Selective Listening for Temporally Staggered Dichotic CV Syllables*

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It is by now well known that when stop-vowel syllables differing only in the initial consonant are delivered simultaneously to opposite ears, recall is more accurate from the right ear than from the left. More recent work on dichotic listening (Lowe et al., 1970; Studdert-Kennedy et al., 1970) has revealed that the maximum suppression of the left ear occurs not when the two syllables are simultaneous but when the syllable delivered to the right ear arrives about 50 msec. after the syllable delivered to the left ear. More generally, an advantage in recall accrues to the lagging consonant regardless of which ear receives that consonant. This lag effect combines with the ear asymmetry to produce the greatest right ear advantage for trials on which the right ear lags in onset behind the left.

The lag effect is as yet poorly understood. We do know that the effect depends on dichotic presentation and that it is, therefore, central in origin and not due to peripheral masking. Moreover, there are indications that, even with dichotic presentation, some types of stimuli do not give a lag advantage. When isolated steady-state vowels are presented dichotically, the leading vowel tends to be heard as clearer than the lagging vowel (Porter et al., 1969). We may speculate that the lag effect is specific to the recall of encoded phones like the stop consonants and that it depends on some fundamental property of the speech decoding mechanisms.

The present study was undertaken primarily to determine whether the lag effect arises during phoneme recognition or whether it arises in the organization of recall after the sounds have been identified. If the lag effect reflects merely a preference for the lagging consonant or a recall strategy in which the syllable arriving second is generally the first to be recalled, then the lagging and leading consonants should be recalled equally well if

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the subject were required to listen for and recall only one of the competing consonants. In previous experiments on the lag effect, the subjects had been instructed to report both consonants on each trial. In the present experiment, the listeners were instructed to report only one of the two stimuli. Each subject performed two selective listening tasks. In one task, called the "ear monitoring" task, the subjects were instructed to report one ear and ignore the stimulus at the other ear. Equal periods of time were spent reporting only the right and only the left ear. In the second task, called the "temporal order" task, the subjects were to attend to the order of arrival of consonants within a dichotic pair. On half the trials they were to report only the lagging consonant from the pair and on half the trials only the leading consonant. If the lag effect is truly a robust perceptual phenomenon, the listeners should be more accurate in their report of lagging consonants than of leading consonants, whether they are selecting by ear of arrival or by order of arrival.

The stimuli for the experiment were nine synthetic syllables, /ba/, /da/, /ga/, /be/, /de/, /ge/, /bɔ/, /dɔ/, /gɔ/, each 350 msec. in duration. Pairs of these syllables were recorded on a two-channel tape in such a way that only the consonant differed between channels, resulting in combinations such as /ba/-/ga/ or /de/-/ge/. One of the syllables of a pair was always delayed in onset relative to the other by 10, 30, 50, 70, or 90 msec. There were 6 seconds between pairs. Timing of the recording was under computer control. The frequency of occurrence of individual syllables was completely balanced over ears, tape channels, delays, and recall conditions. The complete counterbalancing required a total of 720 trials for each subject for each task. Testing was conducted in four one-hour sessions, two sessions for each task.

Each testing session was split into four blocks of ninety trials. Selective recall instructions were given at the beginning of each block of trials. For the ear monitoring task, the subjects were instructed as to which ear to report at the beginning of each set of ninety. For the temporal order test, they were told whether to report the lagging or the leading consonant for each block of trials. The subjects were required to give one response on each trial, even if they had to guess and to respond with B, D, or G.

Twelve right-handed students took the two tests. Half of them did the ear monitoring task first and half the temporal order task.

Very similar results were observed for the ear monitoring and temporal order tasks, so the two tasks will be considered together.

Figure 1 shows the percentage of trials on which the subjects correctly recalled the consonant designated by the selective listening instructions, depending on whether the correct consonant was lagging or leading, whether it was arriving at the left or right ear, and the amount of time between syllable onsets. (The abscissa gives the relative onset time of the correct syllable from 90 msec. lag to 90 msec. lead. The solid line represents trials on which the selected syllable was arriving at the right ear, and the dashed line represents trials on which the selected syllable was arriving at the left ear. Each point is based on 36 trials for each of the twelve subjects, 432 trials in all).

For both the ear monitoring and temporal order task, three factors were found to influence recall. The instructions had some effect, and as might be expected, the subjects were more accurate in monitoring either by ear or by temporal order with longer intervals between the onsets of the competing syllables. The most obvious effect is the right ear advantage. Regardless of whether the subjects were recalling by ear or by temporal order, they were more often correct when the selected syllable was arriving at the right ear than at the left. Finally, there was a large advantage in recall for the lagging syllable compared with the leading syllable within a pair. This lag advantage is indicated by the generally negative slopes of the curves.

