Rhodophyceae[7] which has certain similarities of pigmentation. It appears to resemble most closely the mitosis of *Prymnesium* (Haptophyceae)[14] and to have some similarities with that of *Ochromonas* (Chrysophyceae)[4]. In the endosymbiotic scheme for the origin of plastids and phylogeny of algae proposed by Lee[15], the Cryptophyceae were thought to be ancestral and closely related to the Cyanophyceae. Our findings show no evidence, however, for a primitive condition in nuclear or mitotic structure. It would seem possible that the mitotic process may give quite a different phylogenetic picture from that obtained with chloroplast structure and pigmentation.

B. R. O. thanks the Marshall Aid Commemoration Commission for financial support.

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Received May 1, 1973.

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Linguistic Structure and Speech Shadowing at Very Short Latencies

SPEECH shadowing is an experimental task in which the subject is required to repeat (shadow) speech as he hears it. When the shadower is presented with a sentence, he will start to repeat it before he has heard all of it. The response latency to each word of a sentence can therefore be measured.

The response latencies reported[1,2] for the accurate shadowing of continuous prose typically range between 500 and 1,500 ms. These latencies may be compared with those obtained in reaction-time (RT) experiments in which the subject repeats isolated words or nonsense syllables. In such studies[3–7], the RT's are of the order of 150 to 250 ms. This difference in RT's may seem to reflect differences in complexity between sentences and lists of isolated items for, according to modern psycholinguistic theory, higher order linguistic structure plays an essential role in the process of speech perception. Such higher order structure (syntactic and semantic) is defined over units of analysis at least as large as a phrase. Thus, to use this information, the shadower would not be able to respond until he had heard at least a phrase, and should therefore have longer repetition latencies to prose material than to unstructured lists.

This report establishes that it is possible, however, to shadow continuous prose accurately at latencies as short as those found for isolated items, and examines the question of such shadowers' use of higher order linguistic structure.

Sixty-five subjects were screened in a search for individuals who could shadow closely while still repeating the material clearly. Seven of these proved capable of shadowing at mean delays of 350 ms or less while still maintaining the intelligibility of their speech. All the other subjects were only able to shadow clearly at rather longer latencies (500–800 ms).

The seven close shadowers, together with seven of the more distant shadowers, then shadowed a pair of 300-word passages of normal prose read at a normal conversational speaking rate (160 w.p.m.)[8]. The passages were presented binaurally through headphones. The subjects' production was recorded onto one track of a tape-recorder, while the material they were hearing was simultaneously recorded on a second track. For each passage, the repetition latency was measured from a polygraph tracing of the two records, always at the beginning of an easily identifiable word. The seventy-five measurement points were distributed equally over the passage at different serial positions within sentences, and were the same for all subjects.

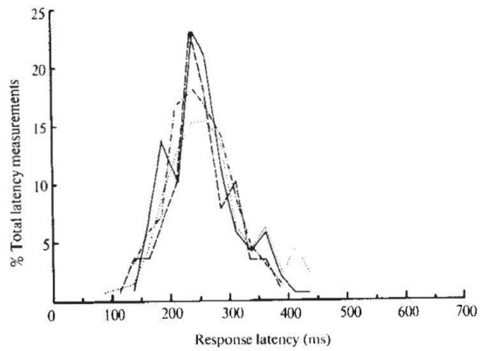

Fig. 1 The distribution of latencies for four very close shadowers.

Of the seven close shadowers, the response latencies of the four closest are plotted in Fig. 1. The mean latencies of these four shadowers ranged between 254 and 287 ms, with standard deviations of between 54 and 85 ms. Their error rates ranged from 1.7 to 6.6%.

In comparison, the responses of two of the less close shadowers and of two of the distant shadowers are plotted in Fig. 2. These curves are typical of those found for subjects not shadowing consistently at very short latencies. The mean latencies for these subjects were 305, 362, 559 and 600 ms respectively. The standard deviations ranged between 85 and 129 ms, with error rates of 0.5 to 5.8%.

The mean syllable duration for material read at a rate of 158 w.p.m. is 200 ms (ref. 9). Thus, to shadow at a distance of 250 ms is to remain little more than a syllable behind the original material. We know that it is possible to repeat isolated syllables with similar or even shorter delays. This suggests that the closest shadowers are processing the incoming material at the level of individual syllables. Such a mode of speech analysis needs to be reconciled with the recent psycholinguistic emphasis on the importance of syntactic and semantic structure in speech perception.

If the close shadower is not using syntactic and/or semantic structure, then he should not have available to him information that could only derive from these levels of analysis. One way of testing this is to question the subject about the content of a passage he has shadowed. Thirteen of the fourteen subjects were given a further passage to shadow, 600 words long and again presented at 160 w.p.m. They were not told in advance that they would be given a memory test. Immediately following the passage, they were asked a series of questions about it. The results showed very little relation between latency and memory for content. There was a small, nonsignificant, negative correlation ($r=0.18$) between increasing latency and memory score. No difference was found between the scores of the shadowers and a control group of listeners.

