

# Hearing Aid Consumer Reviews: A Linguistic Analysis in Relation to Benefit and Satisfaction Ratings

Vinaya Manchaiah,<sup>1,2</sup> De Wet Swanepoel,<sup>3,4,5</sup> Abram Bailey<sup>6</sup> & James W. Pennebaker<sup>7</sup> & Rebecca J. Bennett<sup>4,5</sup>

1. Department of Speech and Hearing Sciences, Lamar University, Beaumont, Texas, United States
2. Department of Speech and Hearing, School of Allied Health Sciences, Manipal University, Manipal, Karnataka, India
3. Department of Speech-Language Pathology and Audiology, University of Pretoria, Gauteng, South Africa
4. Ear Science Institute Australia, Subiaco, Western Australia, Australia
5. Ear Sciences Centre, School of Surgery, The University of Western Australia, Nedlands
6. Hearing Tracker Inc, Austin, TX
7. Department of Psychology, University of Texas at Austin, Austin, Texas

**Corresponding author:** Dr. Vinaya Manchaiah

**Communication address:** Department of Speech and Hearing Sciences,  
Lamar University, Beaumont, Texas 77710, USA

**Email:** [vinaya.manchaiah@lamar.edu](mailto:vinaya.manchaiah@lamar.edu)

**Tel:** +1 (409) 880 8927

**Fax:** +1 (409) 880 2265

## Conflict of Interest

Dr. Abram Bailey is the CEO of HearingTracker.com. Prof. James Pennebaker is the inventor of LIWC software. No conflicts were declared from remaining authors.

## **Funding**

No funding was received for this work.

## **Abstract**

**Purpose:** Online reviews have been used by hearing aid owners to share their experiences and to provide suggestions to potential hearing aid buyers, although they have not been systematically examined. The study was aimed at examining the hearing aid consumer reviews using automated linguistic analysis, and how the linguistic variables relate to self-reported hearing aid benefit and satisfaction ratings.

**Method:** The study used a cross-sectional design. 1,378 consumer hearing aid reviews (i.e., text response to open-ended question), self-reported benefit and satisfaction ratings on hearing aids in a 5-point scale with meta-data (e.g., hearing aid brand, technology level) extracted from the HearingTracker website were analyzed using automated text analysis method known as the Linguistic Inquiry Word Count (LIWC).

**Results:** Self-reported hearing aid benefit and satisfaction ratings were high (i.e., mean rating of 4.04 in a 5-point scale). Examining the association between overall rating and the key linguistic variables point to two broad findings. First, the more people were personally, socially, and emotionally engaged with the hearing device experience, the higher they rated their hearing device(s). Second, a minimal occurrence of clinic-visit language dimensions points to factors that likely affect benefit and satisfaction ratings. For example, if people mention paying too much money (money) their overall ratings are generally lower. Conversely, if people write about their health or home, the ratings were higher. There was no significant difference in linguistic analysis across different hearing aid brands and technology levels.

**Conclusions:** Hearing aid consumers are generally satisfied with their hearing device(s), and their online reviews contain information about social/emotional dimensions as well as clinic-visit related aspects that have bearing towards hearing aid benefit and satisfaction ratings. These results suggest that the natural language used by consumers provide insights on their perceived benefit/satisfaction from their hearing device.

## **Key Words**

Consumer reviews, Hearing aid benefit, Hearing aid satisfaction, Linguistic analysis, Natural language

## **Introduction**

Hearing aid benefit and satisfaction are unique but related constructs. Hearing aid benefit is defined as improvements in hearing function and communication ability as a result of hearing aid use, and is often measured using dimensions such as improvements in hearing, communication, daily life activities and participation, and overall quality of life. Hearing aid satisfaction, in contrast, is defined as a “pleasurable emotional experience as an outcome of an evaluation of performance” (Wong et al., 2003, p. 117). Hearing aid performance and self-reported benefit and satisfaction from hearing aids vary widely across users (Lopez-Poveda et al., 2017; Picou, 2020).

In most countries, insights about hearing aid benefit and satisfaction in clinical settings is obtained simply by asking patients and their significant others informal questions such as “What do you think about your hearing aids?” However, researchers and in some cases, clinicians required to demonstrate success, often use standardized self-reported outcome measures such as

International Outcome Inventory for Hearing Aids (IOI-HA; Cox & Alexander, 2002) or Satisfaction with Amplification in Daily Life (SADL; Cox & Alexander, 1999) to determine hearing aid benefit and satisfaction from the desired population. In addition, large-scale surveys such as MarkeTrak and EuroTrak have reported hearing aid satisfaction across representative populations in the U.S. and Europe over time ( Hougaard & Ruf, 201; Kochkin, 2014). The clinical studies provide insights on hearing aid satisfaction in local populations, whereas these large-scale surveys provide valuable insights on larger representative populations.

