Implications of Hearing Aid Fitting for Orientation and Mobility: A Case Study

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For people who have combined hearing impairment and severe visual impairment, hearing aids are important both for speech understanding and for orientation and mobility purposes. The present report is a case study in which orientation and mobility skills were evaluated first without hearing aids and then with 2 different hearing aid settings. The observations of the orientation and mobility specialist demonstrate that hearing aid settings can affect orientation and mobility skills.

Auditory information about the environment is important for all individuals, and it is particularly critical for people who are blind or who have severe visual impairment and rely on audition to detect warning signals, stationary sound sources, moving sound sources, and also sound from street crossing signal devices (Blumsack, 2003). In addition, variations in the ambient sound field such as "sound shadows" that occur when sounds originate from behind an object and "bright spots" that can occur when ambient noise reflects from a near object more strongly than from distant objects, can provide information about the environment (Ashmead & Wall, 1999). If both vision and hearing are impaired, the input provided by hearing aids must both optimize speech understanding and also provide spatial hearing information. Evidence suggests that spatial hearing can be adversely affected by hearing aid use. In one laboratory study, for example, unaided sound localization performance was superior to sound localization when bilateral behind-the-ear (BTE) hearing aids were used (Noble & Byrne, 1990). It

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 XLII 29-37 2009

is important to note that, in this study, localization performance with the wearer's own hearing aids was superior to performance with "foreign" hearing aids (Noble & Byrne, 1990). This finding suggests that hearing aid users can improve their aided localization skills over time. Subsequent research has indicated that aided localization performance becomes comparable to unaided performance when open earmolds rather than closed earmolds are used (Byrne, Sinclair, & Noble, 1998; Noble, Sinclair, & Byrne, 1998). Results of a recent investigation with bilateral hearing aids equipped with adaptive directional microphones indicated a detrimental effect on sound localization performance (i.e., when directional noise was present at +/- 90°; Van den Bogaert, Klasen, Moonen, Van Deun, & Wouters, 2006). In certain conditions, adaptive directional microphones negatively affected localization performance more than omnidirectional microphones. It has been suggested that wide dynamic range processing in hearing aids can affect interaural cues that are used for sound localization (Simon & Levitt, 2007). Compression circuitry, by modifying gain depending on input level, alters the natural relationship between intensity and distance, and could, conceivably, adversely affect distance judgments (Primeau, 2003; Wiener & Lawson, 1997). In addition, directional microphones may impair one's ability to detect important noise sources in the environment (Primeau, 2003; Wiener & Lawson, 1997), and it is possible that low frequency gain reduction in digital noise reduction and feedback management circuitry could hamper detection of traffic and other sounds that are important for independent travel (Karp, 1983; Primeau, 2003; Wiener & Lawson, 1997).

The following case study is intended to examine hearing aid fitting options as they relate to orientation and mobility. The case involves a new hearing aid user.

The procedures used were approved by the Florida State University Human Subjects Committee.

CASE *A.*

Case A. is a 76-year-old male who became totally blind in childhood as a result of a traumatic injury. For most of his adult life, he had been an independent traveler who used a long cane. He sought audiological assistance, because he recently had begun to notice a decrease in his hearing sensitivity. A. expressed an interest in a trial hearing aid fitting and was invited to participate in a study in which his orientation and mobility skills would be evaluated. Audiometric testing revealed a mild, sloping to severe sensorineural hearing loss in his right ear and a mild, sloping to moderate sensorineural hearing loss in his left ear. His pure tone air conduction thresholds (obtained with insert earphones) and bone conduction thresholds are shown in Table 1.

Prior to initial hearing aid fitting, arrangements were made for an evaluation by an experienced orientation and mobility specialist. The orientation and mobility specialist was given no information regarding the participant's auditory

Table 1

Case A.: Air and Bone Conduction Thresholds

	Frequency (Hz)								
	250	**500**	**1000**	**1500**	**2000**	**3000**	**4000**	**6000**	**8000**
Right ear									
Bone conduction		15	20		20		35		
Air conduction	15	20	20	DNT	25	35	50	70	80
Left ear									
Bone conduction		10	5		30		35		
Air conduction	15	15	10	20	35	DNT	50	65	65

Note. DNT= Did not test.

sensitivity. A. was tested with the use of a cane but was not allowed to tap with the cane. The participant's typical pattern during independent travel only rarely entailed tapping. Disallowing tapping during testing required the participant to use ambient rather than self-generated auditory cues.

