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Identification Performance by Right- and Left-handed Listeners on Dichotic CV Materials

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Abstract

Normative data from 24 right-handed and 24 left-handed subjects were obtained for the dichotic consonant-vowel (CV) materials (pa, ta, ka, ba, da, and ga) recorded on the Veterans Affairs (VA) compact disc (CD) *Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0.* Identification performance by the two subject groups was significantly different. With the right-handed subjects, identification performances on the materials presented to the right ear (RE) were better than performances on the materials presented to the left ear (LE) by (1) 16.3 percent for simultaneous onsets (RE = 72.8%; LE = 56.5%), (2) 11.3 percent for the 90-msec right-ear lag (RE = 86.3%; LE = 75.0%), and (3) 8.7 percent for the 90-msec left-ear lag condition (RE = 85.8%; LE = 77.2%). In comparison to the right-handed subjects, the left-handed subjects exhibited a smaller right-ear advantage and more inter-subject variability. With the left-handed subjects, identification performances on the materials presented to the right ear also were better than performances on the materials presented to the left ear by (1) 1.7 percent for simultaneous onsets (RE = 62.9%; LE = 61.1%), (2) 2.8 percent for the 90-msec right-ear lag (RE = 75.0%; LE = 72.2%), and (3) 3.1 percent for the 90-msec left-ear lag condition (RE = 75.9%; LE = 72.9%). The results are similar to previous dichotic CV data and indicate that the CVs recorded on the VA-CD provide valid estimates of identification performance on the dichotic CV materials.

Key Words: Auditory perceptual assessment, dichotic consonant-vowels (CVs), word identification

Several studies indicate that the identification/recognition performance of left-handed subjects on dichotic speech tasks are different from the performance of right-handed subjects (Lake and Bryden, 1976; McKeever and VanDeventer, 1977; Piazza, 1980). From these studies, which used a variety of response bias paradigms with dichotic nonsense syllables or digits, three relations emerge that differentiate the group performances of left-handed and right-handed subjects. First, both groups demonstrate a right-ear advantage, with the right-ear advantage for the left-handed group being substantially smaller than the right-ear advantage for the right-handed group. Second, a larger percentage of right-handed subjects have a right-ear advantage; conversely, a larger percentage of left-handed subjects have a left-ear advantage. The majority of subjects in both groups, however, demonstrate a right-ear advantage. Third, the performance variability is larger in the left-handed group than in the right-handed group. The purpose of the present study was to re-examine these relations between left- and right-handed subjects using a free recall response paradigm with dichotic consonant-vowel (CV) pairs presented in three onset alignment conditions: simultaneous onset, 90-msec lag in the left ear, and 90-msec lag in the right ear.

METHOD

Twenty-four right-handed subjects (19 to 35 years, mean age = 22.7 years) and 24 left-handed subjects (11 to 57 years, mean age = 30.1 years) who had hearing at 250- to 8000-Hz octave intervals of ≤20 dB HL (ANSI, 1989) served in the 1-hour experiment. Handedness

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was established based on the hand used by the subject to write and eat. Furthermore, the right-handed subjects did not admit to dominant use of their left hands on any task. Six of the left-handed subjects professed dominant right hand use for tasks that were instructed, including batting, golfing, and cutting with scissors. The test stimuli consisted of the six CV nonsense syllables (pa, ta, ka, ba, da, and ga) (Studdert-Kennedy and Shankweiler, 1970) recorded dichotically on the *Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0* (1992) compact disc (Noffsinger et al, 1994). The syllables, which ranged from 241 to 284 msec, were digitized from one channel of the original Kresge Hearing Institute of the South recordings (Berlin et al, 1973) and subsequently were edited to produce the 30 possible CV pairs. Track 5 on the compact disc contains a randomization of the 30 dichotic CVs with simultaneous onsets, whereas track 6 contains a second randomization of the 30 dichotic CVs with a 90-msec onset lag in the left channel. During data collection, the dichotic materials were reproduced by a compact disc player (Sony, Model CDP-497), fed through an audiometer (Grason-Stadler, Model 10), and presented to the subjects at 80 dB SPL through TDH-50P earphones encased in P/N 510C017-1 cushions. All testing was conducted in a double-walled sound booth (Acoustic Systems, Model RC143).

