

Dichotic Listening to Speech: VA-CD Data from Elderly Subjects

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Abstract

The Department of Veterans Affairs (VA) compact disc (VA-CD) *Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0* contains three dichotic speech tests. Two of them, namely, dichotic digits and dichotic synthetic sentences, are tasks that are easily and accurately performed by young normal listeners. The third test, dichotic nonsense syllables, is a more difficult task for normal listeners to perform well. Few data have been gathered from use of the VA-CD with subjects other than young adults with normal hearing sensitivity. This account is about 19 elderly patients with hearing loss in a VA long-term care facility and how they performed on the trio of dichotic tasks on the disc. The digits, sentences, and syllables were presented at 80 dB SPL in a dichotic format requiring two responses to each trial. Trials using syllables were also done at 90 dB SPL to quantify the effects of hearing loss. Digits were recognized better than sentences; both were recognized better than syllables, and this was true for both ears. Compared to results from young listeners, correct responsiveness for older people was most reduced on the syllable task, but performance on dichotic sentences was also reduced. The results corroborate previous reports that suggest that many aging auditory systems do not process dichotic nonsense syllables as well as younger ones. The results also suggest that the dichotic procedures on the VA-CD provide a useful continuum of difficulty for the clinician and investigator.

Key Words: Department of Veterans Affairs compact disc (VA-CD), dichotic digits, dichotic nonsense syllables, dichotic sentences, dichotic speech

In 1994, Volume 5(4) of the *Journal of the American Academy of Audiology* was devoted to a compact disc (CD) produced by the US Department of Veterans Affairs (VA). Both production of the disc under the auspices of the Rehabilitation Research and Development Service of the VA (Wilson, 1993) and data garnered from its use with young listeners were contained therein. The VA-CD, *Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0*, "provides a collection of high-quality materials for use in evaluating what is commonly called central auditory function." Among the reasons for production of the disc was "the

need for standardization of a central battery of auditory tasks that would be clinically and experimentally useful and that would encompass a wide range of complexity" (Noffsinger et al, 1994c, p. 231).

Three arrangements on the VA-CD allow speech materials to be presented dichotically, that is, the signals are presented in pairs, one signal or signal sequence to each ear. The signals (monosyllabic digits, synthetic sentences, or syllables; see Kimura, 1961; Berlin et al, 1973; Fifer et al, 1983; Musiek, 1983; Olsen, 1983; Beck et al, 1985) are presented to the two ears simultaneously or onset staggered by 90 msec, and the listener is instructed to give two responses, even when one or both of them are thought to be coerced guesses. Although such listening situations may occur in real life, the nonsense syllable task is an uncommon listening situation.

In the syllable task as usually administered, the tokens to each ear are exactly or

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nearly simultaneous, have about the same duration and offset, and differ only in a few crucial elements that occur in a brief time. Even at that, one expects that an auditory system of the sophistication possessed by normal human listeners should be able to handle /pa/ to one ear and /ta/ simultaneously to the other ear. And, in fact, the system does relatively well. Subjectively, however, the task is not easy, and, objectively, the normal system produces incorrect responses 25 percent to 40 percent of the time (Wilson and Leigh, 1995).

Previous experiments have shown that, although unsophisticated listeners with good hearing can repeat syllables presented one at a time to one ear virtually without error (a sequential monotic approach), performance deteriorates when a second syllable is delivered to the other ear (the dichotic format). In fact, the sum of the two ears' scores on a dichotic syllable task is usually only about 40 percent to 50 percent better than the performance of either ear by itself (Berlin and McNeill, 1976; Noffsinger, 1985).

The fact that dichotic performance is not equal to the sum of each ear's monotic performance has led to the notion that listening to difficult dichotic signals forces a competition between the signals for processing. Some investigators have used the dichotic/monotic performance profile to posit that signals presented in this format must compete for processing to the detriment of accurate report from each ear. This implies the existence of a single processing center for materials that possess speech attributes. It also suggests that this center has trouble when two such signals demand attention at about the same time. In addition, studies on how people listen dichotically when the two signals are slightly staggered in time have led to theories about auditory recency/primacy phenomena and short-term auditory memory effects (see Cullen et al, 1975; Drachman et al, 1981). Regardless, normal listeners have some difficulty identifying correctly a pair of syllables when one is delivered to one ear and the other is delivered to the other ear. Even when overall performance on such a task is good, the host is often surprised, that is, response confidence is low (see Noffsinger et al, 1994a).

