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Monitoring Soft Palate Movements in Speech

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Abstract

A simple photoelectric device has been constructed which permits easy monitoring of soft palate movements in speech. Since its output signal cannot easily be calibrated it is most useful for detecting the timing of such movements and the *relative* rather than the absolute amount of velopharyngeal opening. Using it, it has been possible to verify others' findings that: (l) The soft palate is lowered more during vowels preceding a nasal consonant than it is during vowels following a nasal consonant. (2) The soft palate begins to lower for an upcoming nasal consonant as soon as it can, i.e., as soon as it is no longer required to be closed for an obstruent. (3) Other things being equal, the soft palate is typically lowered during the production of so-called low "oral" vowels such as [ɑ]. (Supported by the National Science Foundation.)

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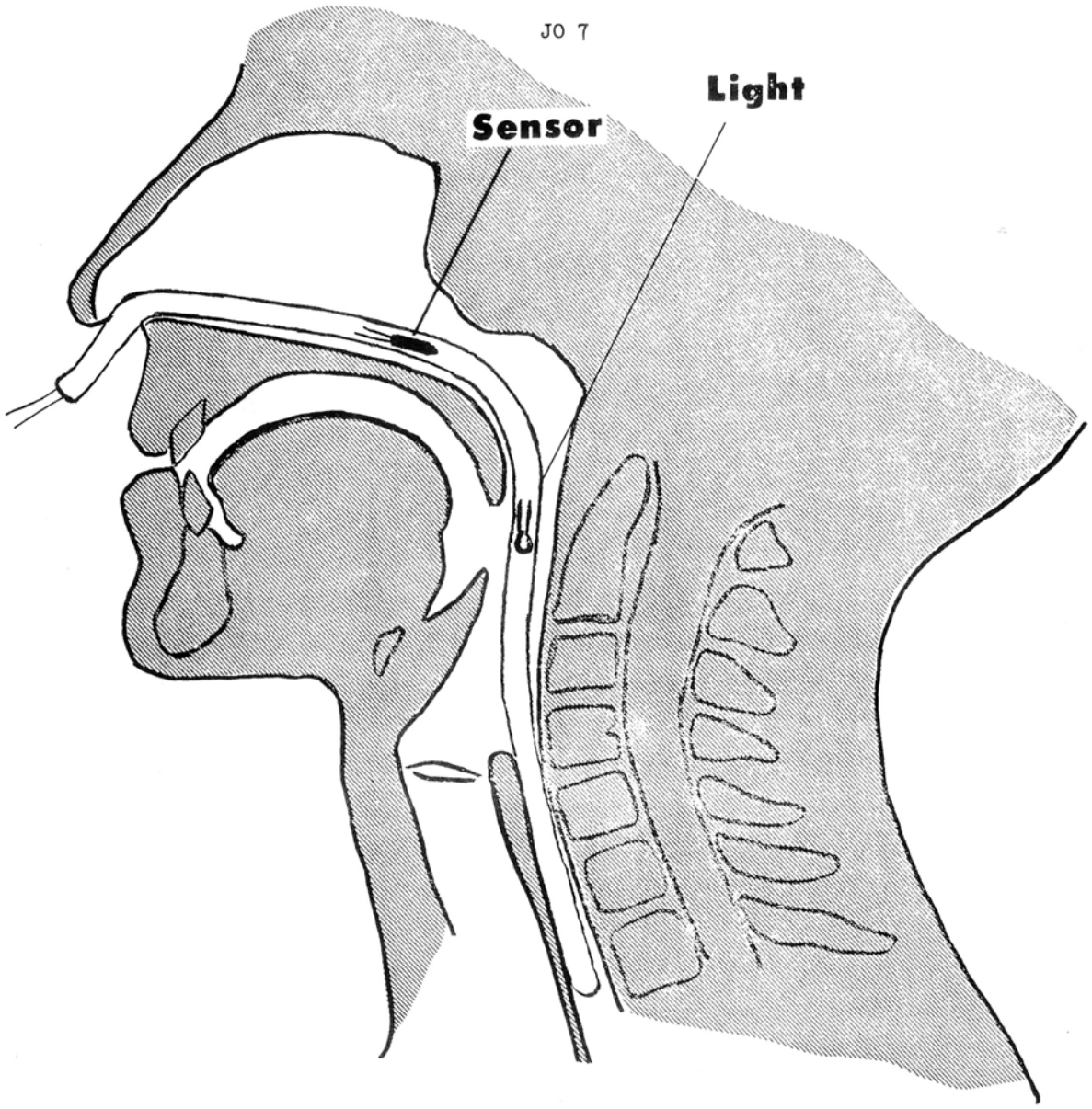
Most of the popular methods used by speech researchers to monitor the movements of the soft palate in speech, for example cinefluorography, although quite exact, necessitate a huge amount of labor (and a certain amount of danger) for the analysis of relatively short bits of speech. And there is no way of knowing in advance, before laboring over the data, whether or not the sample will prove interesting or not. There is a need, then, for a simple technique for measuring palatal movements—a technique whereby rough-cut data may be gathered quickly in great volume so that a preliminary analysis may indicate which speech gestures may be more profitably studied in more detail using, perhaps, cinefluorography.

