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Attitudes of Normal Hearing Listeners Towards Personal Sound Amplification Products: Etymotic Bean

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ATTITUDES OF NORMAL HEARING LISTENERS TOWARDS PERSONAL SOUND AMPLIFICATION PRODUCTS: ETYMOTIC BEAN

by

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ABSTRACT

ATTITUDES OF NORMAL HEARING LISTENERS TOWARDS
PERSONAL SOUND AMPLIFICATION PRODUCTS: ETYMOTIC BEAN

by

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Despite the remarkable prevalence of hearing loss in the United States, only a small percentage of these individuals utilize hearing aids. Many factors have been associated with the non-adoption of hearing aids, including financial reasons and the stigma associated with hearing aid use. Personal sound amplification products (PSAP) have been recently introduced as a more discrete and less costly type of assistive listening technology. While the Food and Drug Administration does not approve these devices for individuals with hearing loss, they are advertised as being useful for boosting soft sounds and amplifying speech in the presence of background noise.

The purpose of this study was to investigate the future usefulness and acceptability of personal sound amplification products (PSAP), particularly the Etymotic BEAN Quiet Sound Amplifier, for twenty-five normal hearing listeners between 21 and 35 years of age. Benefit to speech recognition ability in the presence of background noise was evaluated. A brief questionnaire assessing attitudes toward the BEAN was also administered.

The results revealed no significant differences (p= 0.38745) in speech recognition ability in noise while utilizing the Etymotic BEAN when compared to the unamplified condition. However, questionnaire data determined that the BEAN was rated most often by participants as "good" or "very good" (mode= 4.0 or 5.0) in regard to ease of use, physical comfort, appearance/aesthetics, and sound quality. Participants most often rated the BEAN as "poor" or "fair" (mode= 2.0 or 3.0) in regard to its perceived benefit to speech understanding in noise. When examining willingness to pay, subjects most often reported they would be "somewhat willing" to pay $200-$300 dollars for the BEAN if they needed sounds to be amplified. These results suggest positive attitudes towards and likely acceptability of personal sound amplification products in the future. Lack of benefit to speech understanding in noise is possibly due to the use of normal hearing participants. Further research should investigate the use of personal sound amplification products by participants with slight to mild hearing loss.

Key Words:

Personal sound amplification products, Etymotic BEAN, speech-in-noise, attitudes

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INTRODUCTION

It has been estimated that more than 30.0 million or 12.7% of Americans twelve years or older have bilateral hearing loss, and this estimate increases to 48.1 million or 20.3% when also including individuals with unilateral hearing loss. These numbers suggest that nearly 1 in 5 Americans has a unilateral or bilateral hearing loss (Lin et al., 2011). Over the last generation, researchers believe that the hearing loss population has grown at the rate of 160% of United States population growth primarily due to the aging of America (Kochkin, 2009). Despite the remarkable prevalence of hearing loss in the United States, only 20-25% of these individuals utilize hearing aids (Kochkin, 2007). Regardless of improvements in technology, aesthetics, and size, the prevalence of hearing aid use remains essentially unchanged. A myriad of factors associated with non-adoption of hearing aids have been acknowledged, including claims that they are "not worth the expense" and a financial burden, as well as the stigma associated with hearing aid use (Kochkin, 2007).

On a MarkeTrak VII survey investigating the barriers to hearing aid usage for individuals with hearing loss, nearly half (48%) indicated that stigma contributed to their desire not to wear hearing aids. Additionally, about one-third stated they did not want to admit their hearing loss in public, and that hearing aids were too noticeable. Many also reported that they would be embarrassed to be seen wearing hearing aids in public, and that hearing aids make someone look disabled and old. One out of three participants indicated they were too proud to wear hearing aids, or expressed concern that other people would treat them differently if seen wearing hearing aids. Furthermore, 20% felt that they would be made fun of, or that people would think they were mentally impaired (Kochkin, 2007). It is evident that stigma continues to be the top psychosocial issue contributing to the non-adoption of hearing aids (Kockin, 2012).

A recent consumer survey found that consumers spend $1,800 to $6,800 for a pair of hearing aids, with batteries adding additional costs (Consumer Reports, 2012). Over the course of a lifetime, individuals who wear hearing aids may spend tens of thousands of dollars acquiring and maintaining hearing aids. Given these factors, hearing aids can be among the most expensive items purchased by many Americans with hearing loss, after their home or car. While limited scientific data are available on the specific impact of cost on hearing aid penetration rates, cost is still considered to be one of the primary reasons for non-adoption of hearing aids. Kochkin's MarkeTrak survey (2007) determined that 76% of hearing aid "non-adopters" felt that finances acted as a barrier. Approximately 64% of participants stated they cannot afford hearing aids, and half of the non-adopters indicated cost as a definite reason why they do not use hearing aids.

As an alternative to hearing aids, there are numerous hearing assistive technologies (HAT) or assistive listening devices (ALD) that currently exist to improve sound transmission to a listener by amplifying sounds and reducing the effects of distance from a speech source and background noise. Unlike hearing aids where the microphone is located at the ear of the listener, most hearing assistive technology involves the use of a remote microphone that picks up the speech signal and transmits it directly to the listener's ear while minimizing the effects of reverberation, distance and background noise (Weinstein, 2012). ALDs are geared towards individuals with hearing loss who often require a more favorable signal-to-noise ratio than individuals with normal hearing to effectively understand speech in the presence of background noise (Killion, 1997). These devices can be used in isolation or can often be used in conjunction with a hearing aid or cochlear implant. Hearing assistive technologies typically fall into one of four categories: personal listening systems or sound enhancement technology, telecommunication devices, media or television devices, and signal or alerting devices.

Sound enhancement technology enables people with hearing impairment to better understand the speaker in less than optimal listening situations. This is accomplished by having the signal sent to the listener's ears directly, overcoming the barriers presented by distance and environmental noise and reverberation. A microphone is held or worn near the speaker's mouth, which transmits the speech signal to a receiver worn by the individual with hearing impairment. These devices are ideal in small and large group listening environments such as classrooms and conference settings, or in one-to-one conversations. The technology can be hardwired or wireless. The former case calls for a wired connection between the speaker and listener, as in the case of the Williams Sound "Pocketalker", and requires the speaker to stand within close approximation of the listener. Conversely, in the case of a wireless arrangement using an FM radio signal to transmit the sound, the speaker wears a microphone that wirelessly transmits the speaker's voice to a receiver worn on the listener's ear. Wireless FM systems are often utilized in classroom settings, places of worship, lectures where the speaker is at a distance, and in some health care settings.