The errors made by subjects could almost always be interpreted as failures to judge correctly the order of arrival or ear of arrival rather than as incorrect identifications of the consonants. Trials on which subjects selected the stimulus which they should have ignored are termed "intrusions." The difference in frequency between correct responses and intrusions provides a measure of the accuracy of selective recall. Figure 2 gives the accuracy of selection as a function of the length of the delay between syllables. Discrimination of order of arrival was consistently poorer than discrimination of ear of arrival. Although monitoring on either basis improved with longer delays, considerable difficulty was experienced with delays as long as 90 msec.

In view of the fact that the listeners were more accurate in selecting their responses by ear than by temporal order, one might expect that the influence in recall attributable to the lag effect and laterality effect would be diminished for the ear monitoring task. A comparison of the lag effect and laterality effect for the two tasks is shown in Figure 3, which gives the change in magnitude of each of these effects as a function of the delay between syllable onsets for the two tasks. The graphs were constructed

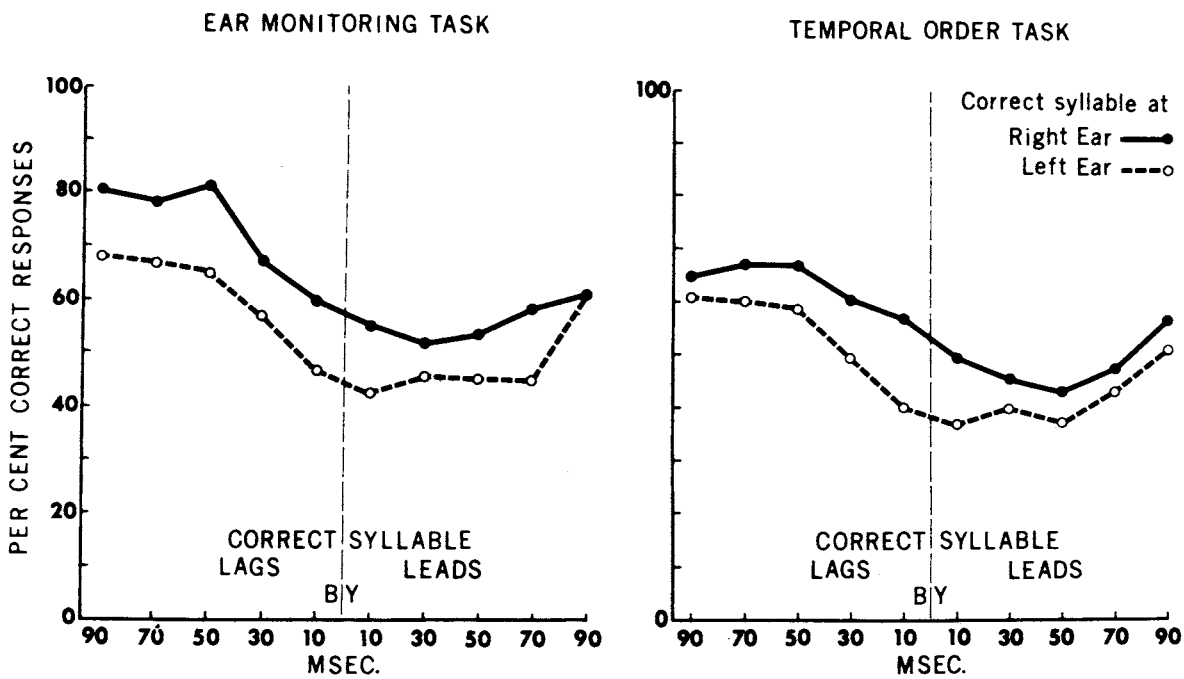
EAR MONITORING TASK
TEMPORAL ORDER TASK
PER CENT CORRECT RESPONSES
100
80
60
40
20
0
90 70 50 30 10 10 30 50 70 90
MSEC.
CORRECT SYLLABLE
LAGS
LEADS
B|Y
Correct syllable at
Right Ear
Left Ear

