Hemispheric specialization for speech opposed by contralateral noise*

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Twenty right-handed Ss listened to a dichotic tape in which one of six consonant-vowel syllables was paired with a burst of white noise on each trial. Eight blocks of 40 trials were presented, with the syllables within a block presented to the same ear. On each trial, Ss decided if /ba/ was presented. Mean RT to right-ear items was 440.0 msec, while mean left-ear RT was 453.6 msec. Responses indicating the presence of /ba/ were made significantly more quickly than responses indicating its absence, with no significant interaction of ear and type of decision. This study demonstrated a right-ear advantage in the perception of spoken syllables when noise is presented to the opposite ear. An interpretation of the RT differences between ears in terms of callosal transmission time is discussed, and implications of this study for the perceptual origins of the ear advantage effect are considered.

It is now a well-established phenomenon that when two different spoken messages are simultaneously presented to Ss through headphones, one message to each ear, most Ss are better able to identify the material delivered to the right ear (Kimura, 1967; Studdert-Kennedy & Shankweiler, 1970). One widely accepted interpretation of these results holds that the right-ear advantage reflects the specialization of the left cerebral hemisphere for speech processing functions in most persons as well as the superiority of contralateral over ipsilateral ear-cortex connections. When speech material is presented to one ear at a time, however, the traditional finding is that the right-ear advantage does not occur, indicating that involvement of both ears is necessary in order to demonstrate the ear asymmetry (Dirks, 1964). To account for this last observation, Kimura (1967) has suggested that the ipsilateral ear-cortex pathways are in some way inhibited during dichotic presentation, thereby giving the right ear privileged access to the left hemisphere, where speech is processed. Speech presented to the left ear in the dichotic paradigm would thus be transmitted to the left hemisphere via the contralateral pathway to the right hemisphere and across to the left hemisphere via the corpus callosum. This would presumably put the left-ear input at a disadvantage relative to the right-ear stimulus, and hence a right-ear advantage would be expected.

As yet unresolved, however, is the nature of the "competing" stimulus which is needed to effect suppression of the ipsilateral pathways to reveal the right-ear superiority. Several researchers have used white

noise in the ear contralateral to the one presented with speech with, on the whole, disappointing results, i.e., no consistent ear advantages were obtained (Corsi, 1967; Darwin, 1971a). This has led at least one researcher to suggest that the two dichotic inputs must be of the same perceptual class in order for the ear advantage to be demonstrated (Darwin, 1971b).

The experiment reported here looked at the effect of contralateral noise on the perception of speech using reaction time (RT) as the response measure. All of the dichotic work referred to so far, including the work with contralateral noise, has used percent correct identification as the measure of performance. Hence, those experiments were asking whether the S heard the stimulus correctly or not. Recently, the use of RT has been shown to be applicable to dichotic listening research, and it appears to parallel the finding obtained with more traditional paradigms, i.e., a situation which produces a right-ear advantage in terms of percent correct also results in shorter RT to the right-ear items (Springer, 1971). Because of its sensitivity to differences which may not be detected in a paradigm which obtained only percent correct data, RT seemed a good tool to examine the effects of contralateral noise on the perception of speech. The goal of the study was to determine whether or not a right-ear advantage could be demonstrated in terms of a shorter response latency to speech stimuli when they were presented to the right ear.

METHOD

Twenty right-handed Stanford University undergraduates with no history of hearing disorder served as Ss. Fifteen were male and five were female, with a mean age of 19.8 years. Each was tested individually for one 45-min session.

The Ss were presented with a dichotic tape in which one of six syllables, /pa/, /ta/, /ka/, /ba/, /da/, and /ga/ was paired with a burst of white noise on each trial. The consonant-vowel (CV) syllables were produced by a female speaker, and the white noise bursts were formed by manually gating a Grason-Stadler noise

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Fig. 1. Mean reaction time for left- and right-ear syllables for /ba/ and -/ba/ trials.

generator. The white noise preceded the onset of each syllable by an average of 50 msec, while the noise lagged syllable offset by an average of 123 msec. The stimuli were presented to Ss on a Revox A77 stereophonic tape recorder through Koss Pro 4A stereo headphones.

