. For example, bilateral wireless connectivity can facilitate significantly better speech recognition than acoustic telephone use (Picou & Ricketts, 2011). More recently we have seen the development of hearing aid apps that enable the client to adjust their own hearing aid settings when they want and to the extent that they want (Høydal et al, 2020). These features enable hearing aid owners to make adjustments when in real-world listening experiences. However, access to these features has been reserved only for higher-end technology (and generally more expensive) hearing aids. It is thus not surprising that consumers self-reporting ownership of the higher level technology hearing aids were more inclined to provide responses that contributed to the cluster describing *Hearing aid adjustment using smartphone*.

Clinical considerations

What can we learn from online consumer reviews? Where previous research has reported various aspects of the lived experience of hearing aid owners (Dawes, Maslin, & Munro, 2014; Laplante-Lévesque, Jensen, Dawes, & Nielsen, 2013; Linssen, Joore, Minten, van Leeuwen, & Anteunis, 2013; Bennett et al, 2019), this study has reported the experiences that hearing aid owners choose to publicize in online hearing aid reviews. As within traditional research studies with hearing aid owners, consumers described the problems that can arise during the process of (i) selecting and provider/clinician, (ii) selecting a hearing aid, and (iii) programming the hearing aid. Consumer reviews also focused on wireless audio streaming, hearing aid adjustments using the smart phone, and hearing in a noisy environment. As reported herein, hearing aid owners who highly rated their hearing aid experience on the HearingTracker website were more likely to provide commentary on the importance of “selecting the right hearing aid”. Where hearing healthcare clinicians have described themselves as a central component in their client’s hearing rehabilitation journey (Laplante-Lévesque et al, 2013), these online consumer reviews suggest that consumers perceive the hearing aid device to be central; as has been suggested in previous reports (Laplante-Lévesque et al, 2013). Those consumers engaging with the website were more likely to own high end technology, and have high expectations of these technologies. Although many consumers described positive experiences with their technology features, many too described negative experiences and warned against purchasing the same features or brands. Research shows that despite the ongoing support offered to clients after they acquire hearing aids, many are hesitant to seek help from their clinician and/or provider, and instead engage in a myriad of helpful and unhelpful behaviors in response to problems that arise with their hearing aid (Bennett et al, 2019). With the future of hearing healthcare looking to include more web-based services, sales and support (Paglialonga et al, 2018; Swanepoel et al, 2010), it is likely that online consumer reviews will play a major role influencing hearing healthcare consumer behaviors. Audiologists may want to familiarize themselves with the common complaints made on hearing aid review websites, and adapt their clinical practices to ensure that they address problems relating to these common issues to avoid receiving poor reviews themselves and risking online reputational damage.

Study Limitations

A core feature of qualitative research is *reflexivity*, the explicit examination and acknowledgement of the researchers’ own views, biases and assumptions. The act of engaging in research may actually affect the process being studied. Thus, reflexivity protects the research process and ensures integrity, trustworthiness, and accountability. Where traditional methods of qualitative research often rely on the research team to develop the research question, elicit the data from participants, and analyze the data, the current study took an objective approach, wherein data was not elicited and data analysis was completed via an automated computational program. For this reason, we suggest that the data reflect the consumer sentiments, and provides novel insights into the views and experiences of this

particular sample of the population. Importantly, data extracted for this study was not generated for the purpose of the study. That is, consumers contributing online reviews did not do so with the intent of describing their entire hearing healthcare experience, rather they were self-motivated to publicize select elements of their experiences so that others may learn from them. As such, we assume that the experiences documented within this study do not paint a complete picture of the hearing healthcare experience, but rather they likely elucidate the personal recommendations provided from one member of the community to another via online forum.

