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Audibility, Cost-Acceptibility and Cosmetic Appearance of IQBuds BOOST in Adults Over the Age of 50

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By

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Abstract

Background: Hearing loss affects 48 million Americans and up to 86% of all adults with hearing loss may not wear hearing aids. Untreated hearing loss is associated with social withdrawal, depression, stress, loss of income, and dementia. Even so, people still tend not to buy or wear hearing aids for a variety of reasons. One recently suggested solution to this problem is low-cost, over the counter (OTC) hearing aids, nicknamed "hearables" This study evaluated the audibility, cost-acceptability and cosmetic appearance of one OTC, IQBuds BOOST.

Methods: Fourteen men and 12 women over 50 years with a hearing loss participated in the study. Word recognition testing was conducted by presenting words embedded with a phrase at 40 dBHL through the loudspeakers in four conditions. The participants completed a Visual Analogue Survey, which included listening and non-listening items, once regarding their aided experience and once regarding their everyday listening experience.

Analyses: Speech perception was scored using both the phoneme scoring and word scoring methods. Mixed ANOVAs were performed on the % correct phoneme scores and word scores. The t-test was performed on the average scores of the first 12 items of the Visual Analogue scale. Descriptive statistics were used to report data on the questions related to cost and acceptability of the hearable device.

Results: For both aided and unaided conditions the word and phoneme recognition scores in noise were significantly poorer than those in quiet. The hearable did not improve the word recognition in quiet or noisy backgrounds. Similarly, there were no significant differences in average listening VAS scores with and without the hearable. On a scale of 1 to 100, participants gave higher than 60 scores for questions regarding the comfort, fit and insertion of the hearable. However, the average scores related to willingness to use, cost, and cosmetic appearance were less than 50.

Conclusions: This study suggests that older participants with mild to moderate hearing loss may not benefit from the hearable used in the current study and the appearance of the device may have to be improved.

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INTRODUCTION

Globally, hearing loss is the fourth leading cause of disability (GBD, 2015), with about 466 million people worldwide suffering from disabling hearing loss (World Health Organization,2020). As we progress through time, hearing loss has slowly, yet consistently, continued to increase in prevalence over time in our society. Although hearing loss is one of the leading causes of disability, the majority of adults with hearing loss do not use hearing aids, therefore leaving their hearing loss untreated. In the United States alone, there are approximately 20 million people ages 60 and older who have untreated clinically significant hearing loss (Mamo, Nieman, & Lin, 2016). Another study reports that 48 million Americans have hearing loss, and half of Americans in their 70s experience hearing loss.

Of the millions of people with hearing loss, only 14% wear hearing aids (Warren & Grassley, 2017, Cunningham & Tucci, 2017). Another study reports that 80% of 55-74 year olds who would benefit from hearing aids do not use them (McCormack & Fortnum, 2013, National Academies of Sciences, Engineering, and Medicine). Hearing aids have been the forefront of auditory rehabilitation for decades, and "current hearing aids offer significantly greater flexibility in shaping the frequency gain response, better signal-to-noise ratio, and superior optimization of microphones" (Kaplan-Neeman, Muchnik, Hildesheimer, & Henkin, 2012).

There are several reasons that adults with hearing loss would choose not to wear hearing aids. First, the hearing loss may simply be unknown to the individual, possibly because the loss was gradual, or because the loss is restricted to high frequency sounds that aren't crucial for speech. The person could also be in denial of their loss, resulting from either

the negative stigma associated with hearing aids, fear of negative social consequences, or fear of inadequacy due to aging. (Rawool & Keihl, 2008; Rawool, V. (2018); Jorgensen & Novak, 2020). Hearing aids are also very expensive, typically costing anywhere from $1400 to $2200 (Cunningham & Tucci, 2017). Although this price would seem high to anyone in the working class, it makes obtaining a hearing aid even more difficult for the 6 million adults of low income over the age of 60 with hearing loss (Mamo, Nieman, & Lin, 2016). In addition to the price, other factors that contribute to poor use include negative social stigma about hearing aids, the inconvenience of multiple appointments with hearing healthcare professionals, (Manchaiah et al., 2017; Jilla et al., 2020)

When adults with hearing loss do not consistently wear their rehabilitative devices, usually hearing aids, they suffer in their social relationships, and therefore quality of life. It is known that untreated or poorly treated hearing loss in adults can lead to depression, anxiety, social withdraw, and even lost income (Martin & Clark, 2019; Preminger & Meeks, 2012; Jilla et al., 2020). These factors can contribute to a low-quality social life, which is “associated with cardiovascular disease, high blood pressure, delayed cancer recovery, and slower wound healing”, but “restoring the ability to communicate… may slow down cognitive decline”. (Weinstein, 2015; Rawool & Keihl, 2008). Thus, hearing rehabilitation can greatly increase both physiological and psychological qualities of life. One study done in Korea found that “higher levels of hearing loss were associated with fewer social contacts among older adults” (Shin, Baik, Chung, Heo, & Ha, 2017). Proper hearing rehabilitations can improve relationships, reduce anger and frustration, reduce depression, improve emotional stability, and enhance group social activity (reviewed in Rawool & Keihl, 2008).