Drachman and colleagues (1981) reported that people in their sixth or later decades respond to difficult dichotic speech signals, such as nonsense syllables, in ways that differ from the response of younger persons. They said that the difference includes both overall accuracy of report and the type of report given.

Kurdziel and Noffsinger (1977) found similar results. They studied 30 healthy, active people aged 65 to 80 years with normal speech reception thresholds and normal monotic word and syllable recognition. The subjects had mild-to-moderate hearing loss above 2 kHz. Dichotic nonsense syllable evaluation revealed that overall responsiveness was below normal. The authors found these results particularly interesting because the older subjects (hospital volunteers) were indistinguishable from young adults on tests of adaptation, loudness growth, tympanometry, and acoustic reflexes.

In summary, there is evidence that the auditory system, as it ages, performs less well on dichotic materials than it did when it was younger. If procedures on the VA-CD discussed in this article are to be useful in clinical evaluations and research investigations of auditory function, a variety of studies in which subject age and other factors are variables must be done. The performance of elderly listeners on the dichotic listening tests included on the VA-CD are reported in this study.

METHOD

General

A description of some of the experimental methods used in this investigation is provided in Noffsinger et al (1994b, c). Many of those details are about the care exercised in constructing the VA-CD, such as the digitization techniques used for the speech, the contents of the CD, the available calibration stimuli on the disc, and strategies used in data collection. In addition, one of the articles (Noffsinger et al, 1994b) contains amplitude-by-time displays of the digital waveforms of the nine digits, six sentences, and six syllables used in the current study, as well as results from their use with young adults with good hearing.

Subjects

Nineteen inhabitants of a long-term, nursing-care residency unit were tested as one part of their audiologic care program. They ranged in age from 58 to 85 years with an average age of 70. These individuals were generally healthy and mobile but, obviously, not well enough to live independently. Table 1 shows details of their routine audiologic profiles. In general, these were listeners with mild hearing loss in the

Table 1 Thresholds* and Word Recognition for 19 Elderly Subjects Used in the VA-CD Dichotic Speech Trials

Ear	Frequency (kHz)								SRT	WR
	.25	.50	1.0	2.0	3.0	4.0	6.0	8.0		
Right										
Mean	16.8	16.0	19.2	28.2	43.1	51.3	61.0	66.0	15.7	91.0
SD	11.0	8.7	12.0	15.7	20.9	25.5	30.0	29.4	9.8	9.5
Low	0	5	5	0	0	5	5	10	0	60
High	50	45	55	55	80	90	105	110	40	100
Left										
Mean	20.5	16.1	19.2	28.9	47.6	61.3	69.7	72.4	16.2	89.1
SD	8.7	8.4	12.4	16.4	20.5	27.9	29.5	27.5	9.5	10.9
Low	5	0	5	0	5	0	15	15	0	56
High	50	40	55	60	85	110	110	110	40	100

*dB HL (ANSI, 1989).

SRT = speech reception threshold; WR = monosyllabic word recognition (percent correct); low = low score in population; high = high score in population.

mid-frequencies (mean 2 kHz threshold was 28 dB) and moderate hearing loss at higher frequencies (mean 6 kHz threshold was 61 dB) with relatively normal spondee recognition thresholds (mean speech reception threshold was 16 dB) and good word recognition skills (mean monosyllabic word recognition was 90%). All 19 listeners received all three of the dichotic tests.

Digits

The digits (male speaker) are the monosyllabic ones from 1 to 10, inclusive. There are 36 possible pairs, all of which were used. They are aligned at the onset of any energy beyond baseline voltage, and their durations ranged from 353 to 561 msec. (Note calibration data in the articles listed earlier.) The same digit was never both parts of a pair.

The task was given at 80 dB SPL (ANSI, 1989). The subjects were given practice items monotonically and dichotically. All could repeat all digits one ear at a time. The subjects were instructed to listen to the pairs of digits and to give two responses to each pair on a check-off answer sheet; however, the response mode was not rigidly insisted on if the participant seemed more comfortable giving verbal or pointing responses that were then recorded by the audiologist. The set of possible stimuli was known to the listener, as was the fact that the same digit never occupied both members of the pair.

