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AN ELECTROMYOGRAPHIC STUDY OF THE KINKI ACCENT*

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Abstract

The Kinki dialect has a variety of accent types in comparison with the Tokyo dialect. In some accent types, there is an ascending or descending tone even within a mora. These accent types in the Kinki dialect are divided into high-start and low-start groups. In order to investigate the physiological characteristics of the accent types, a laryngeal electromyographic study was made on three native speakers of the Kinki dialect.

The results with these two subjects showed that an increase in sternohyoid activity associated with decreasing cricothyroid activity presented a good correspondence with the descending F_0 contour in the accent types with a descending tone. Sternohyoid activity was also clearly observed preceding the onset of voicing in the low-start group. The difference between low-start and high-start groups was presumed to be based on the physiological adjustment of the larynx prior to initiation of voicing.

1. Introduction

Although laryngeal electromyographic studies on Japanese word accent have so far been almost exclusively reported using the Tokyo accent,[1)-5)] investigations on the Kinki accent are considered to be equally important and profitable.

The Kinki dialect had long been the normative dialect of Japanese, and its accent pattern is the only one that can be traced back to the 11th century if we refer to the existing ancient literature and dictionaries using the accent marks of those days.[6)] Dialectal studies have indicated that the Kinki dialect can be the basis for a diachronic and synchronic study of Japanese accent. Moreover, it has a variety of accent types compared to the Tokyo dialect which is often considered to have been derived from the Kinki dialect.[6), 7)] Some of the Kinki accent types are peculiar in that they have a tone change even within a mora. Conventionally, the Kinki accent types are divided into two groups, "high-start" and "low-start".[8)] The feature "high" or "low" is maintained even in contexts.

Acoustic investigations on the Kinki accent have been made by one of the authors and others,[9), 10)] and preliminary studies were also made by the present authors to investigate the physiological correlates of the acoustic features in the Kinki accent.[11)-13)] This paper will report on further results of the physiological studies based on EMG data obtained from three speakers of the Kinki dialect. One particular aim of the present study is to investigate laryngeal control in the production of one and two-

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mora words in different types of the Kinki accent. Another aim is to clarify whether there exist any physiological mechanisms differentiating the low-start group from the high-start group.

2. Characteristics of the Kinki Accent

There are four different accent types in two-mora words of the Kinki dialect. Conventionally and in this paper as well, they are called type A, B, C, and D. The classification is based on the pitch contour of two-mora words.[10] Table 1 shows the four types of accent with some sample words.

Table 1. Kinki accent types

type of accent			words		
type A	$\overline{\text{O}}\text{O}$	(HL)→ $\overline{\text{O}}\,\text{O}\,\triangleright$	kaki (fence)	haʃi (bridge)	hana (flower)
type B	$\text{O}\overset{\searrow}{\text{O}}$	(LHL)→ $\text{O}\,\overline{\text{O}}\,\triangleright$	kaki (oyster)	ame (rain)	haru (spring)
type C	$\text{O}\overline{\text{O}}$	(LH)→ $\text{O}\,\text{O}\,\overline{\triangleright}$	kata (shoulder)	haʃi (chopsticks)	ito (string)
type D	$\overline{\text{O}\text{O}}$	(HH)→ $\overline{\text{O}\,\text{O}\,\triangleright}$	kaki (persimmon)	ame (candy)	haʃi (edge)

O: one-mora of words

$\triangleright$: one-mora particle ("ga" or "wa")

Types A, $\overline{\text{O}}\text{O}$ (high-low), and D $\overline{\text{O}\text{O}}$ (high-high) belong to the high-start group, while types B, $\text{O}\overset{\searrow}{\text{O}}$ (low-high-low), and C $\text{O}\overline{\text{O}}$ (low-high) belong to the low-start group.*

An acoustic analysis of one- and two-mora words of the Kinki dialect was made by adopting a model proposed by Fujisaki and Sudo.[15] The results indicated that the difference between the high-start and low-start groups depends on the difference in the timing of the onset of the accent command. In words of the high-start group, the onset of the accent command precedes the onset of voicing, while in the low-start group it falls in the vicinity of the onset of the second mora.[10]

*There still is no unanimous agreement on the concept of a two-way classification for the Kinki accent types. One of the leading phonological studies of Japanese accent[14] claims that the accent types of certain words should be discussed only in relation to preceding words. It further claims that those words of the so-called low-start group have "falls of accent" or descent in voice pitch immediately before the words, while those of the high-start group do not. However, even with this description, the features of high or low-start in the Kinki dialect is still obscure.

3. Experimental Procedure

3.1. Subjects and Test Words

The subjects for this study were three female native speakers of the Kinki dialect, Y.I., M.M., and S.S., in their twenties. Y.I. with experience in speech studies pronounced the Kinki accent with confidence. M.M. became rather nervous and strained during the experimental session trying not to misread the accent of the words in the list. Both Y.I. and M.M. were born and brought up in Osaka City. S.S. was from Yao City in Osaka Pref. She pronounced the test words with a higher voice pitch than usual. One of the authors found later that when she is strained, she has tendency toward sticking her chin up in raising the pitch, and drawing it down in lowering the pitch. She is very likely to have moved her chin in the same fashion during the experiment.

