CASE STUDY

The Perceived Benefit of an External Microphone Coupled to Post Auricular Amplification

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An external microphone provides direct routing of the desired sound source into the hearing aid via direct auditory input and is used to increase speech understanding in difficult listening situations. To measure the benefit/reduction of disability through use of the external microphone and hearing aid compared to the hearing aid alone, a modified version of the Abbreviated Profile of Hearing Aid Benefit (APHAB) was completed by 15 adults. With the external microphone, a significant perception of benefit/reduction of disability was demonstrated for ease of communication in quiet, noise, and reverberant situations. Subjective comments including advantages and disadvantages of the external microphone provide further insight about patient candidacy and counseling techniques.

One of the most frequent complaints of people with hearing loss is their inability to understand speech in a background of noise. Several studies confirm that, in environments where there is competing noise, individuals with hearing loss perform more poorly than individuals with normal hearing (Finitzo-Hieber & Tillman, 1978; Nabelek & Pickett, 1974; Stone & Moore, 1992). Even successful users of hearing aids frequently complain of difficulty understanding speech in a background of noise. For this reason, much of the current hearing aid research focuses on improving users' performance in competing noise (Fabry, 1991; Keidser, 1996).

While there is no hearing aid on the market today that can amplify speech without amplifying some of the surrounding ambient sounds, the use of assistive listening devices can provide great benefit in difficult listening situations. There is

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ample evidence, for example, that an FM system reduces the deleterious effects of reverberation, distance from the speaker, and competing noise (Boothroyd, 1992; Picard & Lefrancois, 1986; Ross, 1992). FM systems have a long history of use, particularly in educational settings. These systems consist of a wireless microphone/transmitter worn by the speaker and a receiver worn by the listener. The FM signal is transmitted from the microphone/transmitter of the speaker to the receiver worn by the listener. The receiver is typically connected to their behind-the-ear hearing aid(s) via three possibilities: direct-audio input (DAI), an induction loop, or silhouettes. In some FM systems, the receiver is already contained in the behind-the-ear hearing aid or contained in a small audio shoe that attaches to the bottom of the hearing aid.

Although the advantages of an FM system are clearly demonstrated, many adult users of amplification do not use one because of cost and/or the perceived difficulties associated with their use (Jerger, Chmiel, Florin, Pirozzolo, & Wilson, 1996). These difficulties involve dexterity, such as handling the large receiver and the connections to the receiver and/or hearing aid. An alternative is the use of a simple hard-wired system such as the external microphone that functions similarly to the remote microphone of an FM system (Kaplan, 1996). The external microphone is small and relatively inexpensive, couples via DAI or an induction loop to personal hearing aid(s), and its use reduces the distance between the talker's mouth and the input to the hearing aid.

As an assistive listening device, the external microphone has been available for many years, yet it is rarely recommended by audiologists for individuals with hearing loss as a simple solution to listening in noisy situations. Many authors extol the virtues of an FM system for difficult listening situations, yet only brief references concerning the disadvantages/advantages of an external microphone can be found in the professional literature (Alpiner & McCarthy, 1987; Ross, 1992; Sanders, 1993; Tyler & Schum, 1995).

Once a hearing aid has been chosen and fitted, the audiologist can decide what measures will be used to assess the fitting. Validating a successful hearing aid fitting can be quantified objectively and/or reflected subjectively by the judgment of the hearing aid user. Objective measures such as psychophysical and electroacoustic measures do not necessarily provide insight as to whether the hearing aid will decrease the user's feelings of handicap or disability. We may infer that if the hearing aid meets all the requirements necessary to provide benefit for a particular hearing loss that it will also decrease the individual's feelings of disability in everyday life. Through the use of self-assessment handicap and disability questionnaires, we can begin to look at subjective disability in different environments when the individual does or does not wear his/her hearing aid or we can compare one fitting with another.

