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VELAR MOVEMENTS DURING SPEECH IN TWO PATIENTS WITH WERNICKE APHASIA

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Speech sound errors exhibited by brain-injured individuals have drawn considerable interest from many researchers. Few studies, however, have been devoted to direct observation of the articulatory gestures of patients with brain damage. As one such attempt, we studied the articulatory movements in a nonfluent speech patient with an anterior lesion diagnosed as having 'apraxia of speech' by means of a fiberoptic technique (Itoh, Sasanuma, and Ushijima, 1979) and a computer-controlled X-ray microbeam system (Itoh, Sasanuma, Hirose, Yoshioka, and Ushijima, 1980a). Apraxia of speech has been defined as "an articulatory disorder resulting from impairment, due to brain damage, of the capacity to program the positioning of speech musculature for the volitional production of phonemes and the sequencing of muscle movements for the production of words" (Darley, Aronson, and Brown, 1975). It is characterized by such clinical features as slow and somewhat effortful speech, inconsistent articulatory errors, difficulty with the transition from syllable to syllable, and prosodic disturbances. Our previous studies have indicated that (1) the mechanism responsible for the organization (or reorganization) of neural commands to the articulators in the patient is not functioning properly, resulting in an articulatory disorder (for which the term or concept of apraxia of speech is appropriate); and that (2) this type of disorder can occur independently of a phonological impairment.

The purpose of this study was to examine the articulatory gestures of the velum in Wernicke type aphasic patients with posterior lesions who were characterized by fluent speech with occasional sound errors, and to elucidate the nature or underlying mechanism of speech sound errors in fluent aphasic patients in relation to those in nonfluent apraxic patients.

1. Method

The subjects were two male patients with Wernicke aphasia, K.K. and N.S. Table 1 summarizes the age, cause of brain damage, site of lesion and post onset time of the patients. Diagnosis of both patients was made based on the overall pattern of their linguistic impairment as revealed by the Test for the Differential Diagnosis of Aphasia. Their linguistic impairment was mild to moderate and characterized by fluent and grammatical speech with occasional sound errors.

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Table 1 *The age, cause of brain damage, site of lesion and post onset time of the two Wernicke aphasic patients in the present study*

Subject	Age (ys)	Cause of Brain Damage	Site of Lesion*	Post Onset Time
K.K.	50	Operational removal of ruptured aneurysm	Posterior region of the temporal lobe of the left hemisphere	1 year, 6 months
N.S.	66	Operational removal of hematoma	Superior temporal gyrus, optic radiation, angular gyrus and corona radiata of the left hemisphere	2 years, 11 months

* Identified by CT scan

The procedure for gathering and analyzing the data was essentially the same as that reported in our previous study of velar movements in a patient with apraxia of speech (Itoh, et al., 1979). Fiberscopic observation of the subjects' velar movements during speech was made according to the procedure developed by Sawashima and Ushijima (1971) and Sawashima, Ushijima, and Hirose (1976). The velar view was photographed with a 16 mm cinecamera at a rate of 50 frames per second with simultaneous recording of the speech signal and synchronization time marks. Oscillographic traces of the speech signal with the time marks were made to obtain the correspondence between the film frames and the speech sounds. The photographed film frames were examined, frame by frame, by means of a motion picture analyzer.

Two kinds of speech materials were prepared: nonsense syllables and meaningful words. The nonsense syllables were /teNteNteNteN/, where /N/ was the syllable final nasal in Japanese. The meaningful words were combinations of the vowel /e/, the nasal sounds /n/ and /N/, or nonnasal consonants: /deenee/, /deedee/, /seeneN/, /teeneN/, /teedeN/, /see'eN/, and /see'ee/. These words were embedded in a carrier phrase of /. . . . . desu/ ("it is . . . . ."). The subjects were requested to read these speech materials at their conversational rate. Both subjects read the nonsense syllables three times and each of the meaningful words in the carrier phrase five times in random orders.

2. Results

2.1 Consistency in the pattern of velar movements

Figures 1 through 3 compare the superimposed patterns of the velar movements for three repetitions of /teNteNteNteN/, and for five repetitions of /deeneedesu/ and /teedeNdesu/, respectively; in K.K. (a), N.S. (b), an apraxic subject (c) and a normal subject (d).[1]

The ordinate gives an arbitrary scale for the velar height and the abscissa the time course. The short vertical bars across the curve indicate the vowel onset or offset, which were obtained from the audio signal. The thick long vertical bars indicate the onset of /e/ after the initial nonnasal consonant, which served as the line-up point for a comparison among the several velar patterns under different phonemic environments.

The figures indicate that in contrast to a marked variability in the apraxic performance in terms of velum height and segmental duration, one of the two Wernicke patients, K.K., exhibited a fairly high degree of consistency throughout the three or five repetitions of nonsense syllables and meaningful words. The performance of the other patient, N.S., however, was somewhat less consistent in comparison with that of the normal subject.