The technique described in this paper meets this need to a certain extent. It monitors movements of the soft palate in the same way as a glottograph monitors variations in glottal area: a DC light is placed on one side of the opening and a light sensor on the other side (Sonesson 1959, Ohala 1966). The amount of light impinging on the light sensor and thus the voltage developed by it are taken as an indication of the size of the opening.

(FIRST SLIDE)



In this case I inserted both light and light sensor in the same flexible transparent plastic catheter which is sealed at one end and has the leads of the sensor and the light emerging at the other end and connecting to amplifier and dry-cell, respectively. The sealed end is swallowed into the esophagus for increased stabilization and for the subject's comfort. Light and light sensor are separated by about 9 cm. or enough so that the light sensor rests approximately over the junction between the hard and soft palate and the light is well down into the pharynx, approximately at the level of the epiglottis or slightly above. The optimum placement is determined by trial and error. The outer diameter of the tube is about 4 mm; it should eventually be possible to find an even smaller tube. Dedicated subjects report no great discomfort or disruption of natural speech articulation. Due to the similarity of this device to the glottograph, I refer to it as the “nasograph".

The NEXT SLIDE (#2)

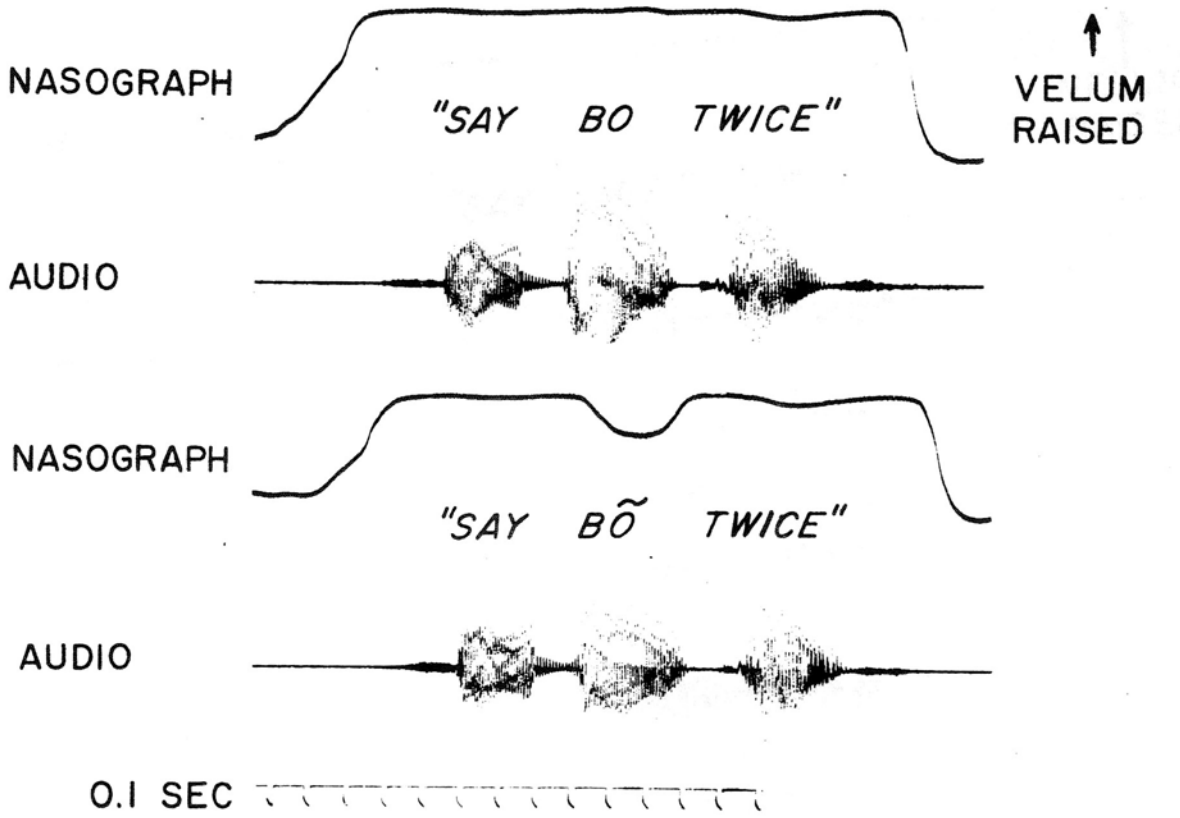
shows the nasograph in use in one of the two subjects who have used it so far. It has been observed that when in use it makes the subject look like a "jack-o-lantern."