The orientation and mobility specialist's report of the evaluation when A. wore no amplification is summarized below. Terms such as impressive and excellent indicate that there were very few or no instances in which physical or verbal prompts were required. A report of some difficulty indicates above average performance, but prompts were necessary.

1. Overall performance was impressive.
2. Indoors: Sound localization, identification, and distance judgment skills were very good.
3. A. showed consistent ability to point to the direction of sounds and to judge their distance.
4. A. exhibited initial difficulty becoming aligned using echolocation/object perception when entering a hallway.
5. When entering the hallway, A. made contact with the wall but once "tuned in" was able to maintain a straight path and consistently tell when he was in close proximity to the parallel wall.
6. A. exhibited preference for the wall on his left side for the purpose of walking parallel.
7. A. consistently showed no detection of the approaching end of hallways with the doors closed until contact was made with the cane.
8. A. showed no detection that a door was ajar.

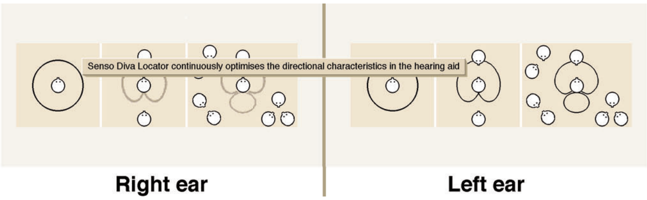

Figure 1. Polar patterns for hearing aids during first aided orientation and mobility evaluation.

9. A. indicated detection of a minor indentation in a wall while walking parallel to a wall on the left side.
10. A. showed excellent skills localizing and tracking parallel vehicular traffic going both toward and away from him.
11. A. showed excellent skill aligning with perpendicular traffic.
12. A. exhibited some difficulty detecting which lane perpendicular traffic was in but this may have resulted from a miscommunication regarding what was expected.

After completion of the initial orientation and mobility evaluation, A. was fit binaurally by a private dispensing audiologist with Widex Diva BTE hearing aids. Programming was conducted with the Widex fitting software (Compass version 3.1), and the manufacturer's fitting protocol for adults and children older than 5 years was used. Modifications were made at the discretion of the dispensing audiologist. For this first fitting, the adaptive directional system was engaged, and the polar pattern changed with changes in auditory input (see Figure

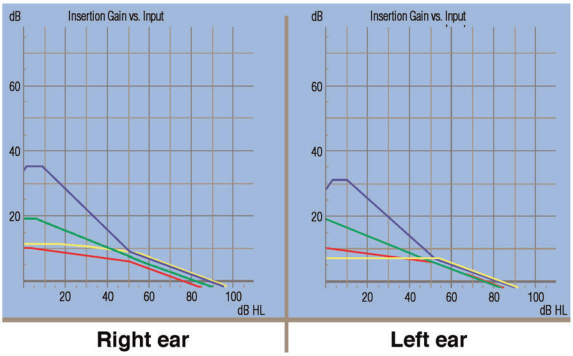

Figure 2. Insertion gain versus input for hearing aids during first aided orientation and mobility evaluation. (Color code: red, 500 Hz; gold, 1000 Hz; green, 2000 Hz; blue, 4000 Hz.)

1). In addition, the feedback canceling circuit was on, the occlusion manager was off, and the automatic output control circuit was on. Both hearing aids were equipped with a volume control. The right and left earmolds were skeleton Lucite models with high frequency modification. The vent size was large and the canal length was short. A graph of insertion gain versus input is shown in Figure 2.