Sentences

The materials (male talker) feature six meaningless groups of meaningful words, that is, "synthetic sentences" (6 of the 10 synthetic sentences of Fifer et al, 1983). The 30 possible pairings of the 6 sentences are digitally aligned at their onsets (for any energy past baseline) and duration matched. They are 2 seconds long. Members of a pair were never the same sentence, a fact known to the listeners. The participants listened and tried to identify the sentences by number from a closed set of six possibilities. Two answers were required for each trial. The response mode was written, but transcription of verbal or pointing responses was also done if the listener preferred.

The sentences were presented at 80 dB SPL. The listeners were given practice and knew the set of possible responses and that the same signal would not occur in both ears. The practice sessions involved both monotic and dichotic presentation of the stimuli, the former to assure the experimenters that all sentences could be accurately identified when heard one ear at a time.

Nonsense Syllables (CVs)

The syllable task features the set of six syllables formed by stop plosives and /a/: pa, ta, ka, ba, da, ga (see Berlin et al, 1973). The disc contains syllable pairs, the onset of which is digitally aligned (by any energy) to be simultaneous or time staggered by 90 msec. Syllable durations range

from 241 to 284 msec. For this experiment, the condition chosen was one in which the syllable alignment had the left ear signal lagging the right ear signal in time by 90 msec, a task that is easier than a simultaneous-onset condition and one that produces roughly equal scores for each ear of young adults (Noffsinger et al, 1994b). One randomization of the 30 possible pairings of the syllables was used.

The syllable pairs were presented at 80 and 90 dB SPL. All of the participants could repeat all of the syllables when they were directed only to one ear. The audibility of the syllables was of particular concern, given previous reports on subjects with hearing loss (Roeser et al, 1976; Speaks et al, 1985).

The study participants knew the set of possible syllable responses and were given practice in repeating the syllables monotically and dichotically. A few dichotic trials were often necessary before subjects were convinced that there were syllables present at each ear. These subjects understood that one syllable would never be both halves of a pair, that they had to give two responses to each trial, and that they should check off their two responses on an answer sheet. Verbal or pointing response modes were allowed.

RESULTS

Digits

The results from 19 listeners (38 ears) on the dichotic digit task are shown in Figure 1 and Table 2. Average performance was excellent, with mean scores in the right ear (98%) and left ear (95%) very near those of young listeners with normal hearing using the same materials (Noffsinger et al, 1994b). Scores obtained from one right ear (83%) and from two left ears (83%

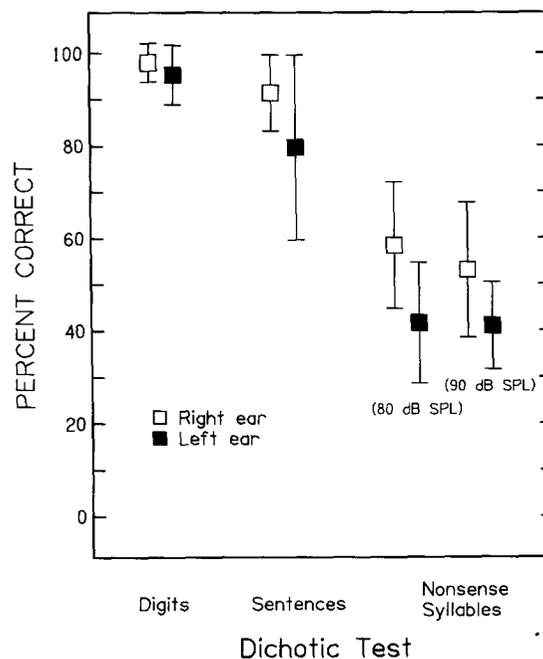


Figure 1 Mean performance (% correct) with one standard deviation for the right ear (open squares) and left ear (closed squares) of 19 elderly subjects for three dichotic conditions: digits, synthetic sentences at 80 dB SPL, and nonsense syllables (CVs) at 80 and 90 dB SPL. The digits and sentences had simultaneous onsets. The syllable onsets were time staggered with the left ear lagging by 90 msec.

and 75%) were below the 90 percent figure (Noffsinger et al, 1994b) suggested as a cut-off point for a normal population's behavior.