The dichotic pairs were presented in blocks of 40 trials with a 4-sec intertrial interval between pairs. Each S received eight blocks of trials, in which ear of syllable presentation was counterbalanced across blocks, with the syllables in a given block all presented to the same ear. In each group of 40 CV-noise pairs, /ba/ had an a priori probability of occurrence of .5, while each of the remaining five syllables occurred 1/10th of the time. Ss were instructed to use the right hand to move a lever switch in one direction if /ba/ occurred and in the other direction if any of the other five syllables occurred. A millisecond decade clock permitted RT, as measured from syllable onset to S response, to be recorded.

RESULTS

A three-way analysis of variance (Ears by Responses by Ss) was performed on the RT data. The mean RT scores for each condition are presented in Fig. 1. Collapsing across type of response, the mean RT for left-ear CV syllables was 453.6 msec compared with 440.0 for right-ear items [$F(1,19) = 6.98, p < .025$]. Seventeen out of 20 Ss showed an advantage in favor of the right ear. Responses indicating the presence of /ba/ were also made more quickly than responses reporting the absence of /ba/ [$F(1,19) = 15.63, p < .01$]. The interaction of Ear by Type of Response was not significant [$F(1,19) = 1.82, p > .1$].

Performance in terms of percent correct was virtually error free. There was an average of 3.5% errors on left-ear items across all Ss and an average of 3.6% errors to right-ear items across all Ss.

DISCUSSION

This experiment has demonstrated a right-ear

advantage in terms of RT for the recognition of speech material opposed by contralateral noise. This strongly supports the contention that the two dichotic stimuli presented on a trial do not have to be of the same perceptual class for an ear advantage to occur. Percent correct, the traditional measure in dichotic tasks, did not show any ear advantage, suggesting that RT might be a more sensitive measure of ear asymmetry and hence a good tool to study stimuli which have not typically shown ear advantage effects. The presence of some signal in the contralateral ear appears to be crucial in obtaining ear advantage effects with RT, however, as noted in an earlier pilot study by the present author as well as in a more recent experiment by Haydon and Spellacy (1972). These investigators found that a right-ear advantage could not be obtained in terms of RT for monotonically presented speech delivered in blocks to one ear.¹

One possible interpretation of the 14-msec latency difference observed between left- and right-ear items is that it reflects the time needed for callosal transfer of information from the right hemisphere to the left hemisphere for the left-ear stimulus. While this value is consistent with estimates obtained in visual experiments using RT to study hemispheric differences (Rizzolatti, Umiltà, & Berlucchi, 1971; Moscovitch & Catlin, 1970), other studies have indicated a much shorter callosal transmission time, on the order of the time needed for a few synaptic transmissions (Poffenberger, 1912; Berlucchi, Heron, Hyman, Rizzolatti, & Umiltà, 1971). Part of the latency difference found here may reflect callosal transmission time, but it is likely that the remainder is due to an increase in decision time associated with the processing of the degraded left-ear signal.

The finding of an ear advantage in terms of RT in a task where the Ss always knew to which ear the speech would be presented also provides evidence against any simple attentional bias interpretation of the right-ear advantage (Kinsbourne, 1970). Dichotic experiments in which two competing speech signals are presented are open to the possibility that Ss are differentially attending to the right ear. Attempts to direct the attention of Ss to one ear or the other are only partly successful in eliminating this factor, since it is conceivable that it is easier to ignore left-ear material when attending to the right ear than it is to ignore right-ear material when attending to the left ear. With the paradigm used in this study, attentional factors were minimized, providing additional support for the perceptual origins of the ear asymmetry phenomenon.

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NOTE

1. In an unpublished study involving the blocked, monotic presentation of CV syllables in a choice RT task, no evidence was found to support the hypothesis that ear advantage effects could be obtained with monotic presentation (Springer, unpublished data, 1970). This finding led to the use of a slightly modified paradigm with contralateral noise, resulting in the positive data found in the experiment reported in the body of this paper. In view of recent results by Jack Catlin (personal communication, December 1972) indicating that a marginally significant right-ear advantage could be obtained with blocked, monotically presented speech verbally identified by Ss while the same experiment with contralateral noise produced a more reliable right-ear advantage, the experiment presented in this paper was repeated without contralateral noise. A new group of 12 Ss was tested in the same paradigm with identical stimuli except for the absence of the contralateral noise (Springer, unpublished data, 1973). Mean left-ear RT was 2.9 msec faster than mean right-ear RT, $t(11) = .48$, $p > .1$. Thus, the evidence for the feasibility of studying hemispheric specialization with blocked, monotically presented speech is conflicting, and this issue will require further experimentation for its resolution.

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