Unilateral versus Bilateral Amplification for Adults with Impaired Hearing

Therese C. Walden*
Brian E. Walden*

Abstract
This study compared unilateral and bilateral aided speech recognition in background noise in 28 patients being fitted with amplification. Aided QuickSIN (Quick Speech-in-Noise test) scores were obtained for bilateral amplification and for unilateral amplification in each ear. In addition, right-ear directed and left-ear directed recall on the Dichotic Digits Test (DDT) was obtained from each participant. Results revealed that the vast majority of patients obtained better speech recognition in background noise on the QuickSIN from unilateral amplification than from bilateral amplification. There was a greater tendency for bilateral amplification to have a deleterious effect among older patients. Most frequently, better aided QuickSIN performance was obtained in the right ear of participants, despite similar hearing thresholds in both ears. Finally, patients tended to perform better on the DDT in the ear that provided less SNR loss on the QuickSIN. Results suggest that bilateral amplification may not always be beneficial in every daily listening environment when background noise is present, and it may be advisable for patients wearing bilateral amplification to remove one hearing aid when difficulty is encountered understanding speech in background noise.

Key Words: Amplification, bilateral, binaural interference, dichotic digits, hearing aids, speech recognition in noise, unilateral

Abbreviations: AASC = Army Audiology and Speech Center; ABR = auditory brainstem response; DDT = Dichotic Digits Test; MLR = middle latency response; QuickSIN = Quick Speech-in-Noise test; SADL = satisfaction with amplification in daily life; SNR = signal-to-noise ratio

Sumario
Este estudio compara el reconocimiento del lenguaje en ruido de fondo, con amplificación unilateral o bilateral, en 28 pacientes a quienes se les adaptaron auxiliares auditivos. Se obtuvieron puntuaciones del QuickSIN (Prueba Rápida de Lenguaje en Ruido) amplificado para adaptación bilateral y para amplificación unilateral en cada oído. Además, se obtuvo de cada participante un registro dirigido al oído derecho y otro dirigido al oído izquierdo, con la Prueba de Dígitos Dicóticos (DDT). Los resultados revelaron que la mayoría de los pacientes obtuvieron un mejor reconocimiento del lenguaje en ruido de fondo con el QuickSIN, usando amplificación unilateral que cuando utilizaron amplificación bilateral. Existió, en los pacientes ancianos, una tendencia a tener un efecto deletéreo con la amplificación bilateral. Más frecuentemente, se obtuvo un mejor desempeño en el QuickSIN con amplificación en el oído derecho de los pacientes, a pesar de tener umbrales auditivos similares en ambos oídos. Finalmente, los pacientes tendieron a funcionar mejor en el DDT, con el oído que mostraba una menor SNR en la Prueba QuickSIN. Los resultados sugieren
Since the introduction of ear-level hearing aids in the 1960s, there has been an increasing trend toward fitting amplification bilaterally. Supported by early reports that patients generally preferred bilateral amplification to unilateral amplification (Brooks and Bulmer, 1981; Erdman and Sedge, 1981), bilateral fittings increased from 25% to 65% of patients fit with amplification in the United States during the decade preceding 1994 (Kochkin, 1994). This trend has undoubtedly continued over the past ten years. Today, the conventional wisdom among most audiologists appears to be that patients should be fit bilaterally when both ears have aidable hearing. When such patients are not fitted with two hearing aids, it is usually due to issues unrelated to hearing, such as economic or cosmetic considerations, or physical limitations of the patient, rather than a belief that the patient will perform better with only one hearing aid.

Given that improved speech understanding is the primary goal of most hearing aid fittings, it is a common assumption that bilateral aided speech recognition is superior to speech recognition with only one hearing aid. This view is supported by early studies comparing speech understanding with bilateral and unilateral amplification (see Ross, 1980; Byrne, 1981, for reviews). The presumed superiority of speech recognition for bilateral fittings may be attributable to head diffraction effects, which improve the signal-to-noise ratio (SNR) at one or the other ear; to binaural squelch, which is a central suppression of interfering noise based on binaural hearing; and to binaural redundancy, which is the advantage obtained from receiving the same information twice at the two ears (Dillon, 2001).