The subjects read the randomized lists of words in Table 2, and sentences containing the same test words, twelve times each.

Table 2. Test words used in the present experiment

type of accent	two-mora words		one-mora words	
A	imi (meaning)	iki (spirit)	e (bait)	i (stomach)
B	imi	iki (chic)		
C	imi	iki (breath)	e (picture)	i (nonsense word)
D	imi	iki (going)	e (handle)	i (well)

3.2. Recording and Processing of Laryngeal Electromyography

Electromyographic (EMG) recordings were made from the lateral cricoarytenoid (LCA), cricothyroid (CT), and sternohyoid (SH) of the subject Y.I., and from the CT and SH of the other subjects, M.M. and S.S.

Conventional hooked-wire electrodes were used, which were inserted into the muscles through the skin using a method previously reported.[2] The EMG signals were recorded on a multi-channel FM data recorder together with the acoustic signals. The signals were then reproduced and computer-processed using a data processing system described in detail elsewhere.[2] To obtain an averaged pattern for a given test word or sentence, the EMG signals were rectified, integrated and averaged with reference to a predetermined time point on the acoustic signal, the voice onset or the end of the first vowel. In order to investigate the EMG pattern of a single token, the wave form of integral calculus, taken from an appropriate sample was smoothed by steps of 50-90 msec to give a time varying curve.

3.3. Acoustic Data Processing

Narrow band sound spectrograms were obtained from the acoustic samples recorded simultaneously with the EMG, and the time varying F_0 contours were obtained.

4. Results and Discussion

Fig. 1 shows the EMG pattern of the three laryngeal muscles in Y.I. for a single token of each of the four accent types of /imi/ together with the envelope of the speech signal. The F_0 contour is also shown in the uppermost part with arrows indicating the onsets of raising (↑) and lowering (↓). A vertical line shows the voice onset of the utterance. The activity of the LCA begins about 200 - 300 msec before the onset of voicing, and continues until the end of the utterance. The LCA activity may be regarded as a response to the neural command of voicing. The temporal course of the EMG curves of the CT and SH appear to correlate with the F_0 contour. In the case of type A of the high-start group, CT activity starts prior to the voice onset, and increases sharply to reach its peak. The activity then rapidly declines after the peak, approximately 100 msec prior to the onset of the descent in the F_0 contour.

Thus, the decrease in CT activity appears to correspond with the pitch lowering. Prior to the cessation of CT activity, SH activity begins to increase. The SH peak occurs about 140 msec later than that of the CT, and about 20 msec later than the onset of the lowering of F_0. It seems reasonable to conclude that SH activity is related to the sharp descent in the F_0 contour of type A. As for type D of high-start group, the activity of the CT prior to the voice onset is also present, but less marked than in type A. CT activity then gradually decreases toward the end of the utterance. There is no apparent activation of the SH in type D.

In the case of types B and C of the low-start group, definite activation of the SH prior to the voice onset was observed. This finding suggests that the role of the SH in pitch lowering is not only subsidiary to the decrease in CT activity, but also active with regard to the onset of voicing of low-start accent types. As for type B, the SH begins to be active about 300 msec prior to the voice onset, while CT activity begins to increase before the cessation of SH activity. The CT peak is at about 30 msec later than the onset of the rise in F_0, and at about 100 msec prior to the peak of the F_0 contour. The SH again becomes very active at about the CT peak, presenting another peak when the CT activity begins to decrease. SH activity rapidly decays after the peak which is at about 20 msec later than the onset of descent in F_0. The timing patterns of these two muscles seem to correlate with a sharp descent in the F_0 contour of type B.

In type C, the activity of the SH starts earlier than in type B. CT activity begins to increase after the decrease in SH activity, but it is not so marked as in type B. SH activity does not increase again even after CT activity gradually decays towards the end of the utterance.