Telecommunication technology facilitates communication via the telephone. For individuals with hearing loss, using the telephone can be a very challenging listening situation given that there is no speech reading or visual/gestural cues, and that the telephone signal often lacks clarity and intensity. Amplified telephones serve to increase the incoming telephone signal between 20 and 50 dB, depending upon how much amplification is needed. Many also allow for adjustments in incoming call volume, ringer volume, and type of visual alert. Some more technologically advanced options utilize digital signal processing to ensure that soft sounds are audible while keeping loud or unwanted sounds such as an echo within a comfortable range for the listener. Another option for enhanced telephone use for individuals who are hearing impaired involves Voice Carry Over (VCO) telephones and Teletypewriter (TTY) Telephones. VCO telephones serve to transmit the incoming call signal as text through a toll free local relay service. TTY telephones allow the listener to read what the person is saying and requires the listener to type their own message back to the speaker. These options tend to be used by persons with severe to profound hearing loss or extremely poor auditory processing ability. With the introduction of e-mail and SMS texting, fewer hearing impaired individuals are adopting these technologies (Power et al., 2007).

Individuals with hearing loss also may have difficulty hearing and/or understanding the auditory broadcast over the television or radio due to the distance from the sound source, background noise, and poor room acoustics and loudspeaker capabilities of the broadcast device. Television and media devices help address some of these factors by using different methods of transmitting the media signal directly to the listener's ears. An infrared (IR) system sends a speech signal to a headset worn by the listener via infrared light waves. This type of system is primarily utilized when watching television or in theaters, at conferences or during live concerts.

Additionally, inductive loop systems are installed in many live performance theaters, lecture halls or places of worship to assist listeners with hearing impairment. The system involves a microphone and a thin wire that is looped around a room or listening area, creating an electromagnetic field. The acoustic speech signal is amplified and circulated through the wire loop. The resulting magnetic energy field is wirelessly detected by a telecoil present in a hearing aid, or by an induction loop receiver connected to earphones, and converted back into acoustic sound heard by the listener. The end result is a high quality amplified reproduction of the original speech signal. This type of hearing assistive technology is useful for individuals with hearing loss because it serves to increase intelligibility by bridging the distance between the speaker and the listener, and reducing any background environmental noise or reverberation. Aside from larger listening environments, induction loop systems are useful in smaller, one-on-one listening situations including service booths/counters, exhibits and museums. It should be noted that for listeners using the telecoil present in their hearing aids, the signal they are receiving is amplified appropriately to their specific prescriptive targets based on their hearing loss.

Bluetooth technology is also becoming a popular method of transmitting sound over short distances between compatible electronic devices for hearing impaired individuals. Bluetooth utilizes short-range, digital, radio-frequency technology to provide secure communication of audio signals from one device to another without using cables. When using the telephone traditionally, hearing aid users often experience acoustic feedback, insufficient volume and telephone interference. Bluetooth technology has the capability to prevent the aforementioned issues by sending a telephone signal through the wearer's own personal hearing aids where it can be customized to that individual's type and degree of hearing loss. Bluetooth technology also allows connection between the hearing instruments and other Bluetooth-enabled devices like televisions, pagers, audio systems, computers, etc. For individuals who need hearing assistance but do not wear hearing aids, amplified Bluetooth headsets can be utilized to allow binaural amplified hearing, which often improves speech recognition and clarity.

Lastly, many common household devices that produce alerting sounds such as alarm clocks, smoke/fire alarms, telephone ringers, doorbells, etc. may not be loud enough to be heard by someone with a significant hearing loss. Alerting devices exist specifically for individuals with significant hearing loss that can indicate the presence of alerting signals in the environment through either auditory, visual, or vibrotactile modalities. For example, a signaler can be hung over a doorway and generate a bright LED flashing light when someone knocks at the door. This same technique can be utilized for a telephone or doorbell so that a light will flash when such devices ring. Also, alarm clocks can be utilized with bed vibrators beneath the mattress, vibrating the bed in addition to producing an alarm up to 113 decibels with flashing LED lights. For emergency situations like house fires and high levels of carbon monoxide posing danger when a signal goes unheard, hearing impaired individuals can purchase smoke detectors that utilize a 90 dB horn siren and flashing strobe lights when they are set off. These devices help to restore a feeling of safety and comfort at home for individuals with substantial hearing loss.

A more recent category of assistive technology that was introduced in 2008 is a personal sound amplification product, or PSAP. PSAPs are wearable electronic products that are intended to amplify sounds. They consist of a microphone, amplifier, receiver and power supply, much like hearing aids. However, these devices do not meet the specifications for hearing aids as defined by the FTC and the FDA and therefore cannot be marketed to people with hearing loss. These ear level devices are thought to be advantageous in numerous ways. They are much more discrete than many other assistive listening device options; some manufacturers have even disguised their product by designing them to look like ear-level Bluetooth devices. Also, they do not require any extra equipment such as electromagnetic looping, speaker microphones or transmitters. Additionally, they are much less costly than hearing aids, and can be purchased "over-the-counter" at drugstores, online, from magazines, etc.

Personal sound amplification products (PSAPs) differ from hearing aids in many additional ways. While they are wearable sound amplifying devices much like hearing aids, they are not intended to compensate for impaired hearing. They are designed and marketed to be used by non-hearing impaired consumers to amplify sounds related to various recreational activities such as hunting, bird watching, watching television with a sleeping spouse, “cleaning up” a conversation to be heard in a noisy room, etc. While they are intended to amplify the aforementioned sounds, most are not programmed to meet the individual needs of a particular consumer or a specific hearing loss. Food and Drug Administration guidelines clearly state that PSAPs are devices intended to amplify environmental sounds for non-hearing impaired consumers, and that they are not intended to compensate for hearing impairment or to address listening situations that are typically associated with and indicative of hearing loss (Food and Drug Administration, 2013).

Etymotic Research Inc. manufacturers a PSAP known as the “BEAN Quiet Sound Amplifier” that is sold on their website for $375.00. The manufacturer states that the BEAN amplifies sounds and enhances the listener’s hearing experience so conversations become more effective in the car, in social situations, and at a distance. Etymotic makes the claim that the BEAN can provide clarity, with a built-in sensor that automatically adjusts to the surrounding noise level. It amplifies soft sounds while keeping the volume steady for louder noises or even reducing it for extremely loud sounds. Moreover, the manufacturer claims that the BEAN boosts soft high-pitched sounds heard in speech, which helps provide clarity for conversations, particularly in less-than-ideal listening environments. The BEAN can also be purchased with an encased telecoil for use with hearing-aid compatible telephones and looping systems for improved hearing in reverberant conditions and when listening to distant speakers (Etymotic Research Inc., 2014).

