nary experiments also indicate that nuclei may be isolated by the same procedure from the young endosperm of corn and from the storage parenchyma of watermelon fruits. Further aspects of these problems will be published later.

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Manuscript received October 11, 1951.

Delayed Speech Feedback as a Test for Auditory Malingering

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Investigators in the fields of speech pathology and communication have recently become interested in the effects of delayed feedback or side-tone delay on speech. Lee has noted that

> in order to produce delayed speech feedback, it is necessary to return the speaker's speech to his own ears approximately one-quarter second after he has spoken. This is best accomplished by means of a magnetic tape recording and reproducing machine which has independent circuits and magnets. A pair of earphones should be used to experience the effect prominently since they deliver delayed speech and exclude the normal air-borne undelayed sound which provides the normal monitoring signal (*1*).

Changes that occur in the speech pattern as a result of delayed feedback have been mentioned by some investigators as being an alteration of the normal melody pattern, slowing of the rate, an increase in loudness, a shift in pitch level, and a disintegration of rhythm. In particular, the effect of delayed side-tone upon vocal rate, intensity, and rhythm has been investigated by Lee (*1–3*) and by Black (*4*). Lee states that the phenomenon is critical with regard to time of delay and volume of the feedback. He mentions that a one-quarter second delay is necessary for the effect to be prominent and that "the volume of the delayed feedback must be sufficiently high to dominate the sound of the subject's voice which he hears through bone conduction."

Black found that even the smallest delay produced a significantly reduced oral reading rate. He noted that rate decreased with increasing time of delay from 0 to .18 sec but that beyond this point, up to a .35-sec delay, the reading rate tended to increase—not returning to normal level, however.

It was the purpose of the present investigators to check Lee's assumption that the effect is critical with respect to the volume of the feedback and at the same time to investigate the possibilities of using the results in constructing a test for the detection of bilateral auditory malingering and/or psychogenic deafness.

In the present investigation a Presto RC-1024 tape recorder was used at a tape speed of 15 in./sec, which provided for a side-tone delay of approximately .14 sec. The output of the tape recorder was led through an appropriate attenuation network to PDR-8 headphones in a sound-isolated room. A volume unit meter enabled the operator to maintain a relatively constant input to the listener's ear. Thirty speech pathology students, with a reasonable degree of sophistication in speech and hearing problems, were chosen as subjects and were divided at random into three groups. Ten listeners received feedback at approximately 35 db above a speech threshold, 10 at 55 db, and 10 at 75 db. Audiometric evaluation of all of these students had revealed that they possessed hearing acuity for pure tones within a normal range.

Speech materials to be read consisted of a 100-word passage taken from *Robinson Crusoe* and modified for ease of reading. Subjects were allowed 5 min to acquaint themselves with the passage before entering the test situation.

The procedure employed was to ask each speaker-listener to read the passage three times. For the first reading the only instruction given was to read the passage in a normal manner. For this condition, although headphones were used and speech was recorded and timed by means of a stop watch, no feedback was employed.

For the second reading the subject was instructed to read the passage as nearly as possible like the first reading. At this time the problem of malingering was explained to him and, although he was not informed of the precise nature of the present test, he was told that he should attempt to keep from being influenced by anything he should hear, since he was to feign deafness. He was told that a deaf person would not respond to any sounds coming from the phones and would therefore read the passage the second time in the same way he had the first time. He was further told that he was to try to "beat the test" by not allowing any difference between the readings. Again this reading was recorded and timed, as well as being fed back at one of the predetermined intensity levels.

For the third reading the subject was given similar instructions but, as in the case of the first reading, no feedback was used. The third reading was employed as a measure of reliability or, in this case, constancy of reading rate. It was hypothesized that, in consequence of increasing familiarity with the material, each successive reading would take less time if the experimental condition had not been imposed; therefore any retardation of rate in the second or experimental reading would be a conservative estimate of the effects of the delayed side-tone as measured by reading time.

1. In order to determine the reliability of duration of repeated readings, t tests were applied to evaluate the significance of the differences between readings 1 and 3. For all three groups these were nonsignificant. The standard error of the mean differences ranged from .15 sec to .41 sec for the three groups, with an average reading time of approximately 27 sec.
2. As readings 1 and 3 are not significantly differ-

ent, it is meaningful to test the significance of the differences between reading 1 or 3 and the feedback reading 2. For all three intensity conditions t values proved to be significant at the 1% level of confidence or beyond. Therefore we are free to reject the hypothesis that reading 1 and reading 2 are the same. It would seem likely, therefore, that the delayed side-tone produces a significantly retarded reading rate for all three intensity conditions. It is well to note that in no case, despite the instructions, did a subject read the delayed reading at a more rapid rate.