FIG. 1

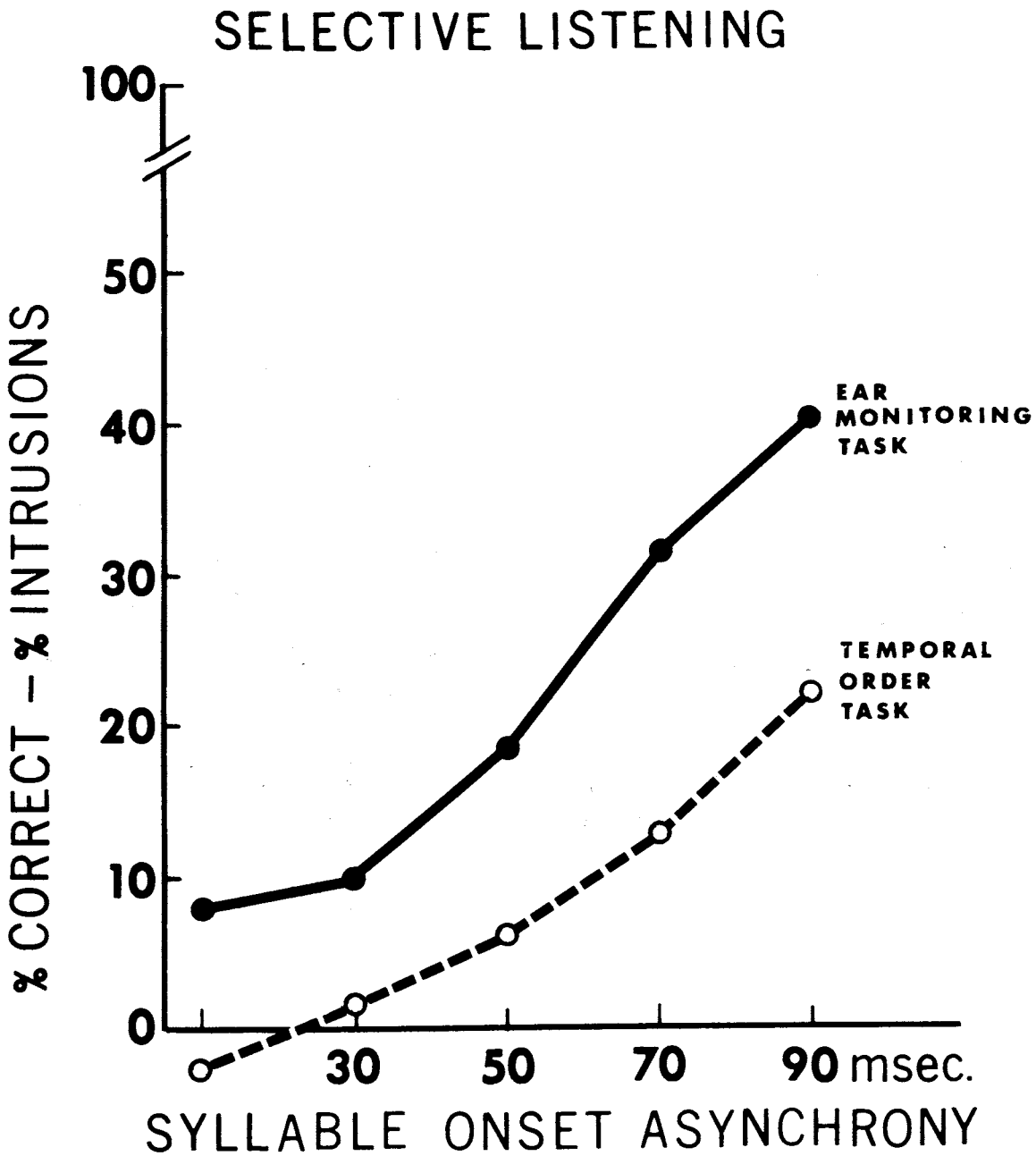
SELECTIVE LISTENING
100
50
40
30
20
10
0
% CORRECT – % INTRUSIONS
EAR MONITORING TASK
TEMPORAL ORDER TASK
30
50
70
90 msec.
SYLLABLE ONSET ASYNCHRONY