Whilst these two methods complement each other (Humes et al., 2002) there are key issues with currently used hearing aid benefit and satisfaction measures (Wong et al. 2003). First, items measured in the structured questionnaires may not be important to persons concerned and may not be applicable to all hearing aid users. Second, the structured questionnaires generally measure satisfaction on a continuum (e.g., “very satisfied” to “very dissatisfied”), although satisfaction may not be an antonym of dissatisfaction as elements of satisfaction and dissatisfaction may coexist. Third, not all users may have evaluated the dimensions to which questions are targeted, which questions the reliability of their response to some items. Fourth, neutral and nonresponses has been reported to be common in hearing aid satisfaction ratings making it problematic to interpret the results (Kochkin, 2000). Finally, many satisfaction measures are not sufficiently sensitive and often lead to ceiling effect (Dillion et al., 1999).

Hearing aid benefit and satisfaction have been examined in relation to various intrinsic factors (i.e., factors that are inherent to the hearing instrument user such as age, gender, hearing loss, hearing aid experience, expectation, attitude and personality, hearing aid usage) and extrinsic

factors (e.g., type of instrument, listening situation, sound quality, problems, counseling). In general, hearing aid benefit and satisfaction have been found to be related to experience, expectation, personality and attitude, usage, type of hearing aids, sound quality, listening situations, and problems in hearing aid use (Kozlowski et al., 2017; Wong et al., 2003), although there is a lot of inconsistency in the literature. Wong et al. (2003) suggests that the possible reasons for the inconsistent findings across studies and difficulties in evaluating the underlying relationships are probably caused by problems with the tools (e.g., lack of validity) and the methods used to evaluate relationships. Since satisfaction is an emotional experience it is highly driven by what the users consider to be important and could be unique to individual users. However, in clinical studies and large-scale surveys the questions that are used to measure satisfaction are developed by clinicians/researcher and are standardized across users. One possible solution is to use open-ended questions to illicit responses that are self-relevant (i.e., most important) to individuals (Wong et al., 2003).

In recent years, it is common for hearing aid users to leave independent and anonymous feedback about their hearing aid experience on various consumer forums (e.g., HearingTracker, Amazon). This usually includes some kind of quantitative rating (e.g., rating in a 5-point scale) in addition to open-text describing perceived benefits and limitations with their device, description of their use and experience, and possible recommendations. Such reports have several advantages since users can focus on elements that are important to them rather than answering questions that were determined by a clinician or researcher. Moreover, as the reviews are written at their own volition the views expressed may be more independent than self-reported measures completed at a clinician's request. Therefore, examining publicly available large-secondary data to understand

the hearing aid benefit and satisfaction from consumer perspectives hold potential to inform clinical care (Manchaiah, Amlani et al., 2019).

Hearing aid owners use natural language when they describe their experiences with their device(s) in online forums that can be evaluated using various qualitative and quantitative methods. In the last few decades there has been tremendous progress in the use of natural language to understand the various psychological dimensions including personalities, individual differences, social processes, and even their mental health—all through the words that people write and speak (Boyd, 2017; Pennebaker & Graybeal, 2001; Tausczik & Pennebaker, 2010). By using modern automated text analysis methods, it is now possible to quickly and accurately extract information about various social, psychological and cognitive processes. In the area of hearing healthcare, there have been some attempts to examine the natural language to gain insights from users' narratives. For example, Manchaiah et al. (2018) used automated text analysis methods to understand the representation about tinnitus in the U.S. newspaper media and in Facebook pages. Kimball et al. (2019) examined the emotional tone and verbal behavior of social media users who self-identified as having tinnitus and/or hyperacusis using automated textual analysis. In another study, Manchaiah, Amlani et al. (2019) analyzed the large text corpus of secondary data generated from Amazon.com customer reviews using automated text pattern analysis methods to understand the benefits and shortcomings of direct-to-consumer hearing devices. The Manchaiah et al. (2018) and Manchaiah, Amlani et al. (2019) studies used cluster analysis to examine the main themes within the textual data, whereas the Kimball et al. (2019) study used the Linguistic Inquiry and Word Count (LIWC) to examine the psychological and social processes within the textual data. These studies using consumer-generated information

belong to an emerging area of study called “consumer health informatics” (i.e., field devoted to informatics from multiple consumer or patient views) and provide consumer points of view (Eysenbach, 2002, 2009, 2011). More recently, Manchaiah et al. (2021) have also applied LIWC to examine psychologically meaningful language dimensions within online consumer reviews on hearing healthcare services. We believe that such an approach can be applied to hearing aid consumer reviews to gain unique insights about the consumer experience of hearing aid benefit and satisfaction. For this reason, we extracted hearing aid reviews and applied various natural language processing techniques. In the first instance, we applied topic modelling approach to examine the key themes in the hearing aid reviews which has been presented in our recent manuscript (Bennett et al., 2021). Following this, we applied LIWC approach to examine psychologically meaningful dimensions in hearing aid reviews which is presented in the current manuscript.