The issue of sampling bias must be addressed. Data was extracted from an online consumer review website. It is likely that individuals who contributed to this online forum varied from the general population in a variety of ways. For example, online review users may be more tech savvy and have a higher preference for technological features. Younger adults are more likely to engage in internet-based activities than older adults, (Ernsting et al, 2017; Prestin et al, 2015) and as we had no demographic data on the consumers it would be precautionary to assume that the data extracted is not likely representative of the wider population of hearing aid owners. Second, almost half of the reviews came from wearers of Phonak and Oticon devices, and over two thirds of the reviews came from owners of the highest level of technology. This may not be representative of the general population, and needs to be considered when interpreting the results of this study. Furthermore, it is possible that consumers are more inclined to write reviews when they have experienced particularly positive or particularly negative experiences (Sen & Lerman, 2007) and so the reviews herein may not have captured the responses of hearing aid owners with “uneventful” hearing aid acquisition experiences. The user meta-data available from the consumer review website was limited, and rendered it impossible to explore how well the sample represented the general population. Over two-thirds of consumers indicated that they owned hearing aid models which were subsequently classified as the highest level of technology; which is not representative of the greater population, and thus the findings should be interpreted with this in mind. Although the automated text analysis provides main themes within the data, the cluster analysis may not pick up subtle themes (positive vs negative) as shown in a recent study by Manchaiah et al (2019). Finally, the HearingTracker website does not collect any identifiable data from consumers, and as such we were unable to determine whether reviews were posted by true hearing aid owners, their country of residence, nor whether they had posted a single or multiple reviews. None-the-less, reviews on the HearingTracker websites are publicly available and regularly accessed by hearing aid owners. Analysis of online consumer hearing aid reviews has provided insight into hearing aid recommendations viewed by thousands of hearing healthcare consumers each year.

CONCLUSION

Online consumer reviews have become an increasingly important source of information for consumers (i.e. what to buy and from who), providers (i.e. customer service ratings), and

manufacturers (i.e. product strengths and weaknesses). Consumer experiences during the process of hearing aid acquisition and ownership as described on a publicly posted online consumer review website has provided valuable insights into the aspects of audiological rehabilitation that are important to hearing aid owners. Consumers described the ups and downs when navigating the process of (i) selecting a provider/clinician, (ii) selecting a hearing aid, and (iii) programming the hearing aid. While many aspects of hearing aid performance were described in the text, consumers focused on three key performance aspects: (i) wireless audio streaming, (ii) hearing aid adjustments using the smart phone, and (iii) hearing in a noisy environment; describing the wins and losses associated with these three. Although consumers indicated high levels of hearing aid performance/benefit when responding to multiple choice questions on the website, they described numerous problems limiting their success with hearing aids. Hearing healthcare clinicians must look beyond simply asking whether their clients are satisfied, and instead employ a patient centered approach to audiological rehabilitation, asking clients to demonstrate their skills and knowledge (Bennett et al., 2018b) and probing into the wide range of hearing aid problems that can occur (Bennett et al., 2020) to ensure that each client's individual needs are met.

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Table 1: Hearing aid meta-data

| Meta-data | n | % |
|--|----------|----------|
| Hearing aid brand | | |
| ▪ Phonak | 307 | 22.3 |
| ▪ ReSound | 166 | 12 |
| ▪ Oticon | 307 | 22.3 |
| ▪ Widex | 131 | 9.5 |
| ▪ Siemens | 39 | 2.8 |
| ▪ Starkey | 113 | 8.2 |
| ▪ Unitron | 73 | 5.3 |
| ▪ Other | 242 | 17.5 |
| Level of hearing aid technology | | |
| ▪ 6 = Highest | 948 | 68.8 |
| ▪ 5 = Second highest | 190 | 13.8 |
| ▪ 4 = Third highest | 154 | 11.2 |
| ▪ 3 = Fourth highest | 61 | 4.4 |
| ▪ 2 = Fifth highest | 25 | 1.8 |
| ▪ 1 = Lowest | 0 | 0 |
| Global performance rating (average rating rounded to whole number) | | |
| ▪ 1 = Very poor | 13 | 0.9 |
| ▪ 2 = Poor | 46 | 3.3 |
| ▪ 3 = Average | 222 | 16.1 |
| ▪ 4 = Good | 594 | 43.1 |
| ▪ 5 = Very good | 503 | 36.5 |

