

Action of the Extrinsic Musculature in the Control of Tongue Position:
Preliminary Report

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The position of the tongue in the mouth is controlled, in part, by a group of muscles which connect it to the mandible and the hyoid bone. In addition, since the tongue itself rests on the hyoid, its position is influenced by forces acting on the hyoid. While the possible functions of the muscles can be inferred from their origins and insertions, as described in the usual anatomical texts, the tongue's position in running speech depends crucially on muscle interactions, which must be directly observed.

The purpose of the present study was twofold: first, to supplement existing normative data on speech function and, second, to continue work begun, particularly by MacNeilage and deClerk (1969) and Smith and Hirano (1968), on the difficult problem of understanding positional variants of the phoneme. Some extremely preliminary results will be reported here.

METHOD

Electrodes were inserted into the genioglossus and various infra- and suprahyoid muscles, by the techniques described by Hirose (1971). Two subjects were used; most of the data reported here are from the second run of one subject. The subjects read random lists of the form /əCVC/. The first consonant was /p/, /t/, or /k/; the second consonant was /p/, /t/, or /k/; and the vowel was /i/, /a/, or /u/.

Output data processing is described by Port (1971). For averaging, the utterances were lined up at the end of voicing for the initial unstressed vowel. In the following figures, line-up is indicated by "0" on the abscissa, while onset and termination of voicing for the stressed vowel are indicated by arrows.

RESULTS

Genioglossus

The output of the genioglossus is shown for the syllables /pip/, /pəp/, and /pup/ in Figure 1. As one might expect from traditional descriptions of the function of the muscle, activity is greatest for /i/, less for /u/, and least for /a/. No distinct peaks were associated with any initial or terminal consonants, although there was some modification of the rise and fall contours of the vowel; the peak heights of the vowels were not influenced by initial and terminal consonants. Our results on this point seem to be roughly comparable with those of Smith and Hirano (1968), although it is difficult to be sure without an opportunity to make more detailed comparisons.