One solution to the inconvenience of price and stigma of traditional hearing aids is an over the counter (OTC) version, called personal sound amplification products (PSAPs), nicknamed “hearables”. Hearables, for our study, are defined as hearing aids sold directly to the consumers in retail shops or through the internet, without consultation from an audiologist (Chan, 2015; Callaway & Punch, 2008; Cheng & McPherson, 2000), and “essentially, a functional microcomputer that is small enough to fit in the ear canal and augment the sound to create a more pleasurable listening experience (Lambden & Banks, 2020). These Hearables offer over the counter sound amplification for a fraction of the cost of traditional hearing aids, available for prices starting as low as $10 in some places. Generally, the devices range from $150 to $350. These devices are not marketed to be a replacement for hearing aids, but instead to amplify sound for non-hearing-impaired consumers. These hearables embrace the era of wearable tech, with some even able to connect to the user’s smartphone. Currently, a reported 61 percent of the global population uses a mobile phone, and that number is projected to increase to 79 percent by 2025 (The Mobile Economy, 2019). Growing numbers of smartphone users only increase the accessibility of app-operated hearing devices. Hearables aim to change the stigma of hearing aids, making them into wearable tech instead of a medical device that makes the user different or disabled. “The present use of both headphones and headsets are ubiquitous in daily life … The idea of a person wearing headphones in public places hardly seems out of place, as does the sight of someone apparently talking to themselves while wearing a headset” (Plazak & Kersten-Oertel, 2018). Because these hearables are OTC, they do not require a prescription from a hearing healthcare professional, although it is recommended to consult with an audiologist before wearing. It is also important to

note that in the United States, hearing aids are regulated by the Food and Drug Administration meaning that only licensed healthcare professionals can sell, fit, or distribute hearing aids (Chan & McPherson, 2015). Hearables are not marketed as medical devices, contrary to some FDA approved over the counter aids that have recently hit the market (U.S Food & Drug Administration, 2018). This could be a new era for sound amplification, as today's generations are not limited to the products advertised to them by medical professionals. The wearable tech market opens assistive hearing devices to younger generations of society. Currently, the majority of adults with hearing loss report that they first noticed a hearing problem over 10 years before they seek treatment, usually once they reach their 70's, and consequently are not as able to adapt to and maintain their hearing aids. It has been suggested that hearables could target younger audiences and promote better hearing health, by way of a seemingly fancy earbud, enabling hearing loss management at earlier ages, therefore reducing the negative consequences of untreated hearing loss (Maidment, Barker, Xia, & Ferguson, 2016).

Some examples of hearables currently on the market include the familiar "AirPods Pro" by Apple ($249.00), which are high-quality earphones with noise cancelling technology and a "transparency mode", which is supposed to let you hear the world around you (https://www.apple.com/airpods-pro); "Hint" by Motorola ($19.40), which is marketed as a noise cancelling, voice controlled, wireless bluetooth headset, (https://www.motorola.com/us/products/motorola-hint) ; and "Xpera Ear" by Sony ($64.99), marketed to operate with voice command, have noise suppression, and echo cancellation technology (https://www.sonymobile.com/us/products/smart-products/xperia-ear/#gref).

Another such device is IQBuds Boost by Nuhera (https://www.nuheara.com/). It is promoted as "The world's smartest hearing buds" at their website. We decided to choose this aid for our study due to the following features offered by this device and its relatively reasonable price of $499.00 at the time of purchase. IQBuds BOOST are "Smart, personalized hearing technology" "…allows you to hear what you want to hear." They claim to allow the user to "turn down background noise and amplify conversations" and make "social, dining, and sporting events…more enjoyable" (Best Buy, 2019). It comes with a free app, Ear ID, that claims to have a "clinical grade hearing assessment that automatically calibrates IQbuds BOOST to your unique hearing profile" (www.nuheara.com). For this elective hearing assessment, the user is presented with a series of tones in each ear and asked to respond when they hear the tone. The functionality of the device is not supposed to be affected by the elective use of the Ear ID test, and the device nor app prompted the use of that feature when we began the current research. The app also allows users to change their device settings and change the sound quality they receive through the buds. Different setting on the device claims to turn down background noise and amplify conversation in different ways.

The purpose of this study was to explore the usefulness and acceptance of one of these OTC hearable devices, IQBuds BOOST, as an alternative to traditional hearing aids.

METHODS

This study was approved by the Institution Review Board at the University of Mississippi.

Study Location

The study took place in Oxford, Mississippi at University of Mississippi in the Audiology and Hearing Science research laboratory.

Participants

Twenty-six adults (14 men and 12 women) over the age of 50 with hearing loss at least at one of the test frequencies served as participants. They ranged in age from 50 to 87 years with an average age of 65.42 years. Each participant was offered a gift card of $20 as an incentive to participate except for those participants who were employed by the University of Mississippi and those related to the authors.

Procedures

The IQBuds BOOST device was ordered online from Amazon, and testing for this study began in July 2019. Upon receiving the device, the IQBuds app was downloaded from the app store onto an iPhone. The same iPhone and set of hearables were used for each participant. A set of 11 pairs of reusable IQBuds tips ranging in size (extra-small to extra-large) and material were also purchased for use in the study, so that we could accommodate each participant's unique ear shape and size. A photo of the device and the variety of tips is included in the appendices (Appendix A).

Questionnaires

Three questionnaires were used for this study. The first questionnaire, titled "Screening Step 1: Questionnaire" (Appendix B) is composed of 10 items and was used to gather information about the participant's hearing history and hearing aid history. The second questionnaire, titled "Visual Analog Scale" (Appendix C), was given after the participants completed the tasks. It is composed of 19 questions that ask the participant to evaluate their listening experiences and cost and cosmetic acceptability related to IQBuds using a visual analog scale (VAS) ranging from 0-100 The VAS was adapted from a previously developed questionnaire by Dr. Rawool after a comprehensive review of literature. The previously developed questionnaire was used in a different, unpublished study the third questionnaire, also titled "Visual Analog Scale", was given to the participants at the end of the study, after they completed the VAS above. This questionnaire is a shortened version of the second questionnaire but stops at question 12. It gathers information about how the participants perceive their hearing ability, and their everyday listening experience. All questionnaires are included in the appendices.