Table 2. Example of a text segment for each cluster in the hearing aid reviews

| Cluster | Example of a text segment |
|---|--|
| Finding the right provider, device and price-point | <p>consider using a hearing aid provider who can provide a loaner or who has a shorter turn around time with their manufacturers or distributors many private hearing centers can provide this service and i never thought that the costco kirkland signature premium hearing aids</p> <p>i investigated many brands went to at least two private hearing centers associated with ent offices and tested a few different hearing aids out i thought the kirkland premium 8 s had the best balance of cost performance and features available the price point of 1699 00 pr along with reviews was a factor in choosing the kirkland signature 7 0 hearing aids when i returned for a 2 week checkup the specialist made an adjustment to the programing because one side seemed muffled</p> |
| Selecting a hearing aid to suite the hearing loss | <p>at the moment i_m wearing phonak audeo q90 since 5 years and now looking to switch to oticon opn or similar solution with best fitting to my sky slope loss and possibly direct to iphone streaming and ha managing solution</p> <p>been using hearing aid for 3 years moderate hearing loss moved from oticon alta pro 5 months ago the silks are very comfortable a big relief to get rid of the behind the ears ha</p> <p>i purchased phonak v90 audeo hearing aids for my mild age related hearing loss over a year and a half ago before purchasing them i attended a free audiologist's information session at my clinic</p> |
| Attaining physical fit and device management skills | <p>i had a problem with perspiration getting into the battery compartment a pair of ear gear covers fixed that i was originally fitted with open domes while that was a big help for higher frequencies it left me still having some trouble with speech recognition</p> <p>i have really small ear canals so finding the right dome size took two tries also i decided to get custom longer receiver wires so that my ha's would fit below where my glasses sit behind my ears</p> <p>i have had no discomfort and they actually feel less noticeable than my 440 s i am using rubber tipped double vent domes that have a new shape the audi fitted my left ear with the medium and my right ear with the small dome</p> |

| | |
|---|---|
| Hearing in noise | <p>in a noisy environment restaurants parties etc it is difficult to hear the person talking to me the hearing aid is not focusing on the person talking to me and does not reduce enough the noise around me</p> <p>for noisier environments like cafés restaurants and the gym it has a great ability to cut out background noise of course it is impossible to remove it completely but speech is audible in a noisy environment and noise tolerable</p> <p>i do hear speech better in noisy environments but I'm also finding the background noise distracting and annoyingly loud so i hope that both my brain and the hearing aids will filter out the unwanted clutter in time</p> |
| Smartphone streaming to hearing aids | <p>i really like the iphone compatibility for streaming phone calls and music but music often sounds distorted due to bluetooth issues</p> <p>the wireless communication with my android phone for adjusting and streaming music and calls and the link with tv sound via the tv connector is great</p> <p>the hearing aids and phone seem to stay paired using bluetooth but the audio streaming sometimes only goes through to one of my hearing aids this happens with calls and streaming music and i'm not sure but it seems to happen more when the batteries are low</p> |
| Hearing aid adjustment using smartphone | <p>for me iphone integration remains first rate years after these aids were introduced for iphone users the resound ios app is a big improvement over carrying a remote</p> <p>oh and the cool thing about it if you have iphone android you can download an app that allows you to add programs and control your hearing aids volume i also have a remote control and tv dex for it and i am in love</p> <p>not having to carry a remote and a phone clip were big pluses in my book within the app i had control over the treble and bass witch made a big difference when streaming the tv or listening to music via the iphone</p> |

Figure 1: Dendrogram (i.e., classification of clusters), size of clusters as percentage of the text segments, and overrepresented words in each cluster in the hearing aid reviews. The words are ordered by chi-square value with words at the bottom having lower value.