The aim of the current study was to examine hearing aid consumer reviews using automated linguistic analysis and to examine how the text relates to self-reported hearing aid benefit and satisfaction ratings. Specific objectives included (a) evaluating the linguistic aspects (i.e., social and emotional dimensions, visit-related issues) of hearing aid consumer reviews (i.e., text responses to open-ended questions) using the LIWC analysis, (b) examine the relationship between linguistic aspects of the consumer reviews and self-reported benefit and satisfaction towards hearing aids (i.e., ratings for structured questionnaire in a 5-point scale), and (c) examine if the linguistic aspects of consumer reviews vary across hearing aid categories in terms of hearing aid brand and technology levels.

## **Method**

### **Study Design**

This study used a cross-sectional design. Consumer reviews about hearing aids (i.e., text responses to open-ended questions), self-reported hearing aid benefit and satisfaction ratings (ratings on a 5-point scale) were analyzed with meta-data (i.e., hearing aid brand, hearing aid technology level). No ethical approval is required as the data was anonymous and no personally identifiable information was included (Ainscough, et al., 2018; Eysenbach & Till, 2001).

### **Data Extraction**

The data was extracted from the Hearing Tracker website (Hearing Tracker, 2021). The Hearing Tracker website collects consumer reviews on hearing aids wherein users provide some demographic data (i.e., unilateral vs bilateral hearing aid use, duration of hearing aid use) and also complete a structured and open-ended questionnaire about their hearing aid experiences. The structured questionnaire has 10-items focusing on benefit (e.g., hearing speech in quiet, hearing speech in noise, improved hearing) and satisfaction (i.e., clear and natural sound, comfortable, reliable) which are rated on a 5-point scale. The open-ended question prompts the consumers (i.e., hearing aid owners) to provide a description of their hearing aid experience using the open-ended question “How are things going with your hearing aid(s)?”

The Hearing Tracker website provides information to consumers about the features and functionalities of most of the current hearing aid models. The website contains a long list of hearing providers and hearing aids, with patient reviews of both. In addition, the website also provides up-to-date news about hearing technologies to consumers. It is likely that the consumers



who are seeking information about hearing aids will find the website through search engine results. Moreover, many consumers have signed up to be on the mailing list of the Hearing Tracker website. However, it is noteworthy that the Hearing Tracker website does not solicit these reviews, and the reviews are left at the consumer's own will.

Hearing Tracker classifies the hearing aids based on brand (8 categories: Phonak=1, Oticon=2, Starkey=3, Widex=4, Siemens=5, Unitron=6, ReSound=7, All Other=8) and hearing aid technology level (1 = Lowest level technology, 6 = Highest level technology). The user rating for the 10-item structured questions were averaged to arrive at an overall rating.

Two thousand three hundred fifty-two individual consumer reviews and their hearing aid meta-data were downloaded. 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. The remaining 1,378 reviews were included in the analysis.

### **Linguistic Analysis of Textual Responses to Open-ended Question**

The LIWC2015 software program (Pennebaker et al., 2015) was used to analyze the open-ended hearing aid reviews. LIWC uses a word count strategy whereby it searches for about 6,400 words or word stems within any given text file. The search words have previously been categorized by independent judges into about 90 language dimensions. These dimensions include standard language categories (e.g., articles, prepositions), psychological processes (e.g., positive and negative emotion categories), etc. After counting the number of words within any given text for each of these categories, the output converts the raw counts to percentage of total words. LIWC

has high internal reliability and external validity (Pennebaker et al., 2015) and has been validated in hundreds of studies (for a review, see Tausczik & Pennebaker, 2010). In addition, although the word counting approach such as LIWC ignores things like context and intended audience, it is still reported to provide surprisingly clear insights into a person's psychology (Boyd, 2017). In the current study, 12 key linguistic variables (see Table 1) which were identified by the research team were included for further analysis.

**Table 1: Key linguistic analyses variables and its descriptions**

<b>Dimension</b>	<b>Importance</b>
Word count	The degree to which users engage in the topic by providing descriptions of their views and experiences to an open-ended question.
Authenticity	An algorithm based on a series of deception studies the correlates with the language of telling the truth (Newman et al., 2003).
<b>Social and emotional dimensions</b>	
Social processes	The degree to which users are thinking about and referring to other people.
I-words	I-words (I, me, my) are used when people are looking inward and being self-reflective and correlate with honesty, anxiety, and self-consciousness.
Positive emotions	The degree to which people express positive emotions.
Negative emotions	The degree to which people express negative emotions.
<b>Clinic-visit related issues</b>	
Hearing	The degree to which users talking about their hearing.
Health	The degree to which users talking about their health.
Time awareness	The degree to which users talk about time which could relate to they having to wait to see a hearing healthcare professional, get their hearing aids, etc.
Money	The degree to which users refer to money.
Work	The degree to which users refer to work.
Home	The degree to which users refer to issues surrounding their home or home life.

## Data Analyses

SPSS software was used for statistical analyses. The data were examined using descriptive statistics. Pearson's correlation was performed to examine the correlation between overall user rating and the linguistic analysis variables. One-way analysis of variance (ANOVA) was performed to examine the difference in each of the linguistic analysis variables among hearing aid brand categories and technology levels. A  $p$ -value of 0.05 was used for statistical significance interpretations.