The foundation for bilateral amplification is an assumption that a useful synthesis of information occurs when auditory signals are presented simultaneously to the two ears, that is, when binaural integration occurs. The result is binaural performance that is superior to monaural performance in either ear. However, under some circumstances, two ears are not necessarily better than one. Specifically, binaural interference can occur. In this case, conflicting information presented to the two ears may cause binaural performance to be inferior to monaural performance. Hence, for certain listening tasks typically involving conflicting auditory signals at the two ears, binaural hearing may actually result in performance that is inferior to the best performing ear by itself.

Most hearing impairments are bilateral and involve damage to the cochlea. Although this often results in generally symmetrical losses in threshold sensitivity at the two ears, asymmetries are common. Further, significant differences in suprathreshold speech recognition ability between ears are also frequently observed clinically, even when relatively symmetrical reductions in threshold sensitivity exist. Under such circumstances, the auditory input to the central nervous system from the two ears may be quite different and, conceivably, could lead to binaural interference for certain listening tasks. Moreover, even when the auditory periphery is symmetrical, it is possible that central processing differences might result in binaural interference.

Despite the general assumption of the superiority of bilateral amplification over unilateral amplification, several case studies suggest that some patients may understand speech better with only one hearing aid, especially among the elderly. Jerger and...
colleagues (1993) reported the case of a 71-year-old female with moderately severe, bilaterally symmetrical threshold sensitivity. Tests of unaided word recognition revealed 50% correct recognition in the left ear and 0% in the right ear. Notably, this patient had been wearing unilateral amplification in her left ear for ten years prior to being fit bilaterally. Monaural aided word recognition was 64% for the left ear and 0% for the right ear, consistent with the unaided scores. However, with bilateral amplification, word recognition dropped to 22%. Similarly, Chmiel and colleagues (1997) reported the case of an 87-year-old female with mild-to-moderate generally symmetrical threshold sensitivity. Unaided word recognition was 96% for the right ear and 76% for the left ear. At the time of evaluation, the patient was wearing hearing aids bilaterally. Aided sentence recognition was obtained for each ear separately and bilaterally, both in quiet and in the presence of background noise. For both test conditions, performance was best for unilateral amplification to the right ear and poorest for unilateral amplification to the left ear. Performance with bilateral amplification was intermediate between the two unilateral amplification conditions. The authors of both studies attributed the relatively poor performance for bilateral amplification to binaural interference; that is, the significantly poorer speech recognition in one ear interfered with performance in the better ear. Chmiel et al also suggested that difficulty with bilateral amplification in some elderly patients might be attributable to “age-related progressive atrophy and/or demyelination of corpus callosal fibers, resulting in delay or other loss of the efficiency of interhemispheric transfer of auditory information” (1997, p. 8). In this regard, it is interesting to note a case study reported by Silman (1995) of a 36-year-old male patient diagnosed with multiple sclerosis who was evaluated during an active phase and during a remission phase of the disease. During the active phase, significant asymmetries were observed for pure-tone thresholds, auditory brainstem response (ABR), and middle latency response (MLR), as well as interference from the affected side for bilateral stimulation during ABR and MLR testing. During the remission phase, the asymmetries observed during the active phase largely disappeared. Further, word-recognition testing under earphones was excellent in each ear. However, in the sound field (50 dB HL input), unaided performance was significantly lower, suggesting central binaural interference. Interestingly, the binaural-interference effect was reduced with monaural amplification to the affected side during the remission phase when there was bilateral normal-hearing sensitivity. The author suggested that amplification of the weaker ear may have overcome the higher-level asymmetry created by the demyelinating disease.

Carter et al (2001) investigated monaural and binaural aided word-recognition in noise and recall on a dichotic digit task in four older patients who reported being unsuccessful wearers of bilateral hearing aids in everyday living. The subjective reports of these patients were confirmed by the laboratory measures. In each case, aided speech recognition performance in the right ear alone was superior both to the left ear alone and to binaural amplification. The dichotic digit task revealed a left-ear deficit in every case. The only test condition under which bilateral amplification was superior to unilateral amplification was for an FM system. The authors suggested that this might be attributable to the improved signal-to-noise ratio provided by the FM system, which resulted in listening conditions closer to quiet. More recently, Holmes (2003) reported a case study of an elderly patient where a unilateral hearing aid fitting was more beneficial than a bilateral fitting. Finally, Walden and Walden (2004) compared hearing aid success, as measured by the International Outcome Inventory for Hearing Aids (IOI-HA; Cox and Alexander, 2002) and the Hearing Aid Usefulness Scale (HAUS), for unilateral versus bilateral fittings in 50 older adults. They observed no significant difference in hearing aid success between patients fit unilaterally and those fit bilaterally for either self-report measure.

