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Performance of Directional Microphone Hearing Aids in Everyday Life

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Abstract

This study explored the use patterns and benefits of directional microphone technology in real-world situations experienced by patients who had been fitted with switchable omnidirectional/directional hearing aids. Telephone interviews and paper-and-pencil questionnaires were used to assess perceived performance with each microphone type in a variety of listening situations. Patients who used their hearing aids regularly and switched between the two microphone configurations reported using the directional mode, on average, about one-quarter of the time. From brief descriptions, patients could identify listening situations in which each microphone mode should provide superior performance. Further, they reported encountering listening situations in which an omnidirectional microphone should provide better performance more frequently than listening situations in which the directional microphones should be superior. Despite using the omnidirectional mode more often and encountering situations in which an omnidirectional microphone should provide superior performance more frequently, participants reported the same level of satisfaction with each microphone type.

Key Words: Directional microphone, hearing aid benefit, hearing aids, satisfaction

Abbreviations: APHAB = Abbreviated Profile of Hearing Aid Benefit; cd = critical difference; MPQ = Microphone Performance Questionnaire

Sumario

El estudio explora el patrón de uso y los beneficios de la tecnología del micrófono direccional en situaciones de la vida real experimentadas por pacientes a quienes se les han adaptado audífonos con un modo intercambiable omnidireccional/direccional. Se utilizaron entrevistas telefónicas y cuestionarios a papel y lápiz para evaluar el rendimiento percibido con cada tipo de micrófono en una variedad de situaciones de escucha. Los pacientes que utilizaron su auxiliar auditivo regularmente y alternaron entre las dos configuraciones microfónicas, reportaron el uso del modo direccional, en promedio, un cuarto del tiempo total. De descripciones breves, los pacientes pudieron identificar situaciones de escucha donde cada modalidad de micrófono debería aportar un rendimiento superior. Más aún, ellos reportaron más frecuentemente situaciones de escucha donde un micrófono omnidireccional debería dar mejor rendimiento, que situaciones en las que un micrófono direccional debería comportarse en forma superior. A pesar de utilizar el modo omnidireccional más a menudo y de encontrar situaciones en las que el micrófono omnidireccional debería dar un rendimiento superior más a menudo, los participantes reportaron el mismo nivel de satisfacción con cada tipo de micrófono.

Palabras Clave: micrófono direccional, beneficio del auxiliar auditivo, auxiliar auditivo, satisfacción

Abreviaturas: APHAB = Perfil Abreviado de Beneficio del Auxiliar Auditivo; cd = diferencia crítica; MPQ = Cuestionario de Rendimiento del Micrófono

Difficulty understanding speech in the presence of background noise is a common complaint of hearing aid users and a primary reason for dissatisfaction with hearing aids (Kochkin, 1993). Directional microphones are one of the few options available on wearable hearing aids that can improve speech understanding in noise. Although many studies have demonstrated this advantage in controlled laboratory situations (Neilsen, 1973; Chasin,

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1994; Valente et al, 1995; Agnew and Block, 1997; Voss, 1997; Preves at al, 1999; Ricketts and Dhar, 1999; Wouters et al, 1999; Boymans and Dreschler, 2000; Pumford et al, 2000), the extent to which this advantage is realized in the real world is less clear. In some studies in which subjective benefit, preference, or both were assessed in everyday life, directional microphones appeared to provide a substantial performance advantage over omnidirectional microphones in certain listening situations (Mueller et al, 1983; Kochkin, 1996; Kuk, 1996; Schuchman et al, 1999; Yueh et al, 2001). Other studies in which both laboratory and field measures were obtained suggest that the directional benefit perceived in everyday listening environments typically is less than might be expected based on the directional advantage observed in the laboratory (Nielsen, 1973; Valente et al, 1995; Preves et al, 1999; Boymans and Dreschler, 2000).

A discrepancy between laboratory and field measures was also noted in a recently completed clinical trial of switchable omnidirectional/directional microphone hearing aids (Walden et al, 2000). Participants performed significantly better on speech recognition in noise tasks in the laboratory when using a directional microphone mode than they did with an omnidirectional microphone mode. However, these dramatic performance differences were not seen in the field measures of perceived benefit in everyday life. When participants were asked to compare the two microphone configurations in everyday listening situations, they reported only small, nonsignificant differences between the omnidirectional and the directional microphones.

There are a number of possible explanations for the disparity between laboratory and real-world performances of directional microphones. Prominent among these is that laboratory measures of speech recognition in noise may overestimate the practical benefits of directional microphones (Amlani, 2001). Laboratory test conditions are often configured to take advantage of directional microphone technology (i.e., signal presented from the front and noise from the back or sides) and may be quite different from listening situations experienced by patients in the real world. The effectiveness of directional microphones is influenced by specific aspects of the acoustic environment, such as reverberation, the listener's distance from the signal, and the degree of separation of the signal from the competing noise (Nielsen and Ludvigsen, 1978; Mueller and Johnson, 1979; Hawkins and Yacullo, 1984; Leeuw and Dreschler, 1991; Ricketts, 2000). In everyday listening situations, such factors are uncontrolled and may interact in complex ways to limit the benefit from directional microphones.