2.2 Coarticulatory patterns of velar movements

The analysis of our previous data from a coarticulatory point of view indicated that anticipatory coarticulation is present in apraxic speech, but some deviation from normal patterns was observed (Itoh, et al., 1979). That is to say, the delay in the anticipatory lowering (opening) of the velum for the nasal in the /CVV'VN/ environment (e.g., /see'eNdesu/), which was observed in the normal's utterances (Fig. 4d), was not evident in the apraxic utterances (Fig. 4c).

As Figs. 4a and 4b show, the anticipatory coarticulatory patterns of both K.K. and N.S. resemble normal patterns. In both of the fluent aphasics' utterances (Figs. 4a and 4b), the velum is kept in a high position in the nonnasal phonemic environment /see'eedesu/, indicated by a dashed line, while for /seeneNdesu/, shown by a solid line, the velar lowering for /n/ starts at a time point around the /s/-/e/ boundary. The delay in the anticipatory velar lowering for /N/ in /see'eNdesu/ (indicated by a dotted line) was also observed in K.K. and N.S. The velar lowering position for /n/ in /seeneNdesu/ in K.K. was relatively high in comparison with that in the other subjects in Fig. 4, but his /n/ production was perceived by the experimenter as being clearly /n/.

2.3 Velar movement patterns during the speech sound error process

One of the two patients, N.S., made several speech sound errors during the experiment, while the other patient, K.K., made only one such error during the experiment. N.S. was well aware of his errors and attempted to correct them immediately. Figs. 5, 6 and 7 depict three such instances. In Fig. 5, N.S. misread /deedee/ as