Consent

Upon arrival, each participant was asked to complete the consent procedures and complete a short screening questionnaire.

Video-otoscopy and cerumen management

Video-otoscopy was completed, and excess cerumen was removed if necessary.

Auditory Threshold Testing

For auditory threshold testing, the patient was seated in the sound booth and given the following instructions:

"You will be hearing tones/beeps; some are going to be easy to hear, and some are going to be really soft. Some sounds will be high pitched, and some will be lower in pitch. We will test one ear at a time. Please press this button as soon as you hear the tones/beeps and let the button go as soon as the tones/beeps stop. Please pay close attention and respond to any tones/beeps you hear, regardless of how soft they are. Do you have any questions? If you have any questions/concerns during testing or need a break, please feel free to speak. I can hear you from outside the booth."

Warbled tone thresholds were then established at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 5000 Hz, 6000 Hz, and 8000 Hz using headphones as the transducers and a button-press as the response method. The modified Hughson Westlake procedure (Carhart and Jerger 1959, ASHA 1987) was used to determine auditory thresholds (the softest sounds that are audible to the participant) at each frequency. The initial presentation level was always 30 dB HL. In the absence of response at this level, the level was increased by 10 dB untill a response was apparent. After appearance of a response, the level was reduced in 10 dB steps untill a lack of response occurred. After there was no response, the level was increased by 5 dB untill a response occurred. The lowest levels at which two responses were apparent out of three ascending (increasing levels) trials was recorded as the threshold.

Next, the button and headphones were removed from each participant.

Word Recognition Test Procedures:

Selection of Background Noise: We decided to use the Speech-Weighted Noise (Speech Noise) readily available on most of the audiometers. This noise has a spectrum that is similar to conversational speech and thus is an efficient masker of speech sounds.

Test selection: For word recognition testing, we decided to use the Maryland CNC test. This test consists of monosyllables consisting of consonant-nucleus-consonant combination. The monosyllables are from a phonemically balance word list created by Lehiste and Peterson (1959). The authors attempted to balance these lists in such a way that each initial consonant, middle vowel (nucleus) and each final consonant would appear with the same frequency within each list. They later revised their lists to eliminate some rare literary words and proper names (Peterson and Lehiste, 1962). Causey et al (1984) developed the Maryland CNC test by embedding each of the words within the lists developed by Peterson and Lehiste (1962) in the phrase "Say the _____ again" to account for the fact that in everyday conversations words do not occur in isolation. Words occur in the context of sentences and thus are influenced by the effects of coarticulation due to the phonemes that immediately follow or precede them. Causey et al (1984) determined that participants with hearing loss yielded a wide range of scores on the Maryland CNC suggesting the possibility to differentiate among varying degrees of hearing loss. They also concluded that only lists 1, 3, 6, 7, 9, and 10 were equivalent for repeated measurement of word-recognition ability (Causey et al, 1984).

In the current study, we used four Maryland CNC lists in four conditions.

Condition 1: Unaided Quiet:

This condition involved presentation of the first 25 words from the Maryland CNC List 1 at 40 dBHL through loudspeakers angled at 45 degrees on the left and right side of the participant, for this condition, the participant did not wear the IQBuds and was not exposed to background noise. For all tasks involving word recognition, the participants were given following instructions:

You are going to hear a list of words over the loudspeaker. Your job is to repeat the words back to me. The word will come in the phrase "say the _____ again", but you only have to repeat back the word. For example, if you here "say the ball again", you should say "BALL". Do you have any questions?

Condition 2: Unaided Noisy:

This condition involved presentation of Maryland CNC List 7 at 40 dBHL from loudspeakers placed at 45 degrees on the left and right side of the participant. In addition, 40 dBEM speech noise was also introduced through both speakers.

The participant was then given the following instructions:

"Now, we're going to repeat the test again. This time, there will be background noise played, so it might be harder to hear the words. Repeat the words back to me as you hear them and remember that it's okay to take a guess if you're not sure. Do you have any questions?"

Condition 3: Aided Quiet:

For this condition, the researcher entered the booth to insert the IQBuds in the participant's ears. If necessary, the tips were changed to ensure good fit. After the buds were inserted and connected to the phone app and the "Home" setting was selected, the participants were given the opportunity to adjust the volume controls to a comfortable level using the app. The participants were given the same instructions from task 1. The first 25 words from Maryland VA List 3 were presented at 40 dBHL through loudspeakers angled at 45 degrees on the left and right side of the participant.

Condition 4: Aided Noisy:

For this, the researcher presented the speech noise at 40 dBEM through both the loudspeakers and then entered the booth. The IQBuds setting was changed to "Restaurant" on the app and the participant was requested to adjust the volume controls on the app while the researcher talked quietly in the presence of the background noise. The participant was given the same instructions from task 2. The first 25 words from Maryland VA List 6 were presented at 40 dBHL through loudspeakers angled at 45 degrees on the left and right side of the participant along with the background Speech Noise of 40 dBEM.

Music Perception Experience

The participant was then brought out of the sound booth into a quiet room. With the IQBuds still in their ears, each participant listened to "Rocket Man" by Elton John and were instructed to analyze the sound quality. We selected "Rocket Man" considering the age-group of our participants. Each participant then completed the two final

questionnaires, one about their experience with the IQBuds, and the other about their personal perception of their everyday listening experience. The entire session took an hour to an hour and a half per participant.

