The iPhone as an Appropriate Hearing Assistive Technology in the Classroom?

SPECIFIC OBJECTIVES:

One of the biggest challenges faced by educational audiologists is resistance from teenagers to use personal hearing assistive technology in the classroom. Even though the improvements in signal-to-noise ratio, decreased listening effort, and improved speech perception are well established (AAA, 2011), many teenagers refuse additional devices or do not use them consistently. This resistance is primarily attributed to social pressures and the negative stigma associated with visible physical equipment that is perceived to highlight a disability (Frank, 2008; Groth, 2017).

A major impetus in the hearing industry is designing assistive technologies to be more discrete and attractive to potential users. Traditional, personal FM/DM systems are continuously being (re)designed as smaller, sleeker, and more appealing cosmetically. For example, the Phonak Roger™ Pen, was specifically designed to be discrete and disassociated from the negative stigma surrounding traditional microphone/transmitter designs, while delivering a high-quality acoustical signal (Phonak, 2013). Another category of hearing assistive devices uses Bluetooth for transmission. Some of these transmit directly from the remote microphone to the hearing aid, circumventing the need for an intermediary streaming device, and reducing the necessary accessory equipment. Alternatively, smartphones may be used as an intermediary streamer, and may even function as the remote microphone (reviewed in Ricketts et al., 2019).

Using a smartphone (specifically, an iPhone) as both the microphone and streamer is the most discrete option available; however, audiologists rarely recommend this as an assistive technology for the classroom. Two obvious concerns include (1) the characteristics of the microphone/quality of the signal and (2) distance from the speaker. Although the effects of microphone distance from the sound source are well established (Rosenberg, 2010), to our knowledge there are no data quantifying the overall acoustic quality of a smartphone used as an assistive device in a classroom. As teenagers become more aware of available technology solutions and as they begin to take on more responsibility for hearing ability, it is essential that audiologists are prepared to have informed discussions with data-based recommendations. Moreover, educational audiologists do encounter the rare student who is using smartphones for hearing assistance in the school setting (personal communication, Donna Merchant, March 15, 2018). The need exists for additional data to quantify how this solution compares to FM/DM, which is considered the gold standard for classrooms. Does the additional discretion/convenience of the smartphone come at the expense of the fidelity of the signal?

The purpose of this study is two-fold. First, we aim to characterize the quality of the smartphone (iPhone) as an assistive technology for teenagers/young adults with hearing impairment by comparing it to the Roger™ Pen DM, which is also designed for discretion but additionally to optimize hearing. The comparison will include electroacoustic outputs (to characterize microphone characteristics), and measures of functional benefit when the device is used in a simulated classroom. The functional measures will be percent correct on speech materials presented amidst competing sounds. Secondly, we aim to compare the listener's preference for each system in a blinded condition (the only available information is the perceived signal quality) and in an un-blinded condition (physical appearance/associated stigma may influence perception). These comparisons will provide insight into the effects of physical appearance and perceived sound quality on preference. Additional factors potentially influencing the preference judgment will be explored using interview questions.

METHODS AND PROCEDURES

Laboratory-owned hearing aids (GN Resound LiNX3D) will be used for all measurements. These devices can be paired to the iPhone (via Live Listen) or to the Roger™ Pen.

1. Electroacoustic Verification: The iPhone and Roger™ Pen remote microphones will be assessed for transparency when transmitting to the laboratory hearing aids. This comparison involves presenting a broadband signal to the transmitting microphone and measuring the acoustic output from the hearing aid (AAA [Supplement A], 2011). The comparison will provide insight regarding signal quality reaching the hearing aid.

Subjects: Twenty-one hearing aid users (ages 13 to 21 yrs) with sensorineural hearing loss ranging from mild to moderately severe and good aided word discrimination, bilaterally, will participate in this study. Behavioral audiograms will be obtained for participants unable to bring a recent audiogram. The laboratory hearing aids will be programmed to DSL v5 targets and verified using real-ear measurements. Fine-tuning adjustments will be made as needed to improve the match of the output to targets to within 5 dB (AAA Guidelines; 2013). It is anticipated that participation, including consent/assent, can be completed within two hours.