1. The data for the apraxic and normal subjects were taken from Itoh, et al. (1979).

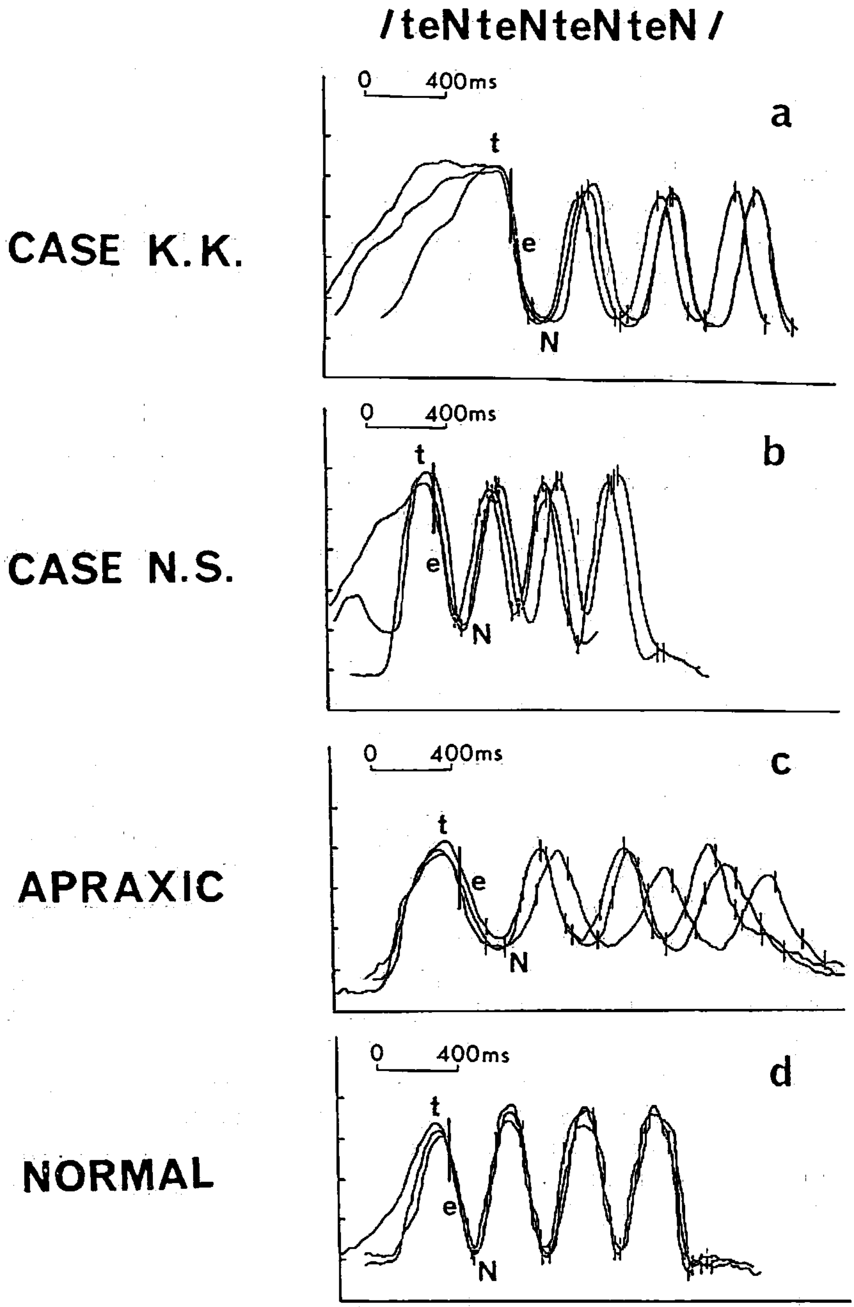

Fig. 1 *Superimposed patterns of the velar movements for three repetitions of /teNteNteNteN/.*

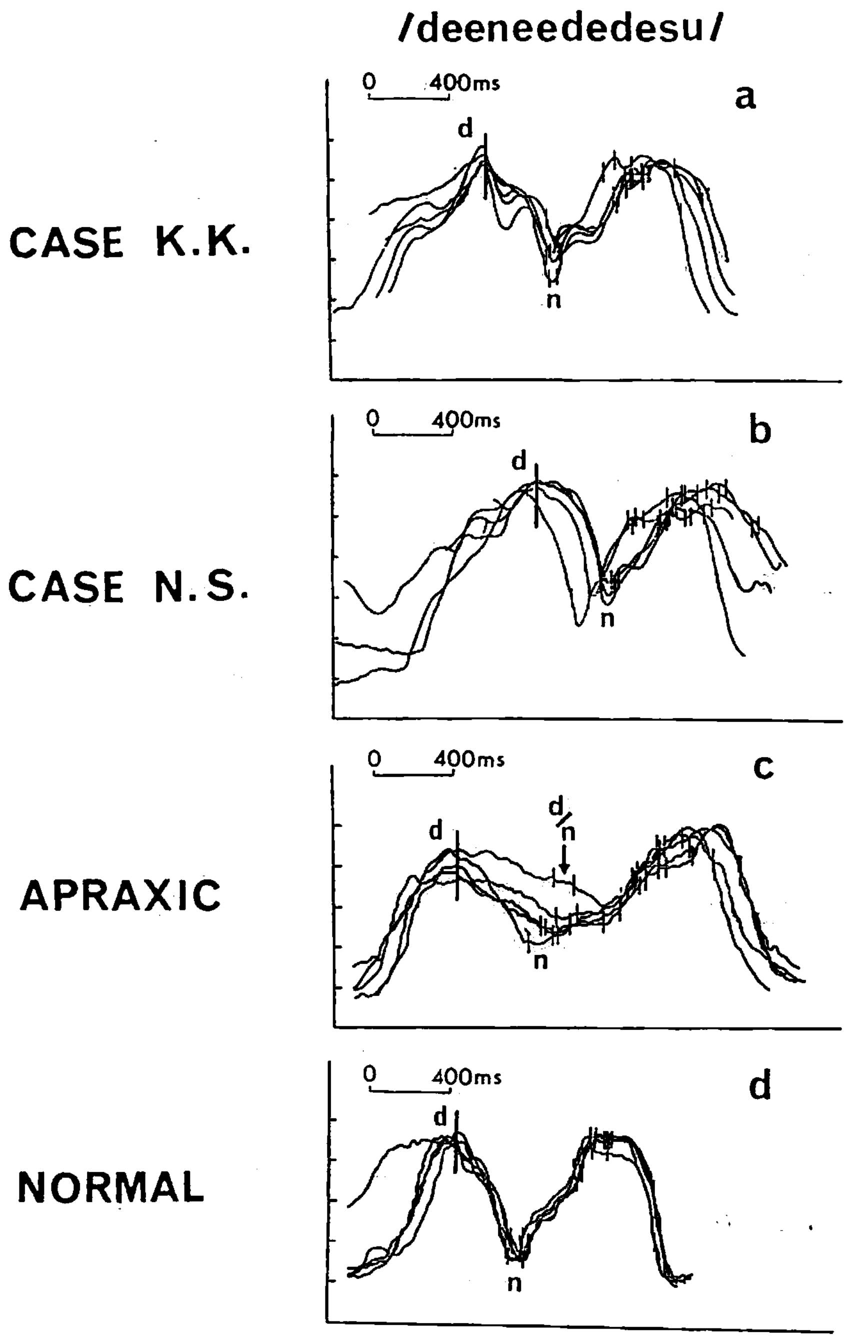

Fig. 2 *Superimposed patterns of the velar movements for five repetitions of /deeneedesu/.*