Within 1 week after the hearing aid fitting, a re-evaluation of the participant's orientation and mobility skills was performed by the same orientation and mobility specialist. The orientation mobility specialist was given no information regarding the settings on the hearing aids. Prior to the evaluation, the participant used the hearing aids in his home and while walking to the mailbox and during a short walk in the neighborhood. As was true during the unaided evaluation, the participant used a cane during the second evaluation but was not allowed to use the cane to produce tapping sounds. The orientation and mobility specialist's report is summarized below.

1. Overall performance was impressive.
2. A. misidentified some sounds (e.g., water coming from a drinking fountain was identified as the hissing of air).
3. A. indicated detection of the widening of a hallway.
4. A. demonstrated an ability to detect the end of a hall with doors closed, in contrast to performance unaided.
5. A. indicated detection that a new hallway had a lower ceiling and a narrower dimension.
6. A. indicated detection and localization of the sound (not the air movement) from an overhead ceiling fan.
7. A. exhibited good sound localization.
8. A. exhibited difficulty judging distance (i.e., he was asked to walk to the location where he had heard keys drop, and the distance was overestimated).
9. Outdoors: A. exhibited difficulty in determining distance of the traffic.
10. A. was able to align himself with both parallel and perpendicular traffic.
11. A. was able to identify a bus after it had turned and stopped.

A. spontaneously reported that, with these hearing aids, he was hearing things that had previously gone unnoticed and that he had to relearn their identity and source. He commented that one example was the rattling of the keys in his

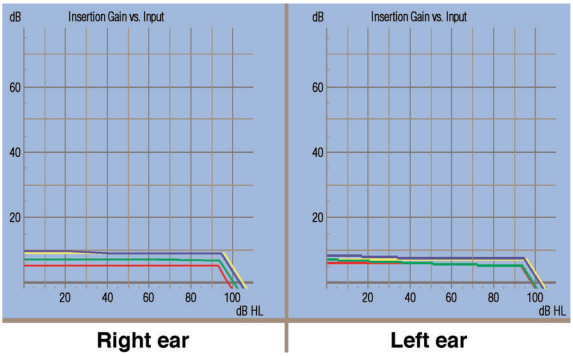

Figure 3. Insertion gain versus input for hearing aids during second aided orientation and mobility evaluation. (Color code: red, 500 Hz; gold, 1000 Hz; green, 2000 Hz; blue, 4000 Hz.)

pocket. He had to learn where the sound was coming from.

For the purposes of this study, A. returned to his dispensing audiologist, so that the settings on his hearing aids could be changed. A graph of the insertion gain versus input is shown in Figure 3. The option settings included the following: the microphone setting was omnidirectional (see Figure 4), the occlusion manager was off, and the automatic output control circuit was on. The feedback canceling circuit was on. Within 1 week after fitting with the new settings, the participant's orientation and mobility performance was again re-evaluated by the same orientation and mobility specialist. No information was provided regarding the hearing aid setting change, and the participant had used the hearing aids with the new settings in ways similar to his use following the previous fitting: in his home and during brief walks outdoors. A summary of the observations follows:

1. There was a noticeable difference in performance.
2. Object perception was poorer.
3. A. exhibited difficulty remaining in the center of the hallway and made numerous contacts with the walls on both sides.

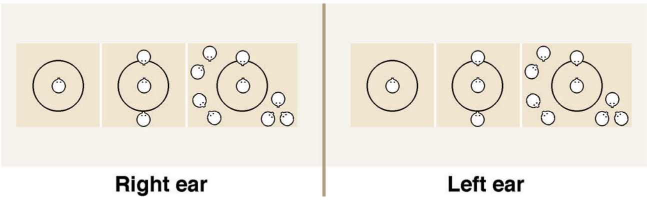

Figure 4. Polar patterns for hearing aids during second aided orientation and mobility evaluation.

4. A. could not tell when he was coming to the end of the hallway.
5. A. could not tell when there was an intersecting hallway unless there was a blatant auditory cue.
6. Localization and sound identification skills were good.
7. A. exhibited initial difficulty in distinguishing which lane traffic was in.
8. Alignment with parallel and perpendicular traffic continued to be good.

