brane. It follows all peripheral nerves (including the autonomic nerves) to their termination, being reflected over the various ganglia on the way to produce their capsules. At the termination of the nerve fibers it forms or completely surrounds the end organs, thus ensuring that the peripheral nervous system is completely enclosed in the equivalent of a blood brain barrier. The pia-arachnoid covering (perineural epithelium) of the optic nerve extends into the eye as the choroid, which, with the endothelial cell layer underlying the cornea, encloses the components of the eye in a cellular membrane, just as the other end organs are enclosed. The perineural epithelium appears to have important functions in the regeneration, physiology, and pathology of peripheral nerves.

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Feedback of Speech Muscle Activity during Silent Reading: Rapid Extinction

Abstract. *Surface electromyograms of the laryngeal muscles were made while subjects read silently. Those who showed an increase in electrical activity over that at relaxation were provided with auditory feedback of the muscle activity. This treatment resulted in immediate and long-lasting cessation of the subvocalization. This method should prove valuable in treating some reading problems.*

The phenomenon of subvocal speech has been of great interest to educators concerned with the teaching of reading. It has, however, received little systematic study, with the exception of the work by Sokolov and by Edfeldt (*1*). Subvocalization is considered one of the most difficult problems to overcome in increasing reading speed. An individual who subvocalizes to any great extent is limited to a top reading speed of approximately 150 words per minute—a maximum attainable while reading aloud. We use the term subvocalization to include a wide range of activity, from inaudible articulations and vocalizations to audible whispering while reading. If subvocal activity includes movements of the lips and jaw, some corrective measures are possible. However, if the activity is limited to the vocal musculature, eliminating the response becomes more complex, especially since individuals are often not aware they are subvocalizing.

The initial study of subvocalization required the examination of several subjects with strong subvocalization patterns to determine whether subvocalization during silent reading could be detected by surface electromyograms recorded from the throat. A successful technique was developed with mesh electrodes placed over the thyroid cartilage. An ink-writing oscillograph was used to record the electromyogram (EMG). At maximum sensitivity of the oscillograph unit, the electrical activity of the vocal muscles can be detected while the subject is reading (if subvocalization is present), in contrast to a minimum signal (approximately 3 μv) obtained when the subject is relaxed, and to an extremely strong signal (approximately 1 mv) obtained when the subject speaks during normal conversation. To determine the presence or absence of subvocalization, the subject first selects reading material which he reads for 30 minutes, and during this time an oscillograph record of the EMG is obtained.

The presence of subvocalization is determined by asking the subject to stop reading, then to begin reading, and then to stop reading. Each time, the changes in the EMG record are noted. The presence of subvocalization can be detected quite reliably, there being a large increase in action potentials when

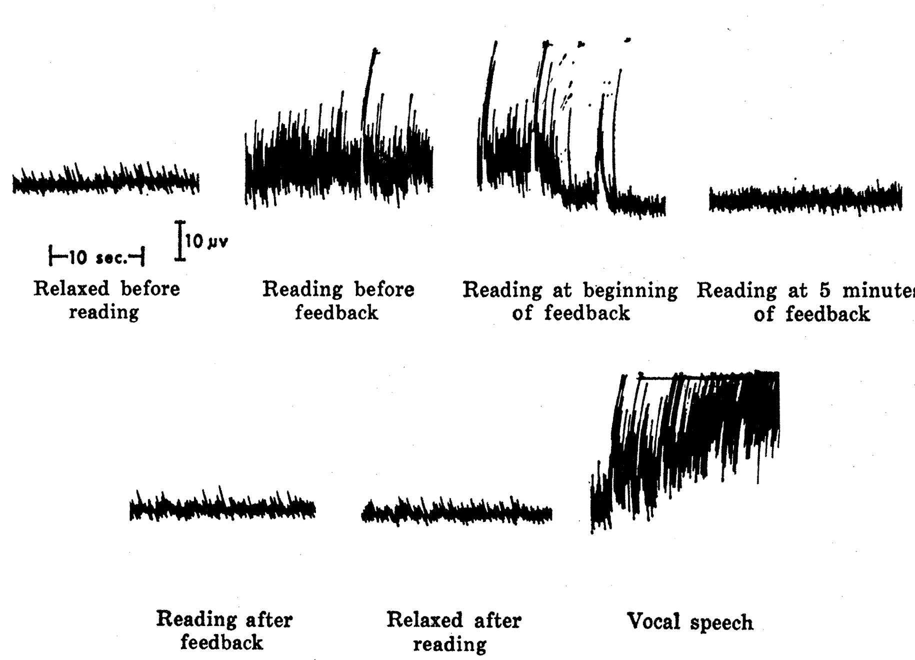

Fig. 1. Electromyograms recorded from the laryngeal muscles. This record is typical of those obtained from the 17 subjects who received feedback treatment.

reading begins and an immediate cessation of this activity when reading stops.