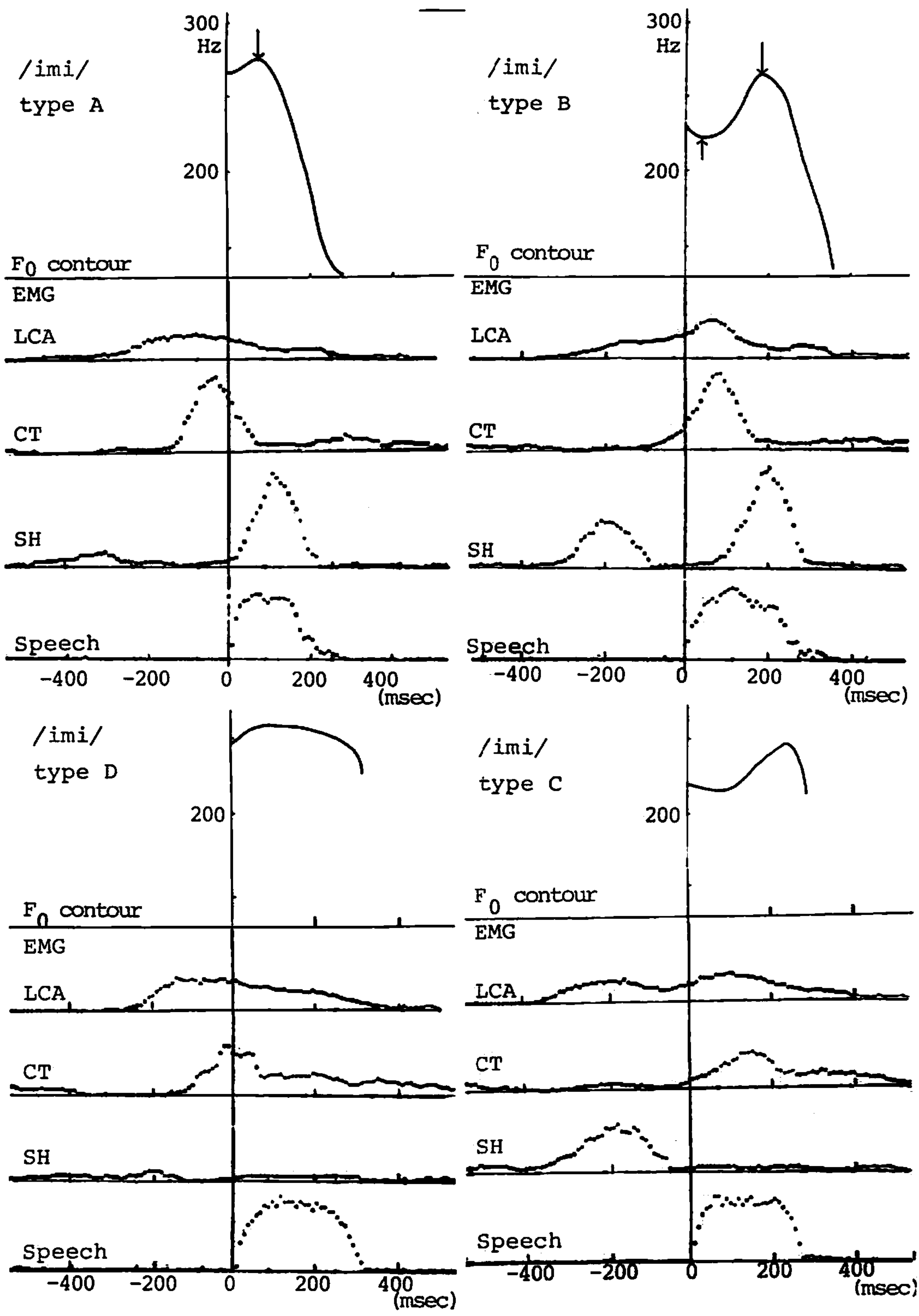

Fig. 1. The EMG patterns, speech envelope and F_0 contour for a single token, /imi/, with each accent type (subject Y. I.).

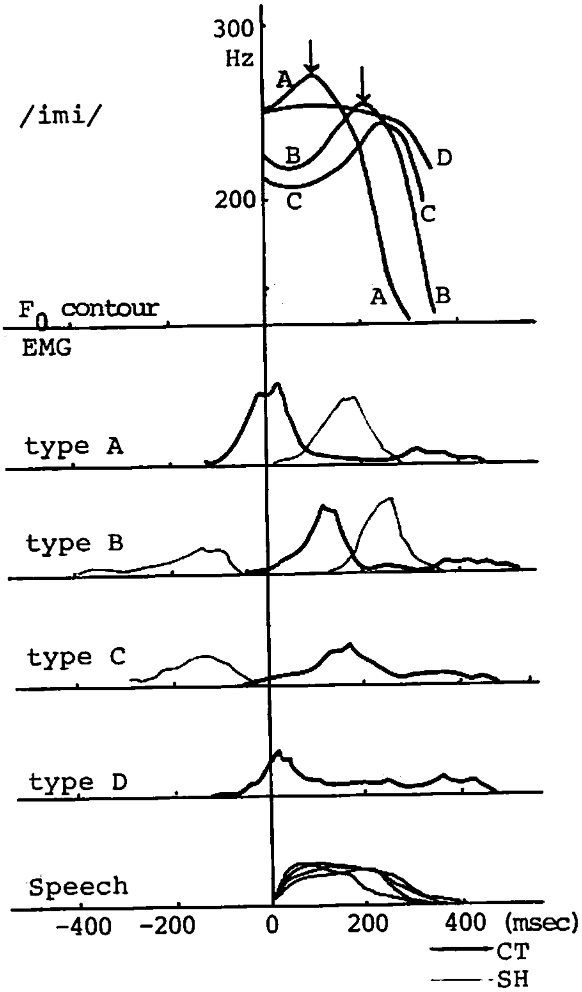

Fig. 2. Averaged EMG patterns, speech envelopes and F_0 contours for /imi/ with four accent types (subject Y. I

Fig. 2 shows the averaged EMG activities of the CT and SH for /imi/ in the four different accent types obtained from the same subject Y. I. The envelopes of the CT (the thick line) and the SH (the thin line) of each accent type are superimposed on the same horizontal axis. The F_0 contours are also averaged. The temporal patterns of the two muscles are essentially quite similar to those presented in Fig. 1.