**Table 2: Hearing aid category based on brand and technology levels**

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
Technology levels		
▪ 1 = Lowest	0	0
▪ 2	25	1.8
▪ 3	61	4.4
▪ 4	154	11.2
▪ 5	190	13.8
▪ 6 = Highest	948	68.8

## Results

### Consumer Review Characteristics

The study included a total of 1,378 hearing aid reviews. Of these, 1,274 (92.5%) were provided by bilateral hearing aid owners and the remaining 104 (i.e., 7.5%) were provided by unilateral hearing aid owners. The hearing aid users tended to own hearing aids with higher technology levels (see Table 2). The average hearing aid use in the current sample was 4.8 (SD 4.1) years.

**Table 3: Self-reported hearing aid benefit and satisfaction ratings (1-5 rating; 1= lowest and 5= highest score)**

Item	Rating in a 5-point scale	
	Mean (SD)	95% CI
1. How much does your hearing aid help you to hear <b>speech in quiet</b> environments?	4.3 (0.85)	4.29 – 4.38
2. How much does your hearing aid help you to hear <b>speech in noisy situations</b> (restaurants, crowds, etc)?	3.67 (1.1)	3.61 – 3.73
3. How much does your hearing aid help you to hear <b>speech on the phone</b> ?	3.85 (1.1)	3.79 – 3.91
4. How <b>clear and natural</b> is sound while wearing your hearing aid?	4.14 (1.0)	4.09 – 4.19
5. How much does your hearing aid improve your <b>hearing for music</b> ?	3.86 (1.1)	3.81 – 3.92
6. How <b>comfortable</b> is the hearing aid?	4.31 (0.9)	4.26 – 4.36
7. How <b>reliable</b> is the hearing aid?	4.05 (1.2)	3.99 – 4.12
8. Does the hearing aid do a good job of <b>stopping unwanted feedback</b> (buzzing and whistling)?	4.08 (1.1)	4.02 – 4.14
9. How much does the hearing aid <b>improve your hearing</b> ?	4.24 (0.9)	4.20 – 4.29
10. How would you rate the <b>value of your hearing aid</b> ?	3.89 (1.2)	3.83 – 3.96
Overall rating (derived from 10-items listed above)	4.04 (0.8)	4.0 – 4.09

### **Self-reported Hearing Aid Benefit and Satisfaction Ratings**

Self-reported hearing aid benefit and satisfaction was rated on a 10-items questionnaire, using a 5-point Likert scale (higher value representing more benefit and satisfaction). The mean ratings ranged between 3.67 (item 2 – hearing in the presence of background noise) to 4.31 (item 6 – comfortable) as illustrated in Table 3. The mean overall rating derived from these items was 4.04 (SD 0.8) suggesting favorable ratings towards hearing aids overall.

### **Linguistic Analyses of Textual Response to Open-ended Question**

The open-ended text from the 1,378 reviews included a total of 114,381 words. Table 4 presents the results of linguistic analyses for hearing aid reviews, normative value for text analyses of normal blogger, and also the correlation between linguistic analyses variables for hearing aids and the overall ratings of hearing aid benefit and satisfaction. The mean number of words was 83 (SD=135.5) suggesting that users were generally engaged with the topic and provided sufficient textual information when leaving reviews on their hearing aids. The mean value for authenticity was 58.35 which is comparable to authenticity ratings of a normal blogger (i.e., mean value of 60.93) or in most text sample (i.e., mean value of 50) suggesting that hearing aid consumer generally provide authentic reports about their experiences.

Examining the social and emotional dimensions suggest that hearing aid reviews very high positive emotions, very low negative emotions, and comparable social process and I-words when compared to typical bloggers. In terms of visit-related issues, as expected hearing aid reviews contain more description about their health and hearing, but comparable descriptions about other aspects (i.e., time awareness, money, time, home) when compared to typical bloggers.

**Table 4: Descriptive statistics of key linguistic analyses variables and its correlation with overall hearing aid benefit and satisfaction ratings. Mean values of linguistic variables for a typical blogger (taken from LIWC handbook; Pennebaker et al., 2015) are reported for comparison.**

<b>Dimension</b>	<b>Normal blogger, Mean</b>	<b>Mean (SD), 95% CI</b>	<b>Correlation with overall rating</b>
<b>Word count</b>	3,206.45	83.01 (135.5), 75.8 to 90.2	.01
<b>Authenticity</b>	60.93	58.35 (34), 56.5 to 60.2	-.04
<b>Social and emotional dimensions</b>			
Social processes	8.95	8.42 (7.5), 8 to 8.8	.09**
I-words	6.26	6.83 (5.5), 6.5 to 7.1	.13**
Positive emotions	3.66	9.08 (16.3), 8.2 to 9.9	.1**
Negative emotions	2.06	1.63 (9.1), 1.5 to 1.8	-.21**
<b>Clinic-visit related issues</b>			
Hearing	0.75	5.4 (5.7), 5.1 to 5.7	.04
Health	0.61	1.76 (3.2), 1.6 to 1.9	.09**
Time awareness	5.86	5.16 (4.9), 4.9 to 5.4	-.05
Money	0.59	0.72 (2.2), 0.6 to 0.8	-.12**
Work	2.04	2.29 (7), 1.9 to 2.6	.04
Home	0.49	0.19 (1.1), 0.1 to 0.2	.05*

Note: \*= $p$ -value of 0.05; \*\*= $p$ -value of 0.01.