Several procedural aspects of the clinical trial done by Walden and colleagues (2000) may also account for the minimal reported differences between the two microphone types in daily life. To minimize bias, participants were not told what the different memories (omnidirectional and directional) of the trial hearing aids were for or how to optimize their use. They were simply instructed to switch between the different memories in each new listening situation they encountered. Furthermore, no control was exercised over the types of listening situations participants encountered in their everyday life over the course of the 6-week trial. Consequently, if participants had encountered few noisy environments during the trial period, they would have had little opportunity to experience the potential benefits of the directional microphone configuration.

To learn more about the real-world benefits of directional microphone technology, clinic patients were queried about their experiences and satisfaction with their switchable omnidirectional/directional hearing aids. Clinic patients, in contrast to the clinical trial participants, received instruction from the dispensing audiologist in how to optimize the directional microphone effect. Further, the majority of these clinic patients presented with the complaint of difficulty hearing in noise with their current hearing aids, which is why the directional microphone hearing aids were recommended to them by their audiologist. We can assume that these patients encounter noisy situations that are enough of a problem that they were willing to invest in new hearing aids with the expectation that their ability to understand speech in noise would be improved.

The following questions were addressed in this investigation:

1. Do patients who are fitted with binaural switchable omnidirectional/directional hearing aids use the directional option in daily living and, if so, how much?
2. Do experienced users of these hearing aids recognize the characteristics of everyday listening situations that provide the greatest performance advantages for directional microphones?
3. How frequently are such listening situations encountered in everyday life?

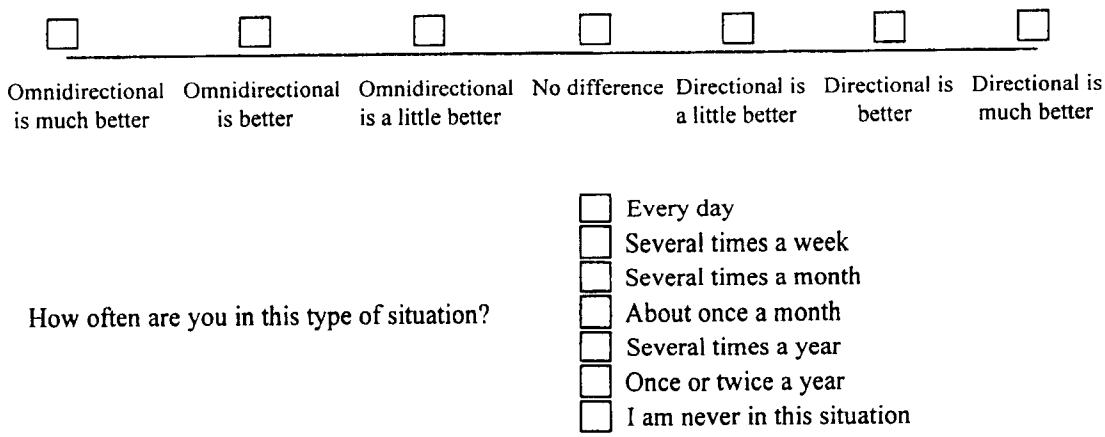

Figure 1 A sample item from the Microphone Performance Questionnaire (MPQ). Items were scored on a 7-point scale, with 1 indicating "omnidirectional is much better" and 7 indicating "directional is much better."

METHOD

Clinic patients who had obtained binaural switchable omnidirectional/directional microphone hearing aids at least 6 months, but not more than 2 years, previously were contacted for a telephone interview. Those who reported regular use of their hearing aids (at least 4 hours/day) and indicated at least occasional use of both microphone configurations were mailed two paper-and-pencil questionnaires designed to compare perceived performance between the two microphone types in a variety of listening environments.

Questionnaires

Abbreviated Profile of Hearing Aid Benefit

Participants were asked to complete the Abbreviated Profile of Hearing Aid Benefit (APHAB, Cox and Alexander, 1995), a 24-item self-assessment inventory designed to assess hearing aid benefit in daily life. The APHAB yields subscale scores for perceived speech communication ability in favorable, reverberant, and noisy environments, as well as for reactions to loud environmental sounds. Participants are asked to indicate their agreement with each statement (e.g., "It's hard for me to understand what is being said at lectures or church services.") on a 7-point response scale.

The standard APHAB response format asks respondents to rate each item twice, to assess both unaided performance ("without my hearing aid") and aided performance ("with my hearing aid"). For this study, the APHAB response form was modified so that a rating was obtained for each microphone type. That is, participants rated each item to indicate their aided performance with the omnidirectional microphone configuration and with the directional microphone configuration.

Microphone Performance Questionnaire

Participants were also asked to complete the Microphone Performance Questionnaire (MPQ). The MPQ was developed for use in this study and describes listening situations in which there should be an advantage for either the omnidirectional or directional microphone configuration. The 31 items were created by systematically varying the listening situations with respect to presence or absence of noise, amount of reverberation, location of the signal, location of the noise, and distance of the listener from the signal. The categorization of each MPQ item according to these situational variables is given in the Appendix. Using a 7-point scale, participants indicated which of the two microphone modes they believed would work best for them in each situation described in the questionnaire. Participants also indicated how frequently they encounter listening situations like the one described. Figure 1 displays a sample item.