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Genioglossus

/pip/
/pap/ ———
/pup/ - - -

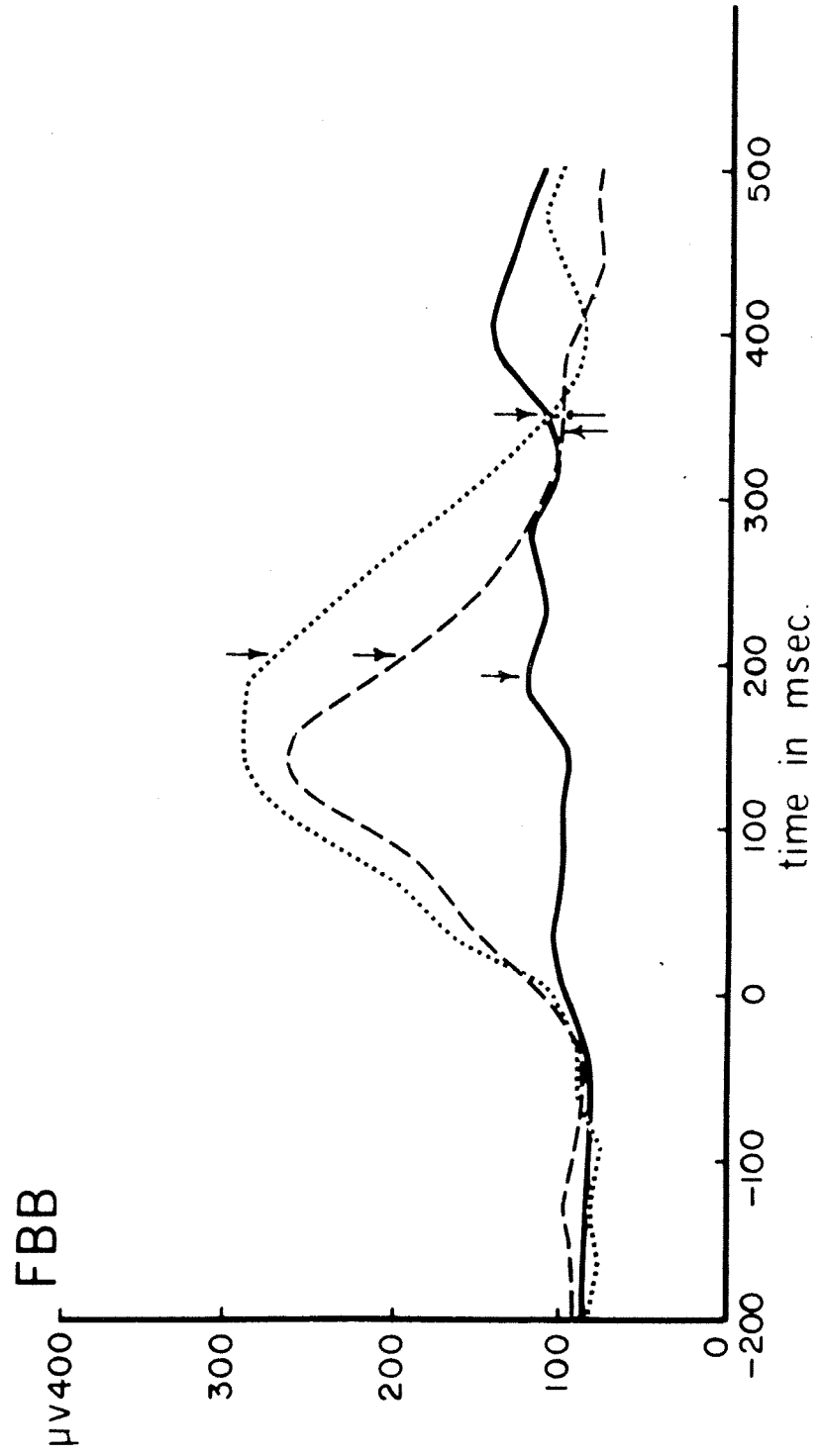


Fig. 1

Anterior Belly of the Digastric

The action of the anterior belly of the digastric is quite clearly to open the jaw. As shown in Figure 2, there is essentially no action for /i/ and /u/ and a large peak for /a/. Peak sizes for the vowel do not seem to be affected by preceding or following consonants. A similar result has been reported by Hirose et al. (1968, 1969).

Strap Muscles

Data from the same three CVC syllables for the sternohyoid, sternothyroid, and thyrohyoid muscles are shown in Figures 3, 4, and 5, respectively. All three appear to be correlated with jaw opening, as is the action of the anterior belly. This result has been previously reported by Ohala and Hirose (1970) and by Gårding et al. (1970). There is some tendency for the peak to be somewhat larger for /i/ than for /u/. However, the data from the thyrohyoid and sternothyroid muscles are most unsatisfactory from the point of view of recording level.

Mylohyoid

The activity of the mylohyoid for the same three utterances is shown in Figure 6. Here /a/ and /u/ show similar patterns, while /i/ is considerably higher. This pattern seems in general agreement with the presumed function of the mylohyoid in raising the floor of the mouth, although the difference between /i/ and /u/ is not explicable on this simple basis. Smith and Hirano (1968) report no activity for any vowel in these environments, which is somewhat puzzling.

The mylohyoid is unlike the other muscles described here in that much more substantial peaks are seen for the consonant [k] than for any vowel and that [t] is also quite large, whether in initial or terminal position. Figure 6 shows an example of this sort. Detailed comparisons of peak sizes can be made by examining Table 1.

As one can see, there are modifications of peak size in the terminal consonant depending on the preceding vowel and modification of the vowel depending on the preceding consonant. In addition, there are modifications of the size of the initial consonant peak depending on the following vowel. Similar, although not identical, results are reported by Smith and Hirano (1968).

COMMENTS

The types of interaction reported here have been previously discussed by MacNeilage (1970), MacNeilage and deClerk (1969), and Smith and Hirano (1968). The modification of the terminal peak by the preceding vowel and the modification of the vowel by the preceding consonant are MacNeilage and deClerk's left-to-right effects and are quite common in EMG studies, as they point out. They do not, however, necessarily represent a modification of target position in movement terms but may merely reflect the fact that muscle contractions will be larger if more movement of the articulators is required. Even if, for example, an X-ray study of the tongue showed the same position for [i] after [k] as after [p], we would expect to find left-to-right effects at the EMG level.