The association between linguistic analyses variables and overall hearing aid benefit and satisfaction rating was examined using Pearson's correlation (see Table 4). Social processes ( $p < .01$ ), I-words ( $p < .01$ ), positive emotions ( $p < .01$ ), health ( $p < .01$ ), and home ( $p < .05$ ) were positively correlated with overall benefit and satisfaction ratings. Negative emotions ( $p < .01$ ) and also money ( $p < .01$ ) were negatively correlated with overall benefit and satisfaction ratings.

### **Linguistic Analyses Variables Across Hearing Aid Categories**

In the ANOVA, variables positive emotions ( $F=2.3, p=0.025$ ) and negative emotions ( $F=2.4, p=0.021$ ) had significant difference between hearing aid brands. Bonferroni post-hoc pairwise comparisons showed no significant differences among brand categories for positive emotions. For negative emotions, the only significant difference was found between brand categories Phonak and Widex (Mean difference=-1.2,  $p=0.008$ ). When examining the difference in linguistic variables among hearing aid technology levels, variables social processes ( $F=4.4, p=0.002$ ) and money ( $F=2.6, p=0.033$ ) had significant difference between hearing aid technology levels. In post-hoc analyses, significant differences were found between technology levels “very high” and “low” (Mean difference=-3.5,  $p=0.004$ ). No significant differences in technology levels were found for money in pairwise comparisons. However, as there was no linear association between technology level and social processes, the results are not meaningful in the broader context. Overall, these results indicate that linguistic analyses variables did not differ much between hearing aid categories based on brand and technology levels.

### **Discussion**

In recent years, an increasing number of hearing aid owners leave consumer reviews about their hearing aids in various online forums; doing so using their natural language. The benefit of natural language is that it “is considered as the most common and reliable way for people to translate their internal thoughts and emotions into a form that others can understand” (Tausczik & Pennebaker, 2010, pp. 25). Thus, the textual response of hearing aid consumer reviews can provide insights into the lived experiences of adult hearing aid owners regarding their acquisition and use of hearing aids. In the current study, the consumer health informatics approach was

taken to examine the hearing aid reviews and its relation to self-reported hearing aid benefit and satisfaction.

Self-reported hearing aid benefit and satisfaction were measured across 10-item and the overall rating based on the 10-items were derived. The dimensions in the questionnaire corresponded broadly to those measured by well-regarded clinical outcome measures, including the SADL (e.g., Bertoli et al., 2009; Kozlowski et al., 2017) and IOI-HA (Cox & Alexander, 2002), as well as large-scale population surveys such as MarkeTrak and EuroTrack which have reported high satisfaction of hearing aid users (Hougaard & Ruf, 2011; Kochkin, 2014; Picou, 2020). In line with studies reporting use of these surveys on large cohorts, our results demonstrate that in general, hearing aid owners self-report highly positive outcomes from the hearing aids.

Nonetheless, individuals do also report some negative experience (Bennett et al, 2020) that appear to impact on their self-perceived overall outcomes ratings (Bennett et al. 2018). However, negative experiences are relatively minor as reported in a recent study (Manchaiah, Abrams et al., 2019) and hearing aid users are generally satisfied with their device.

The linguistic analyses of hearing aid consumer reviews performed using the LIWC software maps words to categories (e.g., “positive emotions” category contain words such as happy, excited, thrilled, love, nice) and presents percentage of words across various dimensions of interest. This basic word counting approach is found to produce reliable and useful results about persons psychological state (i.e., thoughts, emotions, and behaviors) in relation to the topic of interest (for review see Tausczik & Pennebaker, 2010; Boyd, 2017). Examination of linguistic variables in the current study suggest that users were generally engaged with the topic (based on



word count) and provide reliable reports (based on authenticity) about the hearing aid experiences. Moreover, the hearing aid reviews were found to be written with honesty (higher use of I-words), higher positive emotions, lower negative emotions, included more information on a few visit-related factors such as health, hearing, and money when compared to typical bloggers. These results suggest that consumer reviews on hearing aids are generally reliable, honest and includes higher positive emotions that suggest higher benefit and satisfaction from hearing aids (Hougaard & Ruf, 2011; Kochkin, 2014; Picou, 2020).

