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PERCEPTION OF DICHOTICALLY PRESENTED SYNTHETIC SHORT VOWELS

— A PRELIMINARY REPORT —

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The determinants of ear advantages in dichotic speech listening are not completely known. There has been a substantial accumulation of data, however, suggesting that observed ear advantages are a function of such variables as (1) the nature of the particular test stimuli which tap the particular level(s) of language processing, and (2) the degree to which these levels of processing are lateralized (Porter and Berlin, 1975).

In our earlier dichotic listening studies using synthesized steady-state (200 msec) Japanese vowels and CV-syllables, we found that normal subjects as a group showed a significant right-ear advantage (REA) for the CV-syllable test but only a weak nonsignificant REA for the vowel test (Miyoshi, Sasanuma, Tatsumi, Kobayashi and Fujisaki, 1975). These findings, combined with the preliminary data gathered from pathological groups of unilaterally brain damaged patients, were interpreted to be in accord with a multiple-stage speech processing model, in which our vowel test has tapped a relatively lower, less lateralized stage of processing but the CV-syllable test a more central stage which is highly lateralized to the language dominant left hemisphere.

A question in this respect would be somewhat inconclusive results reported in the literature for vowels, although a series of studies in recent years indicate that REA for vowels may be found when listening conditions have been made appropriately difficult by a variety of methods, viz., lower S/N, shortened duration, or others (Godfrey, 1975; Weiss and House, 1973; Darwin, 1971; and Haggard and Parkinson, 1971).

Godfrey(1975), for instance, reported that shortening of the vowel stimuli, as well as addition of noise and the use of a more confusable set of vowels (lax vowels), had the effect of increasing REA. Since his experimental conditions were such that the shortened vowels had at the same time white noise mixed with them, it is difficult to determine whether the obtained increase in the magnitude of REA is attributable to the shortening of vowel duration alone, or to the interaction between shortened duration and lower S/N.

In the present study, our major objective was to investigate the possibility of whether the shortening of the vowel stimuli in dichotic listening experiments with normals has in fact the effect of increasing REA. Our secondary purpose was to find out the extent to which whatever ear advantage a given subject may show on the short-vowel test is related to that of the same subject on the long (200 msec)-vowel and CV-syllable tests, respectively.

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Methods

Stimuli

The five Japanese vowels /i/, /e/, /a/, /o/ and /u/ were synthesized on the YHP 2100A computer with durations of 20, 40 and 60 msec for each. Figure 1 illustrates frequencies of up to the third formant for each vowel. The energy of each vowel of the same duration was made equal, and linear rise and decay time of 10 msec was used to avoid clicks. The test tape was compiled in such a way that these five vowels were combined into 20 possible pairs with a total of 40 stimulus pairs, each member of a pair occurring twice on each channel. In order to prevent fusion, each vowel of a pair had different F_0's, i.e., 125 and 126 Hz. These stimuli were then fed into two channels of digital-to-analog converters at a rate of 12 kHz with an accuracy of 10 bit/sample via low-pass filters with a cut-off frequency of 4.8 kHz. The interval between the successive pairs was set at 5 or 6 sec.

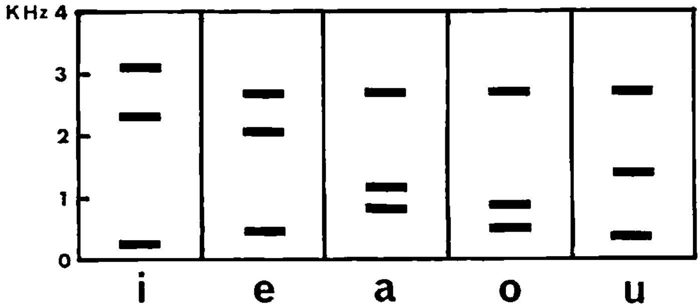


Fig. 1: Frequencies up to the third formant for five synthetic vowels, /i/, /e/, /a/, /o/ and /u/.

Since in a pilot study, monaural identification of 20 msec vowels by normals proved to be as good as that of 40 and 60 msec vowels (i.e., 100% identification), it was decided to use the 20 msec vowel dichotic tape in the following experiment.