Although beyond the scope of this discussion, there is considerable evidence within the gerontology literature that elderly persons often have more difficulty processing complex stimuli than do younger persons (Feyereisen et al, 1998; Simensky and Abeles, 2002). This is true within the psychoacoustics literature as well (Gordon-Salant and Fitzgibbons, 1999). Age-related performance differences have been observed for a variety of speech and nonspeech listening tasks involving temporal manipulation of acoustic
signals and variation in stimulus complexity. For example, older persons often have more difficulty understanding rapid speech or time-compressed speech than younger listeners (Gordon-Salant and Fitzgibbons, 2001). The most common complaint of patients presenting with impaired hearing is difficulty with understanding speech in background noise (Kochkin, 1993). Speech recognition in background noise is a relatively complex task that requires a person to attend to speech cues in the presence of interfering noise. Hence, it is reasonable to expect that elderly persons would have relatively more difficulty under such listening conditions.

Plomp (1978) characterized the effects of hearing impairment on speech understanding as a combination of attenuation and distortion factors. The former corresponds to the loss of threshold sensitivity and, therefore, may be readily addressed via amplification. The distortion factor is equivalent to a decrease in the signal-to-noise ratio (SNR), which is generally unchanged with amplification, at least for conventional omnidirectional microphone hearing aids. Persons with impaired hearing typically require a more favorable SNR to achieve acceptable speech understanding in a given amount of background noise than do persons with normal hearing (Plomp, 1978), although there is considerable variability across patients. Killion (2002) further characterized Plomp’s distortion factor as a loss of channel capacity; although the speech cues may be audible, they are distorted when they reach the brain and, therefore, are not entirely useful. He proposed that the distortion factor may be quantified for individual patients by the “SNR loss,” defined as the increase in SNR required for a person with impaired hearing to achieve 50% correct recognition compared to a person with normal hearing. The QuickSIN (Quick Speech-in-Noise) test (Etymotic Research, 2001) is a clinical measure of SNR loss and is described below in more detail.

Several studies have suggested that age and speech recognition in background noise are related to success with amplification. For example, Walden and Walden (2004) related demographic, audiometric, and global measures of hearing aid success in a group of hearing-impaired patients. Of the audiometric measures evaluated, unaided and aided QuickSIN scores were most strongly related to hearing aid success. However, we also observed that suprathreshold speech recognition in background noise on the QuickSIN tended to diminish with age, independent of the reduction in threshold sensitivity associated with advancing age. Hence, much of the predictive relationship between QuickSIN scores and hearing aid success appeared attributable to age. The findings of Walden and Walden (2004) are consistent with those of Hosford-Dunn and Halpern (2001), who related a variety of demographic and audiometric measures to success with amplification. They obtained patient-related variables (gender, age, years of hearing aid experience, perceived unaided hearing difficulty, pure-tone average) from 257 patients and related these measures to global satisfaction scores on the satisfaction with amplification in daily life scale (SADL; Cox and Alexander, 1999). Only age was significantly correlated with the global SADL scale. A modest, but statistically significant, correlation was observed. Older patients tended to report less overall satisfaction with amplification than younger patients.

Based on the literature, there is reason to assume that bilateral amplification is generally superior to unilateral amplification, due, in part, to a synthesizing of information received by the brain from the two ears (binaural integration). Nevertheless, it also appears that binaural interference can occur under some circumstances, especially when conflicting information is received. Additionally, it appears that the ability to understand speech presented in background noise may diminish in elderly listeners, and they may be somewhat more susceptible to the interfering effects of conflicting information being presented by the two ears. There is also evidence to suggest that success with amplification may diminish in elderly patients. Finally, there are several clinical reports suggesting elderly patients who have not been successful with bilateral amplification may perform better with unilateral amplification. This may be particularly true in difficult listening situations where significant background noise is present.

Taken together, it seems reasonable to hypothesize that bilateral amplification may not always be superior to unilateral amplification, especially in elderly hearing aid wearers, and especially for complex listening tasks such as speech understanding in background noise. This study evaluated this
possibility systematically in a prospective study of 28 older patients who were seen for hearing aid fitting. The specific questions addressed were (1) Do a significant percentage of patients obtain better aided speech recognition in background noise with one hearing aid rather than two? (2) If so, is this more likely to occur with age? (3) Can performance with one versus two hearing aids be related to a measure of binaural interference?