The correlation analysis between overall benefit and satisfaction rating and the linguistic analyses variables point to two broad findings. First, the more that people are personally (I-words), socially (social processes), and emotionally engaged (positive and negative emotions) with the clinic-visit, the higher the ratings. Also, higher ratings were apparent when people used high rates of positive emotion and low rates of negative emotion words. Second, a small number of clinic-visit language dimensions point to factors that likely affect ratings. For example, if people talk about paying too much money (money) their overall ratings are generally lower. Conversely, if people write about their health or home, the ratings were higher. Audiological literature suggest that hearing aid benefit and satisfaction are related to various psychological factors such as experience, expectation, personality and attitude of the individual (Kozlowski et al., 2017; Wong et al., 2003). In addition, hearing aid use has also been reported to bring various psychosocial benefits such as reduced loneliness and depression, higher cognitive function, higher life satisfaction, and improved functional health status (Acar et al., 2011; Ferguson et al., 2017; Weinstein et al., 2016). The current study adds to existing literature by pointing out that

social and emotional dimensions as well as clinic-visit related issues may have bearing towards hearing aid benefit and satisfaction.

Finally, the current study results suggest that there is no difference in linguistic analyses variables across hearing aid categories based on hearing aid brand and technology levels. These results are consistent with previous study by Faraji-Khiavi et al. (2016) who noted that hearing aid users were typically satisfied with their device irrespective of the technology and style. Previous studies also demonstrated no significant difference in hearing aid outcome between basic-feature versus premium-feature hearing aids (Cox et al., 2016; Johnson et al., 2016, 2017). These results are interesting as hearing aid manufacturers advertise their technology to be superior to others in the market although such claims are not supported by research evidence (Cox et al., 2016; Faraji-Khiavi et al., 2016; Johnson et al., 2016, 2017).

### **Study Implications**

The current study has various theoretical and clinical implications. Using natural language to understand self-reported hearing aid outcomes is novel in its methodology and this approach can supplement the knowledge gained from clinical studies and large-scale surveys such as MarkeTrak and EuroTrak. Responses to open-ended question may highlight aspects that are considered important from the patient or consumers and may help overcome some of the caveats of structured benefit and satisfaction measures highlighted earlier (Wong et al., 2003). Also, as the reviews are generally self-initiated without the prompts from clinicians or researchers, the ecological validity of the data can be considered high. In future, more hearing aid users are likely to both write online reviews and use others reviews in decision making about hearing aid

purchase. As the hearing aid research especially about new features and functionalities typically takes several years before appearing in peer-reviewed journals, clinicians and researchers could gain rapid insights on new features and functionalities by analyzing the consumer reviews using automated textual analyses methods. The knowledge gained through these methods can help clinicians in addressing important issues related to hearing aids during hearing rehabilitation. In addition, hearing instruments manufacturers can take note of important issues from the user perspective when developing, designing, and modifying hearing aid design, features and functionalities.

### **Study Limitations and Future Directions**

The current study is the first of its kind to use online consumer reviews to examine hearing aid owner's views and also self-reported benefit and satisfaction towards their hearing aids.

However, this exploratory study has several limitations. First, there is a high possibility of sampling bias as those who leave reviews online may be the ones who had more online presence and also those who are likely to be more comfortable with technology. Also, the spread of hearing aid brands and technology levels (69% of the current sample owned most expensive hearing aids) may not be representative of the U.S. hearing air market. Second, there are some concerns that consumer reviews generated online to include some fake reviews. However, having authenticity values of the text comparable to a typical blogger suggest that the reviews are reliable, although we cannot exclude the possibility of some fake reviews. Third, the review provided by users at a moment in time. It is likely that the users left the reviews when they felt the urge to write reviews (e.g., when they are exceptionally happy or exceptionally disgruntled) and the reviews provide may have some bias. Forth, the study had limited extrinsic and intrinsic

factors related to hearing aid users who provided the reviews. Fifth, the linguistic analyses using the LIWC software ignores important aspects such as context, irony, sarcasm, and idioms (Tausczik & Pennebaker, 2010), although this method has found to be very powerful in providing insights to person's psychology (Boyd, 2017). For these reasons, the study results should be viewed with caution. Replicating this study by drawing more representative sample by recruiting participants from the clinical setting, gathering key demographic and audiological data from hearing aid users, and also gathering data using standardized self-reported measures which can be correlated with the linguistic analyses variables could provide results that are more clinically meaningful and are generalizable. Moreover, more work is needed to validate this methodology specifically for examining hearing aid experiences.

## **Acknowledgements**

The authors would like to thank Ms. Kimberly Boase for assistance with data formatting.

The authors report no conflicts of interest.

## **References**

- Acar, B., Yurekli, M. F., Babademez, M. A., Karabulut, H., & Karasen, R. M. (2011). Effects of hearing aids on cognitive functions and depressive signs in elderly people. *Archives of Gerontology and Geriatrics*, 52(3), 250–252.  
<https://doi.org/10.1016/j.archger.2010.04.013>
- Ainscough, E., Smith, S. N., Greenwell, K., & Hoare, D. J. (2018). Findings and ethical considerations from a thematic analysis of threads within tinnitus online support groups.