Calibration is a problem. I know of no simple way to calibrate it except to compare its output to that obtained by some other technique: cinefluorography, recording nasal air flow, etc. I have not done this. No doubt it is non-linear. The variability of the light impinging directly or by reflection on the light sensor, the possible movement of the plastic catheter itself during movements of the soft palate, etc., probably introduce various errors into the signal. In spite of all these problems it is surprising how well it does work. At any rate it ought to give a fairly reliable indication of *relative* palatal opening and of the *timing* of palatal movements.

The obvious way to test it is to produce speech gestures known to require a raised velum or a

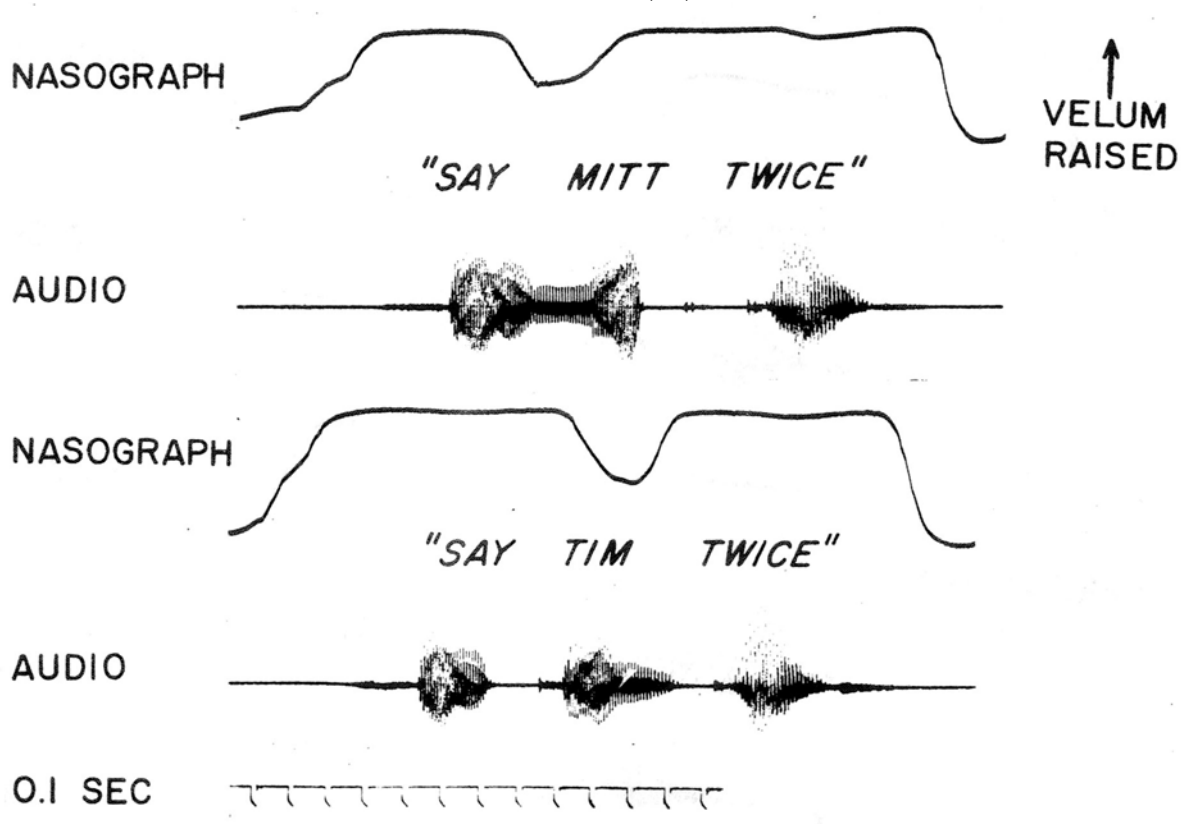
lowered velum and to see that it gives the expected signal. Obstruents (stops, fricatives, and affricates) require an air-tight oral cavity and thus must have a raised velum. Nasal consonants and nasalized vowels require a lowered velum.