NB. The font size of words within each cluster is proportional to the chi-square value in that cluster (i.e., larger font size indicating larger chi-square value); however this comparison is only reliable for comparison with a cluster, i.e. comparisons cannot be made between clusters.

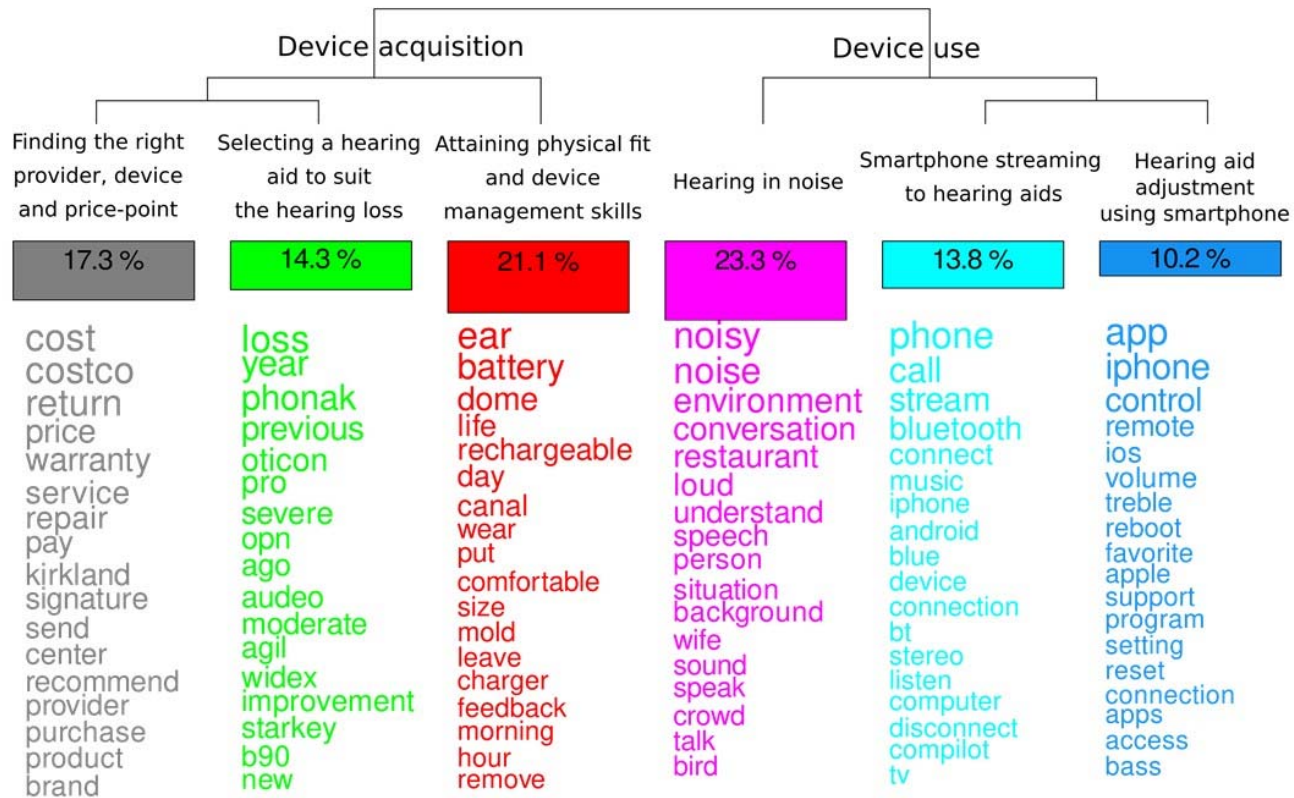


Figure 2: Association between cluster and user rating based on Chi-square analysis. Bars going up represents overrepresentation of user ratings in each cluster and bars going down represent underrepresentation.

* denotes significant association.

