Elimination of auditory evoked responses during auditory shadowing

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Auditory averaged evoked responses (AER) to pure tones were recorded from subjects: (a) in the absence of other auditory stimuli, (b) while passively listening to different messages delivered dichotically and (c) while they "shadowed" either the right-ear or left-ear message. Under condition (c), all components of the AER were eliminated. Significant differences between conditions (a) and (b) were not observed. The findings provide electrophysiological support for the conception of perceptual systems as single-channel processors.

Models of human information processing emphasize the limited channel capacity of perceptual systems. Observers receiving simultaneous inputs in one or more sensory systems appear to be able to acquire and retain information from one channel at a time and, within that channel, only discrete packages or chunks at a time (Broadbent, 1952).

One of the earliest illustrative studies involved a "shadowing" task (Cherry, 1953) in which the subject was given simultaneous messages to the left and the right ears. Prior to these dichotic presentations, the subject was instructed to "shadow" either the left-ear or the right-ear message. The shadowing task is one requiring the subject to articulate, on a word-by-word basis, the speech of another person. The metaphor of the shadow is apt in that perfect shadowing would require the perfect duplication of everything uttered by the other speaker.

While there are abundant nuances in shadowing studies, the fundamental finding is that there is nearly no recall or recognition of information delivered to the nonshadowing ear. Not only is the observer unable to report the contents of the nonshadowed message but he may, as well, be oblivious to changes in the sex of the speaker, or even to changes in the language of the message. However, when the shadowed message is highly familiar (e.g., popular poems or songs, phrases memorized and often confronted in life), there is a marked reduction in shadowing errors and an increased recognition and retention of material delivered to the nonshadowing ear (Cherry, 1953).

In light of the frequently reported differences between averaged evoked responses (AER) to familiar vs unfamiliar or informative vs noninformative stimuli (Davis, 1964; John, 1964; Harter & White, 1967; Sutton, et al, 1967) we were interested in determining the effectiveness of intramodal inputs during a task which otherwise precludes recognition and recall. Specifically,

we wished to examine the amplitudes, latencies, and variances of auditory AERs computed during a task in which the information processing demands on the auditory system were heavy.

METHOD

Subjects

Naive college students served as subjects and were instructed to shadow one of two different, unfamiliar messages presented dichotically through stereophonic headphones. Separate recordings of the subjects' shadowing were made in order to score performance.

Apparatus

Auditory AERs were preamplified and then amplified by the PAR-141 system and were averaged by a Fabri-Tek 1074 signal averager. The latter was slaved to a PDP-8L digital computer programmed to display the AER waveform and ± 1.0 standard deviations around the average. The AER and associated variability were displayed on a Tektronix 504 oscilloscope. Tone clicks were provided by presenting 400-Hz pulses of 20 msec duration, generated by Tektronix pulse and waveform generators. These tones were delivered monaurally at a rate of one every 4 sec.

Procedure

Separate monopolar recordings were taken from left and right temporal areas (C₃ and C₄). Placements were equidistant from the midline, and ground leads were attached to each ear. For a given subject, both left-ear and right-ear shadowing trials were given and, under each of these conditions, auditory signals were delivered to the right ear or the left. In addition, a "listening" control was employed in which subjects were asked to listen to but not verbally repeat the messages while auditory signals were again delivered. Finally, a "speaking" control was employed, in which subjects were instructed to count aloud at a rate of 2 integers per second while tone clicks were again delivered. Resulting AERs were obtained from 65 presentations per condition.

RESULTS

The major findings are offered in Figure 1, which presents the data from three subjects. Data from the different subjects are presented from top to bottom. For the given subject, the separate waveforms, from left to

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CONTRALATERAL AUDITORY EVOKED RESPONSES

Figure 1. Auditory AERs from three subjects under conditions of nonshadowing, shadowing, and passive listening (control). Each separate figure presents the average waveform (center) bracketed above and below by ± 1.0 and -1.0 SD. Waveforms are the result of 65 presentations of tones to the ear that was contralateral to the one receiving messages to be shadowed. Scale = 8.2 microV/cm division.

