Some Effects of Oral Anesthesia upon Speech: An Electromyographic Investigation

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INTRODUCTION

It has been a long-observed fact that when one comes from the dentist's office there is often a disturbance of clearly articulated speech until the effect of the anesthesia has disappeared. It is understandable, therefore, that investigators interested in afferent control of speech should block the sensory nerves of normal speakers with anesthesia in order to study the relationship between feedback from the oral area and articulation of speech. Presumably all feedback channels are used to develop language, audition, taction, and proprioception. The question is whether skilled speakers need depend upon these feedback possibilities during ongoing speech and to what degree or under what circumstances each channel may play a role. Is learned speech centrally patterned, with little or no need under normal circumstances for peripheral control? A series of studies during the 1950s and '60s dealt with this subject. It was found that bilateral mandibular and intraorbital injections of anesthesia increased the number of judged errors in articulation of adult speakers (McCroskey, 1958; Ringel and Steer, 1963). The speech distortions were found to be subtle and were most evident in the production of fricatives and affricates (Scott, 1970; Borden, 1971; Gammon, Smith, Danilof, and Kim, 1971). It was assumed by the investigators that the speech effect was the result of decreased oral sensation as a result of blocking sensory feedback from the tongue via the lingual nerve. A phonetic analysis of the speech effect under anesthesia revealed two factors which prompted further investigation; first was the variability of effect among speakers, with some subjects unaffected by the nerve block, although oral sensation was reported to be lost, and the second factor was the predominance of articulatory distortions among the sibilants and affricates, especially /s/ in consonant clusters, in those subjects who were affected (Borden, 1971). It was decided to study electromyographically the contraction of some of the muscles thought to be implicated in lingual movement under conditions of nerve block and under normal conditions.

FIRST ELECTROMYOGRAPHIC STUDY

Two separate electromyographic (EMG) experiments were conducted in an attempt to find out what happens to certain suprahyoid muscles as subjects speak under conditions of trigeminal nerve block. Since the nerve block seemed to

*This paper reports a portion of the research carried out for a Ph.D. dissertation accepted by the City University of New York in 1971.

+Also City College of the City University of New York.
produce an /s/ effect, muscles which are thought to contribute to tongue elevation were reviewed (Van Riper and Irwin, 1958; Hirano and Smith, 1967; Zemlin, 1968). The muscles which were accessible, clearly identifiable, and of interest for this study were the genioglossus, geniohyoid, mylohyoid, and the anterior belly of the digastric muscles. The orbicularis oris was included as a reference (Figure 1).

Method

The monopolar electrodes used were DISA concentric needle electrodes with a diameter of .45 mm. Needle placement was made through the cutaneous tissue under the chin to the depth required. Correct placement was checked by observing the oscilloscope while protruding the tongue for genioglossal activity, saying "ta" for geniohyoid activity, lowering the mandible for digastric activity, and saying "ka" for mylohyoid activity. Correct placement was checked periodically throughout each run.

The subject for the first experiment was a normal adult speaker. Two runs were produced, the first without nerve block, and the second with bilateral mandibular blocks. A total of 7.5 cc of 2% xylocaine was injected by a dentist, 3 cc in each side and an additional 1.5 cc on one side. The technique was similar to that used by McCroskey (1958), the model for all previous studies. A partial run was recorded with a medial nasopalatine block of 1 cc and an anterior palatine block of 2 cc added, but this part of the study was not analyzed, as the speech effects were not noticeably different from the run with the bilateral mandibular blocks alone. It seems that loss of sensation from the anterior portion of the hard palate and the alveolar ridge adds very little to the speech effect evidenced with the mandibular blocks.

For the EMG studies, material was selected from the utterances used in our previous work. Eleven utterances in sentence form, using the format "It could be the ________," were used to permit the necessary rapid connected speech. Each utterance was represented twice in a randomized list of twenty-two utterances. There were ten such lists, each individually randomized. Each utterance was spoken twenty times during the course of one run. The utterances were as follows:

It could be the snowballs splashing.
It could be the cat's whiskers.
It could be the fixed sweater.
It could be the school blocks.
It could be the thirsty wasp.
It could be the sleeping taxi.
It could be the spider string.
It could be the squirrel nest.
It could be the rooster scratch.
It could be the spring grapes.
It could be the stove smell.