ANALYSES

Speech perception was scored using both the phoneme scoring and word scoring methods. For the phoneme scoring method, the participants were given credit for each phoneme perceived correctly. Mixed ANOVAs were performed on the % correct phoneme scores and word scores using gender as the non-repeated factor. The repeated factors were with and without noise and scores with and without the IQBuds BOOST device.

The t-test was performed on the average scores of the first 12 items of the Visual Analogue scale to compare speech and music perception with and without the IQBuds BOOST device. Descriptive statistics were used to report data on the questions related to cost and acceptability of the IQBuds BOOST device.

RESULTS

Effect of OTC

OTC hearable did not have any significant effect on the phoneme or word scores in quiet or in the presence of background noise. On average, women scored higher than men on the word recognition tasks, but the difference between noise and quiet with and without the OTC scores were not statistically significant, as shown in Figure 1.

The scores in noise were significantly worse than those in quiet with and without the OTC hearable.

There was no significant interaction between the background (quiet or noise) and aided (OTC hearable or no OTC hearable) conditions, shown in Figure 2.

Results related to the VAS scale listening items:

Scores on the first 12 “listening” items were averaged and subjected to ANOVA. There were no significant differences in the listening perceptions with or without the OTC hearable. Women yielded significantly ($p = 0.003$) higher average listening scores on the VAS scale than men, as shown in Figure 3.

Results related to auditory thresholds:

There was a significant effect of frequency. Thresholds were worse at higher frequencies than those at lower frequencies. Although the average thresholds for men were higher than women at some of the higher frequencies as shown in Figure 4, there were no statistically significant differences in thresholds between men and women.

Descriptive stats related to the last six questions of VAS:

The mean scores related to cosmetic appearance, willingness to use and willingness to purchase scores were below 60% with lowest scores on the cosmetic appearance as shown in Figure 5.

The mean scores related to comfort, fit and insertion were higher than 70%.

DISCUSSION

Overall, the results suggest that adults over the age of 50 with hearing loss would receive minimal or no benefit from the OTC hearable, based on the comparison of phoneme and word recognition scores in quiet and in noise and both with and without the OTC device. Participant feedback gathered from the VAS questionnaire suggests that the comfort and fit of the device are acceptable but the cosmetic appearance of the IQBuds BOOST device is likely to deter many participants from selecting this option. These hearables, IQBuds BOOST, are marketed as "the ultimate hearing bud that allows you to hear what you want to hear." They claim to allow the user to "turn down background noise and amplify conversations" and make "social, dining, and sporting events…more enjoyable" (Best Buy, 2019). These claims made by Nuheara are particularly important to be met, as the social impacts of hearing loss routinely are negative without proper treatment. Although the claims made by companies like Nuheara are exciting, feedback from past research suggests that OTC hearables are "very inappropriate... for the elderly target group – likely to have presbycusis hearing loss – [and they] may obtain very little benefit from the reviewed OTC" (Cheng & McPherson, 2000). In their study, Cheng &

McPherson (2000) measured the performance of 10 different OTC hearables using electroacoustic analysis and real ear measurements. The research suggested that the aids they tested were not able to meet the prescription necessities of most elderly clients who usually purchased hearing rehabilitative devices.

Average Phoneme and Word scores on Word Recognition tests with and without OTC

The average phoneme and word scores both in quiet and noise without the OTC vs with the OTC showed no significant difference in the current study. This suggest that the use of the OTC did not enhance the participant's ability to understand the words in speech noise when both words and noise were presented from both the left and the right loudspeaker. The scores in quiet did not differ in the with or without OTC conditions but this lack of difference is due to the ceiling effect created by excellent word recognition in quiet without OTCs. A combination of excellent word recognition in quiet and lack of improvement in word recognition in noise with the OTC is likely to discourage users to use these OTCs on a regular basis.

Other studies found that low cost OTC aids were generally not sufficient for the client's needs (Callaway & Punch, 2008; Sacco et al., 2016). Callaway & Punch (2008) tested 11 different OTC aids ranging in price from low to high by measuring the gain and output of each device. Overall, the findings from the study suggest that low cost (>$100) OTC devices generally did not meet the needs of the client, while midrange ($100-$500) offered an okay solution to a frugal consumer. The midrange devices reviewed by Callaway & Punch (2008) did not include the device used in the current study, IQBuds BOOST. Sacco et al. (2016) tested another low-cost OTC aid, TEO First ($250) and

found that although the aid did somewhat increase the patient's quality of life, use of the OTC did not eliminate the patients' continuous want for traditional hearing aids.

Average threshold levels related to listening scores

In the current study, the average threshold levels for men were higher than women at high frequencies, suggesting that, on average, male participants had worse hearing than female participants although these differences were not statistically significant. On the VAS Questionnaire, women reported higher scores on their perceived listening ability than men, meaning that female participants individually perceived that they had better hearing in the study than the male participants. These finding suggest good validity for the questionnaire.

VAS Questionnaire Analysis

The study found no difference in the participants' listening perception with or without the OTC based on participant responses to the questionnaires regarding their everyday listening experiences and their listening experience with the OTC. While the OTC aids received high scores (above 70%) on the questions regarding comfort, insertion, and fit, the scores for cosmetic appearance, willingness to use, and willingness to purchase were all under 60%, suggesting that participants would be unlikely to purchase the OTC hearing aid after trying it during the study, regardless of the relatively low price. The current research supports previous findings that advise clients to avoid purchasing low cost aids because of the sacrifice in quality or function (Thomas, 2017). The risks of purchasing a low-cost OTC hearing aid may not outweigh the potential benefits of the aid, as the OTC may provide inappropriate amplification (Kimball, 2010; Manchaia et al.