The benefits of the BEAN as reported by the manufacturer include: ability to be purchased from any source without referral, designed to fit comfortably and look good, ready to use right out of the box, no adjustments needed and no controls to adjust, delivers high-fidelity sound quality and amplified hearing, handles high inputs of music without distortion, and does not require custom molds. Technical specifications found on the Etymotic Research website include: 15-23 decibels of gain, analog signal processing, wide dynamic range adaptive compression, maximum output levels from 112.5 dBSPL to 114 dBSPL, 3% total harmonic distortion (THD), 10A zinc-air battery type, and two weeks of battery life (Etymotic Research Inc., 2014). Other widely used personal sound amplification devices that are similar in level of technology and cost include the Sound World Solutions CS50 and the Able Planet Personal Sound Amplifier.

Marketing of PSAPS is a recent source of controversy within the hearing health care industry. Numerous organizations have stated their apprehension toward use of personal sound amplification products. The Food and Drug Administration (FDA) has expressed many concerns about PSAPs, stating that they are *not* Class I medical devices, can only improve ability to hear soft sounds or sounds at a distance, and are *not* intended to improve impaired hearing. Class 1 medical devices must comply with requirements regarding patient and professional labeling, including device model, serial number, date of manufacture, instructional brochure, etc. Because PSAPs are not intended to diagnose, treat, cure or mitigate disease and do not alter the structure or function of the body, they are not devices as defined by the Food, Drug & Cosmetic Act and consequently there is no regulatory classification, product code or definition for these products (Food and Drug Administration, 2013).

The International Hearing Society Position Statement on personal sound amplification products feared potential confusion by the public about appropriate use for these devices, and advised an evaluation by an audiologist for any individual with concerns about their hearing ability (International Hearing Society, 2012). The Hearing Health Organization also issued a statement on PSAPs expressing concern that vendors are marketing PSAPs as if they are hearing aids, and in turn could be putting consumers at risk for undetected medical conditions, hearing damage, poorly fit devices and dissatisfaction (Hearing Health Organization, 2012). Additionally, a statement by the American Academy of Audiology conveyed fear that the marketing, advertising or labeling associated with these products causing them to be represented as hearing aids, or vice versa. They boldly state that while hearing aids are medical devices intended for the treatment of patients with diagnosed hearing loss, PSAP devices are merely simple, sound-amplifying products with severely limited functionality used primarily for recreational purposes (American Academy of Audiology, 2014).

A MarkeTrak study conducted by the Better Hearing Institute (BHI) found that approximately 1.5 million people in the United States use direct-by-mail hearing aids or PSAPs to compensate for hearing loss (Kochkin, 2010). Users of these devices were also shown, on average, to have incomes $10,000 less than those of custom hearing aid users. Despite warning from the Food and Drug Administration that PSAPs should only be used once a hearing loss is ruled out, three out of four PSAP/direct-by-mail device users are audiologic candidates for a traditional hearing aid, suggesting that consumers are using these products as an intervention approach for a hearing loss (Kochkin, 2010). While there is little doubt that PSAPs are used to compensate for hearing sounds that are inaudible, a reasonable estimate determined by this research suggests that less than 18% of PSAP users substituted PSAPs for custom hearing aids.

In the absence of PSAPs in the marketplace, it is likely the majority would have lived with there hearing loss (Kochkin, 2010).

A study conducted by Palmer (2013) sought to investigate satisfaction with personal sound amplification products. Findings suggested that when compared to individuals with traditional amplification, those who used direct-by-mail products perceived their hearing loss to be less severe and are significantly more satisfied. Perhaps this result was due to lower costs, and therefore lower expectations. However, hearing aid users reported greater benefit on the Abbreviated Profile of Hearing Aid Benefit (APHAB) self-assessment inventory. Given the research findings, Palmer suggests that perhaps PSAP devices should be recommended to patients who score between 4-12 on the Hearing Handicap Inventory for Adults (HHIA) or the Elderly (HHIE) whose self-perceived handicap is not very large.

More recently, a qualitative study administered via Internet by the Consumer Electronics Association evaluated consumer attitudes and behavior in regard to PSAPs. Their sample consists of 1,551 United States adults who have either been diagnosed with a hearing loss, or who have at least a little trouble hearing. They determined that nearly half of online U.S. adults have some degree of hearing difficulty. Cost was identified as a major barrier to consumers seeking help for their hearing difficulties and purchasing hearing aids, but PSAPs may help overcome this. The researchers also determined that there is a demand for PSAPs among consumers with trouble hearing. It was determined that current PSAP owners tend to use their device mostly for listening to television, while non-owners who express interest in purchasing such a device would envision using them in a wider range of situations. Consumers also supported the ability to purchase hearing assistance products the way they currently purchase reading glasses (e.g., through the mail or at a local drug store) (CEA, 2014).

Overall, this study concluded that PSAPs offer a viable solution to hearing difficulties, although those with more severe hearing difficulties may still require hearing aids. PSAPs offer a simpler and less expensive alternative for those with minimal hearing difficulty. The price for hearing aids is higher than what most consumers, especially those with lesser degrees of hearing difficulties, are willing to spend. PSAPs could offer a gateway for consumers who may struggle with their hearing, but do not struggle enough to warrant spending large amounts of money on a pair of hearing aids at this time. The researchers also suggest that consumers may even be more likely to seek out medical advice for their hearing difficulties knowing that more affordable options for hearing assistance exist (CEA, 2014).

A new concept that is more recently being applied to the field of audiology and hearing assistive technology is the idea of disruptive innovations. Disruptive innovations have been described as new ideas or products, or new ways of applying old ones, which shake up an existing market. This typically occurs when the market has become sluggish and there is a pent-up demand for products that is not being satisfied by the status quo. Occasionally, these disruptive innovations have been demonstrated to completely replace earlier ways of doing things. Robyn Cox (2014) has suggested that personal sound amplification products are a potential example of a disruptive innovation in our field. She argues that listeners with hearing impairment, specifically those with mild hearing loss, could potentially benefit from PSAPs. She notes that the advantage of using PSAPs is that they are not subject to state or federal regulations and can be easily obtained in stores or online much like non-prescription reading glasses (Cox, 2014).

While low-technology PSAPs have existed for quite some time, Cox feels what has changed more recently is the potential for creating high-technology, high quality PSAPs that might rival the usefulness of traditional hearing aids and can be sold at relatively low cost without professional input. She notes that certain PSAPs that are sold at popular retailers for as little as approximately $400.00 have sixteen bands and channels, digital noise reduction, volume control, a telephone coil, and "speech enhancement circuitry," similar to a hearing aid. While many would assume that these products must be inferior to the products audiologists dispense to their patients, there is remarkably little published evidence to show that premium hearing aids give better real world outcomes than basic hearing aids or PSAPs.

A recent study by Breitbart et al. (2014) compared examples of premium hearing aids, basic hearing aids, and high quality PSAPs. Each device was fit on a KEMAR to match the NAL-NL2 targets for an average mild to moderate hearing loss as well as possible. Three types of everyday sounds were used as test stimuli: speech, noise, and music. Each of these three sounds was recorded through an ear hearing device on the KEMAR. Twenty adult listeners with mild to moderate sensorineural hearing loss listened monaurally using an ER-2 insert phone. Analysis showed that there were no significant differences in preference for premium, basic, and PSAP conditions when the stimulus was music or everyday noises. Also, premium hearing aids were not significantly preferred over basic hearing aids with any stimulus. However, when the stimulus was speech, participants preferred both the premium and the basic hearing aids over the PSAPs, and the differences were statistically significant.