The 220 utterances for each run were printed and mounted on large cards which were flipped as the subject read them, with equal stress attempted on each of the final two words.
Muscles examined in EMG study. Arrows indicate direction of needle insertions. Frontal and sagittal views.
A 16-channel magnetic tape was produced, recording the electrical output of the muscles, which were monopolar recordings; that is, the difference was recorded between the active tissue of the muscles and the inactive tissue of the earlobe. Some of the channels were used for audio signals, such as the utterances produced by the subject and the comments for record-keeping produced by the experimenters. Each utterance was numbered by a pulse code which was laid down on the tape and eventually on the computer output.

The output of the channels was put onto paper tape both at the time of the run and later for locating and inspecting the individual tokens. Each utterance was represented twenty times during each run, and a single point in time, a line-up point, was selected so that all of the tokens of a single type could be averaged by computer for each electrode. The line-up point was chosen at a point of particular interest and marked on the simultaneous recording of the subject's audio recording.

Each tape was subjected to five computer programs to check that the code pulses were in order, to set the gains of the playback amplifiers at levels appropriate for the analog-to-digital converter, to make control tapes of the line-up points and distances from point zero for each utterance, to set each EMG channel at the optimum level, and finally to average the data on the control tapes.

The paper output of this process is a list of numbers for each channel, indicating the averaged value of each electrode in microvolts every 5 msec. The three runs were hand plotted.

Results and Discussion

Inspection of the data reveals that the muscular activity recorded during speech under normal conditions remained high during the nerve-block condition with the exception of two muscles. After the nerve-block injections, it was observed by the experimenters that the activity on the oscilloscope of the mylohyoid muscle and the anterior belly of the digastric muscle dropped dramatically to a state of relative inactivity. The electrodes were checked and found to be in place, but as long as the anesthesia was effective those muscles were in effect "paralyzed." The speech of the subject under nerve block revealed the typical mandibular block effect of distorted sibilants, the /s/ clusters being most prominently affected. Compare the graph of the two affected muscles during the production of the utterance "sleeping taxi" under normal conditions (Figure 2) with the graph of the same electrode placements during nerve block. All eleven utterances showed the same drop in activity for the mylohyoid muscle and the anterior belly of the digastric during anesthesia.

A closer look at the anatomy at the injection area showed us that we should not have been surprised. The mandibular injection which has traditionally been used for these studies deposits half of the solution in the area of the lingual nerve, then moves on to deposit the rest of the solution in the area of the inferior alveolar nerve. It happens that just before the inferior alveolar nerve enters the mandibular foramen into the mandibular canal, it gives off the nerve fibers of what is known as the mylohyoid nerve, the only purely motor component of the otherwise sensory inferior alveolar branch of the trigeminal nerve (Figure 3). The mylohyoid nerve is motor to the mylohyoid muscle and to the anterior belly of the digastric muscle, the two muscles which dropped in activity during the nerve-block condition.
EMG recording of the mylohyoid muscle and the anterior belly of the digastric muscle during normal and nerve-block conditions.
Cross-section of ramus

Inner surface of ramus with needle in the right mandibular sulcus.

Fig. 3
The next consideration was whether the inactivity of either of these muscles could have contributed to the noted speech deterioration. If the speech effect is primarily due to sensory loss, then loss of feedback from the tongue tip region would probably be responsible. If it is due to motor loss, however, then the anterior belly of the digastric muscle and the mylohyoid muscle are probably responsible.

The normal function of the anterior belly of the digastric muscle is to open the jaw. EMG data on this muscle, obtained by recording muscle activity during simple "CVp" utterances, showed no action for /i/ and /u/ and a large peak for /ɑ/ (Harris, 1971). Since there was no perceptible speech effect of the nerve block upon vowels, and since the action of the anterior belly would not reasonably be expected to affect the spical gestures which deteriorated under nerve block, it seems unlikely that its motor loss could have caused the speech effects observed. It may be that other mouth-openers compensate.