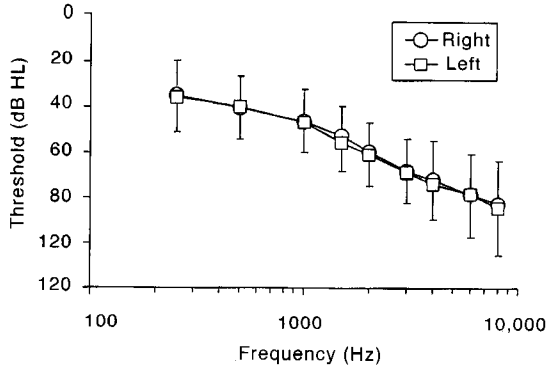

Figure 2 Mean audiometric data for 48 participants. The error bars in this and subsequent figures indicate 1 SD.

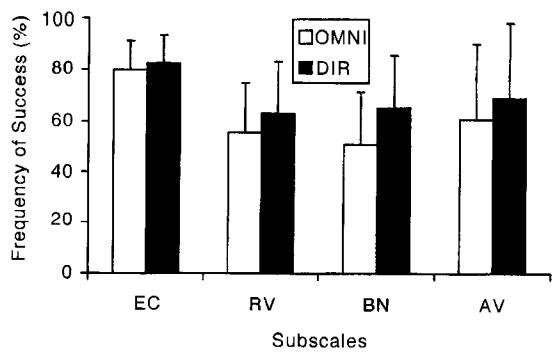

Figure 3 Mean Abbreviated Profile of Hearing Aid Benefit (APHAB) results comparing aided performance with omnidirectional (OMNI) and directional (DIR) microphones. Note that data are presented as "frequency of success" (100 minus the frequency of problems), so that a higher score indicates better performance. APHAB subscales: EC = ease of communication; RV = reverberation; BN = background noise; AV = aversiveness.

RESULTS

Telephone Interview

One hundred and twelve patients were contacted by telephone. Twenty-two (20%) reported less than 4 hours/day of hearing aid use. Four patients had hearing aids in need of repair. Three patients reported using the directional mode very rarely and for only one particular situation (in the car, in a restaurant). Twenty-six patients (23%) were not switching between the two microphone configurations for various reasons (e.g., did not understand the different settings of their hearing aids, did not notice any difference between omnidirectional and directional, just did not bother to switch from the default setting). Because these patients were less likely to make reliable comparisons of the two microphone configurations, they were not asked to complete the questionnaires.

The remaining 57 (51%) patients met the inclusion criteria (reported regular use of their hearing aids and at least occasional use of both microphone configurations) and were mailed the APHAB and the MPQ. Forty-eight patients completed and returned the questionnaires. This group had an average age of 73.6 years (SD = 8.9, range = 45–91). Their mean audiogram is shown in Figure 2. Average duration of hearing aid use was 11.6 years (SD = 7.1, range = 0.5–34) and average duration of hearing aid use per day was 12.3 hours (SD = 4.4, range = 4–18). Several different hearing aid makes and models were worn by these patients, but all featured a switchable directional/omnidirectional microphone through remote control or a switch or button on the hearing aid itself. Detailed descriptions of the hearing aid fittings were not available. However, all instruments were fit by audiologists experienced in the fitting of these devices, following the manufacturer-recommended procedures.

As part of the telephone interview, participants were asked to estimate the percentage of time they used each microphone type. On average, they reported using the omnidirectional microphone 77.7 percent of the time (SD = 24.3, range = 10–99%) and the directional microphone 22.3 percent of the time (SD = 24.3, range = 1–90%).

APHAB

Figure 3 displays the mean APHAB results comparing aided performance between the omnidirectional and directional microphones. Note that data are presented as "frequency of success" (100 minus the frequency of problems), so that a higher score indicates better performance. Four of the returned questionnaires were incomplete. Thus, these results are based on 44 participants. Analysis of variance on the four subscales revealed both a significant main effect for microphone type ($F = 34.4$, $p < .00001$) and a significant interaction of microphone type and subscales ($F = 8.1$, $p < .0001$). T-tests on the individual subscales revealed significant differences between the two microphone configurations (ease of communication, $t = 3.0$, $p < .05$; reverberation, $t = 3.4$, $p < .01$; background noise, $t = 5.4$, $p < .00001$; and aversiveness subscales, $t = 4.3$, $p < .001$). For each subscale, participants reported fewer communication problems when using the directional microphone.