While there are limitations to the real-world generalizability of these findings, it is important to note that there were not substantial differences in preferences among the three types of devices. A noteworthy trend that transpired is that some devices seemed to perform better for speech, whereas others performed better for noises or music, suggesting that different devices were specialized to process difference types of stimuli more efficiently. This emphasizes the significance of personalized, professionally driven device selection. As professionals, it is vital that we truly understand the patient's goals for amplified sound so that we can select the appropriate device to best suit their needs. Interestingly, this research suggests that the best device might not necessarily be a premium level hearing aid (Breitbart et al., 2014).

To continue, Robyn Cox (2014) suggests that audiologists recommend assistive listening devices as a viable option for many listeners who have hearing difficulties in specific settings such as watching evening television with their family. If the patient's hearing difficulties present themselves in a small number of situations, it is likely that they will not feel ready to embrace a commitment to traditional hearing aids, and an appropriately chosen assistive listening device may help to sufficiently resolve the problem. While many audiologists fear that recommending hearing assistive listening technology will negatively impact their revenue, Cox recommends that audiologists present the appropriate patient the option of obtaining their own PSAP or online hearing aid and having a consultation with the audiologist about the pros and cons, and how to optimize usage with the device.

More specifically, Cox (2014) proposes that audiologists start with real-ear verification measures to determine the best PSAP settings to give amplification close to the NAL-NL2 prescription. Through this process, she feels that the audiologist will have the opportunity to counsel the patient about the likely benefits and limitations of the device, and where they may still have difficulty. In addition, the professional would be able to provide expert counseling in regard to managing the patient's communication difficulties, while still obtaining revenue for the appointment. By taking this approach and re-thinking the audiologist's role in treating hearing problems, you are providing professional hearing loss treatment and not just selling hearing aids. With this approach, even if your patient is not ready to move forward with any treatment for their hearing loss, the audiologist will not suffer financially. Instead, you are paid for the time spent in the consultation, and your expertise. From Robyn Cox's perspective, if audiologists do not change and adapt the way they conduct business by accommodating industry changes and embracing innovations like PSAPs, the field of audiology will be overtaken by recent circumstances.

While it appears that personal sound amplification products (PSAP) are here to stay, audiologists continue to have conflicting attitudes towards them. With the advent of improved technology, some professionals are exploring ways PSAPS can be utilized to benefit their patients and to increase early entry into the hearing health care market. One school of thought involves the philosophy that PSAPs could potentially serve as the starting point for persons with mild hearing loss and minimal handicap that do not yet feel ready to pursue and commit to costly hearing aids but need some assistance in selected situations. This population may also be financially unable to purchase a hearing aid at this time. According to the transtheoretical model of health behavior change, these individuals would fall into the contemplation stage of the readiness continuum. In this stage, patients are aware of the pros of change, but are also acutely aware of the cons. They continue to weigh the costs and benefits of choosing to treat their hearing loss, which can often result in ambivalence (Prochaska & Velicer, 1997).

Often, patients who are not ready to purchase hearing aids for a multitude of reasons will leave their audiologist's office empty handed, with nothing to aid the listening difficulties they were likely complaining of when they arrived. If the claims made by PSAP manufacturers about their devices are supported, then perhaps audiologists will be more inclined to offer this cost-effective option to begin to enhance the listening abilities of a percentage of the 22 million Americans with hearing loss who have not yet embraced the idea of hearing aids (Chien & Lin, 2012). Positive experiences with PSAPs as starter devices may promote their use as a “stepping stone” towards individually programmable hearing aids. The existence of a less costly device being dispensed by hearing healthcare professionals to patients who are not yet ready to commit to hearing aids could also motivate those with hearing difficulties to consult with an audiologist and ease them into the idea of wearing an ear level device sooner than they would have.

OBJECTIVES AND RESEARCH QUESTIONS

The purpose of this study is to investigate the future potential for personal sound amplification products (PSAPs) and to assess some of the claims made by the manufacturers, particularly for the Etymotic BEAN Quiet Sound Amplifier. Obtaining such information may allow the researchers to predict the acceptability and usefulness of personal sound amplification products for normal hearing and hearing impaired persons.

The following research questions were addressed:

1. Is there a statistically significant qualitative improvement in speech recognition ability in the presence of background noise when wearing the BEAN as compared to the unamplified condition?
2. What are the attitudes toward Personal Sound Amplification Products (PSAP) such as the BEAN in regard to aesthetics, ease of use, comfort, perceived benefit, willingness to pay, etc.?

METHODS

Participants

Twenty adults between the ages of 21 and 35 years with normal hearing sensitivity and normal middle ear function participated in this study. All participants were fluent speakers of the English language.

Instrumentation

Recorded materials were administered using a two-track compact disc (CD) routed through a GSI-61 audiometer, calibrated to ANSI standards (ANSI, S3.6 – 1996). Two different personal sound amplification products (PSAP) were utilized for data collection: the Etymotic BEAN and the Sound World Solutions CS50. The Etymotic Bean has a two-position switch; the "normal" position was utilized for testing which provides 15 dB of amplification and treble boost for soft sound and no amplification for loud sounds. The Sound World Solutions CS50 has three preset amplification profiles; the second profile "restaurant program" was selected for testing which provided greater boost in the high frequencies and a mild boost in the mid-frequencies. Various sized tips were available for each of the PSAP devices to ensure an appropriate fit for differing ear shapes and sizes.

Materials

Recorded Northwestern University Auditory Test No. 6 (NU-6) word lists and Auditec multi-talker noise were utilized to determine speech recognition testing in the presence of competing background noise. The NU-6 test is composed of four lists of 50 phonemically balanced consonant-nucleus-consonant (CNC) words (Tillman & Carhart, 1966). Two versions of a questionnaire were developed and used (Appendix C), with each version being tailored to its corresponding PSAP device. Topics investigated on the questionnaires included aesthetics, sound quality, ease of insertion/removal, physical comfort, benefit to speech understanding in noise, willingness to pay for the device, etc. A 5-point Likert scale was used with choices ranging from "Very Poor" to "Very Good."

Procedures

Screening

Prior to the collection of data, participants were screened via pure-tone audiometry and tympanometry to ensure that they were not at risk for hearing loss or middle ear issues. All participants were required to pass both screenings. Hearing was screened at 20dBHL at 250, 500, 1000, 2000, 4000 and 8000Hz. A "pass" for immittance testing was defined as having tympanometric results within the following guidelines when using a calibrated GSI-TympStar and a 226Hz probe tone: ear canal volume <2.5 cm^3, static compliance 0.3 to 1.3 mmho, and tympanometric peak pressure between -150 and +150 daPa. These measurements are consistent with Type A tympanograms (Silman & Silverman, 1991).