A. spontaneously reported that hallways seemed much narrower and indicated a strong preference for the original hearing aid settings.

A summary table showing a comparison of observations provided by the orientation and mobility specialist during the unaided and aided conditions is shown in Table 2.

DISCUSSION

The present case study focuses on the ramifications of hearing aid fitting for orientation and mobility skills. Following changes in hearing aid settings, both the participant and the orientation and mobility specialist reported changes in spa-

Table 2

Comparison Table of Observations Provided by Orientation and Mobility Specialist When the Participant was Unaided and When Hearing Aids With Different Settings Were Used

	Unaided	**Fitting #1**	**Fitting #2**
Overall performance	Impressive	Impressive	Noticeable difference in performance
Indoors:			
Localization	Very good	Good	Good
Object identification	Very good	Misidentification of some sounds	Good
Detection of end of hallway	No detection until contact made with cane	Ability to detect the end of a hall	Could not detect end of hallway
Outdoors:			
Tracking parallel vehicular traffic	Excellent skills	Able to align	Good
Aligning with perpendicular traffic	Some difficulty	Able to align	Good

tial hearing.

It is important to recognize that this case study has several limitations. Orientation and mobility testing was not conducted immediately after fitting, and the degree of adaptation that occurred during each interval between the fittings and testing may have been different. Previous research has indicated that localization performance with BTE fittings is superior with the wearer's own instruments in comparison to localization performance with foreign hearing aids (Noble & Byrne, 1990), but the length of time required for such adaptation is unknown. It would be interesting to test orientation and mobility skills repeatedly to evaluate for spatial hearing adaptation to the hearing aid settings. It is also important to note that an order effect could have impacted the participant's behavior and/or the observations of the orientation and mobility specialist.

The present study utilizes the written report of the orientation and mobility specialist. Such a report is by its nature subjective, and a measure such as video recording could provide more objective information.

The observations provided by the orientation and mobility specialist and the spontaneous comments of the participant suggest that changing the settings on the hearing aid affected the participant's orientation and mobility performance. Since more than one feature on the hearing aids was changed, the effect of specific changes cannot be assessed. The same earmolds with large vents were used under both aided test conditions, and sound localization reported by the orientation and mobility specialist was reported to be good during both test sessions, consistent with reported laboratory findings (Byrne et al., 1998; Noble et al., 1998). It is of particular interest that certain aspects of performance were observed by the orientation and mobility specialist to be superior with the settings that included adaptive directional microphones and compression for loud sounds in comparison with performance when omnidirectional microphones were used and relatively linear programming was selected. Specifically, with the initial settings, the participant was observed to be able to detect the end of a hall when doors were closed. He was unable to do this unaided, and he was unable to do this with the hearing aids in the omni/linear mode. The observations of the orientation and mobility specialist suggest, however, that the ability to judge distance, when the initial hearing aid settings were used, was decreased relative to unaided performance. Limited time was available for adaptation to the hearing aids, and it is possible that extended use might have improved distance judgment and also reduced the misidentification of sounds that was observed.

The orientation and mobility specialist observed that the participant preferred to align closer to the left wall rather than the right wall in a hallway. On the audiogram, the high frequency thresholds were approximately 10 dB better in the left ear than in the right, and the effects of this difference may have been observed by the orientation and mobility specialist.

It may be very difficult to develop a set of general guidelines for hearing aid fitting for orientation and mobility purposes because of the wide variety of possible hearing impairments and the considerable variability with respect to orientation and mobility skills and needs. It is clear, however, that hearing aid settings can have an impact on orientation and mobility performance and that this aspect of the hearing needs of a patient who has a severe visual impairment must be considered when fitting decisions are made.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the contributions of Purvis Ponder who passed away prior to the preparation of this manuscript. Mr. Ponder was an associate professor in the Special Education program at Florida State University. The author also wishes to acknowledge the contributions of Lisa Myrick, MS, CCC-A; Deborah Scott; and the participant in this study.

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