NEXT SLIDE (#3).



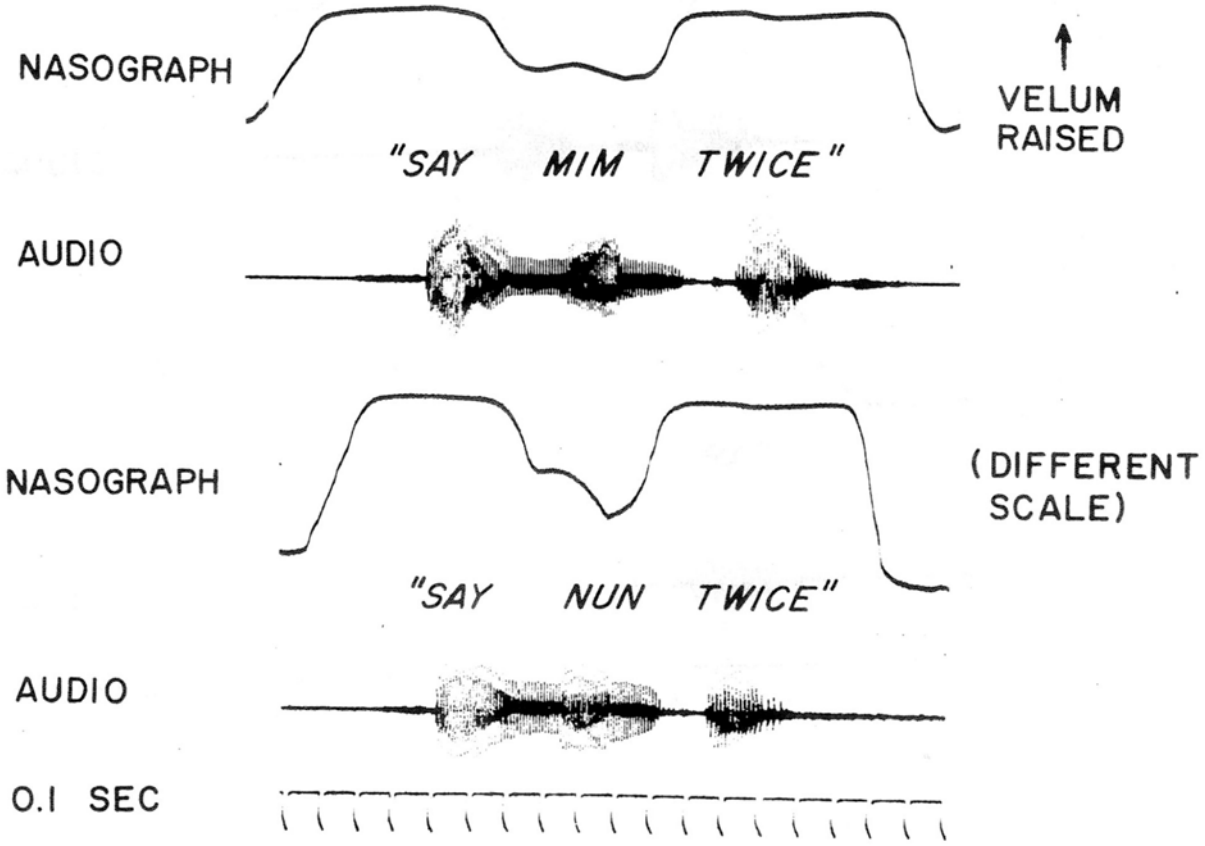
This slide shows at top the output of the nasograph and the microphone signal recorded simultaneously during the production of the utterance "Say bo twice." The bottom of the slide shows the same parameters recorded during the phrase "Say bõ twice." The nasograph signal indicates raised velum by a line near the top, lowered velum by a line near the bottom of its range. The first utterance is devoid of nasals and accordingly the nasograph correctly indicates the velum is raised throughout the utterance. Only before and after the utterance is the velum open while the subject breathes. The second utterance is identical to the first except for the nasalized vowel in the second word—thus the nasograph indicates the velum is lowered on that vowel and is raised again for the following stop /t/. A slight deflection in the signal in the middle of the word 'twice' is apparently *not* an artifact and indicates that the palate may be lowered slightly for low vowels.