METHOD

Participants

Twenty-eight consecutive patients seen by the first author for hearing aid fitting at the Army Audiology and Speech Center (AASC) participated in the study. For all patients, both ears were suitable for amplification according to accepted clinical standards, and bilateral amplification was prescribed. All but two participants were male, reflecting the demographics of the AASC patient population. Twenty-three were experienced bilateral hearing aid users who had worn hearing aids an average of 6.4 years (range: 1–17 years). The remaining five participants were new hearing aid users. The mean age of the 28 participants was 75.1 years (range: 50–90 years). A review of their medical records revealed that none had a history of stroke, dementia, or other neurological disease. Their mean audiogram is shown in Figure 1. All participants had bilateral, symmetric sensorineural hearing impairments.

Sensorineural hearing loss (cochlear site of lesion) was verified by differences between air- and bone-conduction thresholds of 10 dB or less, by normal tympanograms (Type A; Jerger classification, 1970), and by the presence of ipsilateral acoustic reflexes for a 1000 Hz tone. Mean monosyllabic word recognition (NU-6) in quiet at a comfortable listening level was 90.5% (range: 64–100%) and 88.6% (range: 64–100%) in the right and left ears, respectively.

Hearing Aids and Fitting Procedures

Participation in the study occurred in the context of the patient’s regularly scheduled hearing aid evaluation. Patients were fit with hearing aids in each ear, using standard of care procedures. A variety of manufacturers and hearing aid models were represented. The majority of fittings were custom canal or completely-in-the-canal. There were no behind-the-ear fittings. Further, a variety of processor types were represented, although the majority was multimemory DSP (digital signal processing) with a directional microphone option (canal hearing aids). For those participants fit with the directional microphone option, it was not activated during their participation in this study.

Speech Recognition in Noise

Immediately following routine hearing aid fitting and verification of prescriptive targets using real-ear measures, speech recognition in noise was assessed in randomized order under four test conditions: (1) unaided bilaterally, (2) aided right ear, (3) aided left ear, and (4) aided bilaterally. During unilateral aided testing, the contralateral ear was left open. The QuickSIN test (Etymotic Research, 2001) was used to assess speech recognition in noise under each of the four test conditions. Lists of six sentences, each containing five key words and mixed with a four-talker babble, were presented to the participants in the sound field at 70 dB HL (dial setting) from a single loudspeaker positioned at 0° azimuth. One sentence was presented at each of six signal-to-noise ratios (SNR) from +25 dB to 0 dB, in 5 dB steps, resulting in 30 key words per list. The number of key words correctly repeated was subtracted from 25.5. The numerical difference represents the “SNR loss” and reflects the patient’s SNR deficit compared to persons with normal
hearing. For each of the four test conditions, two lists were presented and averaged to obtain the SNR loss.

**Binaural Interference**

Following the speech recognition in noise testing, the Dichotic Digit Test (DDT; Musiek, 1983) was used to assess binaural interference/separation. The DDT is used as a test to detect Central Auditory Processing Disorders (CAPD; Musiek et al, 1982; Musiek et al, 1991). Different spoken digits are presented simultaneously to each ear at levels where the stimuli are clearly audible. The listener’s task is to repeat the digits heard. The DDT is administered in two response paradigms (Strouse and Wilson, 1999). In the free recall paradigm, the listener is instructed to repeat all digits heard regardless of ear. This task indicates general cognitive factors such as speed of processing and memory. In the directed recall condition, the listener is instructed to attend to one or the other ear and to repeat the digits heard in that ear. This latter paradigm reflects auditory processing, including the extent to which conflicting auditory information presented to the contralateral ear may interfere with correct speech recognition in the ipsilateral ear, that is, binaural interference. Given the focus of this study, only data from the directed recall condition will be reported.

The Department of Veterans Affairs compact disc recording of the DDT was used (Noffsinger et al, 1996). For some items, only one digit is presented to each ear. For other items, sequences of two or three digit pairs are simultaneously presented to the two ears. Each digit correctly repeated is scored as a correct response. The DDT is scored as the percentage of digits correctly repeated, for each ear (directed recall) or for both ears (free recall). Age-specific norms (means, confidence intervals) are available in the literature (Strouse and Wilson, 1999).