Procedure

Preceding the main experiment, each subject had a practice session. In the practice session the subject listened binaurally to each of the five 20 msec vowels, and when it was confirmed he was identifying them correctly 100% of the time, he then listened to ten pairs of these vowels presented dichotically at a level 60dB above his pure tone threshold through a TEAC R-740 two-channel tape recorder.

The main experiment consisted of a single session in which the subject listened to two lists of 40 dichotic pairs of short-vowels, reversed the headphones, and listened to the remaining two lists again. The subject was instructed to write down on an answer sheet whatever vowel sounds that he thought he heard through the headphones upon presentation of each dichotic pair. He was not asked, however, to indicate the side of the ear in which he heard the sound.

Subjects

Twenty-two right-handed college students, 13 women and nine men, with a mean age of 23.9 years (22 to 27 years) have participated in the experiment thus far. All of these subjects had previously been given two other dichotic listening tasks, one with the same five synthetic Japanese vowels as those used in the present experiment but with the longer duration of 200 msec., and the other with six synthetic CV syllables /pe/, /te/, /ke/, /be/, /de/, and /ge/. The findings from these two previous experiments are being compared with the results of the present experiments.

Results and Remarks

Overall Performance and Ear Advantages

Table 1 summarizes the performance of the subjects in terms of mean percentage correct for the right-ear (R) and the left-ear (L). The right ear advantage (REA) was expressed in terms of a difference score R minus L (R-L) and is presented in the third column. For the purpose of comparison, results of the same group of subjects on two previous dichotic tests (long-vowel and CV-syllable tests) are included in the table.

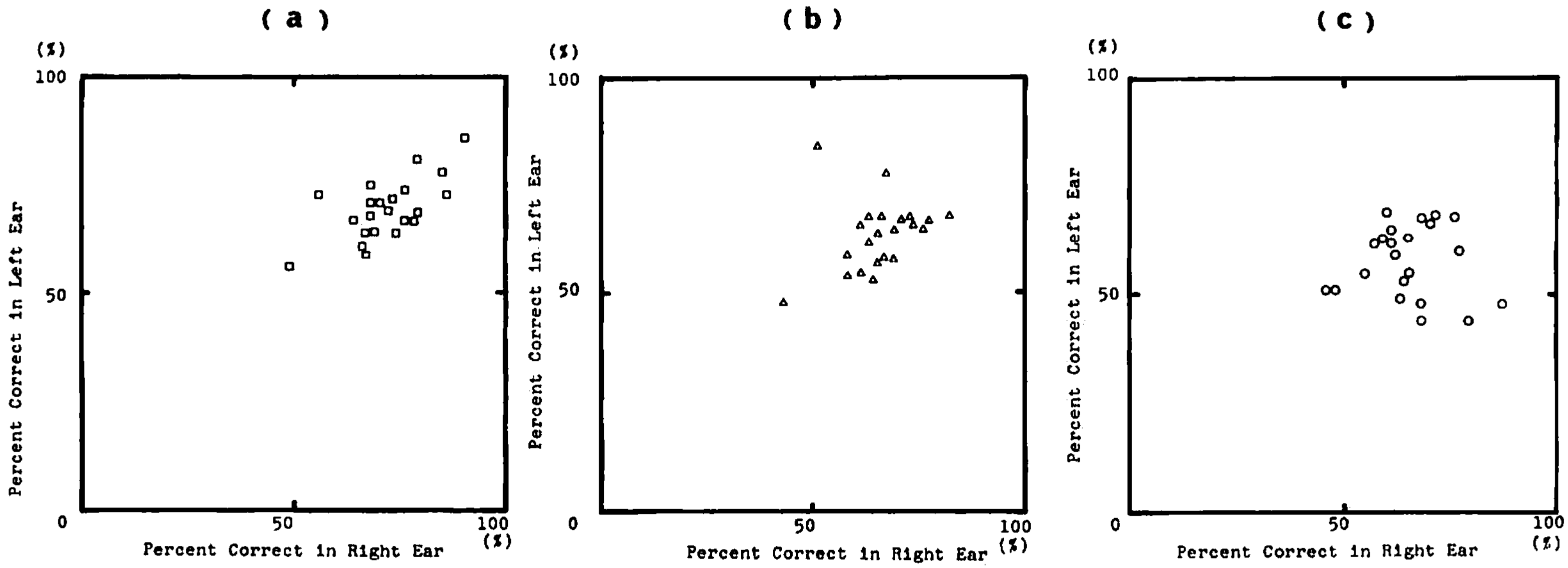
Test stimuli	R	L	R-L
Short (20 msec) vowels	65.43	63.41	2.02
Long (200 msec) vowels	71.19	57.88	7.31
CV-syllables	65.19	57.88	7.31