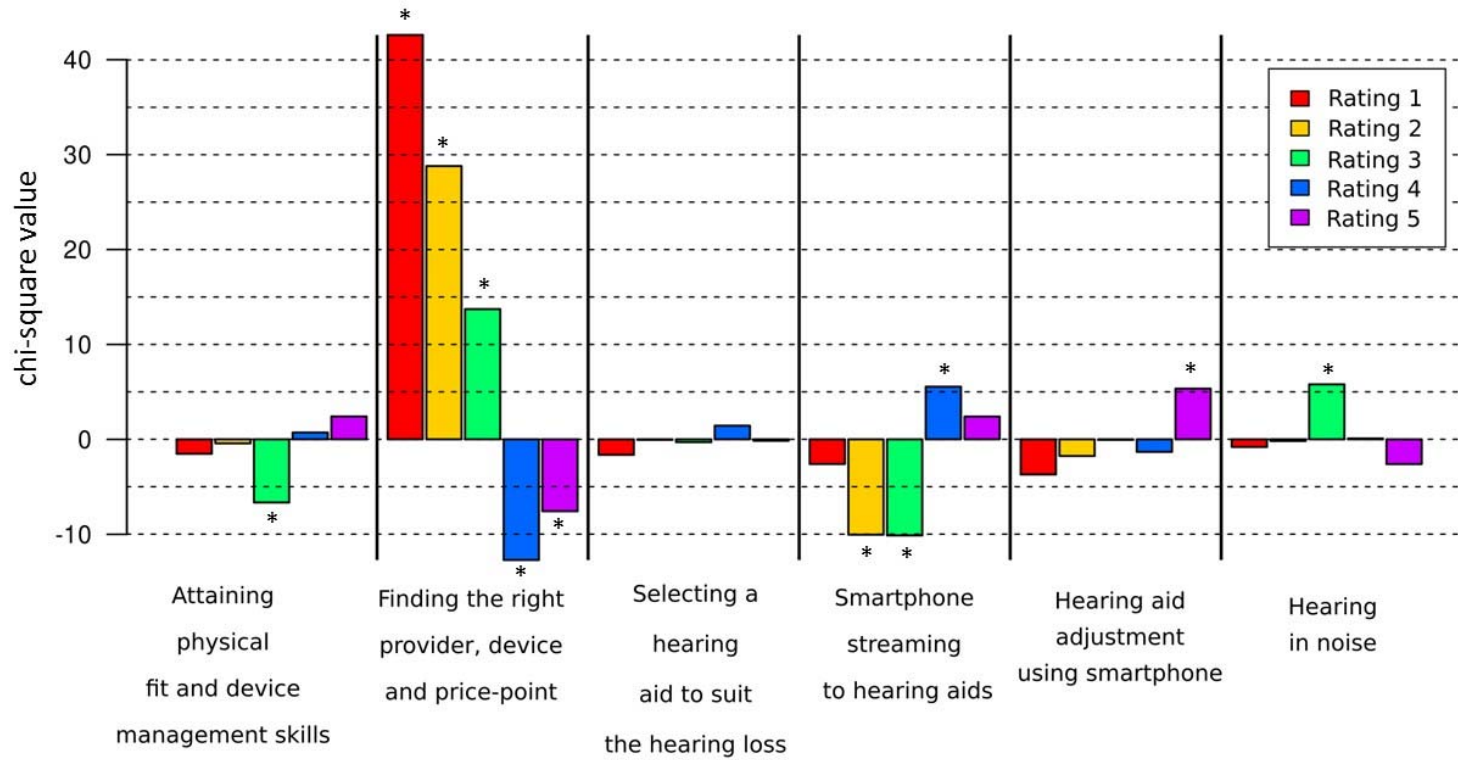


Figure 3: Association between cluster and technology level based on Chi-square analysis. Bars going up represents overrepresentation of technology levels in each cluster and bars going down represent underrepresentation.

* denotes significant association.