The Abbreviated Profile of Hearing Aid Benefit (APHAB), developed by Cox and Alexander (1995), is an outgrowth of revisions of the Profile of Hearing Aid

Performance (PHAP) and Profile of Hearing Aid Benefit (PHAB) (Cox, Alexander, & Gilmore, 1991a, 1991b; Cox & Gilmore, 1990; Cox & Rivera, 1992). The PHAP is a 66-item inventory designed to quantify subjective degree of disability in typical everyday communicative situations encountered by individuals with hearing loss. The PHAB questionnaire is completed with two responses, one in the unaided condition and one in the aided condition. The APHAB is a 24-item subjective assessment scale for quantifying the perceived disability of users with hearing loss and the benefit/reduction of disability that is achieved by hearing aid use. Each item in the APHAB is a statement, with the subject indicating the percentage of time the statement is true. A 7-point scale is provided, which ranges from *A* representing always (99%) to *G* representing never (1%). The subject's response to each question results in an aided and unaided disability score. "Benefit/reduction in perceived disability" (in percent) is defined as the difference between the unaided and aided disability scores. The APHAB assesses perceived disability in four communication situations. The four communication situations are: *Ease of Communication* (EC), speech understanding in relatively easy listening conditions; *Reverberation* (RV), speech understanding in moderately reverberant rooms; *Background Noise* (BN), speech understanding in the presence of other talkers or other environmental competing noise; and *Aversiveness of Sounds* (AV), negative reactions to environmental sounds. The APHAB was used in this study to investigate if using an external microphone in conjunction with amplification resulted in benefit/reduction of perceived disability for various listening situations.

METHOD

Subjects

Subjects were 3 men and 12 women with hearing loss with a mean age of 68 years. See Table 1 for all subject characteristics including age, gender, and audiological data. All information was available from previous audiological evaluations obtained at the League for the Hard of Hearing in New York City. Three-frequency, puretone averages (PTA) in dB HL were derived from air-conduction thresholds (American National Standards Institute, 1989). For subjects who were binaurally aided and used the external microphone coupled to both hearing aids, the PTA was derived from the better ear. For subjects who were monaurally aided, the PTA represents the aided ear. All subjects were experienced hearing aid users of post-auricular amplification. Degree of sensorineural hearing loss ranged from mild to profound with a mean PTA of 79 dB HL. The mean speech recognition score using CID Auditory Test W-22 word list was 65% and using CID Everyday Sentences was 10%. One individual had been assessed with the Isophonemic Word List and obtained 0% word recognition.

Table 1

Individual Age, Gender, and Audiological Data

Subject	Age	Gender	Employment	PTA dB HL	Speech recognition scores	Hearing aid type
1	49	F	Retired	105	24% W-22	Standard BTE
2	87	F	Not employed	85	80% W-22	Standard BTE
3	43	F	Full-time	65	92% W-22	Standard BTE
4	61	F	Part-time	93	32% W-22	Programmable BTE
5	86	F	Not employed	100	36% W-22	Standard BTE
6	80	M	Retired	50	88% W-22	Standard BTE
7	70	M	Retired	90	84% W-22	Programmable BTE
8	84	F	Retired	65	50% W-22	Standard BTE
9	51	F	Not employed	101	0% words, 25% phonemes[a]	Standard BTE
10	85	M	Full-time	53	60% W-22	Standard BTE
11	79	F	Not employed	88	78% W-22	Standard BTE
12	40	F	Not employed	23	92% W-22	Standard BTE
13	74	F	Retired	98	10% CID Sentences	Standard BTE
14	49	F	Not employed	97	10% CID Sentences	Standard BTE
15	82	F	Not employed	83	60% W-22	Standard BTE

Note. BTE represents Behind-the Ear Hearing Aid.

[a]Isophonemic Word List.

Apparatus

The external microphone used for this study by 14 subjects was either the Oticon Mic 30 or 34 coupled via DAI either monaurally or binaurally by a cord which came in a 17" or 70" length. The black microphone is omni-directional with sensitivity at 1000 Hz of -53 dB re 1v/o.1Pa, internal noise was max.26 dB re 20 υPA, and output impedance was 3.5 ohm with a battery drain of 25 υA. The microphone used either a 675 (IEC R44) or 13 (IEC R48) battery. The dimensions of the microphone are 62.5 × 15 mm and it weighs 8.2 g. The external microphone could be held by the listener and directed toward the talker or attached to the talker's clothing near the mouth. The reason for choosing this external microphone was its availability for demonstration, ability to attach via a universal three-prong cord to a hearing aid audio-shoe, portability, small size, and relatively low price. One of the experienced users had obtained a comparable Siemens external microphone with similar specifications.