Classroom Simulation: Montclair's Spatial Hearing Lab will be set up to simulate a classroom. A desk and chair will be placed in the center of the room. Four loudspeakers will be placed at ear height 8' from the center of a desk chair at 0, 90, 180 and 270° azimuth. The iPhone and Roger^{TM} Pen will be placed at the front of the desk.

2. Behavioral Verification: Speech perception will be assessed using BKB-SIN sentences (Bench et al., 1979) presented from a speaker located at 0° azimuth. The level will be calibrated to 65 dBA measured at the location of the participant. Uncorrelated broadband competing signals will be presented at fixed levels (as opposed to adaptive) from loudspeakers located at 90, 180 and 270°. There will be twelve test conditions: three devices (hearing aid alone, iPhone microphone, Roger^{TM} Pen), and four signal-to-noise ratios (SNR; -5, 0, +5 dB and infinite [quiet]). The order of testing each device will be counterbalanced. Participants will be blinded to the device condition. A raised laptop screen will be used as a visual barrier to hide the assistive devices. The order of presenting each listening condition will proceed from most (-5 dB SNR) to least (quiet) challenging. The sentence list used will be randomly chosen. Participants will repeat back each sentence, which will be scored as percent of words correctly repeated. Each list contains 20 sentences.

3. Blinded and Unblinded Preference Assessment/Interview: For the first set of comparisons, the participant will be blinded to the device (hearing aid alone, iPhone microphone, Roger^{TM} Pen) to eliminate any stigma associated with physical appearances from influencing the judgments. *The Rainbow Passage* (Fairbanks, 1940) will be presented from the loudspeaker at 0° azimuth at 65 dBA with uncorrelated, competing signals presented from the remaining loudspeakers at a combined level of 70 dBA (-5 dB SNR). Participants will be instructed to take note of the signal quality, such as clarity, distortion, and ease of comprehension. The passage will be played again for each remaining device (tested in the same order as the behavioral verification component). Participants will then be asked to rank the devices in order of preference (1: most preferred; 3: least preferred). This set of procedures will be repeated without blinding. Participants will then be asked questions regarding their attitudes toward the two assistive devices and whether they would see themselves using either or both outside of the research environment, and specifically, in a classroom setting.

Analysis: The acoustic output of the hearing aid will be compared across frequency for the two assistive devices. Benefit from the assistive devices will be quantified by taking the difference in speech perception scores between the hearing-aid alone condition and either the iPhone or Roger^{TM} Pen conditions. The amount of benefit provided by each device will be compared across the signal-to-noise ratios. The quiet condition provides the best-case scenario for each participant; performance is expected to be essentially equal across devices and will be considered a baseline. Statistical analysis will involve repeated measures analysis of variance on the behavioral percent-correct scores using the factors device and signal-to-noise ratio. Post-hoc analyses will be performed as appropriate. The preference assessment with and without blinding will be compared to assess whether visual input changes attitudes towards the two devices. The informal interview responses will be compiled and evaluated for patterns. Together the preference and interview responses will be considered with respect to the potential influence of stigma.

FACILITIES AND RESOURCES:

The research will be performed within the space designated to the Department of Communication Sciences and Disorders at Montclair State University, which includes clinical, research and teaching areas. Of particular relevance are the Spatial Hearing and Hearing Aid laboratories. Equipment and software includes but is not limited to loudspeaker arrays, amplifiers and mixers, audiometers, sound level meters, hearing-aid test boxes, NOAH, MATLAB and SPSS.

Key personnel: The applicant, Erin Roach, has support from the four faculty members on her capstone committee. All have worked in various pediatric settings and have a range of clinical/applied and research experiences. Maryrose McInerney is CEO of Hackensack Audiology and Hearing Aid Associates, which serves a large pediatric population. A site approval letter has been obtained to aid with subject recruitment efforts for this study.

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