NEXT SLIDE(#4).



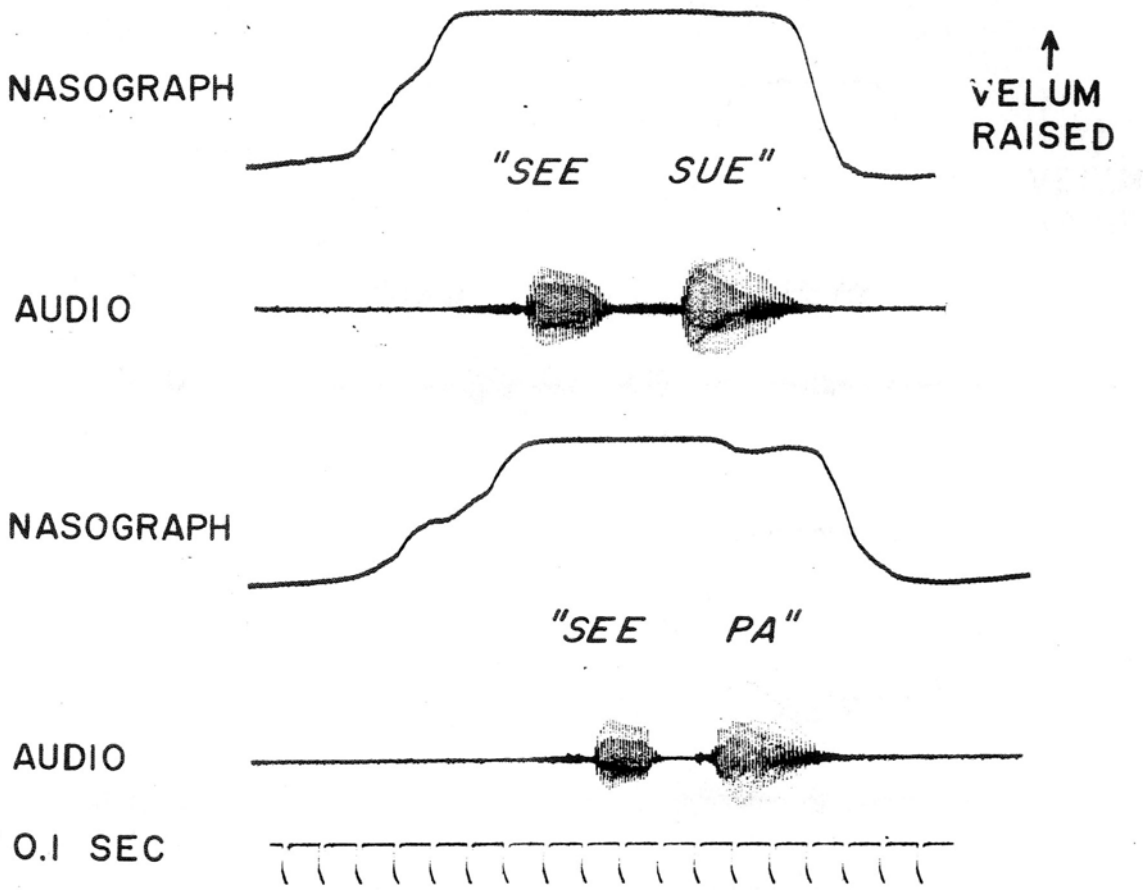
This slide shows the same two parameters for the utterances "Say mitt twice" and "Say Tim twice." As expected the velum is lowered during the nasal consonant /m/ in both cases. In 'mitt' the velum is raised during the vowel following the /m/. Thus this vowel is nasalized. In the word 'Tim' the velum lowers immediately after the /t/ during the vowel preceding the /m/ so this vowel is nasalized, too. This phenomenon, of course, is well known among phoneticians. It also appears that on the average the palate lowers more for word-final nasal consonants than for word-initial nasals. Thus one would expect vowels preceding nasals to be slightly more nasalized than vowels following nasals. This tendency was noted previously by the Indian linguist, A. Kelkar (1968).