Sentences

Performance was also good by the 19 listeners on the dichotic sentence task, but not nearly as good as that offered by younger listeners. Across the 38 ears, right ear performance

Table 2 Performance (% Accurate) by Elderly Subjects on Dichotic Digits, Sentences, and Nonsense Syllables (CVs)

	Task				Syllables			
	Digits (80 dB SPL)		Sentences (80 dB SPL)		(80 dB SPL)		(90 dB SPL)	
	RE	LE	RE	LE	RE	LE	RE	LE
Mean	98.0	95.4	91.4	79.6	58.4	41.6	53.1	41.0
SD	4.2	6.4	8.2	20.0	13.7	13.0	14.6	9.4
Low	83	75	73	23	33	23	30	27
High	100	100	100	97	87	63	80	57

N = 19 persons (38 ears) for each task.

RE = right ear; LE = left ear; low = low score in population; high = high score in population.

Syllable onsets were time staggered by 90 msec, LE lagging.

was 11.8 percent better on average than left ear performance (see Fig. 1 and Table 2). Six right-ear scores and 10 left ear scores fell below 90 percent accuracy, the cut-off suggested by Noffsinger et al (1994b) for a population of young people with good hearing.

Nonsense Syllables (CVs)

Performance from the 19 people was poorer on the dichotic nonsense syllable task. As shown in Figure 1 and Table 2, average performance for the right ear was 58.4 percent; left ear mean accuracy was 41.6 percent. The right ear advantage of 16.8 percent for the 80 dB SPL condition was the largest seen for any of the dichotic tasks employed in the project. The mean scores are 19 percent and 38 percent poorer for the right and left ears, respectively, than mean scores from young listeners with good hearing on the same task.

Although the older listeners had shown the ability to recognize each of the six syllables when they were presented monotonically to each ear, the question of the influence of their hearing loss on the results was still of interest. For that reason, the syllable task was repeated (after a 3-month period) for 16 of the 19 listeners at 90 dB SPL, the highest level for which data were gathered on young listeners using the VA-CD (Noffsinger et al, 1994b). Results are shown in Figure 1 and Table 2 and exhibit little change from the 80 dB SPL data. Fourteen of the 16 subjects retested at 90 dB SPL had total scores (right ear + left ear) within ± 10 percent of their 80 dB SPL scores. The two who did not actually performed worse at the higher presentation level condition. Evidently, the additional acoustic cues available to the listeners at the higher intensity level did not influence performance. At 90 dB SPL, mean right and left ear scores were 53 percent and 41 percent, respectively, a 12 percent right ear advantage.

DISCUSSION

In an earlier study (using the VA-CD) of young adults with good hearing, Noffsinger et al (1994b, p. 253) said that

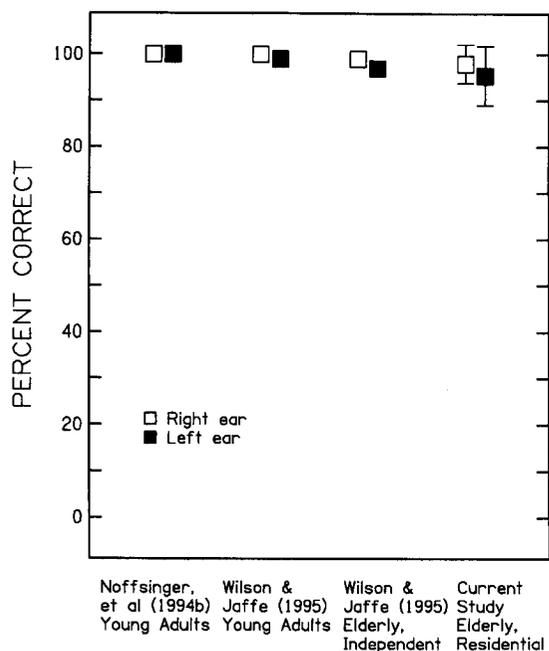
A useful aid in judging normal performance is description of confidence areas for the dichotic tasks. For the most difficult test, nonsense syllables, 93 percent of all ears tested scored 50 percent or better at 50, 60, and 70 dB HL. The 90th percentile was at 56.7 percent. For

digits and sentences, scores below 90 percent accurate were not found for any subjects. Thus, scores below 90 percent accurate for digits and sentences and below 50 percent accurate for nonsense syllables are rare, leaving a clinician or clinical investigator the reasonable conclusion that scores worse than these usually do not occur in a population [of young adults with good hearing].