The stimuli were presented in two blocks, with each block containing the three alignment conditions (simultaneous, right-ear lag, and left-ear lag) in a random order. Thus, each of the three alignment conditions was given two times with 60 test items for each condition (2 trials × 30 items/trial). The channels for the simultaneous condition were alternated so that channel 1 was presented to the left ear of the even-numbered subjects and to the right ear of the odd-numbered subjects. The subjects responded by circling their responses on a prepared answer sheet, which made the listening task one of identification. Two responses were required for each stimulus pair.

All subjects were practiced on the dichotic listening task before data collection was initiated. Practice consisted of 5 to 10 right-ear or left-ear lag presentations followed by 5 to 10 simultaneous onset presentations. During the practice interval, the subjects recorded their responses and were queried periodically concerning their "comfort" in performing the listening/response task. When the subject "felt comfortable" with the task, which typically was after 10 or so practice items, data collection began.

Table 1 Mean Percent Correct Identification and Standard Deviations for Materials Presented to the Right and Left Ears of the Two Subject Groups

Group/Condition/Ear	Trial 1		Trial 2		Both Trials	
	%	SD	%	SD	%	SD
Left-handed Group (n = 24)						
Simultaneous						
RE	63.8	(18.9)	61.9	(18.9)	62.9	(18.1)
LE	60.1	(13.8)	62.1	(15.9)	61.1	(14.1)
RE–LE	3.6	(24.8)	−0.1	(24.5)	1.7	(23.7)
LE Lag						
RE	73.5	(18.8)	78.3	(12.5)	75.9	(14.5)
LE	68.5	(20.6)	77.2	(15.0)	72.9	(16.9)
RE–LE	5.0	(28.0)	1.1	(20.0)	3.1	(23.1)
RE Lag						
RE	74.4	(18.8)	75.6	(16.5)	75.0	(16.6)
LE	72.1	(14.5)	72.2	(17.0)	72.2	(14.4)
RE–LE	2.4	(21.4)	3.3	(21.8)	2.8	(19.5)
Right-handed Group (n = 24)						
Simultaneous						
RE	71.8	(9.6)	73.8	(14.6)	72.8	(10.8)
LE	56.7	(12.8)	56.4	(13.6)	56.5	(12.3)
RE–LE	15.1	(12.9)	17.4	(16.1)	16.3	(13.0)
LE Lag						
RE	84.9	(11.3)	86.8	(10.0)	85.8	(9.2)
LE	76.3	(13.8)	78.1	(14.0)	77.2	(13.2)
RE–LE	8.6	(17.2)	8.8	(14.0)	8.7	(14.9)
RE Lag						
RE	84.9	(9.6)	87.6	(7.2)	86.3	(7.8)
LE	74.2	(14.6)	75.8	(15.5)	75.0	(14.3)
RE–LE	10.7	(16.9)	11.8	(15.7)	11.3	(15.2)

RE = right ear, LE = left ear.

RESULTS

The mean percent correct identification data (and standard deviations) for trial 1, trial 2, and both trials combined are listed in Table 1 and are illustrated in Figure 1 for the materials presented to the right and left ears. Additionally, the differences in performances on the materials presented to the ears (right-ear score minus left-ear score) are given in the table. In Figure 1, the vertical lines represent ±1 standard deviation. A three-way analysis of variance (ANOVA) with repeated measures (2 trials × 3 conditions × 2 ears) was performed on the data. The main effects for the three independent variables were significant[1] (trials: F [1,46] = 7.8,

[1]Throughout this paper, the .05 level of significance is used. The p values listed were provided by the SuperANOVA software (Abacus Concepts, 1989).