- American Journal of Audiology*, 27(3S), 503–512. [https://doi.org/10.1044/2018\\_ajimia3-18-0013](https://doi.org/10.1044/2018_ajimia3-18-0013)
- Bennett, R. J., Kosovich, E. M., Stegeman, I., Ebrahimi-Madiseh, A., Tegg-Quinn, S., & Eikelboom, R. H. (2020). Investigating the prevalence and impact of device-related problems associated with hearing aid use. *International Journal of Audiology*, 59(8), 615–623. <https://doi.org/10.1080/14992027.2020.1731615>
- Bennett, R. J., Meyer, C. J., Eikelboom, R. H., Atlas, J. D., & Atlas, M. D. (2018). Factors associated with self-reported hearing aid management skills and knowledge. *American Journal of Audiology*, 27(4), 604–613. [https://doi.org/10.1044/2018\\_aja-18-0053](https://doi.org/10.1044/2018_aja-18-0053)
- Bennett, R., Swanepoel, D.W., Ratinaud, P., Bailey, A., Pennebaker, J.W., & Manchaiah, V. (Submitted). Hearing aid acquisition and ownership: What can we learn from online consumer reviews?
- Bertoli, S., Staehelin, K., Zemp, E., Schindler, C., Bodmer, D., & Probst, R. (2009). Survey on hearing aid use and satisfaction in Switzerland and their determinants. *International Journal of Audiology*, 48(4), 183–195. <https://doi.org/10.1080/14992020802572627>
- Boyd R.L. (2017) Psychological text analysis in the digital humanities. In: Hai-Jew S. (Eds.) *Data Analytics in digital humanities: Multimedia systems and applications*. (pp. 161-189). Springer International Publishing. <https://doi.org/10.1007/978-3-319-54499-1>
- Cox, R. M., & Alexander, G. C. (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., & Alexander, G. C. (2002). The International Outcome Inventory for Hearing Aids (IOI-HA): Psychometric properties of the English version. *International Journal of Audiology, 41*(1), 30–35. <https://doi.org/10.3109/14992020209101309>
- Cox, R. M., Johnson, J. A., & Xu, J. (2016). Impact of hearing aid technology on outcomes in daily life I: The patient's perspective. *Ear and Hearing, 37*(4), e224–e237. <https://doi.org/10.1097/aud.0000000000000277>
- Dillon, H., Birtles, G., & Lovegrove, R. (1999). Measuring the out- comes of a national rehabilitation program: Normative data for the Client Oriented Scale of Improvement (COSI) and the Hearing Aid User's Questionnaire. *Journal of the American Academy of Audiology, 10*, 67-79.
- Eysenbach, G. (2002). Infodemiology: The epidemiology of (mis)information. *The American Journal of Medicine, 113*(9), 763–765. [https://doi.org/10.1016/s0002-9343\(02\)01473-0](https://doi.org/10.1016/s0002-9343(02)01473-0)
- Eysenbach, G. (2009). Infodemiology and infoveillance: Framework for an emerging set of public health informatics methods to analyze search, communication and publication behavior on the internet. *Journal of Medical Internet Research, 11*(1), e11. <https://doi.org/10.2196/jmir.1157>
- Eysenbach, G. (2011). Infodemiology and infoveillance tracking online health information and cyberbehavior for public health. *American Journal of Preventive Medicine, 40*(5), S154–S158. <https://doi.org/10.1016/j.amepre.2011.02.006>
- Eysenbach, G., & Till, J. E. (2001). Ethical issues in qualitative research on internet communities. *BMJ, 323*(7321), 1103–1105. <https://doi.org/10.1136/bmj.323.7321.1103>

- Faraji-Khiavi, F., Dashti, R., Sameni, S. J., & Bayat, A. (2016). Satisfaction with hearing aids based on technology and style among hearing impaired persons. *Iranian Journal of Otorhinolaryngology*, 28(88), 321–327.
- Ferguson, M. A., Kitterick, P. T., Chong, L. Y., Edmondson-Jones, M., Barker, F., & Hoare, D. J. (2017). Hearing aids for mild to moderate hearing loss in adults. *Cochrane Database of Systematic Reviews*, 9(9). <https://doi.org/10.1002/14651858.cd012023.pub2>
- Hearing Tracker. (2021). *Consumer reviews for hearing aids*. Retrieved from: <https://www.hearingtracker.com/> (accessed on May 10, 2021).
- Hougaard, S. & Ruf, S. (2011). EuroTrak I: A consumer survey about hearing aids in Germany, France, and the UK. *The Hearing Review*. 18(2), 12-28.  
<https://www.hearingreview.com/hearing-products/eurotrak-i-a-consumer-survey-about-hearing-aids-in-germany-france-and-the-uk>
- Humes, L. E., Wilson, D. L., Humes, L., Barlow, N. N., Garner, C. B., & Amos, N. (2002). A comparison of two measures of hearing aid satisfaction in a group of elderly hearing aid wearers. *Ear and Hearing*, 23(5), 422–427. <https://doi.org/10.1097/00003446-200210000-00004>
- Johnson, J. A., Xu, J., & Cox, R. M. (2016). Impact of hearing aid technology on outcomes in daily life II: Speech understanding and listening effort. *Ear and Hearing*, 37(5), 529–540. <https://doi.org/10.1097/aud.0000000000000327>
- Johnson, J. A., Xu, J., & Cox, R. M. (2017). Impact of hearing aid technology on outcomes in daily life III: Localization. *Ear and Hearing*, 38(6), 746–759. <https://doi.org/10.1097/aud.0000000000000473>

