# Listening for Phonemes while Reading

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## 1. Introduction

Investigations of the psychological processing of two or more concurrent linguistic signals have provided extensive evidence for general limits in central processing capacity (e.g.,Martin, 1978, 1980). A finding reported by Martin (1977), however, cannot be accounted for in this way. The auditory detection of phonemic targets (stop consonants) was assessed with or without concurrent reading and compared with that of syntactic targets (adjectives) and semantic targets (temporal reference words). It was found that relative to single-task performance (which was equated in the three conditions), dual-task performance was impaired to an approximately equal extent in syntactic and semantic conditions, and that the impairment was considerably greater in the phonemic condition.

Martin (1977) was able to discard a possible explanation of the phoneme-specific impairment in terms of the distinction between data-limited and resource-limited performance (Norman and Bobrow, 1975). If the three conditions differed in which of these two types of constraint were operative, then rate of presentation of stimuli should have exerted a differential effect. In practice however it did not. Thus an alternative explanation for the finding appears necessary.

The hypothesis to be examined here is the specific attentional impairment arising with stop consonants as a consequence of their very brief duration. It may be the case that in order to detect and discriminate stop consonants, subjects are forced to process in much shorter decision units, using a fine-timing mechanism. If this fine-timing mechanism were also involved in the control or allocation of attention when two tasks are carried out concurrently, it would account for the observed results.

In order to test this hypothesis a new experiment is reported in which detection of stop consonants is compared with that of several other phonemic targets. This allows comparison of (a) stop consonant detection with longer consonant detection, (b) short vowel detection with longer vowel detection, and (c) stop consonant detection with another short consonant detection. The stop consonant, other short consonant and short vowel used were /t/, /n/, and /ɪ/ while the long consonant and vowel were /s/ and /aʊ/. The durations in the short group, as in the long group, were approximately

equal (Umeda, 1975; 1977). Thus the fine-timing hypothesis predicts significant effects within comparison (a) and (b), but not within comparison (c).

## 2. Method

### *Subjects*

The participants were 20 right-handed males from the Oxford Subject Panel aged between 18 and 35 years.

### *Material*

For the auditory monitoring task fifteen lists of 224 each were prepared. There were three lists for each of the five target phonemes /t/, /n/, /s/, /ɪ/, and /aʊ/. Each list contained examples of only one phoneme target type. There were twenty target words in each list embedded in 204 distractors which did not contain the target phoneme. Target words were arranged throughout the list, separated by an average of ten and a minimum of seven distractors, with on average the first five words and last nine words of each list also distractors. Target and distractor words were all polysyllabic. Target phonemes occurred once only in each target word, in any position excluding initial and final phoneme. The lists were spoken by a North American, as in the Umeda (1975; 1977) studies on vowel and consonant duration, at a rate of 1 word per second. Each list commenced 2 sec after a warning signal.

For the reading task seven passages of text were taken from the 'Discourse on Method' of Descartes (1968). This allowed the selection of passages that were two printed pages in length but contained no paragraph indentation.

### *Apparatus*

The word lists were presented via headphones from a tape recorder. A response key was connected to a pure tone oscillator whose signal was fed through a mixer with that of the tape recorder into one channel of a second tape recorder. On the second channel of this tape recorder the subject's voice while reading was recorded.

### *Procedure*

Each participant was tested individually. The experiment proper was preceded by practice trials on each of the types of detection tasks in isolation, on reading in isolation, and on both those concurrently. The order of occurrence of the different conditions in the experiment was balanced over subjects using balanced predecessor Latin squares.



## 3. Results

Analysis of variance showed that the speeds of reading in isolation and in the five target conditions differed significantly, $F(5,95) = 37.13$, $p < .001$, with mean speeds in isolation and with target detection of 223.4 and 158.0 words/minute, respectively. Duncan's multiple range test showed that while detecting consonants the reading rate (in words/minute) was slower for /t/ and /n/ (156.2 and 153.6, respectively) than for /s/ (172.3), and that while detecting vowels the rate was slower for /ɪ/ (145.9), than for /aʊ/ (162.1), $p < .05$ in each case.

Mean target detection rates in isolation and while reading differed significantly at 84.6%, and 65.8%, respectively, $F(1,19) = 63.94$, $p < .001$. However, there was no significant interaction between this factor and the five types of detection, $F(4,76) = .52$, with dual-task detection at 79.5%, 80.2%, 79.6%, 74.8% and 74.2% of performance in isolation for /t/, /n/, /s/, /ɪ/, and /aʊ/, respectively.

## 4. Discussion

The results of this experiment provided evidence that the detection of a stop consonant is more injurious to dual-task performance than that of a longer fricative, while its effects do not differ significantly from those of another short, nasal consonant. Similarly, a short vowel is more injurious than a long one. The investigation of phoneme perception within a dual-task setting has thus been shown to provide significant evidence concerning the temporal characteristics of the human information-processing system, and in particular suggests that specific demands upon a posited fine timing mechanism may be placed both by phoneme detection and by the co-ordination of dual-task performance.

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