In Figure 4, individual difference scores (directional minus omnidirectional) for the four APHAB subscales are displayed. Bars above the zero line indicate better performance with the

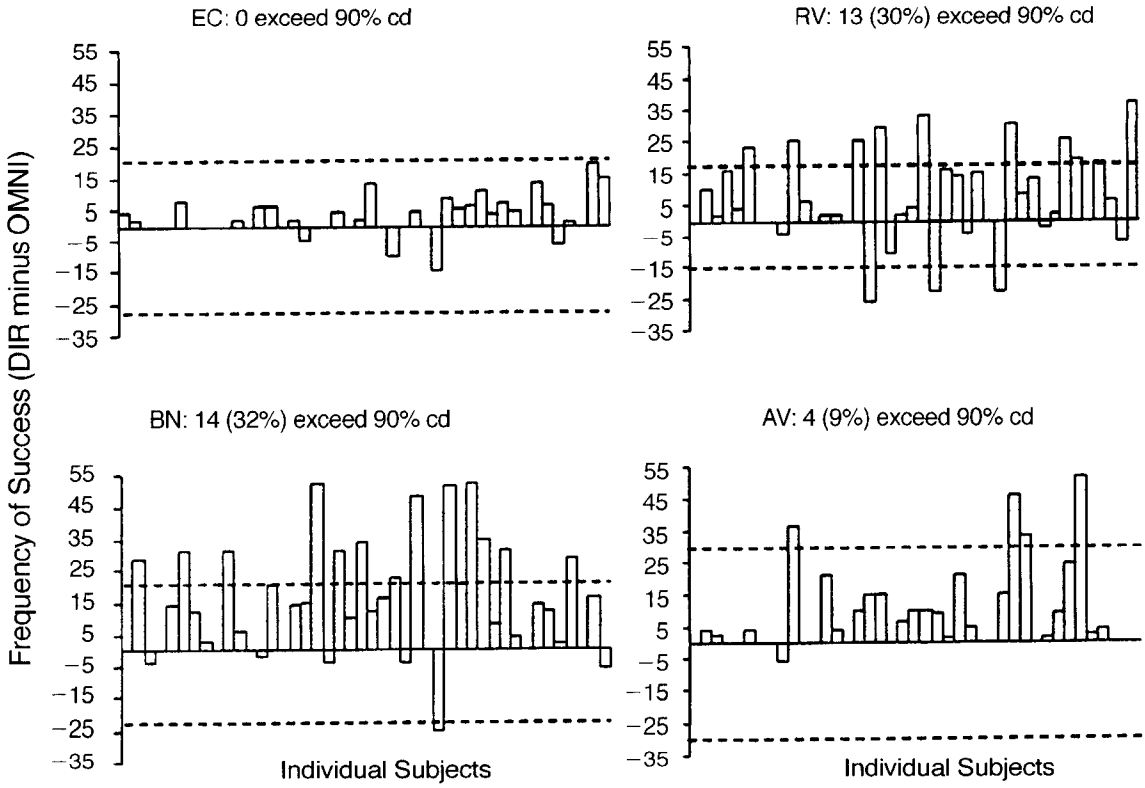

Figure 4 Differences between omnidirectional and directional microphone ratings for the Abbreviated Profile of Hearing Aid Benefit (APHAB) subscales for each of 44 participants. Each bar represents one participant. Bars above the zero line indicate better performance with the directional microphone. Bars below the zero line indicate better performance with the omnidirectional microphone. The 90 percent critical difference (cd) for each subscale is as indicated by the *dashed line*. EC = ease of communication; RV = reverberation; BN = background noise; AV = aversiveness.

directional microphone than with the omnidirectional microphone. The dashed horizontal lines indicate the 90 percent critical difference (cd) values for each subscale. Difference scores that exceed this value likely reflect true differences rather than those occurring by chance. Some of the participants exceeded the cd for the reverberation and background noise subscales, and a few exceeded the cd for the aversiveness subscale. None of the participants exceeded the cd for the ease of communication subscale.

The APHAB revealed relatively small but statistically significant differences for the omnidirectional and directional microphones, with participants reporting fewer communication problems on average when using the directional microphone mode, especially for the background noise subscale. However, individual data revealed relatively few significant differences. It should be noted that the APHAB was not designed to compare microphone configurations. Item wording is quite general; that is, characteristics of the listening environment that may be critical for directional microphone benefit (e.g., location of signal source) are not always apparent.

MPQ

Ratings for each item of the questionnaire were averaged across participants and rank ordered from the item that was rated highest for the directional microphone to the item rated highest for the omnidirectional microphone, and quartiles were calculated. One questionnaire was returned incomplete; therefore, these data are based on the responses of 47 participants. The characteristics of items in each quartile are displayed in Figure 5. The first quartile includes the items that most strongly favored directional microphone use. The mean rating for these items is 5.8, which corresponds to "directional is better" on the 7-point response scale. Panel A displays the characteristics of these items. Note that in every case the location of the signal is in front and that noise is present. Additionally, directional microphones tend to be favored when the signal source is relatively near and when the competing noise is behind the listener, rather than at some other location. An example of an item from the first quartile is "You are at a restaurant having