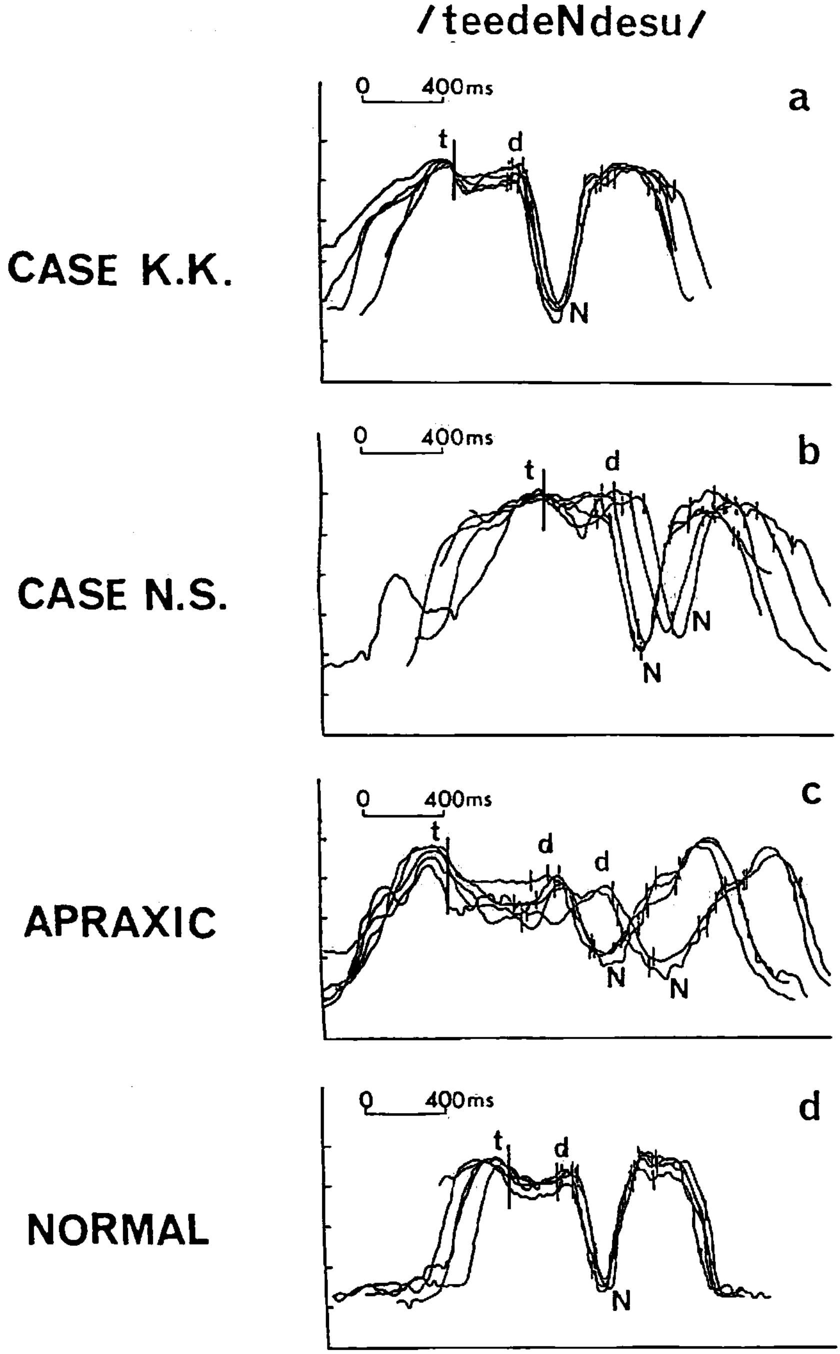

Fig. 3 *Superimposed patterns of the velar movements for five repetitions of /teedeNdesu/.*