Measure

A modified version of the APHAB was used to assess perceived benefit from external microphone use. The APHAB is usually completed with two responses, one in the unaided condition and one in the aided condition. The first set of responses, which is typically "without hearing aid," was replaced in this study by "hearing aid without external microphone." The second set of responses, "with hearing aid," was replaced with "hearing aid and external microphone." Comparing the total scores of both conditions, *with external microphone* and *without external microphone* resulted in the degree of perceived benefit/disability.

The second modification was to exclude the last category of the APHAB, *AV,* from the analysis because it was not relevant to this study as it pertains to uncomfortable loudness levels and hearing aid use. In addition, subjects were asked five questions. Question 1 dealt with the length of time they have used an external microphone with their amplification. The choices for this question were: less than 6 weeks, 6 weeks to 11 months, 1 to 10 years, or over 10 years. These choices are the same as used by the APHAB to establish the length of hearing aid use. The second question addressed how often they used the external microphone and the choices were: infrequently, less than once a week; occasionally, once or twice a week; or frequently, several times a week. These choices were the same as those used by the APHAB to establish hearing aid use. Questions 3, 4, and 5 were open-ended questions. Question 3 addressed the situation in which they found the external microphone most useful and Question 4 addressed how they found out about the external microphone. Question 5 was a request for any additional comments regarding the ease of usage, benefits, and/or disadvantages of the external microphone.

For the three new users of the external microphone, the first condition, *hearing aid without microphone,* was completed prior to receiving the microphone.

Approximately 4-6 weeks later clients were asked to complete the second condition, *hearing aid and external microphone.* The 12 experienced users of the external microphone completed both conditions of the questionnaire at the same time. Questionnaires were completed at the facility or mailed.

Procedure

Twenty-six questionnaires were mailed to known external microphone users. A second request was mailed approximately 1 month later if there was no response. Subjects were offered a free package of batteries for returning the questionnaire by mail. Out of the 26 questionnaires mailed to experienced users, 15 were completed and returned (return rate of 57%). Of the 15 returned, 3 were not used in the study: 1 subject returned the microphone, 1 subject filled out the questionnaire incorrectly, and 1 subject did not anticipate ever using the microphone. In addition, three new users completed the questionnaire resulting in a total of 15.

Each new user was instructed in the use and care of their external microphone and was required to demonstrate proficiency in its handling. Subjects were informed they could come back at any time for further instruction if they experienced difficulties using the microphone. Experienced users were also given the option to receive instructions again on the use and care of their external microphone. Although experienced users did not ask for additional instruction several requested information about coupling the microphone to other audio equipment, second microphones, or a change of cord length or color.

RESULTS

According to Cox (1997), if for the three subscales examined, EC, RV, or BN, there is a difference between aided and unaided conditions ≥22% the clinician can be reasonably certain that it represents a real difference/benefit for the individual client and is not due to chance variations. If the combined scores of all three communication situations (EC, RV, and BN) improve by ≥10%, then there is a 96% probability that a true difference/benefit has occurred; and if it improves by ≥5% then there is an 89% probability that a true difference/benefit has occurred. See Table 2 for APHAB results for each subject.

Using this type of individual analysis comparing aided without the external microphone to aided with the external microphone, only 2 of 15 subjects (9 and 14) showed no significant benefit. Five subjects (1, 2, 3, 5, and 10) demonstrated a difference of ≥22% in EC between when the external microphone was used and when it was not. For 2 of the 5 subjects (2 and 10), this was the only communication situation where there was this significant decrease in disability. Subjects 1, 3, 4, 5, 12, and 15 showed significant benefit in BN and Subject 8 showed a significant benefit in RV. Subjects 1, 3, and 5 were the only individuals that showed significant benefit for two communication situations (EC and