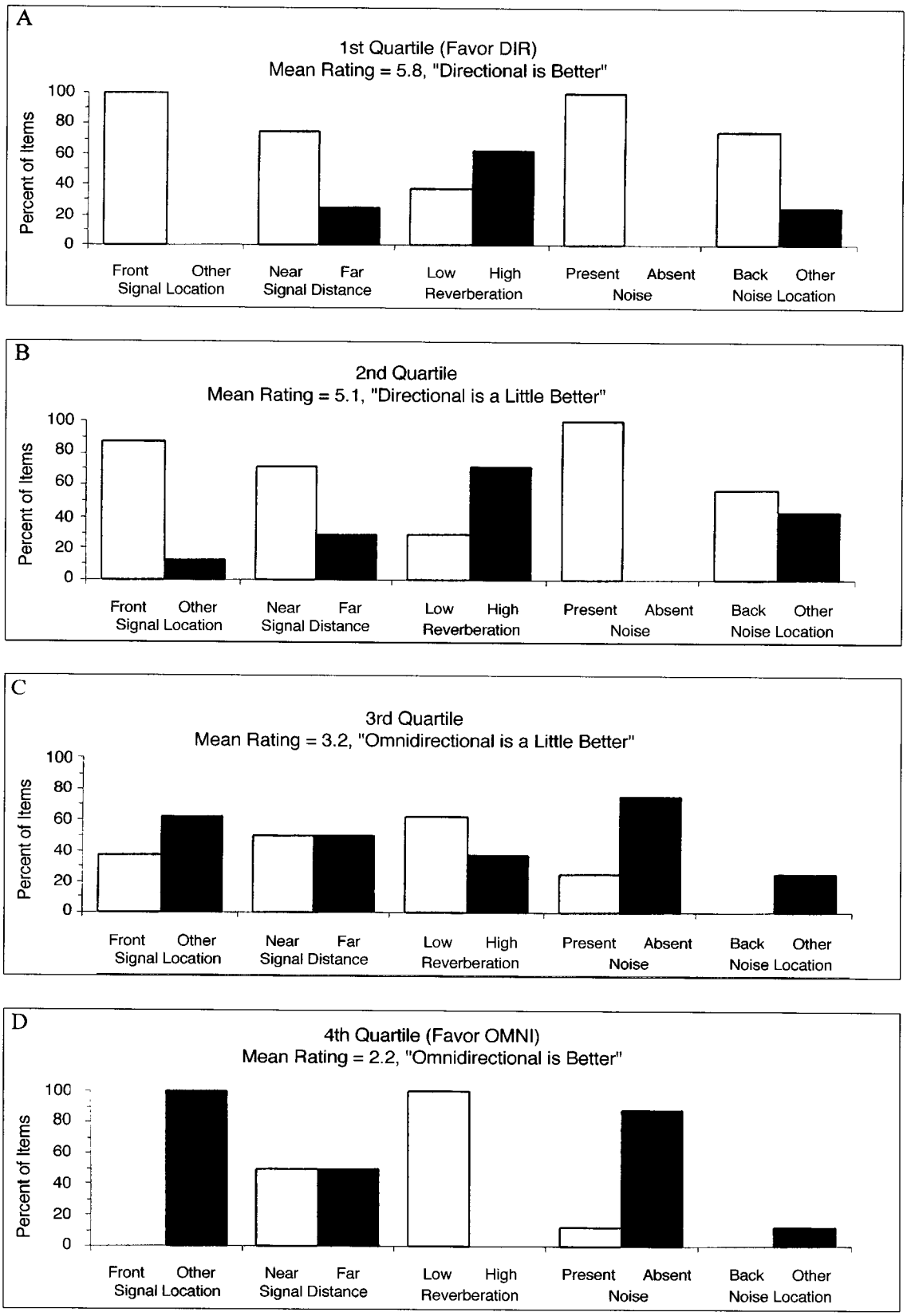

Figure 5 Characteristics of the Microphone Performance Questionnaire (MPQ) items whose mean rating placed them in the first quartile (panel *A*), second quartile (panel *B*), third quartile (panel *C*), and fourth quartile (panel *D*). The first quartile encompasses the items that most strongly favored use of the directional microphone. The fourth quartile encompasses the items that most strongly favored use of the omnidirectional microphone.

lunch with a friend who is seated across the table from you. You are seated with your back toward a large group of people who are talking loudly."

Panel B displays the characteristics of items in the second quartile (mean rating 5.1: "directional is a little better"). These items (i.e., listening situations) share characteristics in common with those in the first quartile, except that more of the items describe situations where reverberation is present or where the competing noise is at a location other than behind the listener (i.e., more diffuse).

Panel C displays the characteristics of items in the third quartile (mean rating 3.2: "omnidirectional is a little better"). The most notable change from the first two quartiles is for signal location: the omnidirectional microphone tends to be preferred when the signal is from a location other than in front of the listener. Additionally, noise is generally absent. In the few instances where noise is present, it is from a location other than behind the listener.

The fourth quartile includes the items that most strongly favor omnidirectional microphone use (mean rating 2.2: "omnidirectional is better"). Panel D displays the characteristics of these items. In these listening situations, the location of the signal is other than front, noise is almost always absent, and reverberation is low. An example of an item that fell in the fourth quartile is "You are out taking a walk on a quiet neighborhood street and want to be able to hear cars, bicycles, and other pedestrians approaching from behind you."

In summary, the results of the MPQ revealed that, overall, the most important situational conditions in determining which microphone configuration is preferred are spatial location and separation of the signal and the competing noise. Participants reported that directional microphones are preferred when the signal is in front and a competing noise is to the rear. As the location of the noise source moves from behind the listener (or becomes more diffuse) or as reverberation increases, the directional microphone is somewhat less effective, though still preferred to the omnidirectional microphone. The omnidirectional microphone is preferred over the directional when the signal is located other than in front of the listener, reverberation is low, and noise is either absent or coming from a location other than behind the listener. The strength of preference for either microphone type decreases as reverberation increases.