The modification in size of the initial [k] and [t] peaks is a right-to-left effect, sometimes described as anticipatory coarticulation. Anticipatory

Anterior belly

/əpip/
/əpap/ ----
/əpup/ ——

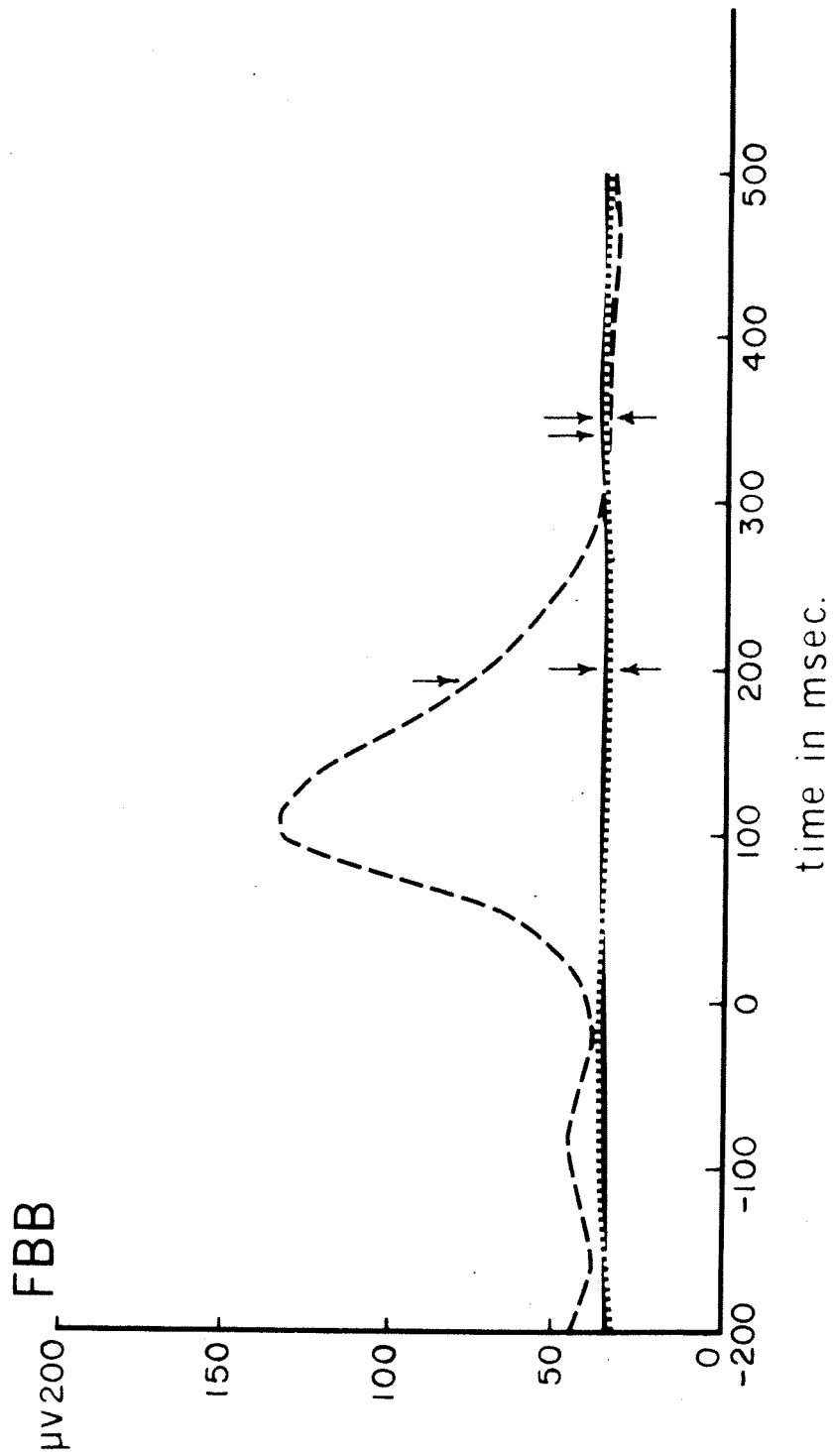