The DDT items were presented to the participants via an insert earphone at 70 dB HL. The test was administered, in randomized order, under the three test conditions: (1) “free recall,” in which the listener was to repeat every digit heard in both ears, (2) “right ear directed,” in which the listener was instructed to repeat only those digits presented to the right ear, and (3) “left ear directed,” in which the listener was to repeat only those digits presented to the left ear.

**RESULTS**

**QuickSIN**

Mean performance for the three aided QuickSIN test conditions are shown in Figure 2. Note that lower scores (less SNR loss) represent better performance. Repeated measures analysis of variance revealed a significant main effect (F = 15.5, p < .001). Post hoc analysis (Bonferroni t-test) revealed that each of the three aided test conditions was significantly different from the other two (p < .05). On average, performance was significantly better (i.e., less SNR loss) in right ears compared to left ears. Further, performance with bilateral amplification was significantly poorer, on average, than performance in either ear alone.

Inspection of the individual data revealed that better performance on the QuickSIN was observed in the right ear compared to the left ear in 22 of the 28 (78.5%) participants. For two participants, the same aided QuickSIN score was obtained in both ears. Because four participants obtained better unilateral performance in their left ears than their right ears, the data are replotted in Figure 3 according to the better ear and poorer ear performance on the QuickSIN. Again, the analysis of variance revealed a highly significant main effect (F = 33.5, p < .001). However, the post hoc analysis revealed a somewhat different pattern of results. Scores in the better performing ear were significantly different (p < .001), both from scores in the poorer performing aided ear and from scores for bilateral amplification. However, the difference in SNR loss between the poorer ear and bilateral amplification did not achieve statistical significance (p = .10).

Further inspection of the individual QuickSIN data of the 28 participants revealed that bilateral amplification was superior (i.e., less SNR loss) to unilateral amplification in only three cases (10.7%). Bilateral amplification was equal to unilateral amplification in the better ear for one participant and equal in all three test conditions for one additional participant. For the remaining 23 participants (82.1%), unilateral amplification was superior to bilateral amplification. Of these, bilateral amplification actually yielded greater SNR losses than the poorer unilateral ear in 16 cases (57.1%). In the remaining seven cases,
bilateral performance was equal to the poorer ear for six participants and between the better and poorer ear results for one participant.

Earlier it was suggested that older patients might be more likely to experience difficulty in a complex auditory task such as speech recognition in background noise. Table 1 shows the correlations between the participant’s age and QuickSIN scores for each of the four test conditions. These correlations are consistent with, although somewhat higher than, the findings of Walden and Walden (2004) and suggest that, in general, the older the patient, the greater the SNR loss. More germane to the focus of this investigation is whether the tendency to perform better with unilateral amplification compared to bilateral amplification increases with age. This was assessed by first subtracting each participant’s QuickSIN SNR loss for the better ear from their SNR loss for bilateral amplification. Because lower SNR loss scores indicate better performance, the larger this numerical difference, the greater the extent to which unilateral aided speech recognition exceeded bilateral aided speech recognition. These difference scores were then correlated with age across the 28 participants. A significant, although relatively weak, correlation \( r = .38, p < .05 \) was obtained. Hence, there was a greater tendency for unilateral performance to exceed bilateral performance for older participants; however, the patient’s age accounted for a relatively small amount of the total variance.

**Dichotic Digits**

Inspection of the directed recall data for the one- and two-pair digit sets revealed that participants made few errors; that is, they were generally able to repeat correctly nearly every digit presented. Consequently, the data summarized here is restricted to directed recall of three-pair digit sets. Figure 4 presents mean percent correct performance.
for the right ear directed and left ear directed test conditions. A t-test for difference between means revealed no significant difference ($t = .53, p = .60$) between ears. However, when the data were reorganized according to the better and poorer performing ear on the QuickSIN, a somewhat different pattern emerged from the analysis. Figure 5 shows mean percent correct for the three-pair digit sets for the better performing (smaller SNR loss) and poorer performing ear, across the 28 participants. Here, there is a tendency for participants to demonstrate better directed recall on the DDT in the ear in which they had the better QuickSIN score. This difference approached, but did not achieve, statistical significance ($t = 1.86, p = .07$).