AUDITORY EVOKED RESPONSE SPEAKING CONTROL

Figure 2. Data from one subject under conditions identical to those of "control" in Figure 1 except subject was required to recite a series of numbers at the rate of approximately 2/sec. While AER variance is increased under this condition, the data indicate that mere vocalization does not eliminate the AER or significantly reduce its amplitude.

right, were obtained: (a) during tone-only presentations (nonshadowing condition), (b) during shadowing, (c) during passive exposure to both sets of messages, in which subjects were instructed to listen to but not verbally repeat either of the messages. The upper traces for each subject under any condition are AERs from the left hemisphere and the lower traces are from the right hemisphere. All traces reflect contralateral AERs; i.e., traces for either hemisphere were obtained with tones delivered to the opposite ear. In fact, the ipsilateral AERs behaved the same way. Space does not permit a separate set of figures for the ipsilateral waveforms.

That the effects were not attributable to mere vocalization can be seen in Figure 2 which shows one subject's AERs to the same tone clicks as the subject counts, at a rate of 2 integers per second, while receiving the tones. The resulting AERs are not different; i.e., tone-only waveforms are the same as those obtained during tone + vocalized counting. This finding is consistent with that offered in the third column of Figure 1. Passive exposure to both messages does not significantly affect AERs.

DISCUSSION

For all subjects, auditory shadowing results in the elimination of all components of the auditory AER. An

AER is not observed in either hemisphere, and this is independent of which ear receives the tones. The particular shadowing task employed was a difficult one in that shadowing accuracy for the subjects was between 60% and 75%; i.e., subjects failed to articulate from 25% to 40% of the relevant message. Under these circumstances, and predictably, recall of information delivered to the nonshadowing side was negligible. At the conclusion of each block of trials, subjects were asked to estimate the number of clicks presented while they were shadowing. While each subject had received 65 such clicks, and while, under the nonshadowing conditions subjective estimates were all between 55 and 70, subjects under the shadowing condition reported either no clicks or "a few." In addition, subjects reported hearing no clicks even when the tones were presented to the "shadowing ear." Also, and consistent with our previous studies (Robinson, 1973; Robinson & Strandburg, 1973), conditions that prevent attentiveness appear also to increase the variability around the AER.

The results of our study indicate that, at least within a single sensory modality, neural processing is channel-limited. Given the cortical origin of AERs and the present findings, it is again clear that filtering is precortical. It is now necessary to determine intermodal shadowing effects in which AER-producing stimuli occur in a different sensory modality than does the message to be shadowed, as well as the quantitative relationship between the difficulty of the shadowing task and the magnitude of AER attenuation. In addition, since there appears to be more high-frequency activity during shadowing (but not during mere vocalization of numbers) it is necessary to determine the possible relationship between such high-frequency activity and nuances of the shadowing task.

REFERENCES

- Broadbent, D. E. Speaking and listening simultaneously. *Journal of Experimental Psychology*, 1952, 43, 267-273.
- Cherry, E. C. Some experiments on the recognition of speech with one and with two ears. *Journal of the Acoustical Society of America*, 1953, 25, 975-979.
- Davis, H. Enhancement of evoked cortical potentials in humans related to a task requiring a decision. *Science*, 1964, 145, 182-183.
- Harter, M. R., & White, C. T. Perceived number and evoked cortical potentials. *Science*, 1967, 156, 406-408.
- John, E. R., Ruchkin, D. S., & Villegas, J. Experimental background: Signal analysis and behavioral correlates of evoked potential configuration in cats. *Annals of the New York Academy of Science*, 1964, 112, 362-420.
- Robinson, D. N. Statistical features of brain responses under conditions of attention and habituation. *Psychological Reports*, 1973, 32, 287-292.
- Robinson, D. N., & Strandburg, R. Differences in inter-hemispheric variance in brain responses of attentive and inattentive human subjects. *Perceptual and Motor Skills*, 1973, 36, 1099-1102.
- Sutton, S., Tueting, P., Zubin, J., & John, E. R. Effects of visual form on the evoked response. *Science*, 1967, 155, 1439-1442.

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