The normal function of the mylohyoid muscle was found by both Harris (1971) and Smith (1970) to be highest for the production of /k/. Its contraction seems to lift the body of the tongue. In the more complex utterances of the present study, it can be seen that the mylohyoid muscle peaked normally in preparation for the /s/ consonant clusters and for the velars (Figure 4). Notice the activity at the beginning of "spring," "spider," and "string," and at the end of "grapes" and "string." Observe the drop in activity of the mylohyoid muscle during the nerve-block condition. The peaks of activity under normal speaking conditions, then, coincided with the speech distortions produced under the nerve-block condition, with the exception of the velars.

The nerve block did not distort the velars sufficiently to be perceived as a distortion. The production of /k/ remained intact, as had been reported in all previous nerve-block experiments. The explanation may lie in the comparatively gross production of /k/ and the fact that we, as listeners, accept as /k/ a less precise gesture than we do as /s/.

It seems, therefore, that the effected "paralysis" of the mylohyoid muscle might reasonably be related to the speech effect, since, for this subject, the mylohyoid muscle appears to be important in lifting and steadying the body of the tongue for consonant clusters, especially those with /s/ (Table 1). This subject produces /s/ with the tongue tip down, making it imperative that the body of the tongue be raised to produce the friction. Deprived of motor ability in the mylohyoid and deprived of lingual sensation, the /s/ clusters were distorted. It is impossible to conclude which of these factors, if not both, is responsible for the distorted speech, but it cannot be assumed, as it has in previous studies, that the effect is due to loss of sensory feedback.

In summary, the clear conclusion of this first EMG experiment was that a motor component existed in what was previously assumed to be a sensory deprivation. The motor loss was evident in two of the suprahylid muscles, the mylohyoid muscle and the anterior belly of the digastric muscle. One of these muscles, the mylohyoid, is normally active for this subject for /s/ clusters and velars. Since this subject produced /s/ with a high dorsum, it is reasonable to assume that the motor loss in the mylohyoid muscle may have contributed to the speech deterioration during anesthesia.
Mylohyoid muscle peaked in this subject under normal conditions for /s/ consonant clusters and for velars.
<table>
<thead>
<tr>
<th>Movement</th>
<th>Normal</th>
<th>NB</th>
<th>msec</th>
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<tbody>
<tr>
<td>Spring Grapes</td>
<td>345</td>
<td>155</td>
<td>285</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>35</td>
<td>20</td>
</tr>
<tr>
<td>(-225)(125)(715)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat Whiskers</td>
<td>315</td>
<td>355</td>
<td>380</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>(-800)(-505)(-140)(200)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thirsty Wasp</td>
<td>185</td>
<td>310</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>(-855)(-255)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stove Smell</td>
<td>335</td>
<td>355</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>(-215)(325)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snowball Splash</td>
<td>415</td>
<td>340</td>
<td>430</td>
</tr>
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<td></td>
<td>30</td>
<td>55</td>
<td>25</td>
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<tr>
<td>(-140)(500)(900)</td>
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</tr>
<tr>
<td>Spider String</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spider String</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeping Taxi</td>
<td>425</td>
<td>265</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>(-155)(300)(635)</td>
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</table>

**SECOND ELECTROMYOGRAPHIC STUDY**

The purpose of the second EMG study was to verify the result of the first study, which was that mylohyoid motor loss accompanied the distorted speech during the nerve-block condition, and also to study further the changes in muscle activity by comparing the electrical potential in normal speech with the electrical potential during nerve block.

**Method**

It was necessary to use a second subject for this experiment. The material consisted of thirty utterances in the frame "the ______." They were randomized into four lists repeated alternatively four times, making sixteen lists of thirty utterances each. Fifteen of the utterances were chosen from the Scott (1970) list in an attempt to observe the muscle changes in the distorted speech which might explain the phonetic changes which she had transcribed. The other fifteen utterances were selected from the sentences in the first study and from
the perceptual study. Two runs were produced. Done on the same morning, the first one was conducted under normal conditions, the second under blocked condition.

The electrodes were .0002-inch wires hooked to remain in place. Correct placement was checked by observing the oscilloscope while lifting the tongue for genioglossal activity, tensing the floor of the mouth while relaxing the tongue for geniohyoid activity, saying "ka" for mylohyoid activity, opening the mouth with jaw effort for anterior belly of digastric activity, saying "pa" for orbicularis oris activity, and lifting the head or opening the mouth under pressure for sternohyoid activity. The genioglossus and geniohyoid were also checked during swallowing, as their activity differs in timing (Hirose, 1971). Electrodes were placed in both sides of the mylohyoid muscle and in both anterior bellies of the digastric muscle.