- Kimball, S. H., Hamilton, T., Benear, E., & Baldwin, J. (2019). Determining emotional tone and verbal behavior in patients with tinnitus and hyperacusis: An exploratory mixed-methods study. *American Journal of Audiology*, 28(3), 660–672. [https://doi.org/10.1044/2019\\_aja-18-0136](https://doi.org/10.1044/2019_aja-18-0136)
- Kochkin S. (2000). MarkeTrak V: Consumer satisfaction revisited. *Hear Journal*, 53(1), 38, 40, 42, 45, 46, 50, 52, 55.  
[https://www.betterhearing.org/HIA/assets/File/public/marketrak/MarkeTrak\\_V\\_Customer\\_Satisfaction\\_Revisited.PDF](https://www.betterhearing.org/HIA/assets/File/public/marketrak/MarkeTrak_V_Customer_Satisfaction_Revisited.PDF)
- Kochkin, S. (2014). A comparison of consumer satisfaction, subjective benefit, and quality of life changes associated with traditional and direct-mail hearing aid use. *The Hearing Review*, 21(1), 16-26. <https://www.hearingreview.com/hearing-products/accessories/earmolds/a-comparison-of-consumer-satisfaction-subjective-benefit-and-quality-of-life-changes-associated-with-traditional-and-direct-mail-hearing-aid-use>
- Kozlowski, L., Almeida, G., Luz, I., & Ribas, A. (2017). Satisfaction of elderly hearing aid users. *International Archives of Otorhinolaryngology*, 21(01), 92–96.  
<https://doi.org/10.1055/s-0036-1579744>
- Lopez-Poveda, E. A., Johannesen, P. T., Pérez-González, P., Blanco, J. L., Kalluri, S., & Edwards, B. (2017). Predictors of hearing-aid outcomes. *Trends in Hearing*, 21, 233121651773052. <https://doi.org/10.1177/2331216517730526>
- Manchaiah, V., Abrams, H., Bailey, A., & Andersson, G. (2019). Negative Side Effects Associated with Hearing Aid Use in Adults with Hearing Loss. *Journal of the American Academy of Audiology*, 30(6). <https://doi.org/10.3766/jaaa.17118>



- Manchaiah, V., Amlani, A. M., Bricker, C. M., Whitfield, C. T., & Ratinaud, P. (2019). Benefits and shortcomings of direct-to-consumer hearing devices: Analysis of large secondary data generated from amazon customer reviews. *Journal of Speech, Language, and Hearing Research, 62*(5), 1506–1516. [https://doi.org/10.1044/2018\\_jslhr-h-18-0370](https://doi.org/10.1044/2018_jslhr-h-18-0370)
- Manchaiah, V., Ratinaud, P., & Andersson, G. (2018). Representation of tinnitus in the US newspaper media and in Facebook pages: Cross-sectional analysis of secondary data. *Interactive Journal of Medical Research, 7*(1), e9. <https://doi.org/10.2196/ijmr.9065>
- Manchaiah, V., Swanepoel, D.W. & Bennett, R.J. (2021). A textual analysis approach to examine psychologically meaningful language dimensions within online consumer reviews on hearing healthcare services. *American Journal of Audiology*, In Press.
- Pennebaker, J. W., Boyd, R. L., Jordan, K., & Blackburn, K. (2015). *The development and psychometric properties of LIWC2015*. Austin: University of Texas at Austin. [https://repositories.lib.utexas.edu/bitstream/handle/2152/31333/LIWC2015\\_LanguageManual.pdf](https://repositories.lib.utexas.edu/bitstream/handle/2152/31333/LIWC2015_LanguageManual.pdf)
- Pennebaker, J. W., & Graybeal, A. (2001). Patterns of natural language use: Disclosure, personality, and social integration. *Current Directions in Psychological Science, 10*(3), 90–93. <https://doi.org/10.1111/1467-8721.00123>
- Picou, E. M. (2020). MarkeTrak 10 (MT10) survey results demonstrate high satisfaction with and benefits from hearing aids. *Seminars in Hearing, 41*(01), 021–036. <https://doi.org/10.1055/s-0040-1701243>
- Tausczik, Y. R., & Pennebaker, J. W. (2010). The psychological meaning of words: LIWC and computerized text analysis methods. *Journal of Language and Social Psychology, 29*(1), 24–54. <https://doi.org/10.1177/0261927x09351676>

Weinstein, B. E., Sirow, L. W., & Moser, S. (2016). Relating hearing aid use to social and emotional loneliness in older adults. *American Journal of Audiology*, 25(1), 54–61.

[https://doi.org/10.1044/2015\\_aja-15-0055](https://doi.org/10.1044/2015_aja-15-0055)

Wong, L. L. N., Hickson, L., & McPherson, B. (2003). Hearing aid satisfaction: What does research from the past 20 years say? *Trends in Amplification*, 7(4), 117–161.

<https://doi.org/10.1177/108471380300700402>