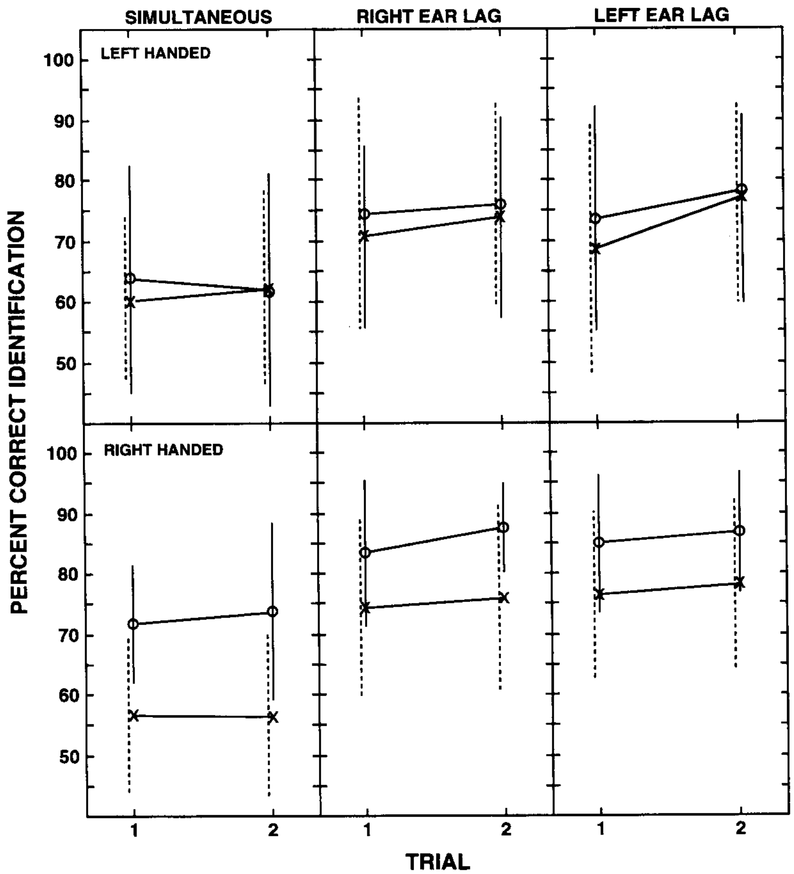

Figure 1 Mean percent correct identification of CV syllables for the right ears (circles) and left ears (crosses) and standard deviations for the left-handed subjects (upper panels) and right-handed subjects (lower panels) for the three listening conditions. The vertical lines in each panel represent ± 1 standard deviation (solid line: right ear; dashed line: left ear).

p = .0077; conditions: F [2,92] = 81.1, p = .0001; ears: F [1,46] = 11.8, p = .0013). The identification performances by the right-handed group and the left-handed group also were significantly different (F [1,46] = 5.1, p = .0282); overall, the right-handed group scored 5.6 percent better than the left-handed group.

Trials

Although, in the ANOVA, the main effect for trials was significant, inspection of the mean data in Table 1 and Figure 1 indicates that, except for the left-ear lag condition of the left-handed group, all differences between the two trials were less than one token (3.3%). For the left-ear lag condition with the left-handed group, which is the apparent source of the trial difference, performance on trial 2 was better than performance on trial 1 by 4.8 percent and 8.7 percent for the right ear and left ear, respectively.

Conditions

Identification performance was 10 percent to 15 percent poorer on the simultaneous condition than on either of the lag conditions. Combined right-ear and left-ear identification performances for the left-handed and right-handed groups were 62 percent and 65 percent (simultaneous condition) and 75 percent and 81 percent (lag conditions), respectively. Means comparisons indicated a significant difference between the simultaneous condition and the left-ear lag condition (F [2,92] = 130.0, p = .0001) and between the simultaneous condition and the right-ear lag condition (F [2,92] = 112.7, p = .0001). The left- and right-ear lag conditions were not significantly different.

Ears

The ANOVA indicated that, overall, there was a significant difference between scores on the materials presented to the right and left ears, with the mean data in Table 1 indicating better performance on the materials presented to the right ear. Additionally, the ear by group interaction was significant ($F [1,46] = 5.4$, $p = .025$). As can be seen in Table 1, the differences between the mean scores for both trials (right-ear score minus left-ear score) of the left-handed group were minimal, ranging from 1.7 percent to 3.1 percent, whereas the same differences for the right-handed group ranged from 8.7 percent for the left-ear lag condition to 11.3 percent for the right-ear lag condition to 16.3 percent for the simultaneous condition. From these relations, the significant ear (main) effect is attributed to the right-ear advantage demonstrated by the right-handed group. The minimal ear difference observed with the left-handed group is considered inconsequential.