Speech In Noise Testing

Listeners were tested individually in a sound treated audiometric booth that met ANSI standards for ambient noise levels. Test stimuli were delivered through a single speaker, with participants seated 3 feet from the test speaker arranged at a zero degree azimuth. Participants completed speech-in-noise testing in three different test conditions: unaided, aided using the Etymotic Bean PSAP, and aided using the Sound World Solutions CS50 PSAP. In each of the three conditions, a recorded NU-6 word list in addition to multi-talker noise were presented simultaneously at 50dBHL with a 0 dB signal-to-noise ratio (SNR). Participants were asked to repeat 50 monosyllabic words to the best of their ability. This process was repeated in each of the three test conditions, resulting in a total of three NU-6 word lists. The order in which the test conditions were completed, as well as the ear each device was worn on were randomized. Word recognition ability was determined as a percentage by awarding 2% for every correctly identified word.

Questionnaire

Immediately following the completion of each aided speech-in-noise test condition, participants were given the opportunity to handle and utilize the features of that particular PSAP (i.e. turning the device on/off, changing batteries, etc). They were also provided with the user manual for each PSAP device. Participants were then asked to complete two brief questionnaires developed by the researchers regarding their attitudes and opinions towards each of the PSAP devices.

Statistical Analyses

Statistical analyses included descriptive statistics for attitudes towards PSAPs, as well as statistics for aided versus unaided speech recognition performance in noise. Measures of central tendency and variability were obtained, and distributions were evaluated for normalcy and skewness to determine whether parametric or nonparametric statistics should be employed. Statistical testing was accomplished using STATA IC 13.1 (College Station, TX).

RESULTS

Twenty-five listeners who passed the hearing screening (9 males and 16 females) ranging in age from 21 to 35 years of age participated in this study. Measures of central tendency and variability for participant age are displayed in Table 1.

Table 1. Descriptive statistics for participant age.

Group	Statistic	Age (Years)
Total (n=25)	Mean	25.28
	Median	25.0
	SD	2.54
	Range	21-35

Speech-In-Noise Testing

The results of descriptive statistics for word recognition ability in background noise when unaided versus aided using the Etymotic BEAN are shown in Table 2. Both test conditions revealed very similar mean percent correct values. Statistical testing using a one-tailed paired t-test revealed no significant differences in speech recognition ability in noise while wearing The BEAN when compared the unamplified condition (p=0.38745) See Appendix D for the output of STATA statistical testing. A histogram displaying the frequency of each word recognition score in the presence of background noise (measured in percent correct) for the unaided condition can be viewed in Figure 1. Scores ranging from 34% to 76%, as well as the mean value of 48.4% (SD=9.64) are visually represented. A histogram displaying the frequency of each word recognition score in the presence of background noise for the aided condition using the Etymotic BEAN Quiet Sound Amplifier can be viewed in Figure 2. Scores ranging from 28% to 70%, as well as the mean value of 47.68 (SD=9.18) are visually represented.

Table 2. Word recognition ability in background noise (% correct).

Statistic	Unaided	The BEAN
Mean (SD)	48.4 (9.64)	47.68 (9.18)
Range	34-76	28-70

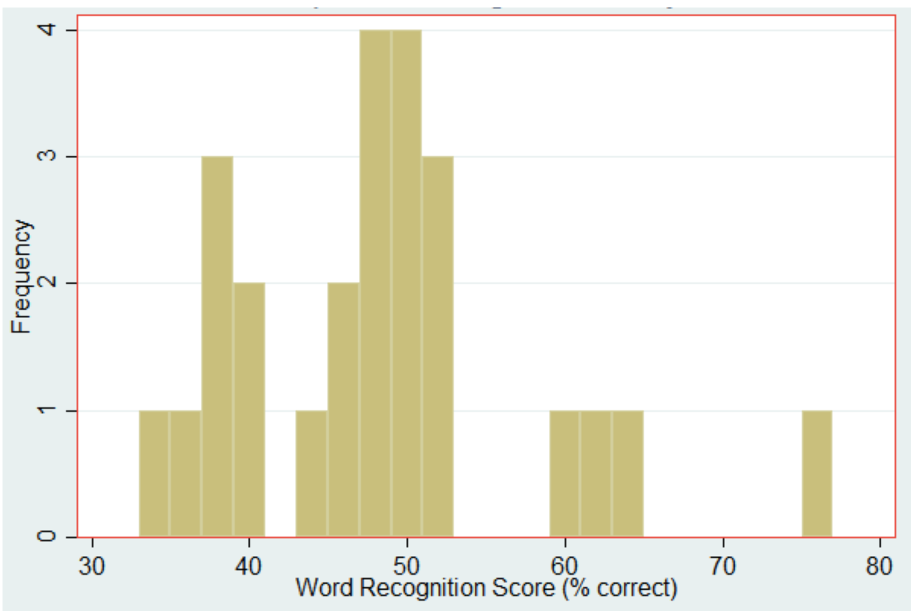

Figure 1: Histogram displaying word recognition ability in noise in the unaided condition.

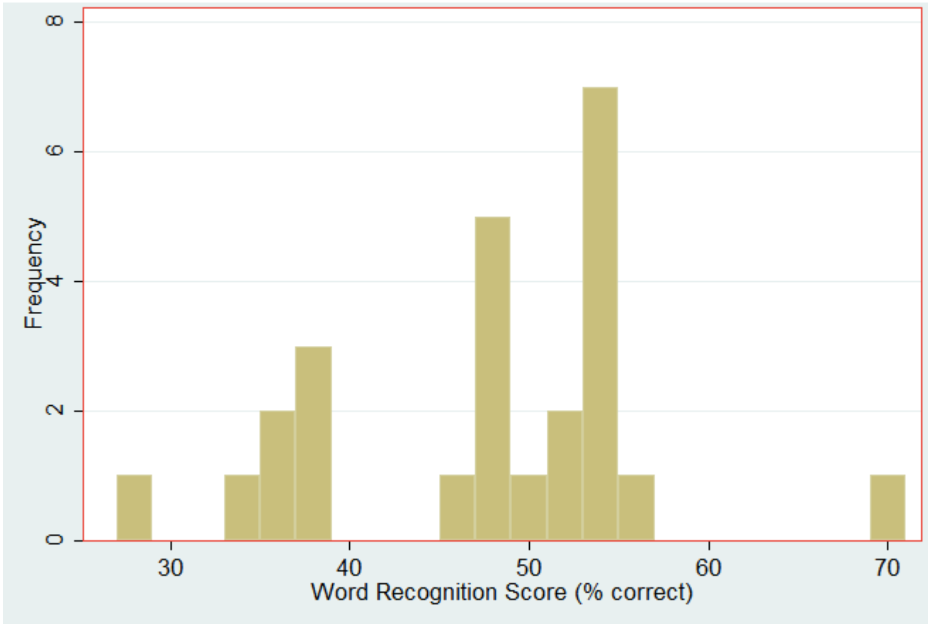

Figure 2: Histogram displaying word recognition ability in noise using the Etymotic BEAN.