One-mora words, /e/ and /i/, with three accent types (type A, C and D) were also studied. Fig. 3 presents the averaged EMG patterns, speech envelopes and F_0 contours of Y. I.'s /i/ with three accent types.

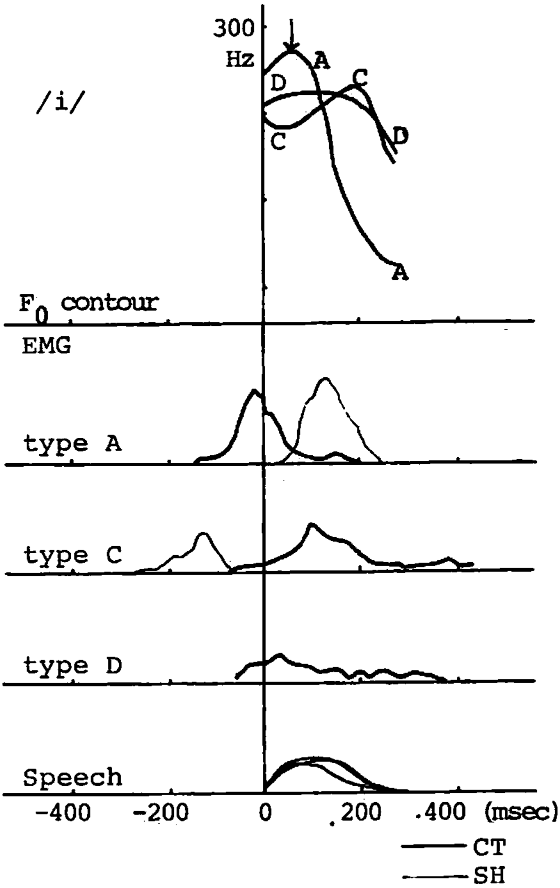

Fig. 3. Averaged EMG patterns, speech envelopes and F_0 contours for a one-mora word, /i/, with three accent types (subject Y. I.).

Only type C here belongs to the low-start group as a one-mora word. It can be seen that the activity pattern of each muscle in the three accent types resembles that of /imi/. In type A the interval of the CT peak and SH peak is shorter and the amplitude of SH activity in /imi/ shown in Fig. 2. These timing relations for both muscles and the large amplitude of SH are presumed to be prerequisite for a very sharp descent in the F_0 contour of /i/.

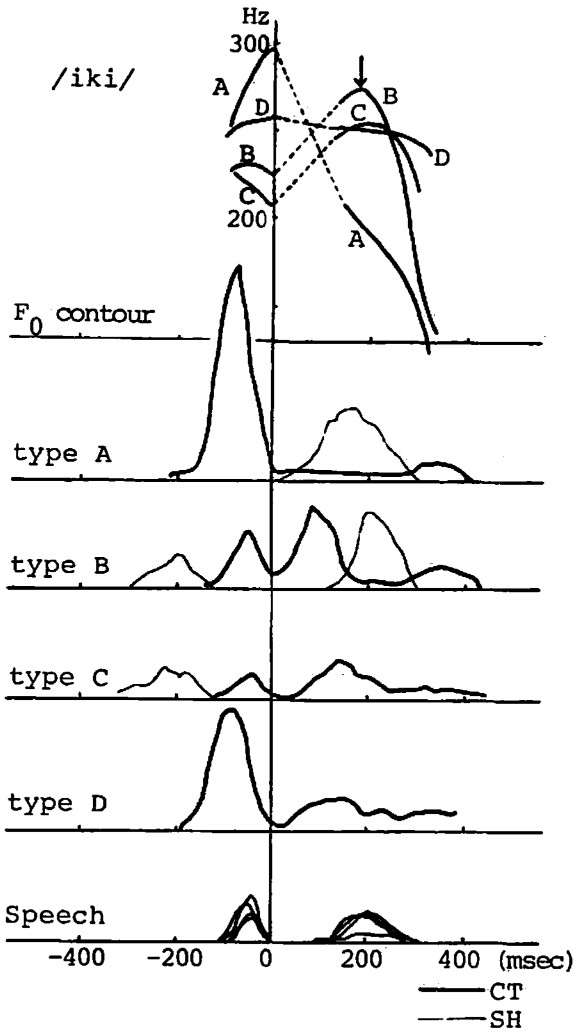

Fig. 4. Averaged EMG patterns, speech envelopes and F_0 contours for /iki/ with four accent types (subject Y. I.).