FIG. 2

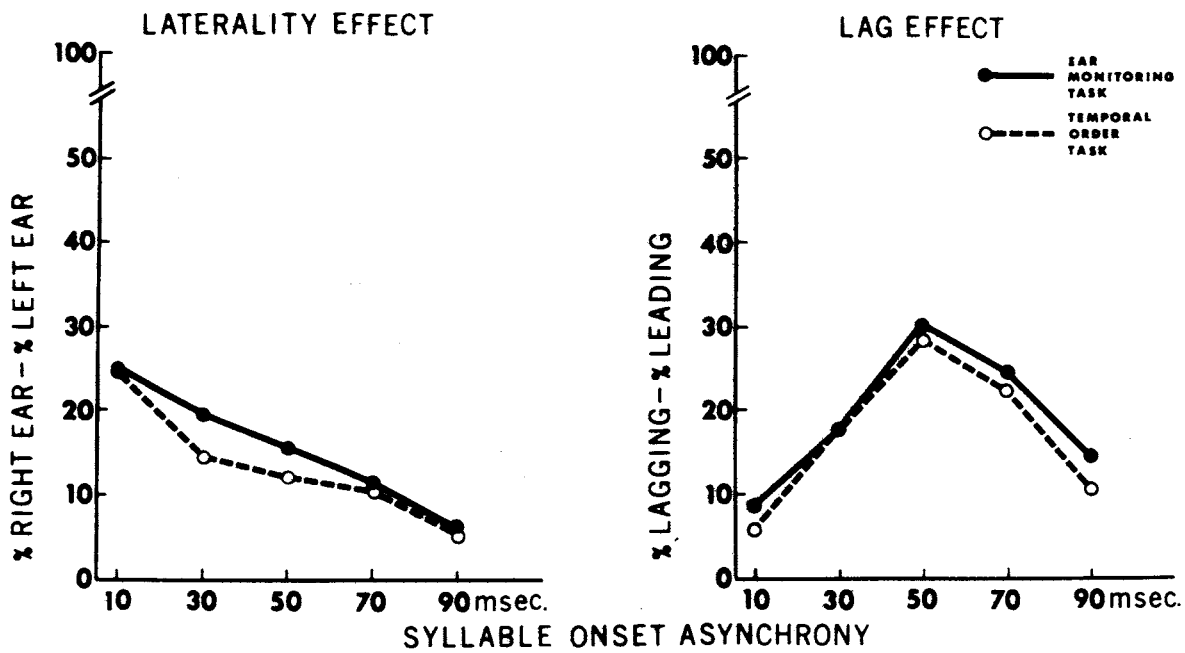
LATERALITY EFFECT
LAG EFFECT
% RIGHT EAR - % LEFT EAR
% LAGGING - % LEADING
100
50
40
30
20
10
0
10
30
50
70
90 msec.
SYLLABLE ONSET ASYNCHRONY
EAR MONITORING TASK
TEMPORAL ORDER TASK

FIG. 3

as follows: each response was classified as to whether it corresponded to a stimulus presented at the right ear, the left ear, or neither and also whether it corresponded to a lagging stimulus, a leading stimulus, or neither. The percentages of all responses falling into each of these categories was computed. The laterality effect chart gives the percentage by which right ear report exceeded left ear report. The lag effect chart gives the percentage by which recall of lagging syllables exceeded recall of leading syllables.

For both the ear monitoring and temporal order tasks, the preference of the right ear was strongest when the two syllables were most nearly simultaneous, that is, with delays of 10 msec. Longer delays between ears reduced the ear effect. The magnitude of the ear advantage did not differ reliably between the two tasks. This decrease in the magnitude of the ear advantage with increases in interaural delay is further evidence that the laterality effect depends on competition between ears. Although the effect does not depend critically on simultaneity of onsets of the competing syllables, it is clear that longer delays reduce the advantage for the right ear over the left.

Turning to the lag effect, it can be seen that the magnitude of the advantage for the lagging ear did not differ between the two tasks. For both the ear monitoring task and the temporal order task, the maximum advantage for the lagging ear was achieved when syllables were separated in onset time by 50 msec. The peaking of the lag effect at 50 msec. is seen more clearly here than in previous experiments. It is possible that the location of the peak depends on the stimuli used. The synthetic syllables used in this experiment had second formant transition lasting from 35 to 50 msec. The peak at 50 msec. may reflect a critical time for processing these transitions.

The results of this experiment suggest that the lag effect and the laterality effect exert an advantage in recall independent of each other and that the magnitude of both these effects is independent of the recall strategy. It seems likely that the lag effect and ear effect do not account for the confusions in selection by ear or temporal order; such selection errors probably occur often in any case because of the fact that the acoustic features which differentiate the competing consonants last no more than 50 msec. Rather, consonants which are lagging or which arrive at the right ear appear to gain in saliency for the listener, while those arriving first or arriving at the left ear appear to lose by the same amount without altering the overall level of performance on the selection task.

In conclusion, the lag advantage and right ear advantage in recall of dichotically presented CV syllables are extremely robust phenomena which cannot be eliminated by manipulation of recall strategy. These asymmetries in recall attributable to ear or order of arrival most likely arise during the identification of consonants and not during the organization of responses for recall. Further research should be undertaken to elucidate the mechanisms underlying these effects.

References

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