**DISCUSSION**

There are three possible ways in which the ears might act together in bilateral amplification to influence speech recognition. The first is that bilateral performance is equal to performance in the better performing ear. This would suggest that there is no real interaction between ears. Rather, the ear with better aided speech understanding dominates when the signal is presented to both ears. A second possibility is that bilateral aided speech recognition is better than unilateral aided speech recognition in either ear. This outcome can be interpreted as binaural integration; that is, there is a synergy of information coming from the two ears that results in speech recognition that is greater than would be predicted from either ear alone. It is the expectation of this outcome that provides a basis for bilateral amplification. A third possible result of bilateral amplification is that speech recognition with two hearing aids is poorer than unilateral aided speech recognition in the better performing ear. This outcome can be interpreted as binaural interference. Input from the poorer ear results in less than optimal processing of input from the better ear. Obviously, this possible outcome of bilateral amplification least recommends the use of two hearing aids. As an extension of this third possibility, bilateral amplification might diminish performance to such an extent that use of two hearing aids results in performance that is poorer than unilateral amplification in the poorer performing ear. This might be thought of as “superinterference.” Bilateral amplification diminishes performance to such an extent

| Table 1. Product-Moment Correlation Coefficients between Participants’ Ages and Their SNR Loss (QuickSIN) Unaided and for Three Aided Test Conditions |
|---------------------------------|---------------------|---------------------|---------------------|---------------------|
| Age                             | Unaided            | Bilateral          | Better Ear         | Poorer Ear         |
|                                 | .74*               | .64*               | .53*               | .61*               |

*p < .01
that the patient is better off listening with *either* hearing aid alone.

For the vast majority of participants in this study, the addition of a second hearing aid diminished unilateral aided performance; that is, binaural interference occurred. Unexpectedly, in more than half the cases, bilateral aided speech recognition was poorer than unilateral aided performance in the poorer performing ear. It appears, therefore, that most of the participants were highly susceptible to binaural interference and found that speech recognition in background noise was easier with only one hearing aid, even if that one aid was in the participant’s poorer ear. This finding should be interpreted with caution as the participants had rather symmetrical hearing losses and very large differences in the SNR loss between ears were not typical. The mean difference was 2.7 dB, and for two participants the difference was only 1 dB. Yet, for purposes of analysis, their ears were classified as better and poorer. Notwithstanding this caution, these data indicate that binaural interference occurred for most participants, and suggest that “super-interference” happened in many cases. In any event, the results provided little support for the idea that bilateral amplification typically results in binaural integration for speech recognition in noise.

There was some evidence to suggest that susceptibility to binaural interference in bilateral amplification increased with age. Using the difference between the SNR loss for the better ear and for both ears as a measure of binaural interference, a significant (but relatively weak) relationship existed between binaural interference and age. This finding is supported by an early study by Jerger et al (1961) who studied word-recognition in noise in middle-aged and elderly patients. Although a slight improvement in performance was observed for the younger listeners for bilateral compared to unilateral amplification, there was a slight decrease in performance in the older listeners. These authors concluded more than 40 years ago that “binaural amplification produces little or no objectively demonstrable improvement in the ability to understand speech in ... noise” (Jerger et al, 1961, p. 147). Our results suggest that, although this may be somewhat more true in older compared to middle-aged adults, it does not appear to be limited to elderly persons.

Despite having symmetrical hearing losses, nearly 80% of the participants had better aided speech recognition (i.e., smaller QuickSIN SNR losses) in the right ear compared to the left ear. This finding is in agreement with Carter et al (2001), who observed better unilateral aided speech recognition in background noise in the right ears of all four subjects, and is consistent with a view that the right and left hemispheres of the brain may age at different rates (Johnson et al, 1979; Goldstein and Shelly, 1981; Meudell and Greenhalgh, 1987). Taken together, this suggests that older patients with symmetrical hearing losses generally should be fit in the right ear when only unilateral amplification is being considered. Further, these data suggest that older patients fit with bilateral amplification may obtain better speech recognition in noisy listening situations by removing the hearing aid in their left ear. Although these recommendations are supported by research findings, it is important to note that they are based on mean data. Individual patients can yield a different pattern of findings. For example, in the present study, four participants obtained better unilateral aided speech recognition in their left ear. Further, again it should be noted that all of these patients had rather symmetrical hearing losses. When asymmetrical aidable hearing losses exist and the right ear is distinctly more impaired than the left, it is likely that the propensity to perform better in the right ear would be offset by the asymmetry. Hence, the fitting and use recommendations above should be followed as general guidelines rather than clinical convention.