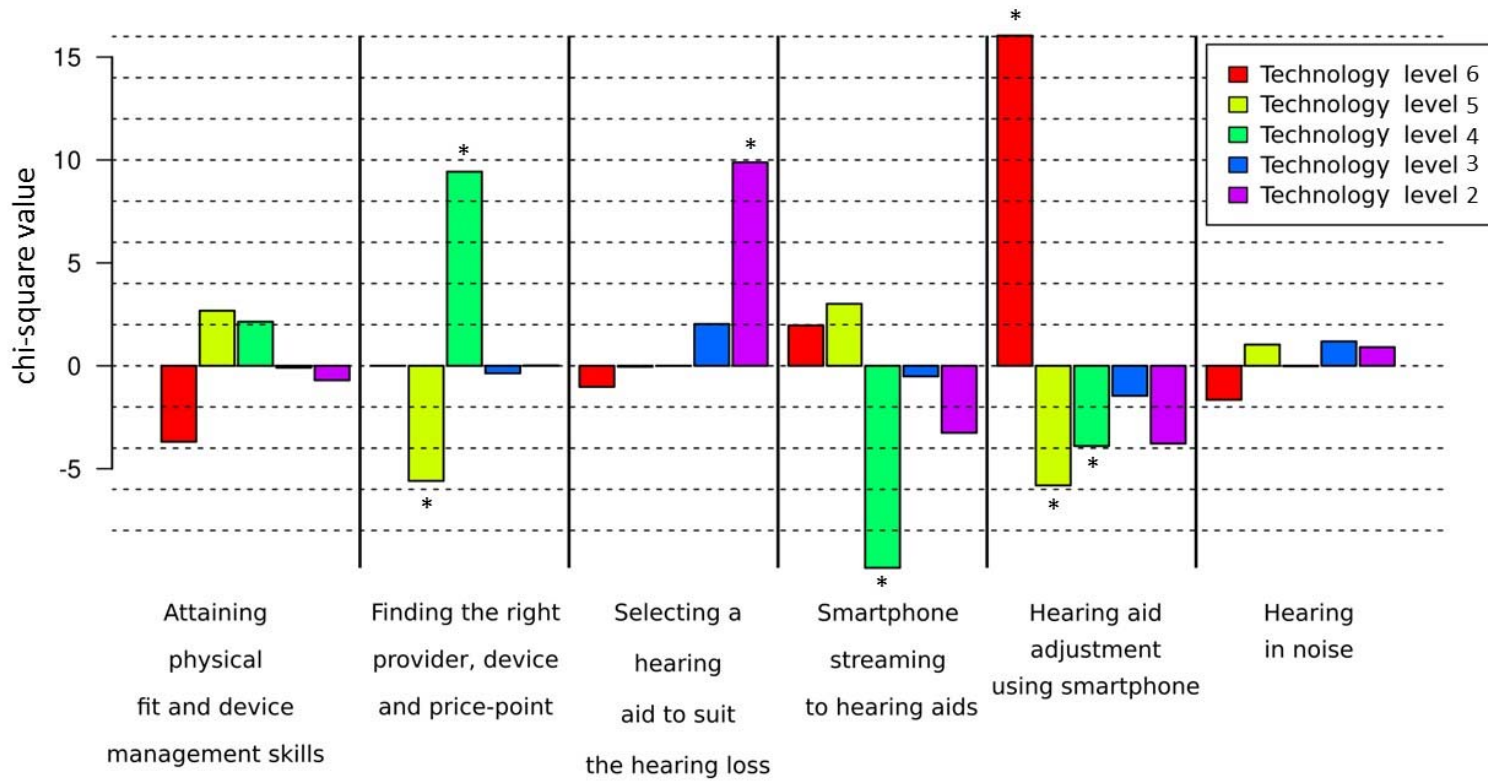


Figure 4: Association between cluster and hearing aid brand based on Chi-square analysis. Bars going up represents overrepresentation of hearing aid brands in each cluster and bars going down represent underrepresentation.

* denotes significant association.