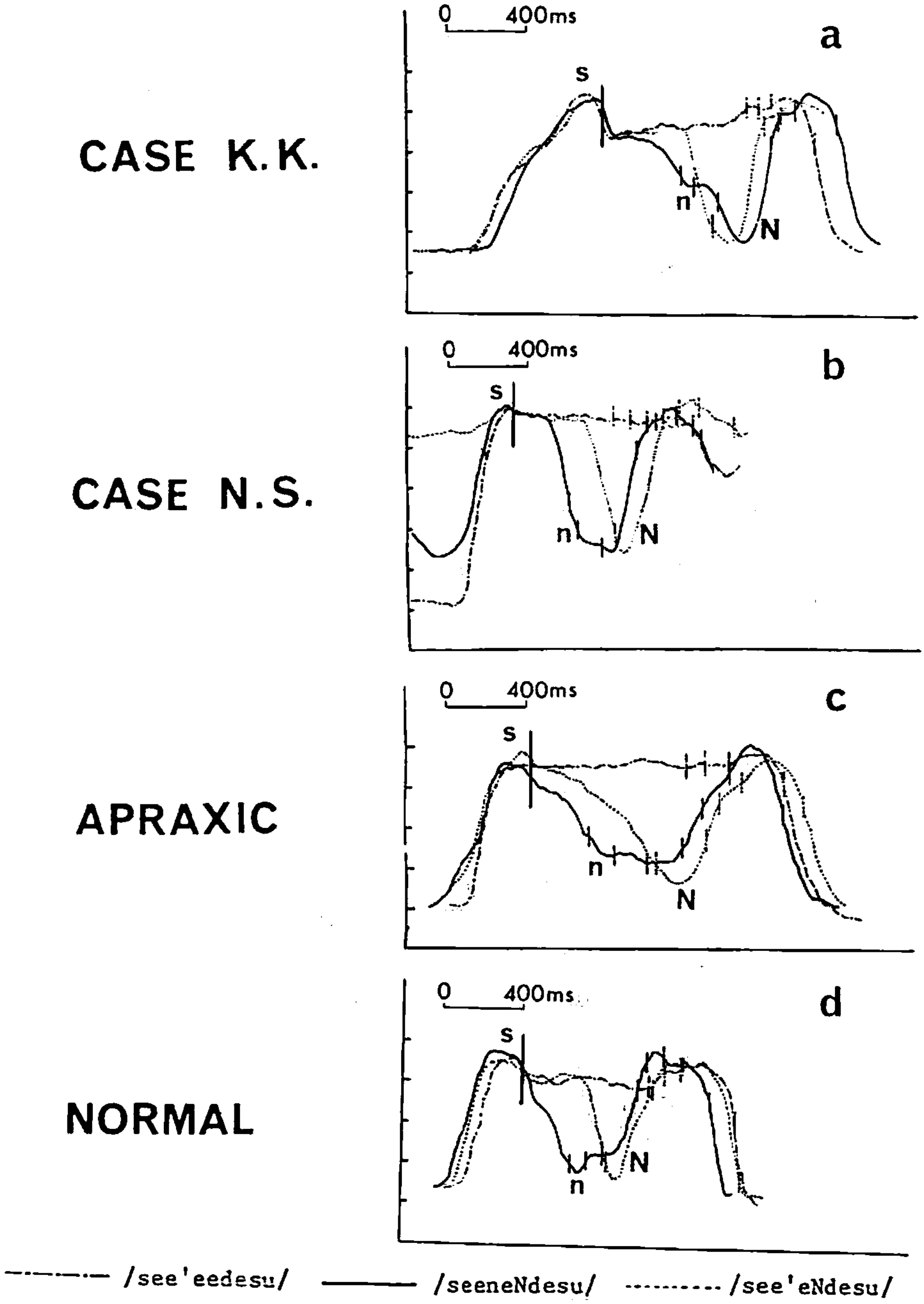

Fig. 4 *Movements of the velum during the production of /see'eedesu/, /seeneNdesu/, and /see'eNdesu/.*

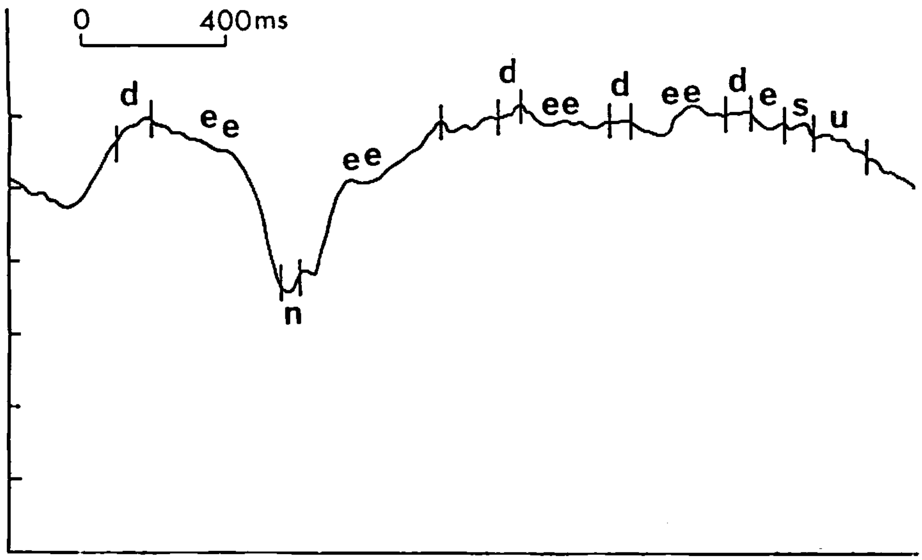

Fig. 5 *Movements of the velum during the phonemic substitution and self-correction process of Case N.S. for /deedeedesu/.*