After the normal run, a total of 7.5 cc of 2% xylocaine was injected into the oral region of the subject. There are two general types of dental injections, supraperiosteal injections and block injections. A supraperiosteal injection, sometimes called an infiltration, is a procedure in which the anesthetic solution is deposited in the periosteum opposite the roots of certain teeth. The solution is carried by diffusion through the periosteum and bony plate to the nerves. The only infiltration injection used in this experiment was the anesthetization of the posterior superior alveolar nerve. A block injection is one in which the anesthetic solution is deposited between the brain and the field of operation. The solution penetrates the nerve trunk or nerve fibers and blocks either the sensations coming from the distal field or the motor impulses coming from the brain. All of the injections used in this study were nerve blocks, except the one to the posterior superior alveolar nerve (Cook-Waite Labs, 1971). A summary of the injections is given in Table 2.*

A rough check of two-point discrimination was made, and when the experimenters and subject were satisfied that sensation was lost in the tongue and the palate, Ringel's (1969) fifty-five-item oral discrimination test of ten plastic forms was administered. When the subject had returned to normal, the Ringel test was again administered. The subject made nine errors in normal condition and fifteen errors in the nerve-block condition, the difference being errors of shape, not size. Confusion of shape occurred three times in normal condition and nine times in nerve-block condition. Nevertheless, the experimenters were surprised that there was so little difference in performance on this test. It was noted that the subject used the usual tongue manipulations during normal condition but relied on deep pressure against the palate when sensation was decreased. This technique was reported as the method used by successful subjects in the previously mentioned study on the effect of anesthesia on oral stereognosis (Mason, 1967).

The multichannel magnetic tapes which were produced for each of these runs were analyzed in much the same way as the first experiment. There were some

*The reason that such extensive injections were administered was to enable the experimenters to compare results with the Scott data. In the present study, the dentist attempted to hit the lingual nerve and to avoid the mylohyoid nerve. The intent was to produce a purely sensory block without any motor effects.
TABLE 2: Injections of anesthesia administered in the second EMG study.

<table>
<thead>
<tr>
<th>Cranial Nerve</th>
<th>Branch</th>
<th>Amount of Solution</th>
<th>Location of Injection</th>
<th>Area of Sensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>V (mand.)</td>
<td>Inf. Alveol. n.</td>
<td>1.5 cc ea. side</td>
<td>pterygomand. triangle</td>
<td>mand. alv. ridge, lip, gums</td>
</tr>
<tr>
<td></td>
<td>Lingual n.</td>
<td></td>
<td></td>
<td>ant. 2/3 tongue</td>
</tr>
<tr>
<td>V (mand.)</td>
<td>Long Buccal n.</td>
<td>.5 cc ea. side</td>
<td>1st molar</td>
<td>buccal</td>
</tr>
<tr>
<td>V (max.)</td>
<td>Infraorbital</td>
<td>.5 cc ea. side</td>
<td>infraorbital foramen</td>
<td>upper lip</td>
</tr>
<tr>
<td></td>
<td>Ant. Sup. Alv.</td>
<td></td>
<td></td>
<td>alv. ridge</td>
</tr>
<tr>
<td></td>
<td>Middle Sup. Alv.</td>
<td></td>
<td></td>
<td>ant. teeth</td>
</tr>
<tr>
<td>V (max.)</td>
<td>Nasopalatine n.</td>
<td>.5 cc midline</td>
<td>post. to central incisors</td>
<td>ant. 1/3 palate</td>
</tr>
<tr>
<td>V (max.)</td>
<td>Post. Sup. Alv. n.</td>
<td>.5 cc ea. side</td>
<td>2nd molar</td>
<td>molars</td>
</tr>
<tr>
<td>V (max.)</td>
<td>Greater Palatine n.</td>
<td>.5 cc ea. side</td>
<td>palate 3rd mol.</td>
<td>post. 2/3 palate</td>
</tr>
</tbody>
</table>

Refinements in the computer programs. A concise description of the analysis procedure is reported by Port (1971).