3. It is of interest to note that the magnitude of the differences between readings 1 and 2 increases with increases in intensity of the feedback over the ranges studied (35, 55, and 75 db). The mean difference between readings 1 and 2 for the 75-db intensity was 11.3 sec, for 55 db intensity 7.6 sec, and for 35 db intensity 2.7 sec. To determine whether these mean differences were different, an F test was applied. This revealed that the null hypothesis could be rejected at the .1% level of confidence.

It appears probable that reading rate is a positive function of the intensity of the delayed side-tone.

The important finding of this study would seem to be that, despite all efforts of the sophisticated subjects to overcome the effect of delayed speech, even at intensity levels which were reported by listeners as not distracting, differences exceeding normal variation in rate were found for our sample.

Shortly after completion of this study a case of possible psychogenic deafness was presented to the authors for evaluation by the technique described. This was the case of an 11-year-old girl reporting to the Department of Otolaryngology at the State University of Iowa Hospitals complaining of severe hearing loss. Initial audiometric studies revealed losses for pure tones of between 75 and 85 db bilaterally. Her response to speech appeared inconsistent with these findings. This fact, coupled with a case history revealing emotional trauma, led the examining physician and psychologist to suspect a possible psychogenic etiology for the apparent hearing loss. So as not to reveal the actual purpose of the test, the girl was told that she would read from a picture story-book and make a record so that hospital personnel could determine what effect, if any, her hearing loss had on her speech. After establishing a normal reading pattern, the following technique was employed. Having no accurate knowledge of the loss for speech, we used an intensity of about 50-db feedback for a first reading. The abrupt and radical change in the speech pattern was so marked that no close measure was necessary to realize that the patient was responding to the feedback. From this point on the intensity level was reduced to a loudness level within the normal range of hearing acuity. It was found finally that this girl had, as far as this test was concerned, normal hearing for speech.

In view of these findings and the technique employed, it would appear that the use of the delayed side-tone or the feedback speech phenomena is feasible in the detection of malingering, and/or psychogenic deafness.[1]

References

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Manuscript received August 13, 1951.

[1] The authors would like to point out that during the early discussion of this technique as a test for auditory malingering, it was discovered that other investigators, including E. G. Witting, of the Signal Corps Engineering Laboratories, cited by Lee (*1*), and S. R. Silverman, of Central Institute for the Deaf, St. Louis, had also proposed a similar notion in the course of informal conversations reported to the present writers by Scott N. Reger.

Cis-trans Isomers of Vitamin A and Retinene in Vision

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We have recently described the synthesis of rhodopsin *in vitro* in a system of four components: vitamin A,[2] the precursor of the rhodopsin chromophore; opsin, the protein moiety of rhodopsin; and liver alcohol dehydrogenase and cozymase, the enzyme and coenzyme that oxidize vitamin A to retinene (*2, 3*). The vitamin A in our original experiments was a concentrate from fish liver oils. When this was replaced with an equivalent amount of crystalline vitamin A, the system no longer synthesized rhodopsin.

It seemed at once that this difference in behavior must have the following significance: Vitamin A, like other carotenoids, exists in a number of stereoisomeric forms, depending upon whether the groups adjacent to its double bonds are in cis- or trans- arrangement (*4, 5*). For steric reasons, only four different isomers are likely to occur in appreciable quantities (*6, 7*). Their structures are shown in Fig. 1.

The usual preparations of crystalline vitamin A probably represent the most stable, di-trans isomer. A second isomer, called neovitamin A, was crystallized by Robeson and Baxter (*5*); it probably is the Δ_5-cis form. A third modification, synthesized by Graham, van Dorp, and Arens (*8*), is probably the Δ_3-cis isomer. The di-cis isomer has not yet been identified with certainty. Fish liver oils contain mixtures of

[1] This research was supported in part by a grant from the Medical Sciences Division of the Office of Naval Research. Portions of the data were presented at the spring meeting of the Society of Biological Chemists in Cleveland in 1951 (*1*), and at the Symposium on Vitamins and Trace Elements held in honor of E. V. McCollum at The Johns Hopkins University Sept. 10–11, 1951. A detailed account of this investigation will be published in the *Journal of General Physiology*.

[2] Throughout this paper the terms vitamin A and retinene refer to vitamin A_1 and retinene$_1$. There is every reason to suppose that a similar situation involves vitamin A_2 and retinene$_2$ in the porphyropsin system, but this has not yet been explored.