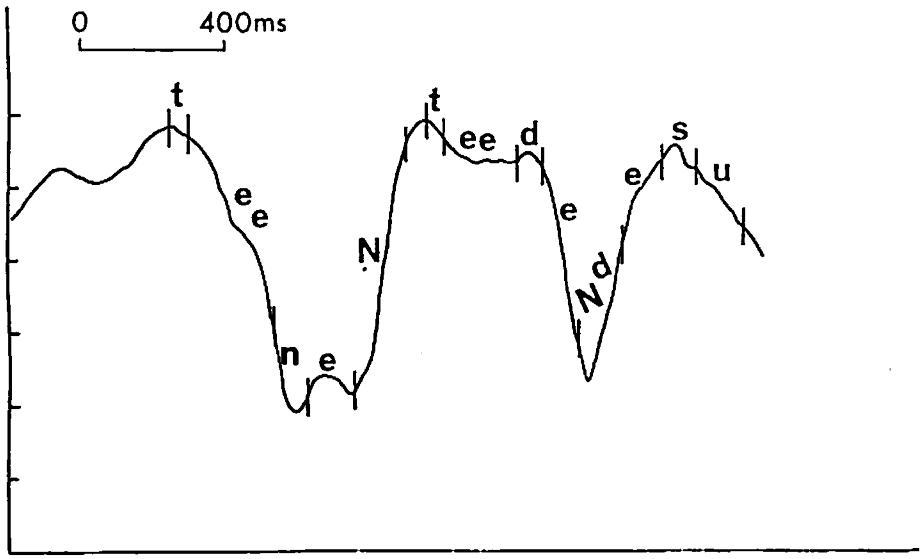

Fig. 6 *Movements of the velum during the phonemic substitution and self-correction process of Case N.S. for /teedeNdesu/.*

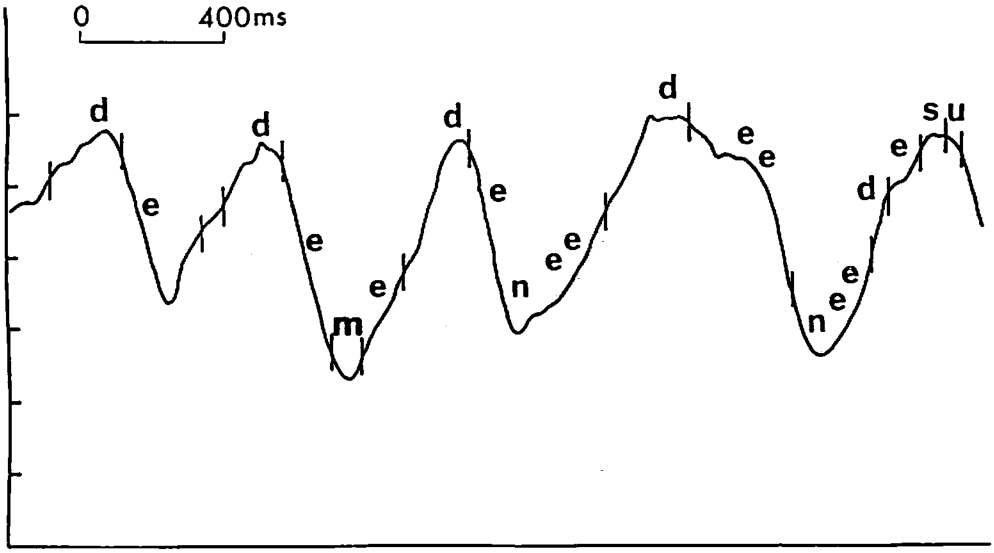

Fig. 7 *Movements of the velum during the phonemic substitution and self-correction process of Case N.S. for /deeneedesu/.*

/deenee/ first and then corrected it. On this occasion, the pattern of the anticipatory velar opening for /n/ occurred immediately after /d/ on the first attempt, but at the second attempt the velum was been kept in a high position because of the nonnasal phonemic environment /deedeedesu/. Fig. 6 shows another example of this kind of phenomenon. In this case, N.S. misread /teedeN/ as /teeneN/ and immediately corrected it. Fig. 7 depicts his struggle to get the correct sound sequence /deeneedesu/. On this occasion, the pattern of anticipatory velar opening occurred immediately after /d/ throughout his attempt, which is indicative of his constant search for a nasal sound.

K.K.'s only error was his misreading of /teeneN/ as /teenee/. K.K. was not aware of his error and consequently did not correct it. His velar movement patterns for /teeneNdesu/ as well as for /teeneedesu/ are shown in Fig. 8. It appears that the two patterns are quite different. That is, in /teeneedesu/ (Fig. 8a) the velar movement pattern is characterized by an anticipatory velar lowering for /n/ after the initial /t/, followed by a gradual elevation for /desu/. On the other hand, in /teeneNdesu/ (Fig. 8b) the velar elevation for /e/ after /n/ is not so obvious but the velum further descends for /N/, followed by an abrupt elevation for /desu/.

