Laryngeal Activity Accompanying the Moment of Stuttering: A Preliminary Report of EMG Investigations*

Frances J. Freeman + and Tatsujiro Ushijima ++
Haskins Laboratories, New Haven, Conn.

Throughout the history of man's interest in stuttering, certain conditions or circumstances have been found to produce immediate and marked improvement in the stutterer's fluency. As surveyed and reported by Bloodstein in 1950, such conditions include: (1) speaking to an imposed rhythm, (2) singing, (3) choral speaking and shadowing, (4) whispering, (5) shouting, (6) imitation of another speaker or dialect, and (7) speaking under conditions of diminished auditory sensitivity. Wingate (1969, 1970) has advanced the hypothesis that the conditions that effect a notable reduction in stuttering have a common feature—they all reflect some change in the mode or manner of vocalizing. According to Wingate, in these circumstances which improve fluency, "the stutterer does something with his voice that he does not ordinarily do."

Adams and Reis (1971) tested the relationship between phonation and dysfluency with an experiment using two 100-word prose passages. One passage was composed entirely of voiced sounds, while the other contained both voiced and voiceless segments. Stutterers had significantly fewer blocks in reading the all-voiced passage. More stuttering occurred when they had to make voiced-voiceless adjustments. The experiment has since been replicated with essentially the same results (Adams and Reis, in press).

Brenner, Perkins, and Soderberg (1972) looked at the effects of four rehearsal conditions on stuttering. They compared silent rehearsals without lip movement, silent rehearsals with lip movement, whispered rehearsals, and speaking aloud rehearsals. Only the rehearsal condition of speaking aloud resulted in significantly less stuttering. The authors concluded that stutterers have difficulty coordinating phonatory movements with articulatory movements.

These studies implicate the phonatory mechanism in stuttering by demonstrating changes in overt stuttering behavior—changes that result from manipulation of variables related to phonation.


Also City University of New York.

++ Also University of Tokyo, Japan.

Using techniques of direct and indirect observations, three studies have reported positive findings of laryngeal involvement in the moment of stuttering. Chevre-Muller (1963) used a glottalgraphic technique with 27 stuttersers; Fujita (1966) did a cine-laryngographic study of a Japanese stutterer; and Ushijima, Kamiyama, Hirose, and Niimi (1969) used the fiberscope to film laryngeal activity in stuttering.

The present electromyographic study attempts to move one step further into the speech production system to investigate the "motor commands" that result in the abnormal movement patterns observed by these researchers.

The experimental procedures are those developed at Haskins Laboratories and reported previously (Hirose, 1971; Port, 1971; Gay, Strome, Hirose, and Sawashima, 1972; Hirose and Gay, 1972, 1973; Keyley-Port, 1973, 1974). This preliminary paper reports data obtained on only one stuttering subject. Simultaneous recordings were obtained from four intrinsic laryngeal muscles (the posterior cricoarytenoid, the lateral cricoarytenoid, the vocalis, and the cricothyroid); three lingual muscles (the inferior longitudinal, the superior longitudinal, and the genioglossus); and one labial muscle (the orbicularis oris).

Comparisons were made of the stuttering subject's fluent and stuttered utterances of the same words. Similar comparisons were made of a normal speaking subject's fluent and "faked" stuttered utterances. Results indicate that fluent utterance is characterized by precise balance and timing of laryngeal abductor and adductor forces.

Figure 1 illustrates the normal pattern of adductor-abductor forces. In this pattern, increases in adductor activity accompany decreases in adductor activity, and conversely, when adductive activity increases abductor activity decreases. Activity patterns are shown here for three intrinsic laryngeal muscles—the posterior cricoarytenoid, the vocalis, and the lateral cricoarytenoid. The top tracing is for the abductor and the two lower are for adductors. On the left is an averaged number of tokens of the utterance glottal stop /a/, while on the right is a single token record for a swallow. All of the stuttered data represent single tokens.

Note that the lateral cricoarytenoid, an adductor with the specific function of applying medial compression, shows a high level of activity for the tight closure of the glottal stop and for the first portion of the swallow. As an adductor, the vocalis participates in the glottal stop and swallow closures, and like the lateral cricoarytenoid, is active for the vowel segment. The posterior cricoarytenoid (PCA) is suppressed during the closure periods of the glottal stop and the swallow and also during the vowel segment. A brief, very slight increase in PCA activity occurs just after the glottal stop, and a strong burst of PCA activity follows the closure in the swallow. The abductor-adductor reciprocity is readily apparent.

The abductor-adductor reciprocity, so characteristic of fluent utterance, is disrupted in stuttered utterance. The most common pattern occurring during moments of stuttering is simultaneous, presumably antagonistic, abductor-adductor activity.

In Figure 2 the stuttered utterance of the word "llllllless" is contrasted with the fluent utterance "less." The upper channel traces the abductor activity
Figure 1
of the PCA, while the second channel shows the adductor activity of the vocalis. The third channel is the superior longitudinal. Activity in this muscle correlates with raising and retraction of the tongue tip. Here activity in the superior longitudinal, presumably for raising the tongue tip for /l/, occurs 2300 msec before the word is uttered. This activity occurs 660 msec before any acoustic signal is detected. During this "silent" period, PCA abductive activity gradually builds, as does activity in the vocalis. At this point (-1600 msec) a higher level of vocalis activity corresponds to the onset of the prolonged utterance of the /l/. The segment is sustained for 1420 msec, a period characterized by high levels of simultaneous adductor-abductor activity. One-hundred-sixty msec before the lineup point, two things occur: there is a sharp drop in PCA activity, and the subject moves through the block. Reciprocity appears reestablished, for the following increase in PCA activity for the voiceless segment /s/ is timed to correspond to a marked suppression of adductor activity. The fluent utterance shown on the right of Figure 2 requires less than 300 msec.

In addition to the disruptions of reciprocity already noted, the stuttered utterances were frequently characterized by high levels of lateral cricoarytenoid activity. In direct contrast, the subject's periods of fluent utterance were found to occur in association with marked suppression of activity in this adductor. Figure 3 illustrates this finding. In this example, the stutterer uttered the word "effect" three times, with progressive adaptation from a severe block to a mild block to a fluent utterance. The degree of lateral cricoarytenoid activity correlates with the degree of dysfluency.

In most cases, higher levels of activity were recorded during stuttering blocks than during fluent utterance. The successful termination of a block was frequently found to coincide with a marked drop in adductor and/or abductor activity.

Figure 4, which shows progressive adaptation in the utterance of the word "ancient," illustrates each of the three findings already discussed:

1) Abductor-adductor reciprocity is disrupted in the two stuttered utterances;

2) Progressively lower levels of lateral cricoarytenoid activity accompany the more fluent utterances; and

3) Somewhat higher levels of activity occur in the strongly stuttered utterance, where a marked drop in activity coincides with the termination of the block.

In fact, inspection of the final portions of the stuttered utterances indicates that successful termination of a block coincides with a pattern of laryngeal muscle activity that approximates the pattern characteristic of fluent utterance of the same word. In other words, the same balance of abductor-adductor forces characteristic of fluent utterance is characteristic of the termination of the block.

REFERENCES

Figure 3
Figure 4

Bloodstein, O. (1950) A rating scale study of conditions under which stuttering is reduced or absent. J. Speech Hearing Dis. 15, 19-36.