Table 1: Mean percentage correct for the right-ear (R) and left ear (L) and R-L ear scores on short-vowel, long-vowel and CV-syllable dichotic tests, for 22 normal subjects.

As can be seen the overall performance level (R+L) was highest for the long-vowel test followed by short-vowel and CV-syllable tests, in this order ($p < .05$ between short and long-vowel tests and $p < .10$ between short-vowel and CV-syllable tests). This can be interpreted to indicate that the degree of perceptual difficulty of each test increases in this order, although the nature of the "perceptual difficulty" might be quite different from test to test.

With respect to the ear advantage, only a weak nonsignificant REA (2.02) was exhibited on the short-vowel test in the present study. A similarly weak nonsignificant REA (2.45) was obtained for the long-vowel test, whereas a significant REA (7.31: $p < .05$) was revealed for the CV-syllable test.

Figures 2-a, 2-b, and 2-c are graphic representation of the performance of individual subjects on these three tests, i.e., long-vowel, short-vowel, and CV-syllable tests from left to right. As will be seen, scores for about two thirds (2/3) of the subjects in the present study (Figure 2-b)



Figs. 2-a, b, c: Performance of 22 normal subjects on long-vowel(a), short-vowel (b), and CV-syllable (c) dichotic listening tests. The abscissa represents percent correct in the right ear and the ordinate percent correct in the left ear.

are distributed on the right of the diagonal line, indicating weak to moderate REAs, while the scores for the rest of the subjects are closely congregated on the left of the line, indicating weak left ear advantages (LEA) (except one whose score is located somewhat off the mode, indicating a strong LEA).

The relative position and the shape of the distribution of scores for the long-vowel test (Figure 2-a), on the other hand, indicate a better overall performance level but almost the same degree of REA as compared to the short-vowel test, while those for the CV-syllable test (Figure 2-c) show a somewhat poorer overall performance level but a clearly stronger REA.

Taken together, these results would seem to highlight a clear-cut difference between the CV-syllable test and vowel tests (whether using short or long vowels as stimuli) in terms of revealing ear advantages, a fact which in turn may indicate different strategies used by the subjects in processing these stimuli.

It is also apparent from these results that shortening of the vowel stimuli from 200 to 20 msec, while appreciably increasing the level of perceptual difficulty, contributes but little to the size of the REA. This is a finding which is not in accord with Godfrey's results that shortening of vowel stimuli had the effect of increasing REA, nor with the hypothesis that the REA is a function of the perceptual difficulty of the dichotic task. A partial explanation for this discrepancy may be found in the different experimental conditions used (i. e., no lowering of S/N in our study) and this possibility should be examined in later experiments.

Correlations between Ear Advantages on Different Tests

Our second question was whether there is any relationship between the ear advantage (its size as well as direction) of an individual on the short-vowel test on one hand, and that of the same individual on the long-vowel or CV-syllable tests on the other. The answer was obtained by computing Pearson product moment correlations between REAs (or R-Ls) on these tests. The results showed only a weak correlation of $r=.32$ between the REAs on short- and long-vowel tests, and a similarly weak correlation of $r=.33$ between the REAs on short-vowel and CV-syllable tests, indicating a great variability of performance for each subject from one test to another. Factors contributing to this variability are not beyond our speculation at this point, but exploration of these in further studies should be crucial for identification of determinants of ear advantages in dichotic speech listening.

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