Attitudes Toward The BEAN

The results of descriptive statistics for attitudes toward The BEAN Quiet Sound Amplifier are exhibited in Table 3 and Table 4. Participants most often rated the BEAN as "very good" (mode= 5.0, median= 5.0) in regard to ease of inserting and removing the device. The BEAN was most often rated by our participants as "good" and "very good" (mode= 4.0 and 5.0, median= 4.0) when considering ease of adjusting the volume or program on the device. Participants most often rated the BEAN as "good" (mode= 4.0, median= 4.0) in regard to ease of changing the battery, physical comfort, appearance/aesthetics, and sound quality. In respect to perceived benefit to speech understanding in noise, participants most often rated the BEAN as "poor" or "fair" (mode= 2.0 or 3.0, median=3.0).

Table 3. Descriptive statistics for attitudes toward the BEAN.

Statistic	Parameter	Rating (1=Very Poor, 5=Very Good)
Mean (SD)	Ease of insertion/removal	4.32 (0.85)
Median		5.0
Mode		5.0
Mean (SD)	Ease of changing the battery	3.6 (1.0)
Median		4.0
Mode		4.0
Mean (SD)	Ease of changing volume/program	3.8 (1.08)
Median		4.0
Mode		4.0, 5.0
Mean (SD)	Physical comfort	3.96 (0.84)
Median		4.0
Mode		4.0
Mean (SD)	Appearance/aesthetics	3.88 (1.01)
Median		4.0
Mode		4.0
Mean (SD)	Sound quality	3.56 (0.87)
Median		4.0
Mode		4.0
Mean (SD)	Perceived benefit to speech understanding in noise	3.0 (1.04)
Median		3.0

Mode	2.0, 3.0

When considering willingness to pay, the data suggests that subjects would most often be “somewhat willing” (mode= 4.0) to pay $200-$300 for the BEAN if they needed sounds to be amplified/made louder (Figure 3).

Table 4. Descriptive statistics for participant’s willingness to pay for the BEAN.

Statistic	**Parameter**	**Rating (1=Very Unwilling, 5=Very Willing)**
Mean (SD)	Willingness to pay	3.0 (1.22)
Median		3.0
Mode		4.0

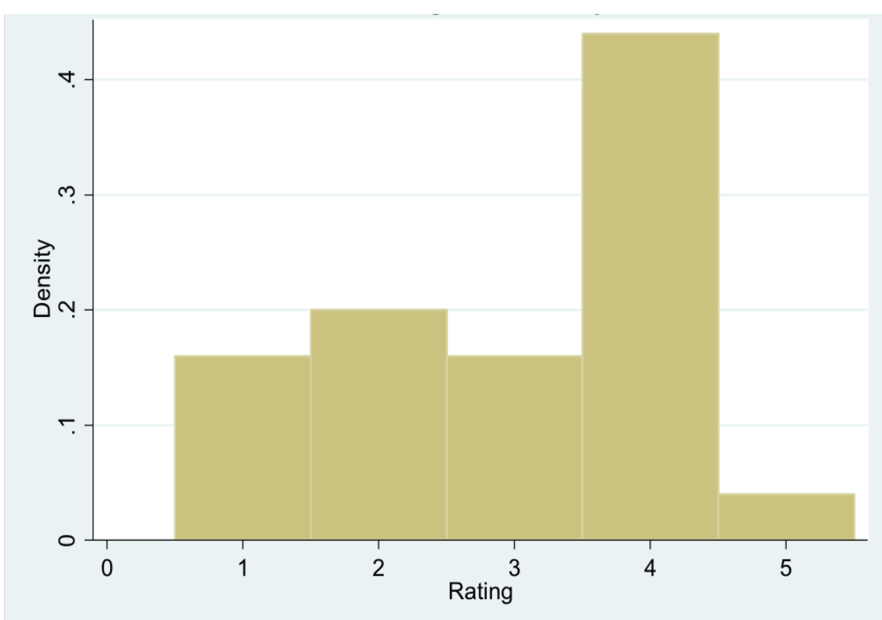

Figure 3: Histogram displaying participant’s willingness to pay $200-$300 for the BEAN.

DISCUSSION

The purpose of this study was to investigate whether or not a statistically significant quantitative improvement in speech recognition ability in the presence of background noise exists when wearing the BEAN as compared to the unamplified condition. A secondary purpose was to investigate the attitudes toward Personal Sound Amplification Products (PSAP) such as the BEAN in regard to aesthetics, ease of use, comfort, perceived benefit, willingness to pay, etc.

Speech Recognition in Noise

The data from this study displayed no significant differences in speech recognition ability in noise while wearing the BEAN when compared the unamplified condition. Despite claims made on the Etymotic Research Inc. website (2014) that the BEAN is capable of adjusting to surrounding noise levels to provide clarity in less-than-ideal listening environments, the normal hearing participants in this study did not display any notable improvement in speech recognition in noisy environments. Seeing as the subject population in this study was limited to normal hearing listeners, perhaps an improvement in speech understanding in noise would occur if participants presented with a slight to mild hearing loss, or complained of self perceived difficulty listening in background noise.

A study conducted by Kochkin (2014) determined that direct-mail non-prescriptive hearing devices and traditional hearing aids provided equivalent benefit according to the consumer in business meetings, while watching television, in places of worship, while talking on the telephone, in small gatherings, and while engaging in conversations in quiet. Traditional hearing aid fittings were shown to be significantly superior in restaurants, at large public lectures, and in conversations on the street. These findings yielded from previous research corroborate the results from this study suggesting that PSAP devices such as the BEAN Quiet

Sound Amplifier do not significantly improve speech recognition ability in the presence of background noise.

Attitudes towards the BEAN

Descriptive data collected via questionnaire displayed primarily positive attitudes towards the BEAN Quiet Sound Amplifier in regard to its ease of use. Participants most often rated the BEAN as either "good" or "very good" in regard to ease of inserting and removing the device, changing its batteries, and changing its volume or programs. This suggests that participants overall felt comfortable and capable of manipulating the device successfully, likely to promote self-efficacy. Previous research conducted by Kochkin (2014) found no significant differences between traditional hearing aids and direct-mail non-prescriptive hearing aids when consumers rated their satisfaction with their ease of changing batteries or ease of insertion/removal from ear. Remarkably, the aforementioned study also determined that consumers were more satisfied with the ease of making volume adjustments with direct-mail hearing devices than traditional hearing aids.