Table 2

APHAB Scores for All Subjects

Subjects	Communication situations: Communication ease (EC)	Communication situations: Reverberation (RV)	Communication situations: Background noise (BN)	Total benefit all three conditions (EC, RV, BN)
1	55.00[a]	12.00	57.00[a]	124.00[b]
2	25.00[a]	10.00	12.00	47.00[b]
3	35.00[a]	7.00	35.00[a]	77.00[b]
4	20.00	20.00	36.00[a]	76.00[b]
5	25.00[a]	0.00	25.00[a]	50.00[b]
6	0.00	0.00	15.00	15.00[b]
7	5.00	15.00	17.00	37.00[b]
8	18.00	32.00[a]	0.00	50.00[b]
9	0.00	0.00	2.00	2.00
10	25.00[a]	15.00	12.00	52.00[b]
11	15.00	0.00	-10.00	5.00[c]
12	18.00	17.00	30.00[a]	65.00[b]
13	17.00	0.00	15.00	32.00[b]
14	2.00	3.00	-10.00	-5.00
15	10.00	16.00	25.00[a]	51.00[b]

Note. Cox (1997). The values represent percentage of benefit.

[a]Significant benefit in one condition, EC, RV, or BN (≥22%). [b]Significant benefit in a combination of all three conditions, EC and RV and BN (≥10%). [c]Significant benefit in a combination of all three conditions, EC and RV and BN (≥5%).

BN).

Using an improvement of either ≥10% or ≥5% for the combination of all three listening situations, EC, RV, and BN, all subjects except for 9 and 14 showed a significant decrease in disability. In reviewing individual data, no obvious explanation for the lack of benefit for these subjects was apparent. However, these subjects were two of the three individuals who used the external microphone less than one time per week.

Client Comments: Strategies, Advantages, and Disadvantages

Subjects' responses to the open-ended questions are shown in Table 3. Both advantages and disadvantages with using the external microphone were reported. Although most participants reported being able to communicate better in difficult listening situations some felt encumbered by the length of wire and had difficulty attaching it to their hearing aids. One user's strategy was to attach the microphone before attending a function and therefore she was ready to extend it when needed. At large gatherings and noisy restaurants, some users reported hearing

Table 3

Hearing Aid and External Microphone Usage

Subject	Aided	Years of hearing aid usage	Hours of hearing aid usage	Total time external microphone usage	Weekly external microphone usage	How the subject found out about the external microphone
1	Monaural	>10	8-16	1-10 years	Several ×s week	SHHH
2	Monaural	>10	8-16	6 weeks - 11 months	1-2 ×s per week	Audiologist
3	Monaural	>10	8-16	6 weeks - 11 months	1-2 ×s per week	Friend who uses one
4	Binaural	>10	8-16	6 weeks - 11 months	1-2 ×s per week	Audiologist
5	Binaural	>10	8-16	6 weeks - 11 months	Several ×s week	SHHH and League for the Hard of Hearing
6	Binaural	1-10	8-16	<6 weeks	1-2 ×s per week	Speech reading teacher
7	Binaural	>10	8-16	<6 week	1-2 ×s per week	ALD catalogs[a]
8	Binaural	1-10	8-16	6 weeks - 11 months	<1 × per week	Saw someone using one
9	Binaural	>10	8-16	6 weeks - 11 months	<1 × per week	Audiologist

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Table 3 *Continued from previous page*

Subject	Aided	Years of hearing aid usage	Hours of hearing aid usage	Total time external microphone usage	Weekly external microphone usage	How the subject found out about the external microphone
10	Binaural	1-10	8-16	1-10 years	Several ×s week	Audiologist
11	Binaural	>10	8-16	<6 weeks	Several ×s week	Audiologist
12	Binaural	1-10	4-8	6 weeks-11 months	1-2 ×s per week	Audiologist
13	Binaural	1-10	8-16	1-10 years	1-2 ×s per week	Audiologist
14	Monaural	>10	8-16	6 weeks-11 months	<1 × per week	Audiologist
15	Binaural	>10	8-16	6 weeks-11 months	Several ×s week	Friend uses one

Note. SHHH represents the Self-Help for Hard of Hearing People, Inc.
[a]Commercially available assistive devices catalog.