Treatment of subvocalization is done in the following manner. The subject is asked if he is aware that he subvocalizes or reads aloud to himself. A brief discussion is held with the subject, informing him of his response tendencies while reading. The feedback technique is then introduced. The subject is told that he will be able to hear the activity of his vocal muscles as he reads, and that this will help him to eliminate the problem. The manner in which signals emanating from the vocal muscles are detected is explained to him. The subject is then given earphones to wear, and is asked to remain relaxed. Feedback is introduced by channeling the output of the oscillograph amplifier to an audio-amplifier, and then to earphones. When the subject is relaxed, the audio-circuit is opened and the subject is asked to swallow. The swallow results in an immediate burst of static in the earphones. The subject is then requested to experiment with the sound to satisfy himself that he can control it (stop it and start it) by such actions as talking, swallowing, turning his head, clenching his jaw muscles, and so forth. The subject is allowed to continue experimenting with the feedback, and with its control, until he states that is is able to control its presence or absence. The subject then begins reading while attempting to keep the EMG feedback to a minimum, that is, to maintain silence in the earphones.

A total of 50 college students from a reading improvement class were tested; it was found that 17 subvocalized. All subjects who subvocalized were treated in the manner described above. Originally, it was planned to administer the feedback treatment over several sessions to determine the number of feedback treatments necessary to establish normal reading patterns. This was found to be unnecessary. The feedback treatment was remarkably effective (Fig. 1). In all cases one session of the feedback was sufficient to produce complete cessation of subvocalization.

Most of the subjects showed a reduction of speech muscle activity to resting levels within a 5-minute period. At the end of the 30-minute experimental session in which feedback was given, all subjects were able to read with speech muscle activity at the same level as during relaxation. The level of speech muscle activity was monitored at the end of 1 month, and again after 3 months. During these tests, the subject read for 30 minutes; no feedback was used. None of the subjects gave any evidence of subvocalization in either of these tests.

In many ways, this is a surprising phenomenon. One does not expect the extinction of a habit—especially a habit which presumably had existed during the entire time the subject had been reading—to occur so quickly and easily. However, if the overlearned response of subvocalization is placed in conflict with a second, even more strongly overlearned response, extinction should be quite rapid. Such a second response is the ability to make a fine motor adjustment of the speech musculature on the basis of auditory cues. Exactly this response is involved under conditions of feedback of laryngeal EMG activity. The subject is required to make fine motor adjustments on the basis of auditory cues. Attempts to reduce the speech muscle activity by instructions alone were not successful. The subjects were not aware of their subvocal activity even when told they were subvocalizing, and were unable to reduce it without the feedback.

This ability to make fine motor adjustments of restricted muscle groups has been reported by Basmajian (*2*) who found that subjects can control the contractions of single motor units on the basis of auditory and visual cues. His subjects also achieved stable control of the muscles within 15 to 30 minutes. He reports, however, that the aural feedback in all subjects is more useful than visual display on a cathode ray tube monitor; the visual display served a subsidiary purpose (*2*).

The motor-auditory feedback loop as a cue produced by response might well be of considerable importance. Such phenomena as the marked disruption of speech under conditions of delayed auditory feedback provide ample evidence for the importance of this cue to normal speech. Consequently, the evocation of this overlearned response-produced cue may result in the rapid extinction of subvocalization under the conditions of auditory feedback.

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Monkeys Reared in Isolation with Pictures as Visual Input: Evidence for an Innate Releasing Mechanism

Abstract. *Monkeys reared in isolation from birth to 9 months received varied visual input solely from colored slides of monkeys in various activities and from nonmonkey pictures. Exploration, play, vocalization, and disturbance occurred most frequently with pictures of monkeys threatening and pictures of infants. From 2.5 to 4 months threat pictures yielded a high frequency of disturbance. Lever-touching to turn threat pictures on was very low during this period. Pictures of infants and of threat thus appear to have prepotent general activating properties, while pictures of threat appear to release a developmentally determined, inborn fear response.*

Research on a wide variety of animals has shown that early experiences can be important determinants of later social and nonsocial behavior (*1*). Some of these experiences apparently must occur during a limited developmental period if the animal is to exhibit behavior patterns normal for its species. One important, but relatively neglected, area of study in primate behavior involves determination of the developmental importance of different types of sensory input early in life. The experiment reported here is part of a study examining the effects of visual social and nonsocial stimulation presented to monkeys otherwise reared in total social isolation. The present study asks if totally naive infant monkeys will show differential behaviors toward specific types of visual stimulation, and whether such differential behaviors mature at specific periods during the monkey's development.

Four male and four female rhesus monkeys (*Macaca mulatta*) were reared