Fig. 4 presents the averaged EMG patterns of Y. I. 's /iki/ in the four accent types. Dotted lines in the F_0 contours show the voiceless portion, each of which simply connects the F_0 values at the end of the first vowel and the onset of the second vowel. A thick vertical line indicates the end of the first vowels, which was taken to the line-up for averaging. In the case of /iki/, the CT activities appear to differ from those in /imi/ and /i/. In type A the peak amplitude of CT activity is extremely large, and in types B and C CT activity presents two peaks. In type D, a large CT peak is followed by another small, dull peak. These different patterns of CT activity in the production of /iki/ are considered to be due to the existence of the consonant /k/. As for the SH, the activity patterns are similar to those shown in Figs. 1 - 3, i.e., it becomes active after the CT peak in types A and B, while its activity starts before the voice onset in types B and C.

In order to observe the effects of /k/ on CT activity, the CT curves for the four accent types of /iki/ are superimposed on the same horizontal axis in Fig. 5. In addition, the SH activities and speech signals are also presented. It can be seen that, regardless of the difference in the accent types, CT activity decays in the vicinity of the vertical line, which again indicates the end of the first vowel of each word. The decay can thus be regarded as CT suppression for the production of the voiceless consonant /k/. The patterns of the CT for the four accent types are quite similar before the vertical line. In particular, CT activity for types A and D begins and ends with almost the same timing, suggesting that it is related to the F_0 rise in the first vowel. Since the F_0 value of type A is observed to be higher than that of type D towards the end of the first vowel, the apparent difference in the height of CT peaks between types A and D is assumed to be related to the difference in F_0 values. The first vowel of

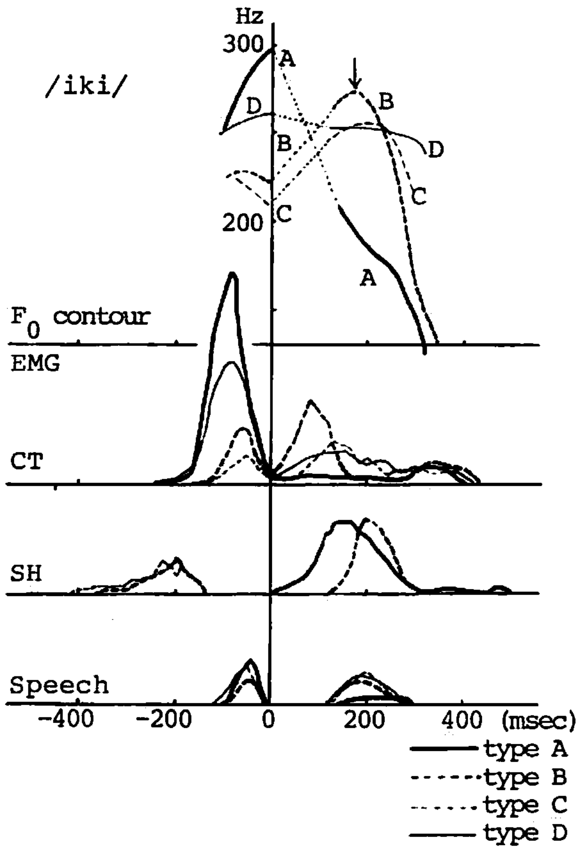

Fig. 5. Averaged EMG patterns, speech envelopes and F_0 contours for /iki/ with four accent types superimposed (subject Y. I.).