NEXT SLIDE (#5).



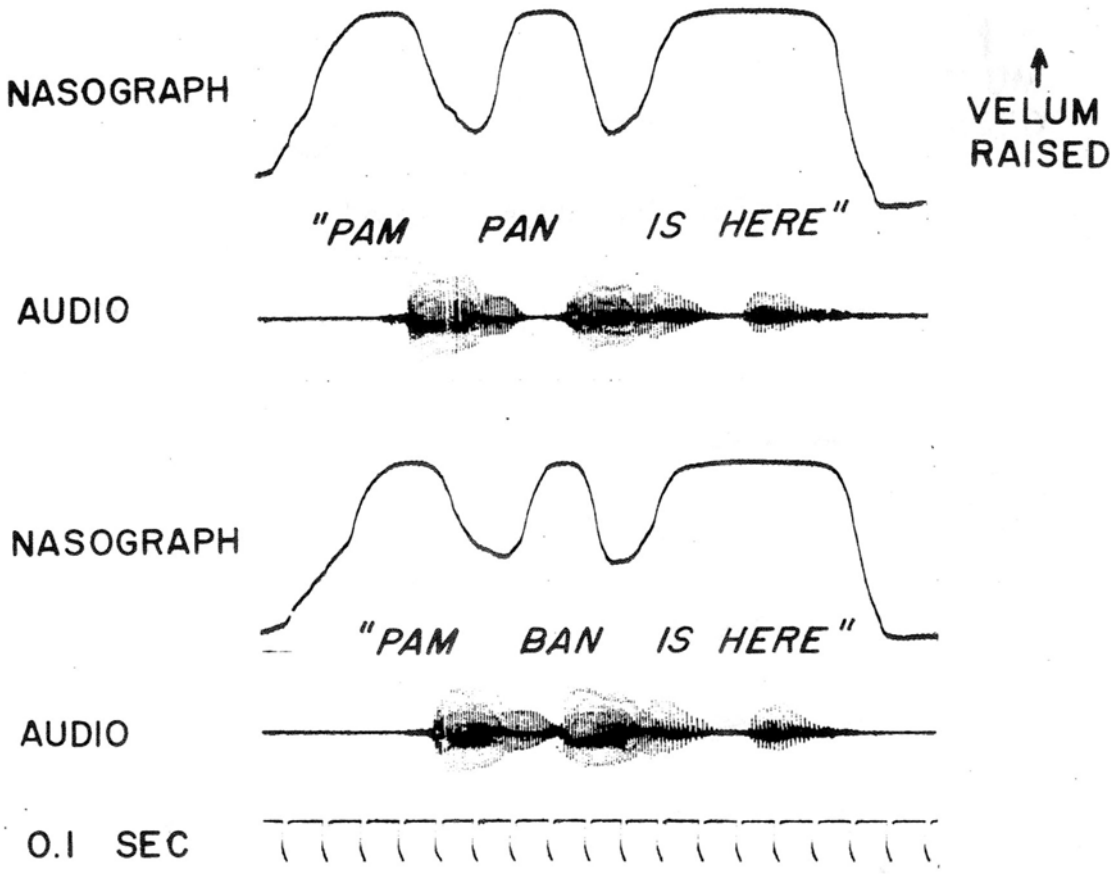
This slide shows the two utterances "Say mim twice" and "Say nun twice." (At Berkeley the word 'mim' is not a nonsense word; it is the pronounceable acronym for our lab's "Monthly Internal Memorandum.") Again, the general tendency for the velum to lower more for final nasals than for initial nasals can be seen. Curiously, after opening for the first nasal, there is a slight closing movement. This merits further study.

NEXT SLIDE
(#6).