As was noted earlier, the overall identification performance of the two subject groups was

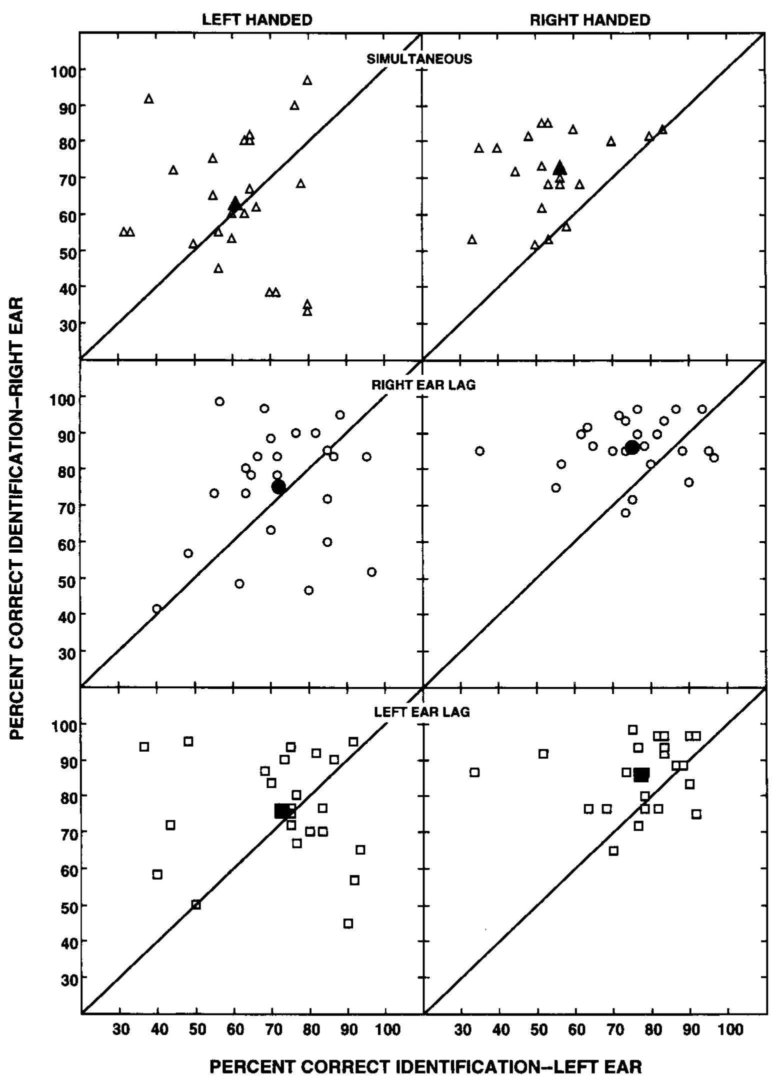

Figure 2 Bivariate plots of the individual subject identification responses for trials 1 and 2 for the left- and right-handed subjects. In each panel, subject performance on material presented to the right ear is plotted on the ordinate, whereas subject performance on the material presented to the left ear is plotted on the abscissa. The filled symbols represent the mean data for each of the conditions. The diagonal line in each panel represents equal performance.

significantly different, with the right-handed group having about 5.6 percent overall better performance than the left-handed group. Examination of the data in Table 1 reveals that the average ear difference between groups (the mean from the right-handed group minus the mean from the left-handed group) was 10.4 percent for the right ear (9.9% for simultaneous and left-ear lag and 11.3% for right-ear lag) and 0.8 percent for the left ear (−4.6% for simultaneous, 4.3% for left-ear lag, and 2.8% for right-ear lag). From these data, one may conclude that performance by the two subject groups was different on materials presented to the right ears but was not different on the materials presented to the left ears.