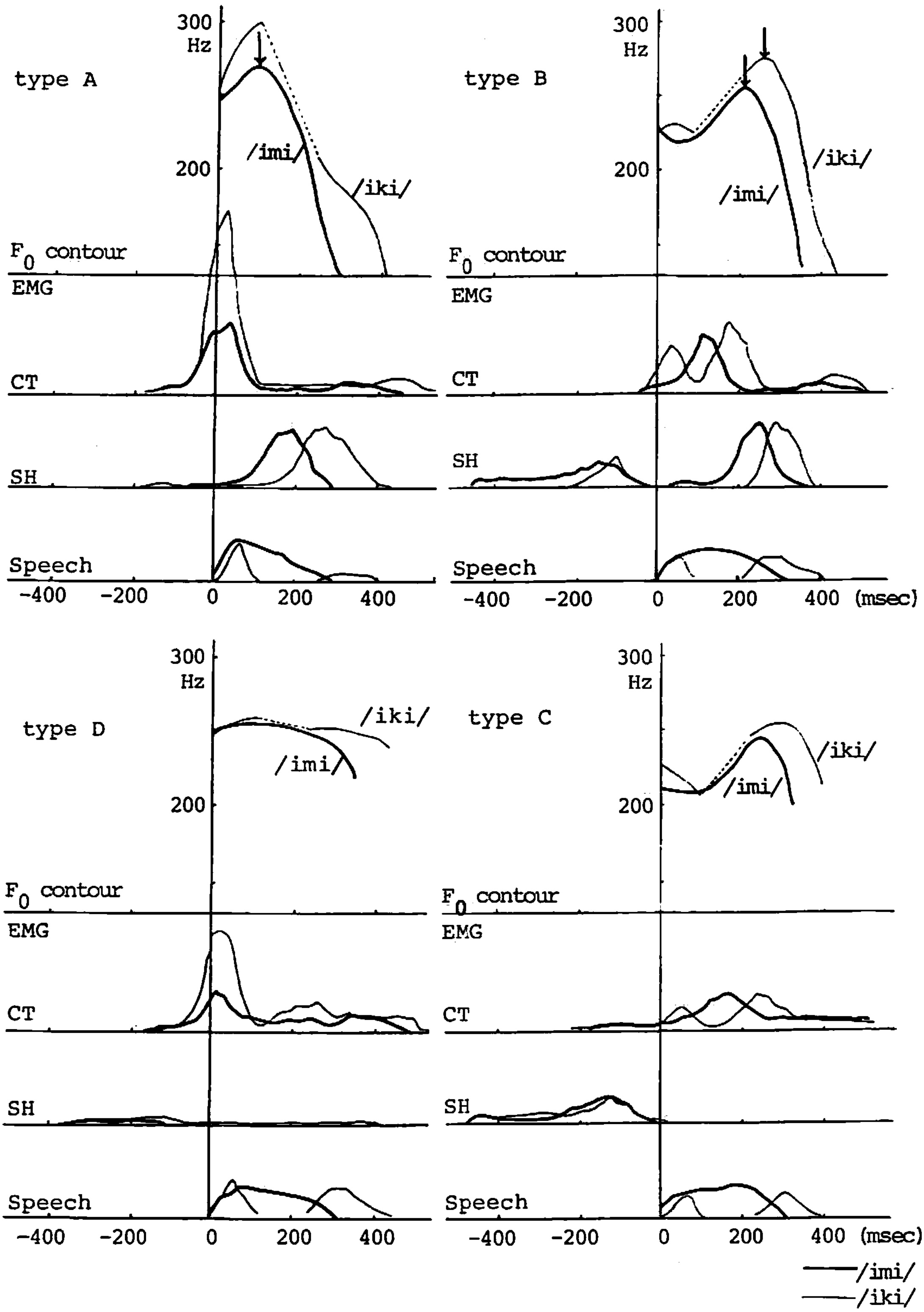

Fig. 6. Averaged EMG patterns, speech envelopes and F_0 contours for /imi/ and /iki/ (subject Y. I.).

types B and C starts low, and the first peak of CT for types B and C appears to have nothing to do with the raising of F_0.

To examine the effects of /k/ more precisely, the CT and SH activities for /iki/ are compared to those for /imi/ in Fig. 6. In type A, there is a considerable difference in the amplitude of CT activity between /iki/ and /imi/. The timing of CT activity for both types is similar, but the SH activity for /iki/ starts considerably later than that for /imi/. The difference is considered to correlate with the duration of both words, since the averaged duration of type A /iki/ is about 430 msec, about 110 msec longer than that of /imi/.

In type D, the effect of /k/ upon the CT signal is clearly observed. As the F_0 values of both words are similar, a larger amplitude of CT activity for /iki/ can be regarded as an effect of the presence of /k/. This seems to hold true in type A, as well. As for the type B of /imi/, the second CT peak is 120 msec later than the voice onset. As the onset of F_0 lowering is 220 msec later than the voice onset, the onset of F_0 lowering in delayed 100 msec behind the CT peak, while in type B of /iki/ the difference between the second CT peak and the onset of F_0 lowering is 97 msec. Both values are very similar.

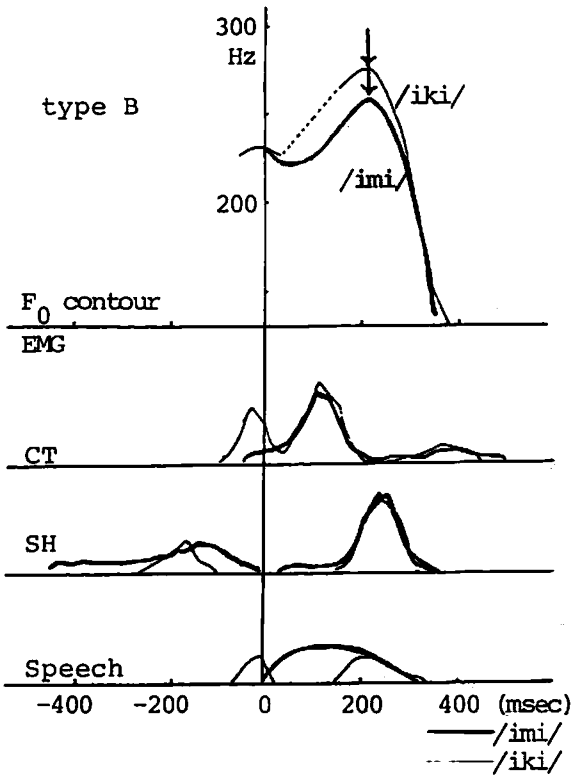

Fig. 7. EMG patterns, speech envelopes and F_0 contours for type B of /imi/ and /iki/ (subject Y. I.). The curves are superimposed with reference to the onset of F_0 lowering on the time axis.