The results of the memory test show that syntactic/semantic information is available to the shadower irrespective of his shadowing latency, but this does not exclude the possibility that the shadower performs the higher level analysis of the material after he shadows it. The close shadowers could produce their output on the basis of a low level analysis and perform the rest of the analysis later. Such a procedure should be reflected in the subjects' errors.

If the shadower's performance is based, for example, on a syllabic analysis of the material, then his errors should be constrained by the syllabic character of the material, but not by its semantic or syntactic character. Furthermore, if the relative distance of an individual's shadowing performance is a function of the "depth" to which he analyses the material, then there should be latency-dependent differences in the types of errors which the subjects make.

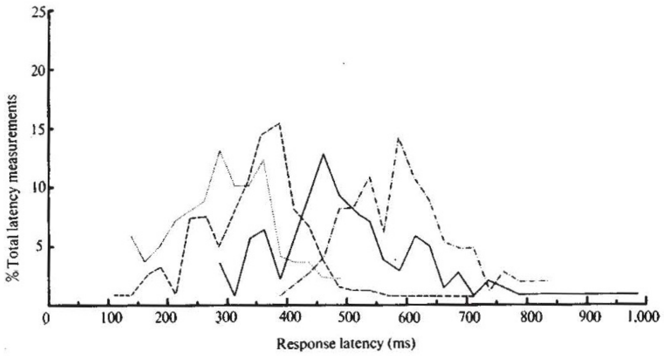

Fig. 2 The distribution of latencies for four subjects shadowing at distances greater than 300 msec.

The errors made on the two passages of normal prose were therefore analysed. Of the total of 402 errors made by the fourteen subjects, 221 were delivery errors (slurring, hesitations, etc.), 49 were omission errors, and 132 were constructive errors in which subjects either added or changed entire words, or changed part of a word so as to make it into a different word. Twenty-one of the latter resulted in syntactically/semantically unanalysable nonsense words.

The remaining 111 constructive errors were analysed according to their grammatical suitability with respect to the preceding context. Of these, only three were structurally inappropriate. All the other errors were both semantically and syntactically congruent with the preceding context. A regression analysis showed there to be no systematic relationship between shadowing latency and grammaticality of errors. Although the closer subjects tended to make more errors overall ($t=2.403$(d.f.$=13$), $P<0.025$), this difference derived more from the delivery errors ($t=2.308$(d.f.$=13$), $P<0.025$) than from the constructure errors ($t=1.411$(d.f.$=13$), $P<0.10$). Indeed, if each subject's total grammatical errors are expressed as a proportion of his total errors, then one finds no latency-dependent differences at all ($t=0.248$(d.f.$=13$), $P<0.50$). These results are not consistent with the idea that higher order structure is not available at very short latencies.

The constructive errors of close and distant shadowers are also qualitatively very similar, and indeed the same errors were sometimes made by subjects in both groups. For example, in the sentence "It was beginning to be light enough so I could see . . .", two subjects inserted the deleted "that" following "so": one shadowing at 254 ms, the other at 559 ms. In the sentence beginning "He had heard at the brigade . . .", five subjects replaced "heard at" with "heard that": their latencies were 264, 287, 362, 444, and 553 ms. Nor do these errors occur only when the subject's shadowing delay is longer than usual. These errors, especially in the case of the closest shadowers, usually occur when the subjects' latencies are shorter than average, as if they are placing more reliance on the predictive properties of the higher order context.

These examples, and the errors in general, also show that the subjects' output can be constrained by the preceding context up to and including the word immediately before the error. The error "that" in the first example is clearly contingent on knowing that the preceding word is "so". Similarly, in the second example, the subjects would need to have extracted the structural implications of "heard" to make the grammatically appropriate error of saying "that" instead of "at".

There seems to be no difference between close and distant shadowers in their use of the semantic and syntactic information available. The data suggest that all the subjects analyse the material up to a semantic level as they repeat it, and that this analysis helps to determine the ongoing series of perceptual decisions underlying their shadowing performance. The significance, therefore, of very close shadowing is not that it indicates some anomalous minimal mode of speech processing, but that it seems congruent with what we know of normal speech perceptual processes. The present results, in these terms, pose problems for any theory of speech perception which requires that the assignment of higher order structural descriptions await the end of a major constituent.

I thank Drs M. Garrett, J. A. Fodor, M. C. Potter and H.-L. Teuber for their help and encouragement, and J. Klayman for assisting in the error analysis. This research was supported by grants from the Alfred P. Sloan Foundation and from the NIMH.

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Received March 9; revised April 29, 1973.

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Axenic Culture of a Plant Pathogenic Spiroplasma

EVIDENCE has accumulated that a number of insect-transmitted plant diseases of the "yellows" group result from the infection of plants by organisms resembling mycoplasmas[1,2]. Circumstantial evidence suggests that two such diseases, corn stunt and citrus stubborn, may be caused by a novel type of helical prokaryotic microorganism lacking a cell wall, for which the trivial name "spiroplasma" has been proposed[3]. The agent of corn stunt has so far defied attempts at culture in a cell-free medium and although an organism associated with citrus stubborn disease has been successfully cultured from diseased