Fig. 2

/əpip/
 /əpəp/ - - -
 /əpup/ ———

Sternohyoid

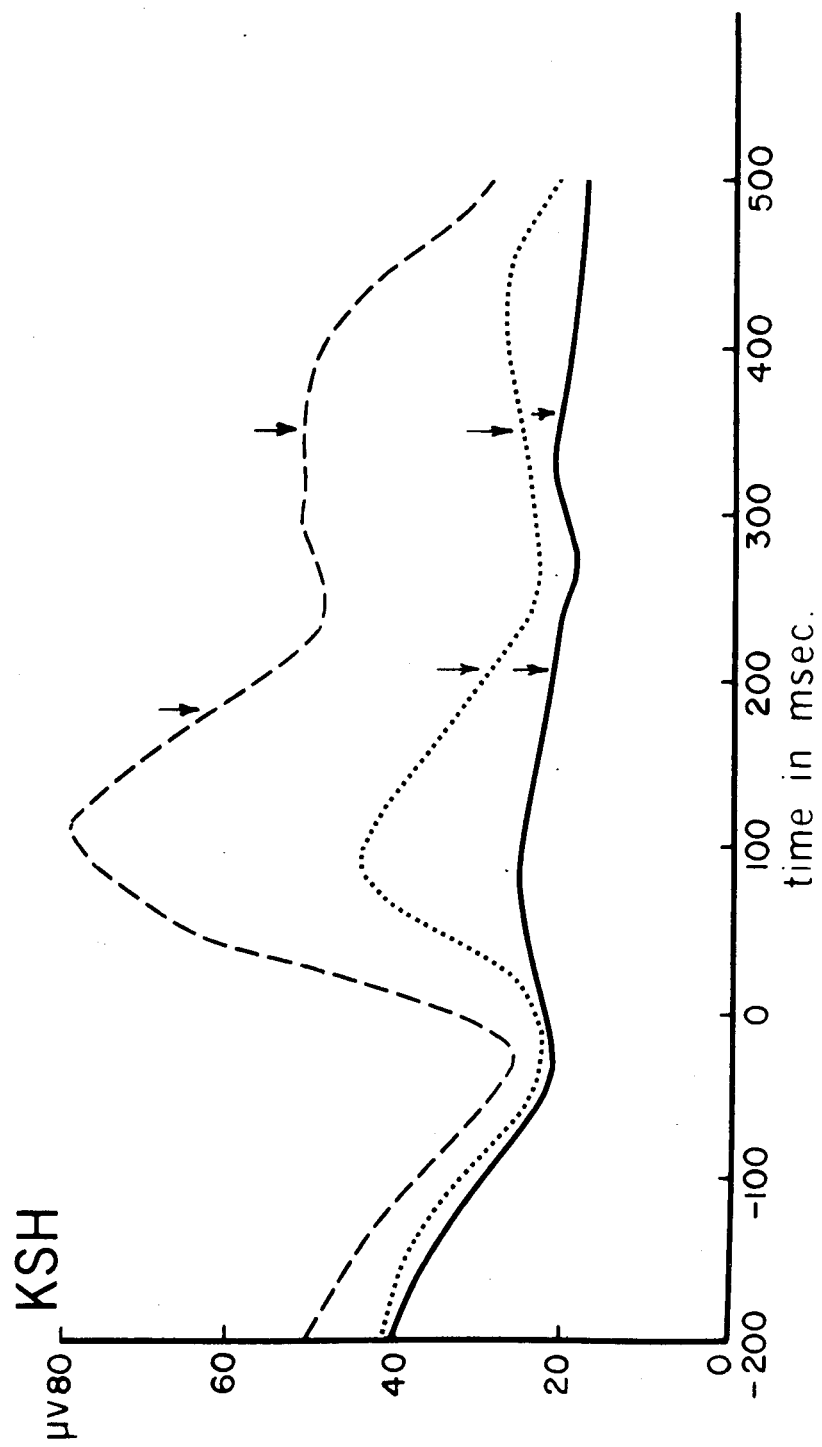


Fig. 3

Sternothyroid

- /əpip/ (dotted line)
- /əpap/ - - - (dashed line)
- /əpup/ — (solid line)