The older subjects described here performed well on the digit, sentence, and syllable tasks, although not as well as younger adults nor as well as the elderly subjects with similar hearing sensitivity reported by Kurdziel and Noffsinger (1977). This last finding was somewhat predictable. The earlier study was of old people who were independent, active hospital volunteers. The people in the current report were in a residential facility in which their activity was largely unrestricted, but they were not independent. Although about half of the current study's subjects were 70 to 85 years old and half were 58 to 68 years old, their hearing and performance on the dichotic tests were not much different. This may reflect the importance of considering both behavioral and chronological aging as critical indices to performance.

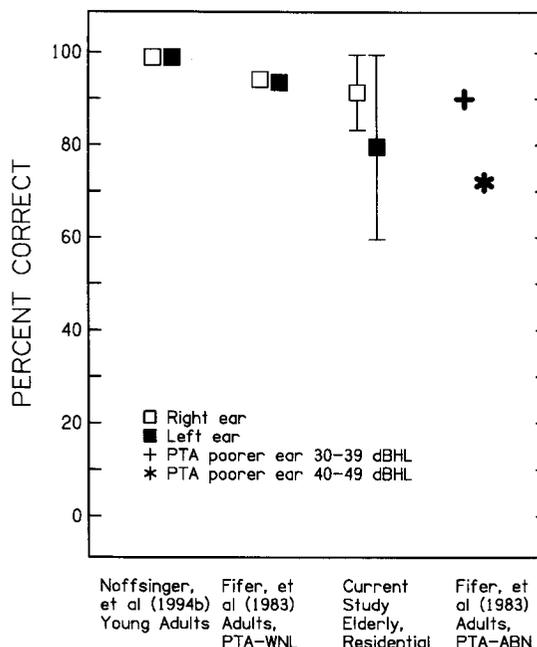
Certainly, given these results, different borders demarcating normal or at least common performance from uncommon performance by elderly patients in a long-term care setting would be useful. In this group of 19 such people, only three ears (8% of the total) scored below 90 percent on the digit task. This is not much different from the results yielded by young adults with good hearing, so 90 percent performance is still a useful benchmark. For sentences, only three (left) ears (8%) scored below 60 percent accurate, so this level of performance could serve as a reasonable dividing line. Such performance, however, is quite different from that of younger listeners, for whom virtually perfect performance on the sentences is a reasonable expectation.

For dichotic syllables, the scores from the population used in the current study were low enough to raise questions about the clinical utility of the task with such patients. As was also apparent to a lesser degree in the dichotic sentence results, there is a definite right ear advantage (16.8%) in the syllable data that is larger than that reported by others (e.g., Noffsinger, 1985) for large populations of adults with good hearing. In fact, in this older population, half of the participants had right ear advantages



Dichotic Digits

Figure 2 Mean performance (% correct) for dichotic digits from four studies. Symbols for ear identification are shown in the figure. Data from the current study include one standard deviation around the mean. Noffsinger et al (1994b): N = 40; level = 80 dB SPL; ages = 17-32 years old; hearing = normal. Wilson and Jaffe (1995): N = 20; level = 70 dB SPL; ages = < 30 years old; hearing = normal. Wilson and Jaffe (1995): N = 20; level = 70 dB SPL; ages = 60-75 years old; hearing = mild-to-moderate high-frequency hearing loss; status = independent living. Current study: N = 19; level = 80 dB SPL; ages = 58-85 years old; hearing = mild-to-moderate high-frequency hearing loss; status = institutional living.



Dichotic Sentences

Figure 3 Mean performance (% correct) for dichotic sentences from four studies. Symbols for ear identification are shown. Data from the current study include one standard deviation around the mean. Noffsinger et al (1994b): N = 40; level = 80 dB SPL; ages = 17-32 years old; hearing = normal. Fifer et al (1983): N = 14; level = 70 dB SPL; ages = 23-55 years old; hearing = normal. Current study: N = 19; level = 80 dB SPL; ages = 58-85 years old; hearing = mild-to-moderate high-frequency hearing loss; status = institutional living. Fifer et al (1983): N = 28; level = 70 dB SPL; ages = 24-67; hearing = see notation in figure.

exceeding 15 percent. Examination of the data suggests that the greater right ear superiority is a product of a disproportionate decrease in left ear skill.