Participants also responded positively in regard to their physical comfort while wearing the BEAN in their ear, suggesting that they would not be deterred from using this PSAP due to lack of comfort. Interestingly, 21% of individuals with hearing loss participating in a MarkeTrak VII study that did not utilize hearing aids listed the claim that they are "uncomfortable" as a reason for non-adoption, and 25% listed that "they did not fit well" as a reason for non-adoption (Kochkin, 2007). Perhaps PSAP devices such as the BEAN could also serve as a more physically comfortable device to compete with traditional hearing aids for patients with less significant hearing loss configurations who may not be ready to commit to a hearing aid.

One of the primary reasons for non-adoption of hearing aids has been determined to be their associated stigma. In Kochkin's MarkeTrak VII study (2007), 29% of listeners listed the fact that hearing aids are "too noticeable" as a reason for non-adoption, and 30% stated they were "too embarrassed to wear hearing aids." In contrast, participants in this study most often described the appearance and aesthetics of the Etymotic BEAN PSAP as "good," suggesting positive attitudes towards their appearance. While the subject population of this study was limited to normal hearing listeners, perhaps the small, sleek design of this particular PSAP would be more appealing to listeners with a mild hearing loss that could benefit from a hearing aid but have chosen not to be fit with amplification for aesthetic or stigma-related reasons.

In regard to sound output, participants in this study most often rated the sound quality of the BEAN as "good." Prior research has found that hearing aids are rated slightly better overall than direct-by-mail hearing devices on sound quality, but only by a margin of six percentage points. No significant differences between devices were noted for sound quality factors such as clearness, sound of voice, naturalness, directionality, feedback, or richness (Kochkin, 2014). The fact that PSAP devices such as the BEAN have generated comparable sound quality satisfaction ratings by consumers to traditional hearing aids suggests that PSAP devices have potential as less costly, more accessible products to compete with traditional hearing aids for listeners with lesser degrees of hearing loss.

On average, participants rated their perceived benefit of the BEAN's ability to enhance their speech understanding in noise as "fair" (Mean=3.0). A Consumer Electronics Association PSAP study (2014) determined that 17% of U.S. adults with some degree of hearing loss who own a PSAP use their device in noisy settings. The results of the present study corroborate the

CEA study findings, suggesting that only a portion of PSAP users will find PSAPs beneficial to speech understanding in noise. The generalizability of these findings to potential PSAP users is obviously limited given our normal hearing participant population.

When surveyed regarding their willingness to pay $200-$300 for the BEAN if sounds needed to be amplified, participants most often stated they would be “somewhat willing” to pay for the aforementioned PSAP. Previous research has shown that the primary motivator to purchase direct-by-mail non-prescriptive hearing devices by first-time uses is price. Additionally, the out-of-pocket price per hearing device to the direct-by-mail consumer is only 20% of the price of a traditional hearing aid (Kochkin, 2014). The questionnaire data obtained in this study investigating willingness to pay for the BEAN supports our hypothesis that there may be a market for PSAPs amongst listeners who are interested in sounds being slightly boosted, but may not be willing to pay the exorbitant price of a traditional hearing aid.

In previous literature, when examining satisfaction and perceived benefit by the consumer for non-prescriptive PSAP devices in conjunction with their significantly cheaper price, the consumer of non-prescriptive PSAPs rates their device significantly higher on value compared to the traditional hearing aid consumer. Recent studies have also shown that both traditional hearing aid users and direct-by-mail hearing device users report equivalent quality of life improvements attributed to their selected method of amplification (Kochkin, 2014). Overall, the positive questionnaire outcomes obtained from our study in conjunction with earlier literature determining PSAP devices are functionally comparable to prescriptive hearing aids in many situations supports the likelihood of a potential increase in the market for PSAP devices in the near future of audiology. The findings from this study also further support Robyn Cox's suggestion that audiologists begin to consider implementing PSAPs in their practice. Given the positive attitudes and level of acceptability by the participants in this study, perhaps audiologists could benefit from recommending PSAPs as a viable option for patients who are not yet ready to adopt hearing aids.

LIMITATONS & FUTURE RESEARCH

Limitations to the generalizability of the findings of this study include our reduced number of participants (n=25) in addition to our exclusively normal hearing young adult population. While restricting the participant population to normal hearing listeners allowed the researchers to eliminate confounding variables such as varying degrees or types of hearing loss, normal hearing listeners may be less likely to demonstrate benefit from a PSAP if they were not originally experiencing difficulty listening in noise. Further research should aim to explore the benefit of PSAP devices to speech recognition ability in noise for listeners with slight to mild hearing loss, or for listeners who complain of self-perceived hearing difficulties despite having normal hearing.

Additionally, while young adult participants are easily accessible for research purposes, they are not most representative of the patient population that is likely to experience hearing difficulties that may warrant the purchase of a PSAP. It would be advantageous to investigate the benefits of and attitudes towards PSAP devices in older adult populations, considering that adults with age-related hearing difficulties are likely to express interest in such a device.

Furthermore, the various test conditions developed for this study only permitted participants to experience unilateral listening with one PSAP device at a time. The benefits of binaural amplification with traditional, prescriptive hearing aids when listening in background noise are well documented (Stender, 2014). Given the gaps in the literature when considering this phenomenon with PSAP devices, future research should examine the benefits of using one PSAP versus binaural PSAP devices, particularly in the presence of background noise.

Lastly, speech-in-noise testing performed in this study was arranged such that both the speech signal and multi-talker babble noise were presented at 0 degrees azimuth. Given that hearing assistive technology often utilizes directional microphones to suppress background noise and enhance the speech signal, it would have been useful to assess the BEAN's benefit to speech understanding in noise if the background noise was presented from behind the listener (180 degrees azimuth) or from the sides (90 or 270 degrees azimuth). If the aforementioned arrangement had been utilized, perhaps an improvement in speech understanding in noise using the BEAN device would have been noted when compared to the unamplified condition. Given the set-up of this study, the directional microphone capabilities of the BEAN Quiet Sound Amplifier could not truly be assessed.

CONCLUSION

The results of this study indicate that young adult normal hearing listeners do not demonstrate an improvement in speech recognition ability in the presence of background noise when wearing the BEAN Quiet Sound Amplifier as compared to the unamplified condition. Despite lack of improvement in speech recognition in noise, young adults with normal hearing overall displayed positive attitudes toward personal sound amplification products such as the BEAN in regard to ease of use, physical comfort, appearance/aesthetics, sound quality and willingness to pay. Results suggest that personal sound amplification products such as the BEAN are likely to have future potential in the field of audiology given the positive responses and level of acceptability displayed in this study.