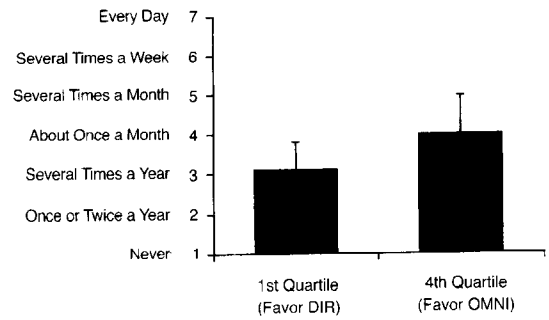

Figure 6 Mean ratings of the frequency with which situations described in the first and fourth quartiles of the Microphone Performance Questionnaire (MPQ) are encountered (n = 47).

How Often Are These Situations Encountered?

Recall that the MPQ asked participants to rate (on a 7-point scale) how often they experience the listening situations described by each item. Figure 6 displays the frequency with which the situations in the first quartile (favor directional) and fourth quartile (favor omnidirectional) are encountered in participants' everyday life. Participants reportedly encounter significantly more situations that favor omnidirectional microphone use ($p < .0001$). This is consistent with the report noted earlier that, on average, participants used the omnidirectional mode 77.7 percent of the time and the directional mode only 22.3 percent of the time.

Satisfaction

As part of the initial telephone interview, patients were asked to rate overall satisfaction with their hearing aids, as well as satisfaction with the omnidirectional microphone mode and the directional microphone mode. These results are displayed in Figure 7. Overall, the 48 participants reported being "satisfied" with their hearing aids and with each microphone configuration. Even though most participants used the directional microphone much less frequently than the omnidirectional microphone, they were equally satisfied with the performance of the directional microphone in situations where they did use it.

DISCUSSION

This study explored the real-world use patterns and perceived benefits of directional microphone technology among experienced users

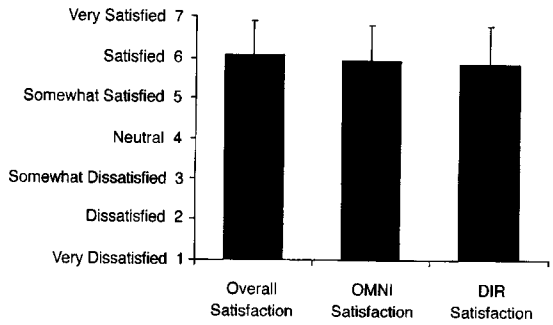

Figure 7 Mean ratings for overall hearing aid satisfaction, satisfaction with the omnidirectional microphone mode, and satisfaction with the directional microphone mode (n = 48).

of switchable omnidirectional/directional microphone hearing aids. The following questions were addressed:

Do patients who are fitted with binaural switchable omnidirectional / directional hearing aids use the directional option in daily living and, if so, how much? It appears that a substantial percentage of patients who are fitted with switchable omnidirectional/directional hearing aids eventually do not use the directional microphone option. Of the patients contacted who reported using their hearing aids for at least 4 hours/day, over one-third of them were not switching between the two microphone configurations, generally leaving the hearing aids set to the default (omnidirectional) mode. This finding is in agreement with that of Kuk (1996), who observed that one-third of patients fitted with switchable omnidirectional/directional hearing aids used their instruments almost exclusively in one mode, usually omnidirectional. Two reasons were commonly reported by the participants in the current study for not using the directional microphones. First, many of these patients could not remember what the different programs of their hearing aids were or how to use them. Second, a number of patients reported that the directional microphone feature provided no advantage over the omnidirectional when they had tried to use it.

The patients who used both microphone modes reported using the omnidirectional mode, on average, more than three-quarters of the time. This use pattern may be influenced by the omnidirectional mode being programmed as the default setting of the hearing aids for all the participants in this study. Patients fitted with switchable omnidirectional/directional hearing aids are generally instructed to use the default setting for most situations and to switch to the directional mode when in a noisy place.

Do experienced users of these hearing aids recognize the characteristics of everyday listening situations that provide the greatest performance advantages for directional microphones? Patients who reported regularly using both microphone modes could recognize listening situations in which directional microphones should provide a performance advantage over an omnidirectional microphone. Results of the APHAB showed a significant preference for the directional microphone in situations where background noise was present. This finding is in general agreement with APHAB results reported by Valente and colleagues (1995), Preves and colleagues (1999), and Boymans and Dreschler (2000).

Results of the MPQ revealed that the directional microphone mode was judged to be most helpful in situations where noise is present, the signal is in front of the listener, and the signal source is relatively near. As the noise becomes more diffuse or reverberation increases, the directional microphone mode was judged to be less helpful. Patients reported the omnidirectional microphone to be most helpful in situations where the location of the signal was other than front (i.e., behind, beside, all around) and noise was absent.