2017). Purchasing and using an OTC aid can put the consumer at risk for further hearing damage via over amplification (Disarno, 2017). Current legislation for consumer access to FDA approved OTC aids is in the making (U.S Food & Drug Administration, 2018), and Warren & Grassley, (2017) argue that "[the] FDA should revise its current legislations for PSAPs… and clearly distinguish OTC aids, non-OTC aids, and other [types of devices]. ASHA is clear on its statement that it "only support's the sale of OTC hearing aids for mild hearing loss (Disarno, 2017). Most of our participants had mild hearing loss in the range of 250 to 4000 Hz. Such individuals are expected to perform well in quiet surroundings and our findings suggest that their word recognition is not enhanced in background noise. Similarly, no differences were apparent in music perception.

LIMITATIONS

Further studies of newly released OTC hearing devices will be necessary for evaluating the effectiveness as well as risks associated with of other OTC aids and products. Although our results are consistent with previous results, limitations for the study do exist. The noise mitigating software that is used in IQBoost's software is proprietary, so we were limited to the information that has been released by the company and what we gathered from our own observations. Ear ID was a feature that was not utilized during the current research, as it is a personal setting and would need to be reset for each participant, and the Ear ID is meant to be for one user to further personalize, or fine tune, their sound experience. Since the hearing loss varied across participants, the software may have had difficulty adapting to the changing needs for various participants in the presence of background noise. Also, only one OTC product was tested in the study and the findings are only related to it. Evaluation of other low-cost OTC aids using the same methodology is recommended in future studies. In addition, comparison of the low-cost OTC with high end hearing aids fitted by audiologists will also be useful.

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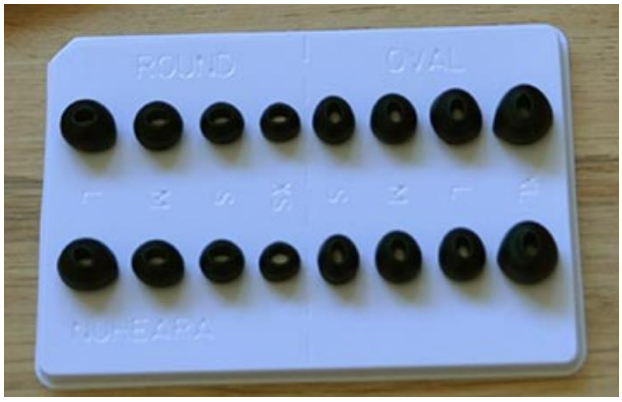
APPENDICIES

Appendix A



IQBuds BOOST replacement tips and IQBuds BOOST device with charging case

Appendix B

Study Title: Audibility, Cost-Acceptability and Cosmetic Appeal of IQbuds in Adults over the Age of 50

Participant Code: _____

Screening Step I, Questionnaire.

1. How old are you? _____

2. Do you experience any of the following symptoms (Check all that apply) ?
Hearing Loss ____
Distortion of Sounds ____
Hyperacusis ____
Tinnitus _____
Other Describe: _____

3. Do you have any significant memory problems? Yes ___ No ___

4. Have you worked in a noisy environment (including loud music) without ear protection?

Yes __ No __

5. Do you have a history of chronic ear canal or middle-ear problems?

Yes ___ No ___

6. Do you currently take any ototoxic medications or tranquilizers?

Yes ____ No __

7. Do you own hearing aids?

Yes ____ No_____

8. If you own hearing aids, do you wear them?

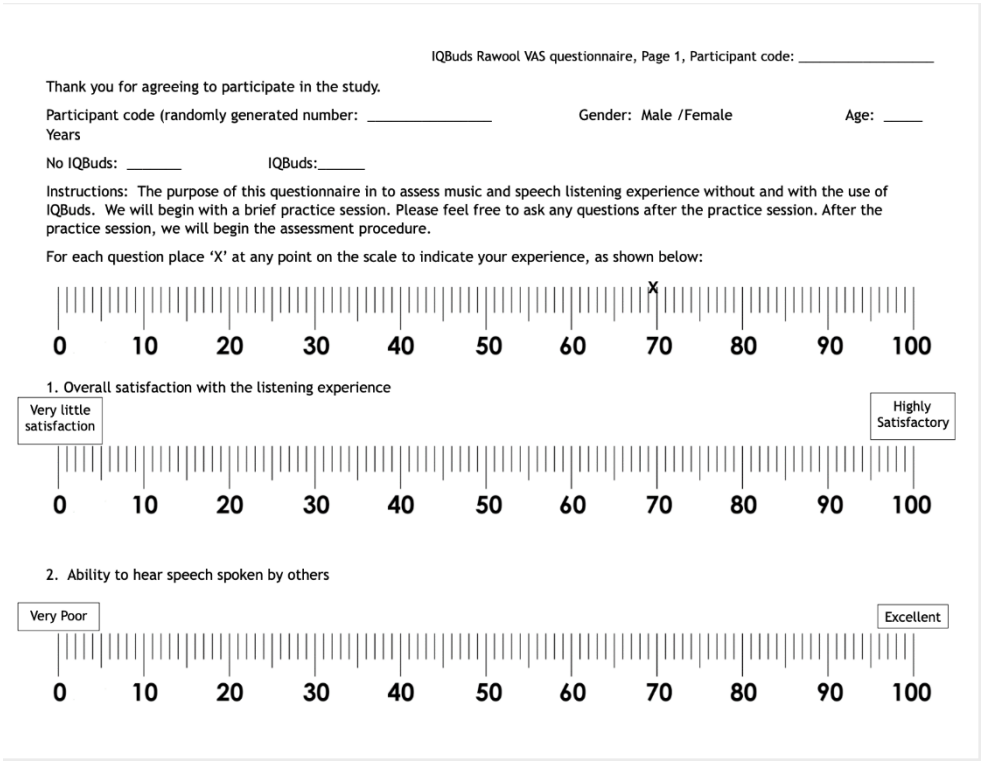
Yes_____ No_____

9. If you wear hearing aids, how often do you wear them?

Very rarely____ Rarely_____ Sometimes_____ often_____

10. Is there anything about your current hearing aids that you find bothersome?

Appendix C



IQBuds Rawool VAS questionnaire, Page 1, Participant code: _____

Thank you for agreeing to participate in the study.