Results and Discussion

As a result of the first EMG experiment, the investigators were particularly interested in this second study in the activity of the mylohyoid muscle. Since there were bilateral placements of electrodes in both the mylohyoid muscle and the anterior belly of the digastric muscles, the investigators had an opportunity to study the activity on both sides of these muscles. During the normal run, before the injections of anesthesia, the mylohyoid and the anterior bellies showed activity similar to the first subject. The anterior belly peaked for mouth opening and the mylohyoid for velar gestures and somewhat for the /s/ clusters.

During the condition of nerve block, however, there was a decrease in activity in both muscles on the right side. The right anterior belly of the digastric was in all cases significantly less active than normal after anesthesia. The right mylohyoid was consistently less active than normal for velar gestures, but for the /s/ clusters, it was sometimes less active and sometimes more active than normal. The decreased activity on the right side in this experiment was not as pronounced as it had been in the first EMG study, indicating that the attempt on the part of the dentist to avoid the motor mylohyoid nerve was partially successful. The limited effect on the right side was presumed by the investigators to be the result of some infiltration of the anesthetic in the area of the mylohyoid nerve.
In contrast with the decreased activity observed on the right side of the mylohyoid and anterior belly of the digastric muscles, the left side of these muscles were usually more active than normal while the anesthesia was in effect. Figure 5 demonstrates the asymmetry of effect. The right peak in each of the four graphs represents the labial closing for /p/ in "duckpond." It can be seen that the right side of both muscles was quite active during normal speech but dropped in activity during speech with nerve block. The left electrode placement in the mylohyoid was in a slightly less active field than the right side. That is, there were fewer motor units firing near the electrodes on the left side. The left-side placement of the electrode into the anterior belly of the digastric was in a particularly inactive field. The problem of electrode placement into a more or less active field of the muscle is less important in this study than in many, because our interest is in comparing the activity recorded at a single site under two different conditions, normal and nerve block. Relative values, therefore, are more important than absolute values. A final look at Figure 5 shows both muscles on the left side to be more active during nerve block than they were normally.

We have no explanation of these results except to assume that the anesthetic solution had a motor effect on one side of the subject and that there was some reorganization of motor function on the opposite side to compensate for the motor loss. Typically, bilateral injections of anesthesia result in some asymmetry of effect. In the perceptual study we sometimes had to reinject a subject on one side, due to insufficient loss of sensation. The subject for the first EMG study required an additional 1.5 cc of xylocaine on one side to equalize the desensitivity. It is reasonable to assume, therefore, that there would be the same possibilities for asymmetry of motor effect, depending upon the amount of infiltration of the anesthetic solution into the fibers of the motor mylohyoid nerve.

The most prominent result of this study, therefore, was that despite considerably less anesthesia and an attempt to avoid the mylohyoid nerve, there was a unilateral drop in mylohyoid and anterior belly of digastric activity during anesthesia, although the other apparently unaffected side demonstrated efforts at compensation, by showing more than normal activity.

A second interesting result of this EMG experiment was that the subject's articulation appeared to be clear under nerve block. There were no discernible phonetic distortions. The speech sounded as acceptable under the nerve-block condition as under the normal condition. The utterances were louder under nerve block and produced with what might be described as overarticulation.

This variability of nerve-block effect among subjects was observed during the perceptual part of this series of studies. It is unclear why there was no speech effect. It might be a difference in muscle use, as this subject produces /s/ with tip of the tongue raised and might not rely on mylohyoid muscle activity as much as the first subject, who produces /s/ with dorsum of the tongue raised, keeping the tip down. Another explanation for no speech effect might be a difference in anesthesia, either in amount or in technique of injection. It is customary in these studies to inject anesthesia until the subject reports loss of sensation. In the mandibular block, loss of sensation is reported immediately when the lingual nerve has been hit directly, as it was in the case of this second subject. Only 1.5 cc of xylocaine solution was injected into each side, whereas 4.5 cc in each side was necessary before the subject of the first experiment lost sensation. The solution presumably anesthetized the
Decreased right side activity and increased left side activity during nerve block of the mylohyoid and anterior belly of the digastric muscles. Obicularis oris is included as a reference.
mylohyoid nerve of the first subject, as we have indicated mylohyoid muscle
and anterior belly of the digastric muscle inactivity. In this subject there
was less anesthesia needed to effect loss of sensation and the solution
apparently did not penetrate the mylohyoid motor nerve fibers on one side.