These patient reports are consistent with the signal processing provided by each microphone type and suggest that patients can identify listening situations in their everyday lives that should favor one microphone type or the other. It may be argued that participants were simply reporting back what they had been told by their audiologist or read in hearing aid pamphlets about listening situations that should favor each microphone mode. However, it is unlikely that, after 6 months to 2 years of experience, users would continue to switch to the directional microphone if it did not provide benefit over the omnidirectional mode. That participants were able to discern the influences of reverberation and signal distance on microphone effectiveness and did not base their responses strictly on the presence or absence of noise in the listening environment provides further support for the notion that participant responses were based on real-world experience.

How frequently are such listening situations encountered in everyday life? In everyday life, participants reported encountering far fewer situations of the type that favored directional microphone use than of the type that favored omnidirectional microphone use. However, the frequency with which situations that favor one or the other microphone mode were encountered was not

related to overall hearing aid satisfaction or satisfaction with either microphone configuration.

CONCLUSIONS

A number of studies have demonstrated the superiority of directional microphone technology for improved speech understanding in noise in controlled laboratory settings. However, this dramatic directional microphone advantage has not been observed in some field measures of perceived benefit in everyday life. Results of this study suggest that the disparity between laboratory and field results are primarily due to the specific characteristics of the listening situations encountered in daily living. When the everyday listening situation closely matches the ideal conditions in the laboratory (i.e., signal in front of and relatively close to the listener, spatial separation of the signal and the noise), a strong preference for the directional microphone is reported. However, it appears that this specific set of circumstances occurs less frequently in daily living than conditions that are less favorable to directional microphones or that actually favor omnidirectional microphone use.

The results of this study reinforce the importance of the prefitting evaluation of patients who may be candidates for switchable omnidirectional/directional hearing aids, as well as the importance of long-term follow up of patients who are fitted with these devices. Clearly, many patients do not use the directional microphone option after a few months. Some of these may have been poor candidates for this technology in the first place because they do not regularly encounter listening situations in their daily lives in which directional microphones can provide a performance advantage. Others may become discouraged and quit using the directional mode if they do not notice dramatic improvement in speech understanding in difficult listening situations. The companion to this study (Surr et al, 2002) suggests that hearing aid users do not notice significant performance differences between omnidirectional and directional microphones in the majority of listening situations encountered in everyday life. Participants used switchable omnidirectional/directional hearing aids for a 6-week period. They were instructed to find and describe one situation each day in which one setting (i.e., microphone type) worked better than the other. Participants were blinded to how the two settings differed and were simply told that they process sound in different ways. In general, the participants had difficulty finding situations in their daily lives in which there was a clear performance advantage for one microphone mode over the other, and, in situations where performance differences were noted, they tended to be subtle. The findings of the study of Surr and colleagues (2002) highlight the importance of counseling patients regarding realistic expectations of directional microphone technology. The results of the current study demonstrate that patients who persist in experimenting with the directional microphone option in daily living are eventually able to identify the listening situations in which they will derive significant benefit from its use.

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APPENDIX

Microphone Performance Questionnaire (MPQ) Items

Item Number	*Item*	*Mean Item Rating*	*Signal (Front/ Other)*	*Signal (Near/ Far)*	*Noise (Present/ Absent)*	*Noise (Back/ Other)*	*Reverberation (Low/ High)*
4	You are at a restaurant having lunch with a friend who is seated across the table from you. You are seated with your back toward a large group of people who are talking loudly.	6.15	Front	Near	Present	Back	High
13	You are seated in the middle of a large, crowded, noisy cafeteria or dining hall having lunch and are conversing with the person seated directly across the table from you. There are the sounds of many people talking at tables all around you, trays, dishes, and cutlery clattering, etc.	6.00	Front	Near	Present	Other	High
16	You are having a face-to-face conversation with someone at a reception in a hotel ballroom. You are standing with your back toward the band, which is playing loud music.	5.98	Front	Near	Present	Back	High
6	You are outdoors at a large, noisy party or reception and are in face-to-face conversation with one person. There is music playing and people are talking loudly all around you.	5.93	Front	Near	Present	Other	Low
18	You are at an outdoor gathering talking to a friend or family member. Behind you, adults are trying to comfort a crying child.	5.70	Front	Near	Present	Back	Low

APPENDIX (continued)

Microphone Performance Questionnaire (MPQ) Items

Item Number	*Item*	*Mean Item Rating*	*Signal (Front/ Other)*	*Signal (Near/ Far)*	*Noise (Present/ Absent)*	*Noise (Back/ Other)*	*Reverberation (Low/ High)*
3	You are seated near the head table at a luncheon meeting in a hotel banquet room. You have turned your chair to face the keynote speaker who is standing at the head table. Waiters are moving around the room behind you serving coffee and dessert.	5.64	Front	Far	Present	Back	High
19	You are in a large lecture hall listening to the speaker at the podium in the front of the room. You are seated toward the front of the audience and people behind you are whispering and rustling papers.	5.62	Front	Far	Present	Back	High
12	You are in your front yard chatting with your next door neighbor. Another neighbor, two doors down, is cutting his grass with a power mower. You are standing with your back toward the lawnmower noise.	5.60	Front	Near	Present	Back	Low
28	You are at a small theater watching a comedy play. You are seated close to the stage. There is frequent laughter from the audience behind you as you try to hear the dialogue.	5.51	Front	Far	Present	Back	High
24	You are in a large, noisy department store.You are talking to the clerk, who is standing in front of you showing you merchandise. Other people are talking among themselves while standing around waiting to be helped.	5.39	Front	Near	Present	Other	High
25	You are seated at the kitchen table having a face-to-face discussion with your partner. Behind you, the dishwasher is running.	5.37	Front	Near	Present	Back	High
9	You are at the dinner table with your family or a small group of friends. You are conversing with the person across the table from you while other conversations are going on around you.	5.33	Front	Near	Present	Other	Low
8	You are in a small waiting room talking . with a person seated near you. Behind you, a TV is playing a news program. The waiting room is sound treated with carpet and drapes	5.14	Front	Near	Present	Back	Low
31	You are standing in the kitchen in face-to-face conversation with a family member. You have your back toward a radio, which is playing a news broadcast.	5.00	Front	Near	Present	Back	High
15	You are attending a neighborhood meeting in the local firehall. The room is filled with people and you are seated near the center of the group. People in the group are taking turns making comments to the group about the topic under discussion. Others in the group are talking among themselves. You are interested in hearing all the comments.	4.02	Other	Far	Present	Other	High