better, but some felt uncomfortable asking others to either attach the microphone to their clothing or speak into it. Participants reported that not everyone was receptive to using the microphone as they refused to speak into it or hold it. One subject felt insecure asking others to speak into the microphone. Others felt that louder speech did not necessarily equal clearer speech. They were pleased, however, that the microphone kept their conversational partner in front of them where they could take advantage of visual cues. The microphone was considered a valuable tool especially in everyday situations such as at the bank where it could be passed under the glass partition, at the doctor's office, or when shopping. A psychiatrist found that many times his patients speak in a very low voice causing him to miss important information. When he used his external microphone, he reported missing very little. Some participants felt the microphone was not useful at the dinner table when there was more than one person they wanted to hear, and passing the microphone was either not possible or too distracting. However, one user solved this problem when he was visiting with a couple by using two microphones attached to a binaural cord.

Although participants did not use the external microphone all the time, for some participants, it solved what they previously felt was an insurmountable problem. One participant used it only on car trips, so he could communicate with his wife while driving. Several individuals used the microphone with their television or radio by placing it close to the speaker. When comfortable using the microphone, users reported a reduction in the stress of communicating in difficult listening situations.

DISCUSSION

This investigation was undertaken because of frequent complaints heard from adult clients regarding understanding speech when they are in difficult listening situations such as background noise. The external microphone is one solution that is significantly less expensive than an FM system and is relatively simple to use. The results of this study demonstrate significant decreases in perceived disability when using the microphone for understanding speech in relatively easy listening conditions, in moderately reverberant rooms, and in the presence of other talkers or other environmental competing noise. The external microphone provides an improved auditory signal in an environment with competing sounds. It also helps maintain the visual cues provided by the speaker. For example, if the person talking is holding an external microphone, he or she is less likely to move or turn away from the listener.

Most users in this study were able to incorporate the external microphone into their daily communication situations. Individuals used their external microphone in the car, at a restaurant, at a party or small gathering, with a television or radio, at the doctor's office, or in the bank. Some external microphone users incorporated it into most of their communication situations, others in only one situation.

Using an external microphone requires a certain level of assertive behavior. The person with a hearing loss must take the responsibility to be assertive by pinpointing the source of the communication breakdown (e.g., speaking too softly or rapidly, mumbling, covering their mouth, walking away when speaking), informing the speaker about the difficulties, and suggesting solutions. One such solution is using the external microphone.

Audiologists provide rehabilitative services to individuals. Results of this study revealed a significant decrease in feelings of disability for all three communication situations (EC, BN, and RV) when the external microphone was used. Audiologists are increasingly required to provide documentation on the therapeutic outcome of their rehabilitative intervention. Self-assessment scales allow service providers and clients to address the issues of realistic expectations and to what degree they are being met (Newman, Jacobson, Hug, Weinstein, & Malinoff, 1991; Weinstein, 1991; Weinstein, Richards, & Montano, 1995).

The APHAB is a powerful counseling tool and valuable clinical instrument. It can be used to quantify the disability associated with a hearing loss and the reduction of that disability achieved through intervention. By examining the responses together with clients, an open dialogue regarding the identification and management of their particular communication problem can occur. The clinician and user can decide together whether the benefits outweigh the disadvantages. The benefits can be demonstrated through objective tests as well as subjective evidence that the intervention has resulted in a decrease in their feelings of disability.

Audiologists and their clients need to work together during the process of rehabilitation. If problems cannot be solved by conventional amplification alone, we need to know what assistive devices are available and the advantages and disadvantages associated with them so that a viable solution can be found. Of particular importance are the individuals' needs and their perception of disability for particular communication situations. For example, recommending an FM system for a child in school is common practice; however, we do not always offer similar information to adults that will improve function in difficult listening situations (Ross & Yuzon, 1994). Through self-assessment scales, counseling, amplification, and assistive technology we can provide objective and subjective evidence of the positive impact of rehabilitative services. Our clients must be provided appropriate information to boost confidence and to help those who are struggling to communicate in noisy environments. The goal of this study was to provide information on the benefits of using an external microphone in conjunction with personal amplification. The external microphone may prove to be a simple, inexpensive solution, and a trial period should be recommended for individuals who use amplification but are still having difficulty communicating in their daily lives.

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