If one considers the ears separately at 80 dB SPL, two right ears (11%) scored below 43 percent on the syllable task, and such scores should probably be considered uncommon. For the left ear, however, nine ears scored below 43 percent and seven between 23 percent and 33 percent. Performance in the two ears was no better at 90 dB SPL. Floor-effect performance limitations and performance that might be expected by chance make setting common/uncommon limits for the left ear difficult for this task with these subjects. Said another way, performance by these institutionalized elderly subjects via the left ear was sufficiently poor that discerning additional focal lesion effects on the left ear would have been difficult.

Putting the current study in some perspective, Figures 2 (digits), 3 (sentences), and 4 (syllables) recast data from the current study along with data from other studies that used subjects of various ages, status, and amounts of hearing loss. A survey of these figures illustrates the often coincident influences of increasing age, behavioral independence, hearing loss, and task difficulty on dichotic listening. Perusal of all of the data reported in the experiments referenced in these figures makes apparent the strength of these influences. The most obvious of the influences, age and hearing loss, certainly affect dichotic listening performance: as people get older and hearing deteriorates, overall correct responsiveness declines. Less obvious before the current study was that factors contributing to institutionalization, even with relatively intact elderly people, may also contribute to or be reflected in reduced dichotic listening skills.

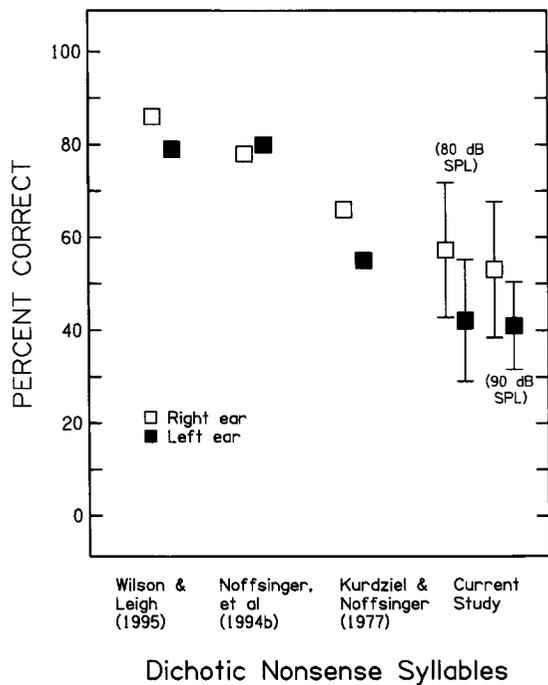


Figure 4 Mean performance (% correct) for dichotic nonsense syllables (CVs) from four studies. The dichotic condition in all studies was one featuring a 90-msec delay in the onset of the left ear signal. Subjects in the studies were predominantly or all right handed. Symbols for ear identification are shown. Data from the current study include one standard deviation around the mean. Wilson and Leigh (1995): N = 24; level = 80 dB SPL; ages = 19–35 years old; hearing = normal. Noffsinger et al (1994b): N = 40; level = 80 dB SPL; ages = 17–32 years old; hearing = normal. Kurdziel and Noffsinger (1977): N = 30; level = 78 dB SPL; ages = 65–80 years old; hearing = mild-to-moderate high-frequency hearing loss; status = independent living. Current study: N = 19; level = 80 and 90 dB SPL; ages = 58–85 years old; hearing = mild-to-moderate high-frequency hearing loss; status = institutional living.

That is, within a group of people in a long-term care facility whose ages ranged over almost 3 decades, performance on dichotic tests was not decade dependent. All of their performances were alike and usually worse than expected for elderly people of the same age with similar amounts of hearing loss who were not in institutions, that is, behavioral independence was a factor.

Finally, data from the current study also suggest that the right ear gets more dominant (the left ear gets less strong) in dichotic tasks as the auditory system gets older, something that others have reported (e.g., Jerger and Jordan, 1992; Jerger et al, 1994) and disputed (Gelfand et al, 1980). That this phenomenon and other

unusual dichotic behavior are products of aging, and that these effects are particularly notable when using appropriate and/or difficult dichotic materials, are topics of long-time interest still under study in our laboratory.

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