APPENDIX A

Doctoral Program of Audiology
The Graduate Center, City University of New York (CUNY)

WE ARE CONDUCTING RESEARCH TO STUDY ATTITUDES TOWARDS PERSONAL SOUND AMPLIFICATION DEVICES

We are looking for volunteers:

- Adults 18-40 years old who are fluent in English
- No history of hearing loss or middle ear disease

Benefits:

- You will receive $10.00
- You will help us to better understand the possible benefits of Personal Sound Amplification Products and their potential for use in the future

Procedure:

- You will participate in one 30-60 minute session at the CUNY Graduate Center's Hearing Research Laboratory – 365 Fifth Avenue Room 7306, NYC
- You will be asked to repeat words in the presence of background nice while wearing two Personal Sound Amplification Products and answer a short questionnaire regarding your perceptions of the two devices.

Contact:

If you are interested in participating or for more information, please contact us:
Marisa Viets – mviets@gc.cuny.edu
Jennifer Rhoades – jrhoades@gc.cuny.edu

APPENDIX B

Participant #: ___________ **Age:** ___________ **Sex:** ___________

Middle Ear Screening:

	Right	**Left**
ECV		
Peak		
Static		
Pass/Fail		

Pure Tone Screening @ 20dBHL:

	250Hz	**500Hz**	**1000Hz**	**2000Hz**	**4000Hz**	**8000Hz**	**Pass/Fail**
Right							
Left							

Speech in Noise Testing:

Unaided SRS: ___________

Bean SRS: ___________

CS50 SRS: ___________

APPENDIX C

Attitudes of Normal Hearing Listeners Towards Personal Sound Amplification Products

ETYMOTIC BEAN

1. How would you rate the ease of inserting and removing the Bean from your ear?

Very Poor	Poor	Fair	Good	Very Good
1	2	3	4	5

2. How would you rate the ease of changing the battery of the Bean?

Very Poor	Poor	Fair	Good	Very Good
1	2	3	4	5

3. How would you rate the ease of changing the volume and/or programs of the Bean?

Very Poor	Poor	Fair	Good	Very Good
1	2	3	4	5

4. How would you rate the physical comfort of the Bean in your ear?

Very Poor	Poor	Fair	Good	Very Good
1	2	3	4	5

5. How would you rate the appearance/aesthetics of the Bean?

Very Poor	Poor	Fair	Good	Very Good
1	2	3	4	5

6. How would you rate the sound quality of the Bean?

Very Poor	Poor	Fair	Good	Very Good
1	2	3	4	5

7. How would you rate the Bean's benefit to your speech understanding in noise, as compared to when you are not wearing any device?

Very Poor	Poor	Fair	Good	Very Good
1	2	3	4	5

8. If you needed sounds to be amplified/made louder, how willing would you be to pay $200-$300 for the Bean?

Very Unwilling	Somewhat Unwilling	Neither Willing nor Unwilling	Somewhat Willing	Very Willing
1	2	3	4	5

APPENDIX D

STATA Statistical Testing Output

```
. ttest unaided = bean

Paired t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
 unaided |      25        48.4     1.92873    9.643651     44.4193     52.3807
    bean |      25       47.68    1.835502    9.177509    43.89171    51.46829
---------+--------------------------------------------------------------------
    diff |      25         .72    2.489659    12.44829   -4.418403    5.858403
------------------------------------------------------------------------------
     mean(diff) = mean(unaided - bean)                            t =   0.2892
 Ho: mean(diff) = 0                              degrees of freedom =       24

 Ha: mean(diff) < 0           Ha: mean(diff) != 0           Ha: mean(diff) > 0
 Pr(T < t) = 0.6125         Pr(|T| > |t|) = 0.7749          Pr(T > t) = 0.3875

. . summarize Q1, detail

                              Q1
-------------------------------------------------------------
      Percentiles      Smallest
 1%            2              2
 5%            3              3
10%            3              3       Obs                  25
25%            4              3       Sum of Wgt.          25

50%            5                      Mean               4.32
                        Largest       Std. Dev.      .8524475
75%            5              5
90%            5              5       Variance       .7266667
95%            5              5       Skewness      -1.068328
99%            5              5       Kurtosis       3.365205

. . summarize Q2, detail

                              Q2
-------------------------------------------------------------
      Percentiles      Smallest
 1%            2              2
 5%            2              2
10%            2              2       Obs                  25
25%            3              2       Sum of Wgt.          25

50%            4                      Mean                3.6
                        Largest       Std. Dev.             1
75%            4              5
90%            5              5       Variance              1
95%            5              5       Skewness      -.1530931
99%            5              5       Kurtosis       2.020833
```

```
. . summarize Q3, detail

                             Q3
-------------------------------------------------------------
      Percentiles      Smallest
 1%            2              2
 5%            2              2
10%            2              2       Obs                  25
25%            3              2       Sum of Wgt.          25

50%            4                      Mean                3.8
                        Largest       Std. Dev.      1.080123
75%            5              5
90%            5              5       Variance       1.166667
95%            5              5       Skewness      -.4049619
99%            5              5       Kurtosis       1.933673
```

```
. . summarize Q4, detail

                             Q4
-------------------------------------------------------------
      Percentiles      Smallest
 1%            2              2
 5%            3              3
10%            3              3       Obs                  25
25%            3              3       Sum of Wgt.          25

50%            4                      Mean               3.96
                        Largest       Std. Dev.      .8406347
75%            5              5
90%            5              5       Variance       .7066667
95%            5              5       Skewness      -.3552982
99%            5              5       Kurtosis       2.437322
```

```
. . summarize Q5, detail

                             Q5
-------------------------------------------------------------
      Percentiles      Smallest
 1%            2              2
 5%            2              2
10%            2              2       Obs                  25
25%            3              3       Sum of Wgt.          25

50%            4                      Mean               3.88
                        Largest       Std. Dev.      1.013246
75%            5              5
90%            5              5       Variance       1.026667
95%            5              5       Skewness      -.4940898
99%            5              5       Kurtosis       2.185054
```

```
. . summarize Q6, detail

                             Q6
-------------------------------------------------------------
      Percentiles      Smallest
 1%            1              1
 5%            2              2
10%            2              2       Obs                  25
25%            3              3       Sum of Wgt.          25

50%            4                      Mean               3.56
                        Largest       Std. Dev.      .8698659
75%            4              4
90%            4              4       Variance       .7566667
95%            4              4       Skewness      -1.350286
99%            5              5       Kurtosis       4.562489

. . summarize Q7, detail

                             Q7
-------------------------------------------------------------
      Percentiles      Smallest
 1%            1              1
 5%            2              2
10%            2              2       Obs                  25
25%            2              2       Sum of Wgt.          25

50%            3                      Mean                  3
                        Largest       Std. Dev.      1.040833
75%            4              4
90%            4              4       Variance       1.083333
95%            5              5       Skewness       .2262878
99%            5              5       Kurtosis       2.292899
```

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