3. Discussion

The present study revealed that one of our two patients with Wernicke aphasia, K.K., exhibited a fairly high consistency in velar movement patterns over three or five repetitions of a given sequence of sounds, which is in sharp contrast to the marked variability observed in the apraxic performance. Although the performance of the other patient, N.S., was somewhat variable in comparison with the consistency of normal performance, the variability in N.S.'s performance in terms of velum height and segmental duration was not large enough to result in any

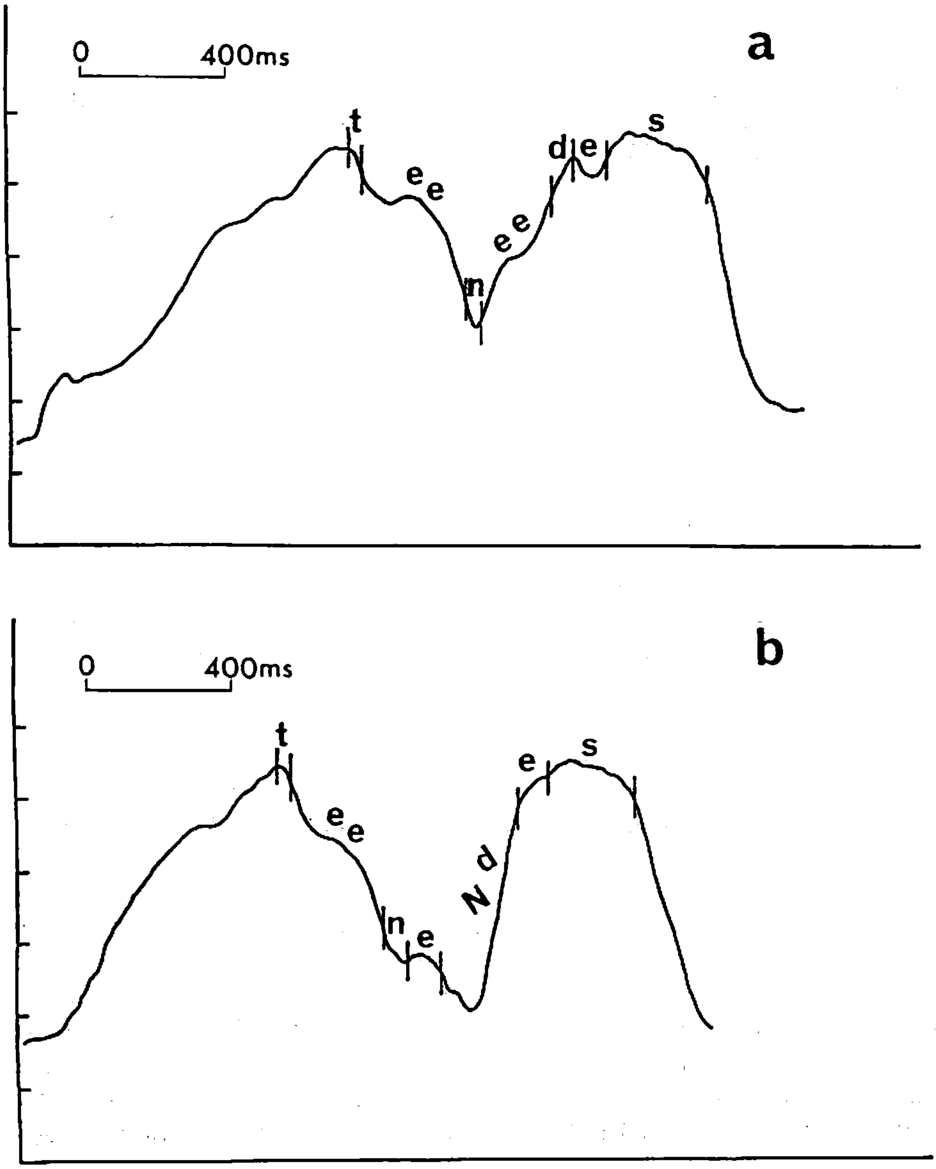

Fig. 8 *The pattern of the velar movements in Case K.K. for /teeneedesu/ (top) and for /teeneNdesu/ (bottom).*

phonetic changes. A possible reason for the variations in N.S.'s performance will be discussed later.

Furthermore, throughout this experiment there was no single occasion of any phonetic changes indicative of some difficulty in the process of motor programming for speech for either of the two patients. We often observed such phonetic changes in apraxic production during our previous experiments (Itoh, et al., 1979; 1980a). It was also found that both of the fluent aphasic patients exhibited a normal pattern for anticipatory coarticulation.

Then, what is the underlying mechanism responsible for the speech sound errors in fluent aphasic patients?