The third result of the second EMG study was a fairly consistent pattern
of muscle reorganization under nerve block. Table 3 summarizes the muscle
activity in general for each utterance during nerve block as it compares to its

<table>
<thead>
<tr>
<th></th>
<th>More Active Than Normal</th>
<th>Less Active Than Normal</th>
<th>Same As Normal</th>
<th>Different Than Normal</th>
</tr>
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<tbody>
<tr>
<td>OO</td>
<td>11</td>
<td>5</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>GG</td>
<td>1</td>
<td>8</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>GH</td>
<td></td>
<td>29</td>
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<tr>
<td>SH</td>
<td>22</td>
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<td>7</td>
<td>1</td>
</tr>
<tr>
<td>MHR</td>
<td>4</td>
<td>14</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>MHL</td>
<td>24</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>ADR</td>
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<td>30</td>
<td></td>
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</tr>
<tr>
<td>ADL</td>
<td>15</td>
<td></td>
<td>15</td>
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</table>

own activity normally. The orbicularis oris was usually either the same as
normal or more active than normal. The genioglossus tended to be the same.
Inexplicably, the geniohyoid was less active during nerve block. The rest of
the muscles follow a reasonable pattern of adjustment. The right side of the
mylohyoid muscle and the anterior digastric lost activity during nerve block,
as previously discussed. The scatter plot of the differences in peak values of
the right anterior digastric during the two conditions is clear. It was always
higher normally than during anesthesia (Figure 6). The right mylohyoid showed
the same decreased activity for the normally active velar gestures, but for the
high front gestures such as /t/ or /s/ clusters, there was increased activity
during nerve block (Figure 7).

Shifting our attention to the left mylohyoid and anterior digastric, we
see that again the anterior belly clearly increases activity during nerve block,
perhaps as compensation for the less active left side (Figure 8). The left
mylohyoid, however, is somewhat more complex. It, too, was more active during
nerve block. Notice that for the less active front consonant gestures, there
was less increase in activity during nerve block than for the already normally
active velars (Figure 9). When the right side of the mylohyoid dropped for the
velars, the left side soared. Finally, the sternohyoid was interesting as it
was consistently more active during nerve block than under normal conditions and
might reasonably be expected to compensate for the inactivity of the anterior
digastric. The anterior belly of the digastric opens the jaw, as does the
sternohyoid (Figure 10). In summary, the muscles do seem to be behaving

40
ANTERIOR DIGASTRIC RIGHT
KSH
Peak Values in μv

FIG. 6

NERVE BLOCK

NORMAL
FIG. 9

NERVE BLOCK

NORMAL

MYLOHYOID LEFT
KSH
Peak Values in μv

- VELARS
- NON-VELARS
Fig. 10

Sternohyoid
KSH
Peak Values in µV

Nerve Block
differently during the nerve-block condition. They do not seem to change their pattern of function so much as their amplitude. Finally, there are some instances which look like compensatory action as a result of decreased activity on the opposite side or in another muscle.

Whether the speech of this subject might have remained sharp and clear even had the mylohyoid nerve been bilaterally affected by the anesthesia resulting in mylohyoid muscle "paralysis," as seemed to be the case with the first subject, remains unclear. Is the speech deterioration, when it exists, related to a loss of tactile and kinesthetic sensation, as has traditionally been suggested? Or might it be related to a loss of motor function, which these studies force us to consider? Or might it possibly be related to some reorganization of the unaffected muscles in an attempt to compensate for the motor loss, an attempt which perhaps succeeds except on phonemes demanding rapidity and precision of gesture such as /s/ and /r/ in consonant clusters?

The conclusion which we must draw from these experiments is that there is an error of method in the experimental technique which has been traditionally used to study tactile and kinesthetic loss of sensation on speech. The most critical injection of anesthesia, the mandicular block, produces not only a sensory loss but a motor loss. These studies have demonstrated, furthermore, that the use of EMG is important in experiments on sensory deprivation as a direct check on motor function.

REFERENCES