In Fig. 7, temporal adjustment is made so as to make the timing for F_0 lowering coincide between /imi/ and /iki/ of type B. In this figure the activity patterns of SH and CT (the second peak) stand at just the same timing. This figure indicates that the steep decrease in CT activity and the subsequent SH activation are essential correlates for the rapid downward transition of F_0 in /imi/ as well as in /iki/.

In the case of subject Y. I., the relation between the EMG patterns and F_0 contours so far described were also observed in the rest of the experimental materials including the words embedded in the carrier.

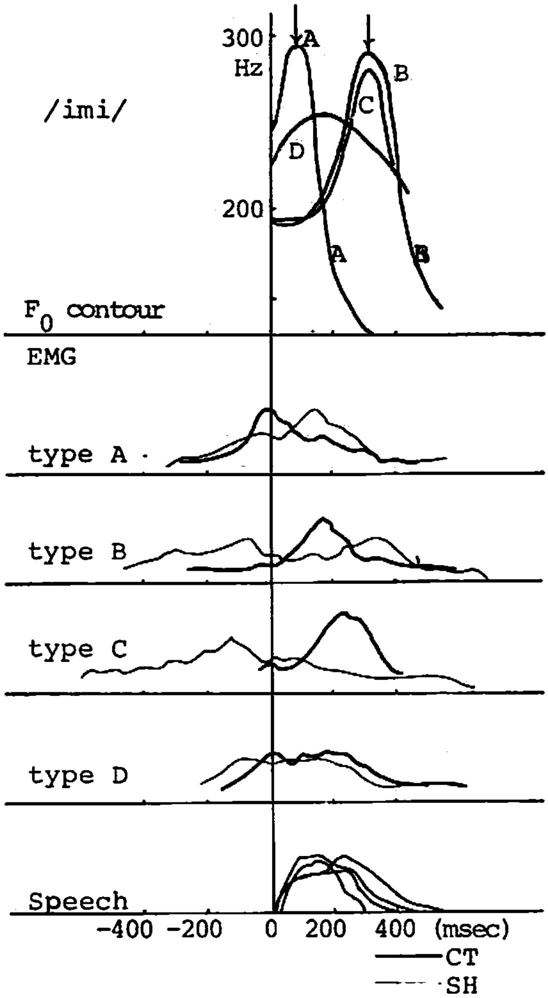

Fig. 8. Averaged EMG patterns, speech envelopes and F_0 contours for /imi/ (subject M. M.).

Fig. 8 shows the EMG patterns of M. M.'s /imi/. The SH activity is also observed before the voice onset in types B and C. In this subject, the activity pattern of each muscle generally correlates with the F_0 contour as observed in subject Y. I.

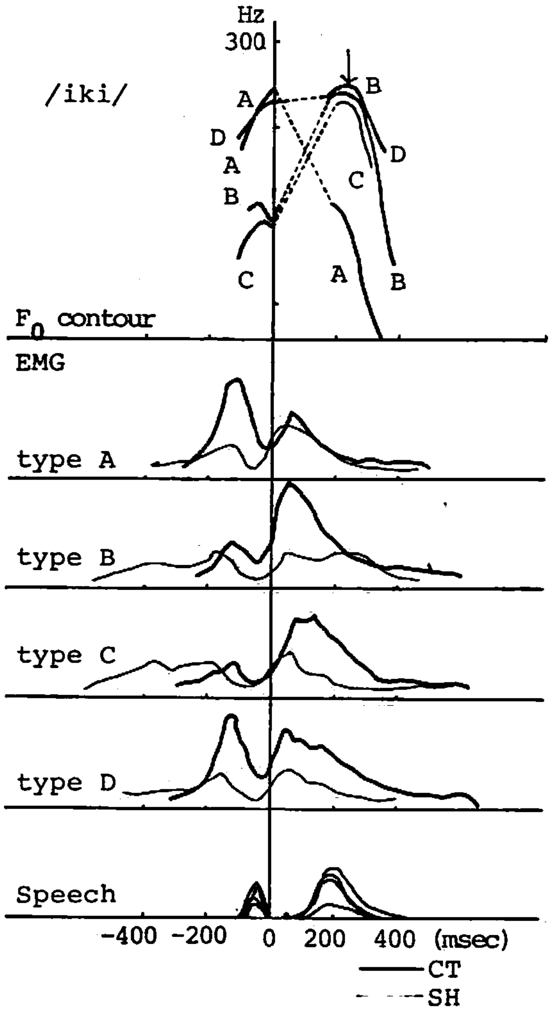

Fig. 9. Averaged EMG patterns, speech envelopes and F_0 contours for /iki/ (subject M. M.).