Participant code (randomly generated number: _____ Gender: Male /Female Age: _____ Years

No IQBuds: _____ IQBuds:_____

Instructions: The purpose of this questionnaire in to assess music and speech listening experience without and with the use of IQBuds. We will begin with a brief practice session. Please feel free to ask any questions after the practice session. After the practice session, we will begin the assessment procedure.

For each question place 'X' at any point on the scale to indicate your experience, as shown below:

0 10 20 30 40 50 60 70 80 90 100 (X)

1. Overall satisfaction with the listening experience

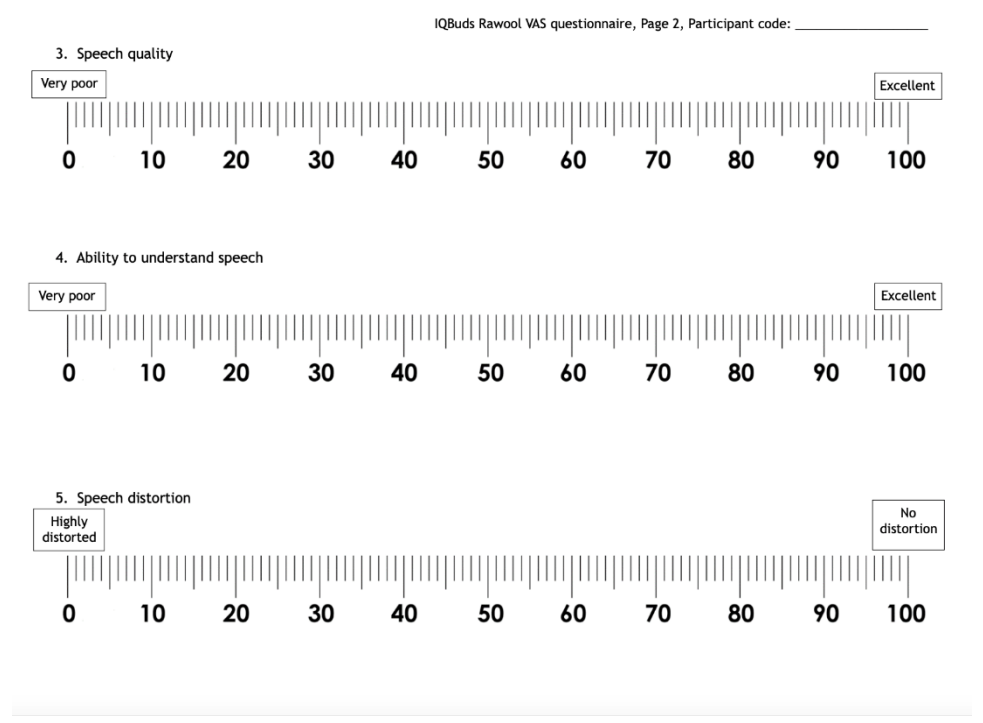
Very little satisfaction — Highly Satisfactory

0 10 20 30 40 50 60 70 80 90 100

2. Ability to hear speech spoken by others

Very Poor — Excellent

0 10 20 30 40 50 60 70 80 90 100



IQBuds Rawool VAS questionnaire, Page 2, Participant code: _____

3. Speech quality

Very poor — Excellent

0 10 20 30 40 50 60 70 80 90 100

4. Ability to understand speech

Very poor — Excellent

0 10 20 30 40 50 60 70 80 90 100

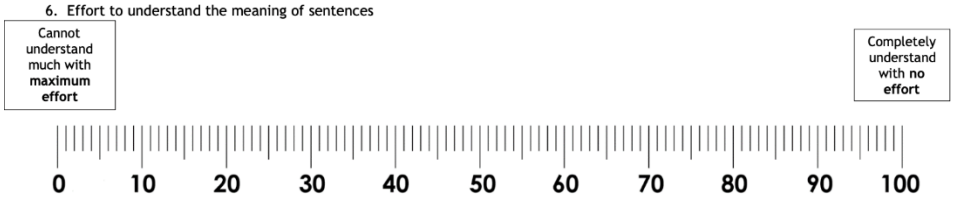
5. Speech distortion

Highly distorted — No distortion

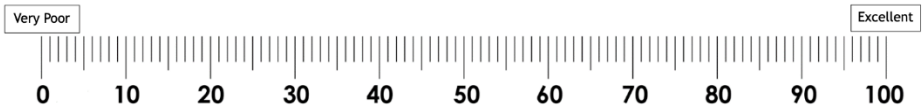
0 10 20 30 40 50 60 70 80 90 100

IQBuds Rawool VAS questionnaire, Page 3, Participant code: _____

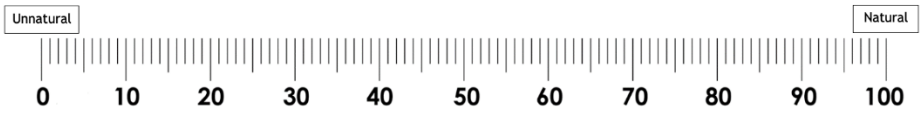
6. Effort to understand the meaning of sentences