APPENDIX (continued)

Microphone Performance Questionnaire (MPQ) Items

Item Number	*Item*	*Mean Item Rating*	*Signal (Front/ Other)*	*Signal (Near/ Far)*	*Noise (Present/ Absent)*	*Noise (Back/ Other)*	*Reverberation (Low/ High)*
5	You are discussing your insurance policies with your agent in a small, private office. You are facing the agent across a desk.	3.90	Front	Near	Absent	NA	Low
11	You are alone with your doctor in a quiet office discussing the results of your medical tests.	3.78	Front	Near	Absent	NA	Low
30	You are attending a community meeting in the local elementary school cafeteria. Approximately 50 people are present at the meeting and you are seated near the center of the group. There is a lively open discussion going on all around you about a topic to be voted upon.	3.33	Other	Far	Present	Other	High
26	You are sitting in your quiet living room chatting with a friend who stopped by for a visit.	3.11	Front	Near	Absent	NA	Low
17	You are seated in a small, quiet restaurant lobby waiting for your table. Two people seated behind you are engaged in an interesting conversation that you are trying to overhear. Several other people in the lobby are talking quietly among themselves.	2.97	Other	Near	Present	Other	Low
27	You are seated near the front of a large lecture hall. The lecture has ended and members of the audience are making comments and asking questions of the lecturer. You want to hear the comments and questions. Others in the audience are quietly listening.	2.94	Other	Far	Absent	NA	High
7	You are seated in a quiet living room sorting the mail while listening in on a family conversation going on behind you in the doorway of the room.	2.69	Other	Far	Absent	NA	Low
14	You are seated toward the front of a large auditorium. The presentation has concluded and there is a question-and-answer period. You are interested in hearing the questions people in the audience are asking. The audience is quiet as they listen to the questions and answers.	2.64	Other	Far	Absent	NA	High
21	You are seated on the edge of the bed in your quiet bedroom. You ask your partner if there is anything further to discuss before you remove your hearing aids for the night. You have your back turned as you listen to your partner's reply.	2.45	Other	Near	Absent	NA	Low
2	You partner relays a telephone message from the doorway while you are reading in a quiet living room. You are seated with your back to the doorway.	2.42	Other	Near	Absent	NA	Low
22	You are listening to music on your stereo system in a quiet room at home. The room is sound treated with carpeting and drapes.	2.42	Other	Far	Absent	NA	Low

APPENDIX (continued)

Microphone Performance Questionnaire (MPQ) Items

Item Number	*Item*	*Mean Item Rating*	*Signal (Front/ Other)*	*Signal (Near/ Far)*	*Noise (Present/ Absent)*	*Noise (Back/ Other)*	*Reverberation (Low/ High)*
23	You are driving in your car with some friends. Two of your friends are in the back seat and you are particularly interested in hearing their discussion. Your car windows are closed and the radio is off.	2.39	Other	Near	Present	Other	Low
1	You are in a small, quiet diner having breakfast and reading the morning paper. You wish to overhear the conversation going on at the booth behind you.	2.29	Other	Near	Absent	NA	Low
29	You are doing quiet work while seated at your desk in your office or den. You have your back toward the door and want to be able to hear people approaching from behind you.	2.15	Other	Far	Absent	NA	Low
10	You are out taking a walk on a quiet neighborhood street and want to be able to hear cars, bicycles and other pedestrians approaching from behind you.	1.86	Other	Far	Absent	NA	Low
20	You are taking a walk in the woods or in a quiet park. You are listening to the sounds of nature around you (birds singing, leaves rustling, etc).	1.70	Other	Far	Absent	NA	Low

MPQ items are rank ordered from items rated highest for the directional microphone to those rated highest for the omnidirectional microphone. Rankings are based on the mean ratings of 47 participants. Also displayed are the characteristics of the listening situations described in each item: signal location (in front of the listener or from some other direction), signal distance (relatively near or relatively far from the listener), absence or presence of noise, location of noise (from behind the listener or from some other direction), and level of reverberation (relatively high or relatively low). Note that items were presented to participants in the format shown in Figure 1 and in the order shown here as "item number".

NA = not applicable.