In order to determine the nature of the speech sound errors in fluent aphasic patients, we looked at the velar movement patterns during the speech sound error processes of N.S. and K.K. The results revealed an interesting fact. For example, when N.S. misread /deedee/ as /deenee/ and then corrected it, the pattern of the anticipatory velar lowering for /n/ occurred immediately after /d/ on the first attempt but on the second attempt the velum was kept in a high position due to the nonnasal phonemic environment /deedeedesu/ (Fig. 5). It should be pointed out here that the pattern of the velar movement on his first attempt was identical with the velar movement pattern for /deeneedesu/ in his correct utterances (Figs. 2b and 7). This result clearly indicates that the sound change from /d/ to /n/ on his first attempt was due to a selection or retrieval error of a target phoneme in the process of speech production. Another example of speech sound errors shown in Fig. 6 can also be interpreted as an indication of a selection or retrieval error of a target phoneme, since the observed velar patterns of the first and second attempts were essentially different in terms of their anticipatory velar opening. Some hesitation in articulatory movements may occur in the process of searching for a target phoneme (cf. Fig. 7). Such hesitation would occur even when a target phoneme is correctly selected. This could be a possible reason for the variations in N.S.'s performance. The analysis of a single instance of K.K.'s speech sound errors in terms of velar movement patterns also indicated that this error was due to a selection or retrieval error of a target phoneme (Fig. 8).

These results can be interpreted as indicating that the mechanism responsible for the organization (or reorganization) of neural commands to the articulators in K.K. and N.S. is functioning properly. This observation is in accord with the results of our comparison of voice onset time characteristics in apraxic speech with those in fluent (both Wernicke and conduction) aphasic speech (Itoh, Sasanuma, Tatsumi, Hata, Fukusako, and Suzuki, 1980b; Itoh, Sasanuma, Tatsumi, Murakami, Fukusako and Suzuki, in press).

Thus, these results reconfirm our hypothesis that the nature or underlying mechanism of speech sound errors in fluent aphasic patients is different from that in nonfluent apraxic patients (Itoh, et al., in press; Monoi, Fukusako, Itoh, and Sasanuma, in preparation). That is, the analysis of the velar movement patterns of our two Wernicke aphasic patients suggests that the speech sound errors exhibited by them are not attributable to any impairment at the level of articulatory programming, but to an impairment at another level of the speech production process such as the level of phonological processing (phoneme selection or retrieval).

4. Summary

The articulatory gestures of the velum in two fluent (Wernicke) aphasic patients were examined to compare their performances with those of an apraxic patient by means of the fiberoptic technique. In contrast to the marked variability in the apraxic performance in terms of velum height and segmental duration, the two fluent aphasic subjects showed a relatively high degree of consistency in velar movements through several repetitions of nonsense syllables and meaningful words. In addition, both patients exhibited a normal pattern of anticipatory coarticulation. Analyses of the velar movement patterns during the speech sound error processes of both patients suggested that these errors were not due to an impairment at the level of articulatory programming but to an error in the selection of a target phoneme. Based on these results, it was concluded that the nature of speech sound errors in fluent aphasic patients is different from that in nonfluent apraxic patients.

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References

Darley, F.L., A.E. Aronson, and J.R. Brown (1975); Motor speech disorders. Philadelphia: Saunders.

Itoh, M., S. Sasanuma, and T. Ushijima (1979); Velar movements during speech in a patient with apraxia of speech. Brain and Language, 7, 227-239.

Itoh, M., S. Sasanuma, H. Hirose, H. Yoshioka, and T. Ushijima (1980a); Abnormal articulatory dynamics in a patient with apraxia of speech: X-ray microbeam observation. Brain and Language, 11, 66-75.

Itoh, M., S. Sasanuma, I.F. Tatsumi, S. Hata, Y. Fukusako, and T. Suzuki (1980b). Voice onset time characteristics of apraxia of speech, Part II. Annual Bulletin, Research Institute of Logopedics and Phoniatrics, University of Tokyo, 14, 273-284.

Itoh, M., S. Sasanuma, I.F. Tatsumi, S. Murakami, Y. Fukusako, and T. Suzuki. Voice onset time characteristics in apraxia of speech. Brain and Language (in press).

Monoi, H., Y. Fukusako, M. Itoh, and S. Sasanuma. Speech sound errors in conduction and Broca's aphasics (submitted to Brain and Language).

Sawashima, M., and T. Ushijima (1971); Use of fiberscope in speech research. Annual Bulletin, Research Institute of Logopedics and Phoniatrics, University of Tokyo, 5, 25-34.

Sawashima, M., T. Ushijima, and H. Hirose (1976); Movements of the velum in speech articulation. Transactions of the Committee on the Speech Research, Acoustical Society of Japan. S75-56, (in Japanese).