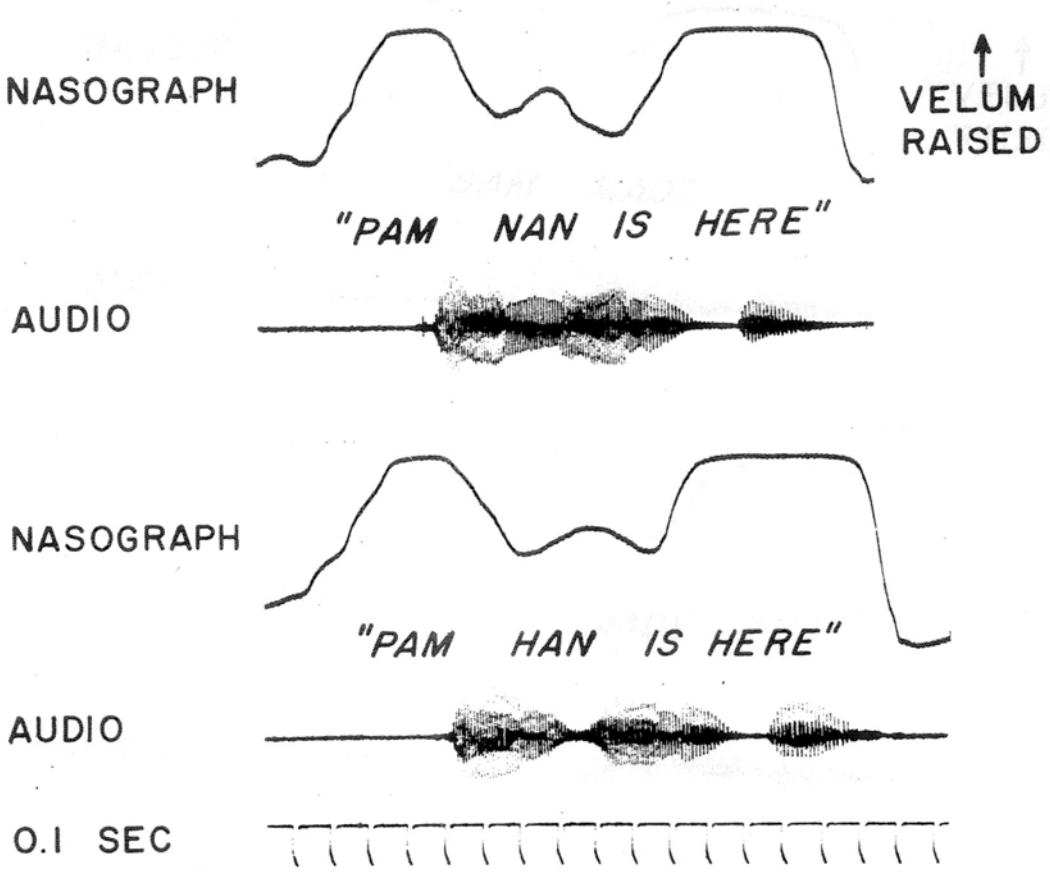
This shows the two utterances: "See Sue" on top and "See Pa" on the bottom. The velum is raised throughout the first utterance. During the last vowel in the second utterance, however, it is apparent that the velum lowers a bit. A lowering of the palate for low vowels, that is, vowels with a high first formant, as in this case, was quite common. This is, again, a well-known phenomenon (Moll 1962).

NEXT SLIDE (#7).