DISCUSSION

Analysis of the individual subject data provides insight into the group data. The individual subject identification responses for both trials combined are presented as bivariate plots in Figure 2, with the left and right panels devoted to the left- and right-handed subjects, respectively. In each graph in Figure 2, subject performance on material presented to the right ear is plotted on the ordinate, whereas subject performance on the material presented to the left ear is plotted on the abscissa. The diagonal line in each panel represents equal identification performance. Thus, datum points below the diagonal line represent identification performance that is better on the materials presented to the left ear than on the materials presented to the right ear. The solid symbols in each panel depict the mean correct identification for that condition.

Two relations are apparent from the data in Figure 2. First, the majority of datum points from the right-handed subjects are above the diagonal line, indicating better performance on the materials presented to the right ear than on the materials presented to the left ear. The same relation is observed for the left-handed subjects, but, with the left-handed group, there are a number of datum points below the diagonal line. Second, the datum points for the left-handed subjects are much more dispersed than the datum points for the right-handed subjects, which indicates that there is more variability in the left-handed group than in the right-handed group. For both trials combined, the average standard deviations for the three conditions (see Table 1) were 9.3 percent and 13.3 percent for the right and left ears of the right-handed subjects versus 16.4 percent and 15.1 percent for the right and left ears of the left-handed subjects. Thus, as other investigators have reported (Lake and Bryden, 1976; Piazza, 1980; McKeever et al, 1984; Bryden, 1988), left-handed subjects as a group are less homogeneous in their performance on a dichotic listening task than are right-handed subjects, and left-handed subjects tend to exhibit a right-ear advantage more often than they exhibit a left-ear advantage.

The mean correct scores (see Table 1) for the simultaneous condition (72.8% for the right ear, 56.5% for the left ear, and a 16.3% difference) are almost identical to the data reported by Berlin et al (1973) for 12 subjects and by Noffsinger (1985) for 75 subjects, both of whom used the CVs that were spoken by the speaker used in the current study. For both lag conditions in the right-handed group, the mean performance on the materials presented to the right ear (86% correct) was better than the mean performance on the materials presented to the left ear (76% correct). This relation is consistent with earlier reports (Gelfand et al, 1980; Noffsinger, 1985) in which there was a slight right-ear advantage for right-handed subjects for both the right-ear lag and left-ear lag conditions when the presentation lag to one ear was 90 msec.

The data from the right-handed group in the current study are in contrast to data reported from 120 listeners who were involved in the normalization standards (clinical trials) for the materials on the *Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0* (Noffsinger et al, 1994). The data from that report, which involved 10 test sites, indicated slightly better overall performance on the materials presented to the left ear than on the materials presented to the right ear. Noffsinger et al suggested that two factors may have accounted for the unexpected finding of a left-ear advantage in the clinical trials. First, although the CV stimuli on the compact disc were digitized from an analog version of the original Kresge tape, the stimuli subsequently were edited and aligned before being compiled on the compact disc. The alignment process may have produced dichotic stimuli that differed from the original CV materials and thereby may have produced the unexpected left-ear advantage. Second, experimental errors may have been introduced during data collection, response coding, and analysis at the various clinical trial sites. During a test session in the clinical trials, each subject was given 12 different test materials (e.g., compressed speech, masking-level difference, dichotic digits, filtered speech, etc.), each of which involved a different monaural or binaural paradigm, different presentation levels, and different test procedures. Thus, the dichotic CVs were only a small part of a larger set of experimental conditions. Except for the dichotic conditions, all of the conditions in the clinical trials were straightforward monaural or binaural paradigms in which the ear to which the materials were presented was not an important control variable. Even for two of the dichotic speech tasks (digits and sentences), ear was not an important variable because performance on those two tasks was near maximum. Only for the dichotic CV materials was the ear to which the materials were presented an important control variable. The current data from the right-handed subjects indicate that the dichotic CV materials on the Veterans Affairs compact disc are sensitive to the "right-ear advantage" reported in the literature. The current data, therefore, support the Noffsinger et al (1994) conjecture that the lack of a "right-ear advantage" in the clinical trials with the same dichotic CV materials must have been caused by the design/conduct of the clinical trials and was not attributable to problems with the stimulus materials.

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