7. Ability to hear the music

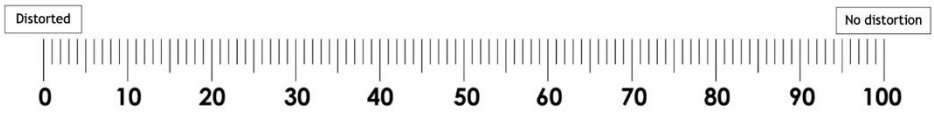


8. Quality/sonority of music

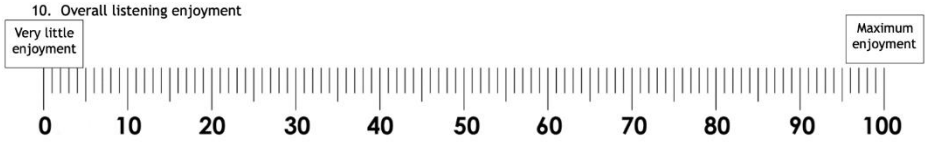


IQBuds Rawool VAS questionnaire, Page 4, Participant code: _____

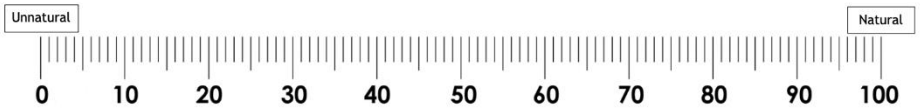
9. Distortion of music



10. Overall listening enjoyment

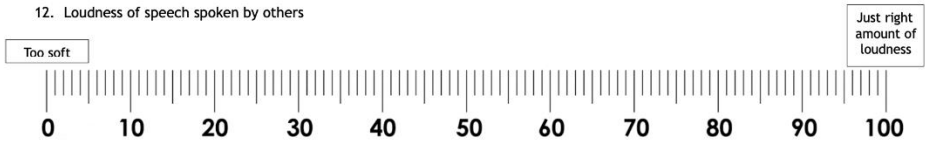


11. Quality of own voice (Say numbers 1 to 10 before placing the X mark)

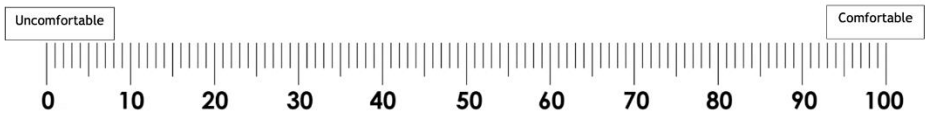


IQBuds Rawool VAS questionnaire, Page 5, Participant code: _____

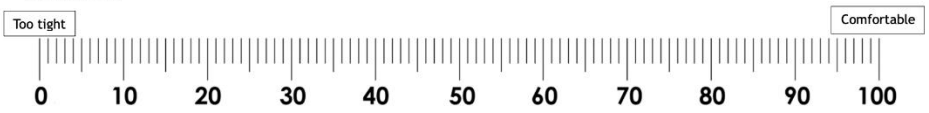
12. Loudness of speech spoken by others



13. Comfort of IQBuds in the ear canal

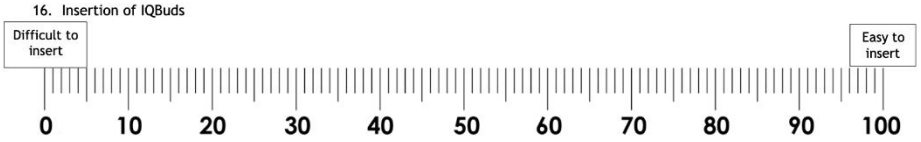


15. IQBud Fit

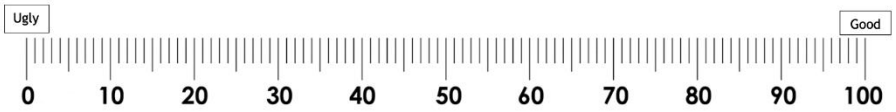


IQBuds Rawool VAS questionnaire, Page 6, Participant code: _____

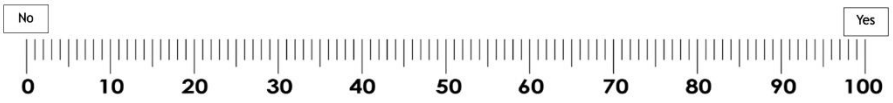
16. Insertion of IQBuds



17. How do the IQBuds look in your ears? (Look in the hand mirror)



18. Will you be willing to use IQBuds for an entire day, every day if you have or had hearing loss?



19. The cost of the IQBuds is approximately $500.00 and there will be additional maintenance costs for batteries, eartips etc? Will you be willing to buy IQBuds?

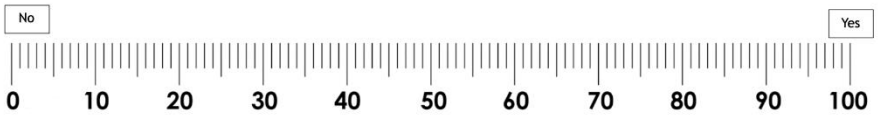


Figure 1: Effect of OTC in background noise

	Gender of participants	Mean
Phoneme scores in quiet without OTC	Male	94.0000
	Female	98.7778
	Total	95.9545
Phoneme scores in quiet with OTC	Male	95.3077
	Female	99.3333
	Total	96.9545
Phoneme scores in noise without OTC	Male	86.4615
	Female	94.0000
	Total	89.5455
Phoneme scores in noise with OTC	Male	83.3846
	Female	94.2222
	Total	87.8182