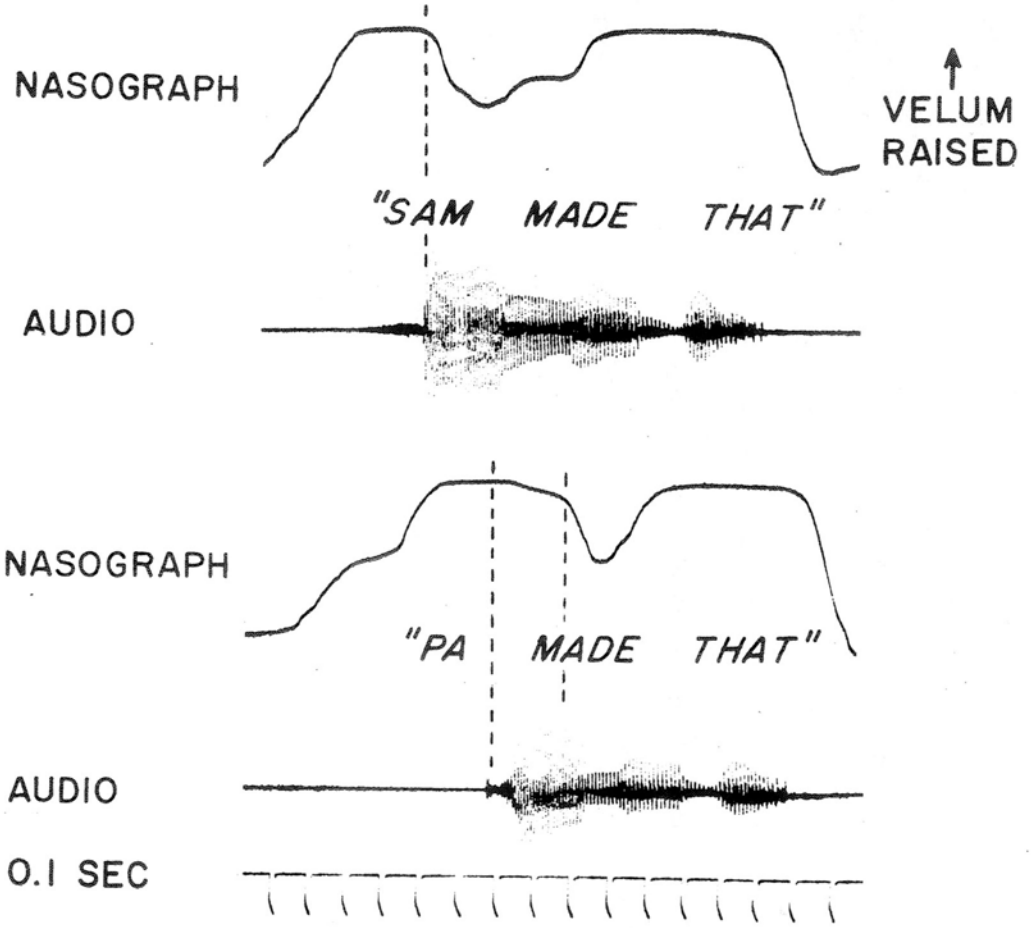
In this slide the two utterances "Pam Pan is here" and "Pam Ban is here" are shown. As expected the velum is raised during the four bilabial stops but opens for the up-coming nasals as soon as these stops are released. This pattern was observed in the previous slides, too, with an exception to be noted.

NEXT SLIDE (#8).



Here the consonants /n/ and /h/ were inserted into the same frame as that used in the previous slide. The velum is, of course, open during the /n/. It also remains open during the glottal fricative /h/. This pattern was also observed during the glottal stop (that is, in a nasalized environment). Evidently a lowered velum in no way interferes with the correct production of these glottal consonants. /l/ and /r/ likewise could tolerate a somewhat lowered palate. The combination /h/ plus low vowel has been observed to give rise to nasalization in many languages, including some Semitic languages in Ethiopia (Hetzron 1969), many in the Lolo-Burmese and Sino-Tibetan families (James Matisoff, personal communication; Matthew Chen, personal communication), not to mention affected British R.P. in which 'half' is sometimes rendered with a nasalized vowel, as in "Meet me in [hɑ̃f] 'n 'our" (pointed out to me by James Matisoff).

NEXT SLIDE (# 9) .



This shows the two utterances "Sam made that" and "Pa made that." I suggested previously that the palate begins to lower for an upcoming nasal consonant as soon as it can. Thus the earliest it can lower for the first nasal /m/ in the first utterance is immediately after the obstruent /s/—and this is what it does. Thus it lowers some 200 msec before the nasal proper. However in the second utterance the first nasal is in the second word and although the velum lowers after the /p/ it seems to lower no more than it ordinarily would for a low vowel. The lowering for the nasal consonant proper seems to start only about 50-60 msec before the nasal. Thus, how soon the anticipatory lowering of the velum begins before a nasal consonant seems to depend on whether a word boundary precedes the nasal. If this observation is correct it contradicts some previous findings of Moll and Daniloff (1968), who claimed the presence of word boundaries makes no difference for this kind of anticipatory lowering of the velum.

LIGHTS.

These findings, which were identical for both of the subjects studied, are, of course, highly tentative, considering the primitive state of development of the nasograph. However, the data do point out areas for further, hopefully fruitful study—and this was all that I hoped to accomplish with the device.

Thank you.

References

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