Results of the DDT did not provide unambiguous support for the idea that binaural interference is asymmetric based upon hemispheric differences. No significant difference was observed between the right-ear directed and left-ear directed scores for the three-pair digit sets across the 28 participants. This result does not replicate Carter et al (2001), who observed a consistent left-ear deficit on the DDT in their four subjects, despite having symmetrical pure-tone audiograms and word-recognition scores. The right-ear directed and left-ear directed DDT data also do not mirror the significant performance difference observed in the mean QuickSIN scores for the right and left ears of the 28 participants. However, when the DDT data were analyzed according to the better-performing and poorer-performing ear on the QuickSIN, greater agreement between the QuickSIN and DDT results emerged. These
data, therefore, suggest that the QuickSIN and the DDT may reflect the same underlying auditory processing mechanisms.

SUMMARY AND CONCLUSIONS

The majority of patients in this study performed better on the QuickSIN with unilateral amplification than with bilateral amplification. Further, there was a somewhat greater tendency in older patients to obtain better speech recognition in noise with unilateral amplification than with bilateral amplification. Speech recognition in noise was typically better in right ears than left ears, although this was not true for every patient. Finally, there was a tendency for participants to obtain better recall on the DDT in the ear that had less SNR loss on the QuickSIN.

Overall, these results contribute additional evidence that speech recognition in background noise may not be better with bilateral amplification than with unilateral amplification in many patients. Although perhaps not a widely held perspective, this idea is not new or unique. In a survey of adult hearing aid wearers conducted more than 40 years ago, Dirks and Carhart (1962) observed that, although patients fit bilaterally reported greater success in relatively quiet everyday listening situations than did patients fit unilaterally, bilateral amplification provided no advantage in everyday listening in environments where significant background noise was present. This conclusion has been supported by a number of subsequent case studies, patient surveys, and laboratory studies, many of which are cited above.

It appears that at least some patients will not achieve greater success with bilateral amplification than with unilateral amplification, at least in some everyday listening environments. Specifically, some patients fit with bilateral amplification are likely to achieve better speech recognition in noisy listening situations by removing one hearing aid. This may be especially true for elderly hearing aid wearers. Although, as noted, these findings are consistent with those of a number of earlier laboratory studies and field surveys comparing bilateral and unilateral amplification, it must be noted that the data of this study are limited to speech recognition measured in noise with the QuickSIN, where both speech and noise are presented from a single speaker located directly in front of the listener. There are undoubtedly other performance measures for which bilateral amplification would be superior to unilateral amplification and, conceivably, measurement paradigms where speech recognition in background noise might be better with two hearing aids. Such possibilities should be investigated systematically in future studies. Taken in the broader context of hearing aid use, therefore, we do not interpret these data as an argument against bilateral amplification. However, we believe these data do suggest that our patients wearing bilateral amplification should be counseled to try removing one hearing aid, generally the one fit to the left ear, when they experience difficulty in noisy listening situations.

Acknowledgments. Local monitoring of the study was provided by the Department of Clinical Investigation, Walter Reed Army Medical Center, Washington, DC, under Work Unit No. 04-25015. All persons included in this study volunteered to participate and provided informed consent. The opinions and assertions presented are the private views of the authors and are not to be construed as official or as necessarily reflecting the views of the Department of the Army or the Department of Defense. Parts of the work reported here were presented at the 2004 annual convention of the American Academy of Audiology, Salt Lake City, UT. The technical assistance of Van Summers, Mary Cord, and Michelle Molis is gratefully acknowledged. Finally, the authors wish to thank Jim Jerger for encouraging us to systematically evaluate our clinical observation that many older patients report better performance in background noise with unilateral amplification than with bilateral amplification.

NOTE

1. The focus of this study is speech recognition. However, the role of binaural hearing in the localization of sound is well known (DiCarlo and Brown, 1960; Schreurs and Olsen, 1985), and binaural hearing may also play a role in sound quality and in the suppression of tinnitus (Brooks and Bulmer, 1981). In addition, loudness summation between ears can result in less gain being required for each hearing aid, thereby reducing the possibility of loudness discomfort and acoustic feedback (Mueller and Grimes, 1993). Although potentially important in decisions regarding whether or not to prescribe bilateral amplification, these latter topics are not the subject of this investigation.

REFERENCES


Carter AS, Noe CM, Wilson RH. (2001) Listeners...