Figure 2: Mean phoneme scores with and without IQBuds BOOST & background noise

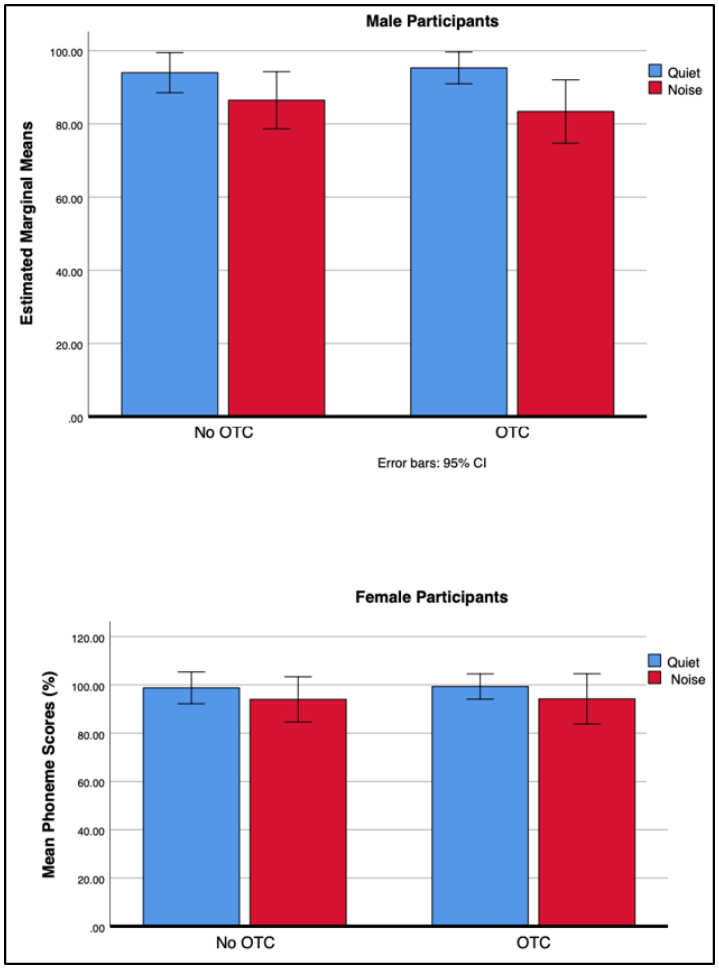


Figure 3: Average Listening Scores with and without OTC

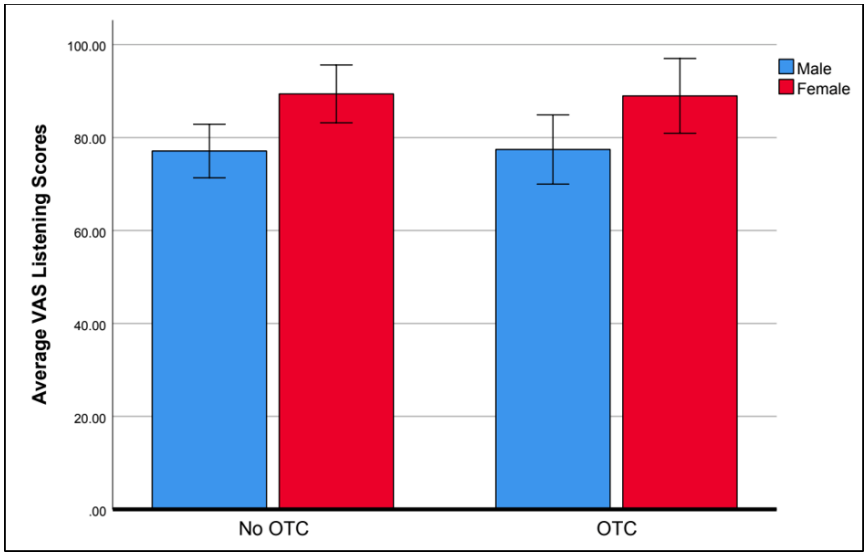


Figure 4: Average Threshold Levels

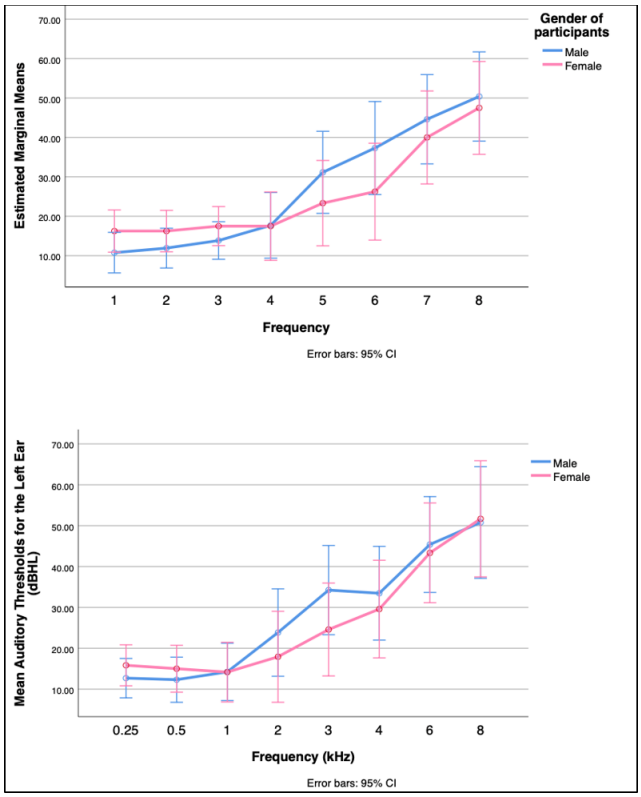


Figure 5: Average Scores for Descriptive VAS Questions