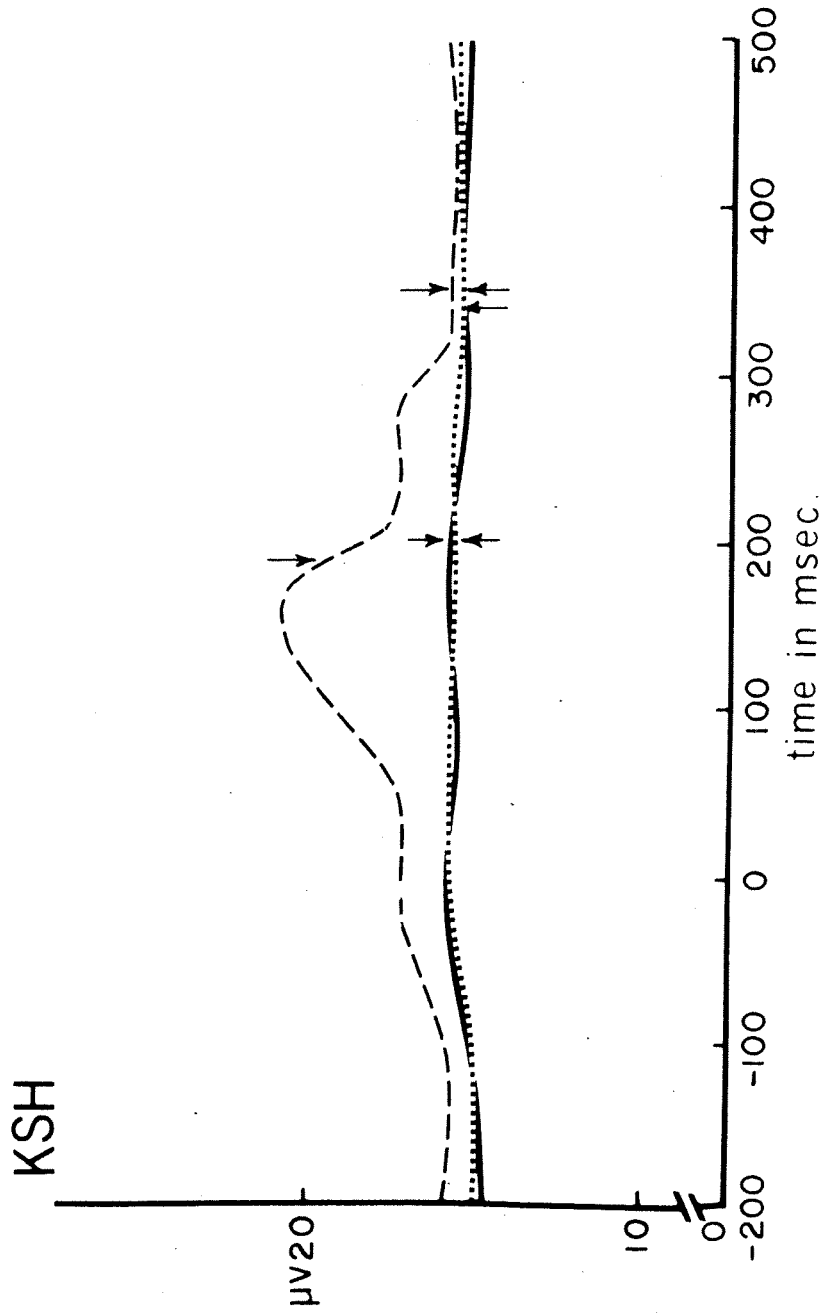


Fig. 4

Thyrohyoid

/əpip/
/əpap/ ----
/əpup/ ———

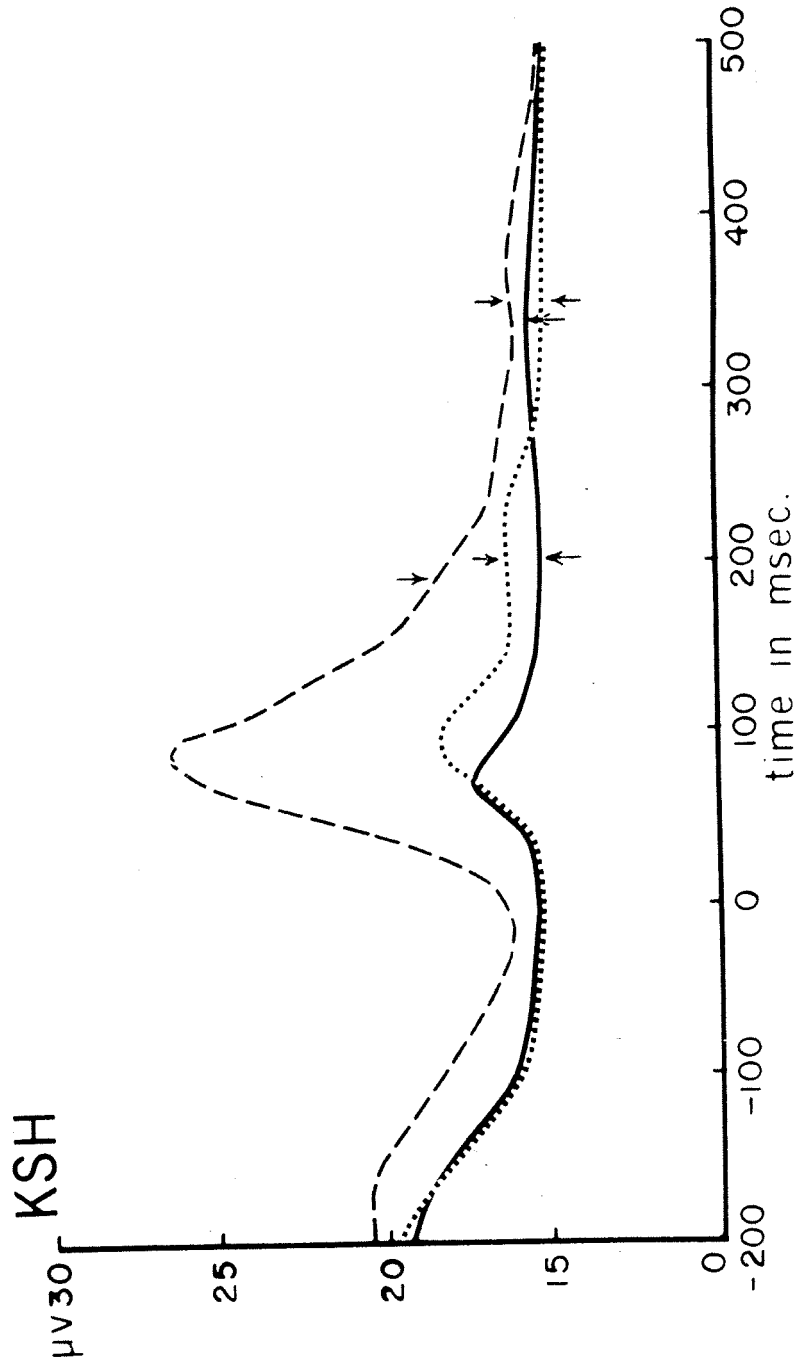


Fig. 5

Mylohyoid

/pik/
/pak/ ———
/puk/ - - -

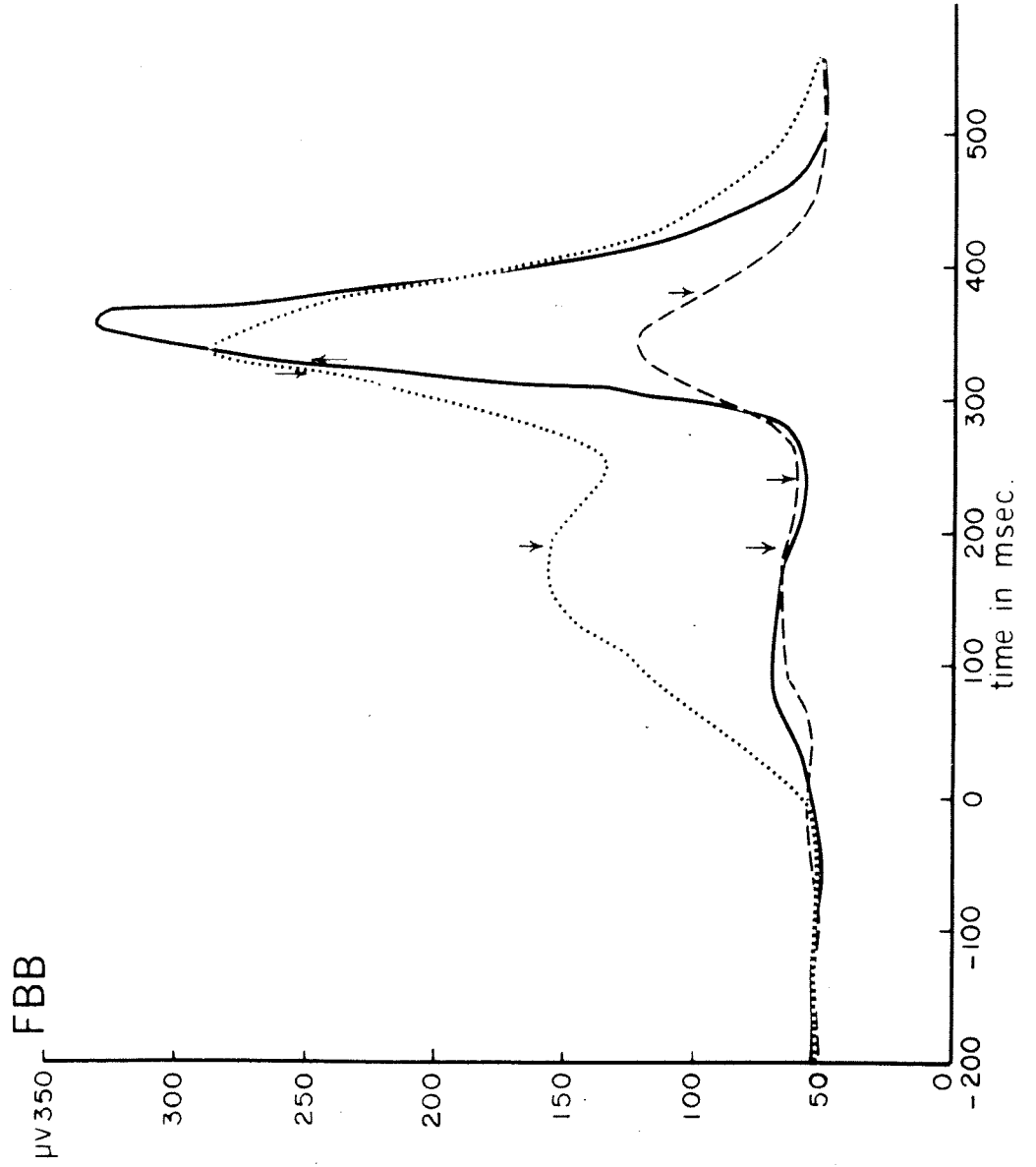


Fig. 6

Table I

	P ₁	P ₂	P ₃		P ₁	P ₂	P ₃		P ₁	P ₂	P ₃
pip	50	150	50	tip	100	150	60	kip	360	135	80
pit	60	170	55	tit	105	160	120	kit	320	130	115
pik	50	155	290	tik	130	150	210	kik	310	145	270
pap	50	80	55	tap	195	80	60	kap	435	60	75
pat	60	85	55	tat	150	75	65	kat	490	65	80
pak	55	70	330	tak	175	75	325	kak	480	65	320
pup	50	75	50	tup	130	90	65	kup	390	55	55
put	55	80	75	tut	115	90	120	kut	385	60	155
puk	55	70	125	tuk	115	75	175	kuk	435	55	190

coarticulation has been studied before both at the EMG level and at the movement level (see Amerman et al., 1970, for example). However, two rather different kinds of phenomena are described this way. The common example given is the rounding of the lips during [t] closure, when the following vowel is [u]. This may represent simply a change in timing of the activity associated with the vowel and does not necessarily indicate a change in the muscular organization of vowel formation.

The example here is quite different; we might hypothesize that the [k] peak is made by the combined action of the genioglossus and the mylohyoid (and probably other muscles) when the genioglossus is active for the vowel but by the mylohyoid when the genioglossus is not active for the vowel and when, in addition, the jaw is opening for the vowel. Although mere timing changes in muscle action could explain the lip-rounding example, they cannot explain this type of reorganization. Indeed, any explanation must depend on some complex type of preprogramming, since reorganization depends on events from which feedback is not yet available. Obviously, these phenomena will require detailed study in the future.

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