Fig. 9. shows the EMG patterns of M. M.'s /iki/. The EMG patterns of the CT show two peaks, though they are not so remarkable as those of subject Y. I. The higher peak of CT activity in types A, B and C correlates with the F_0 rise as do the two peaks in type D with a high level tone. SH activity seems to correlate with F_0 lowering, but other factors such as the tongue lowering for /k/ release are also to be taken into consideration. SH activity is also observed before the onset of voicing in the low-start group.

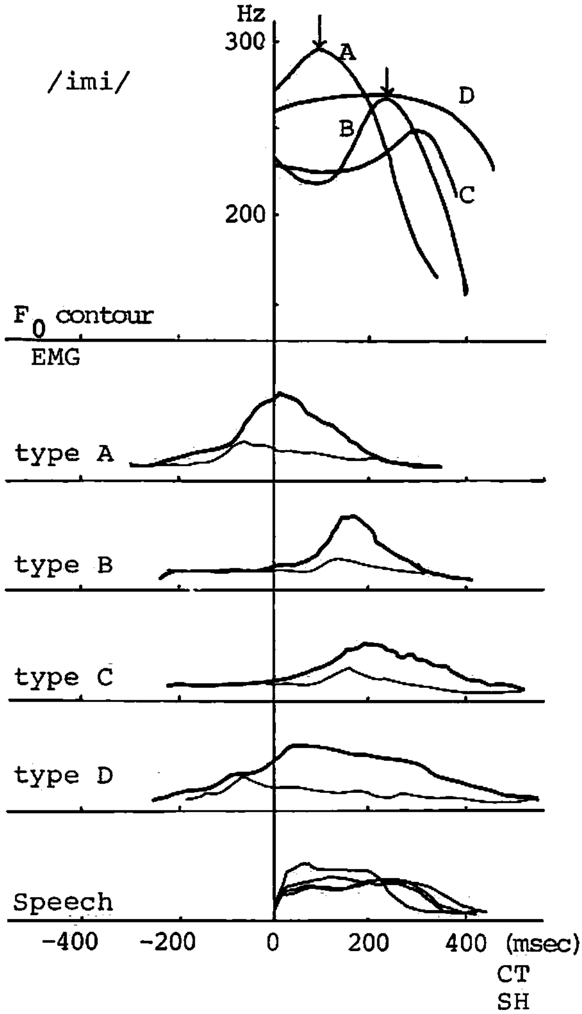

Fig. 10. Averaged EMG patterns, speech envelopes and F_0 contours for /imi/ (subject S. S.).

Fig. 10 shows the averaged EMG patterns of /imi/ obtained from subject S. S. The relation between F_0 rise and CT activity was clearly observed. However, the pattern of SH activity was rather equivocal.

In the case of S. S.'s /iki/ shown in Fig. 11, the ascent and descent in the CT activity also correlate with the raising and lowering of F_0. SH activity again does not correlate with F_0 lowering but seem to be related to voice onset and /k/ release.

As mentioned earlier, subject S. S. possibly moved her chin up and down during the experiment. To what extent the movement of the chin affected the pattern of SH activity in this particular subject will be clarified by further studies.

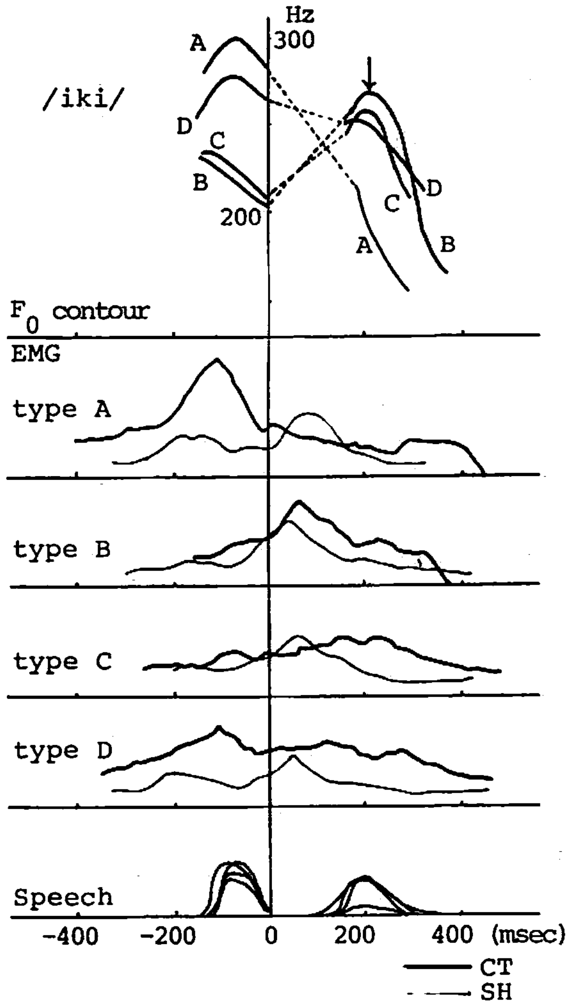

Fig. 11. Averaged EMG patterns, speech envelopes and F_0 contours for /iki/ (subject S. S.).

5. Summary

The relationship between laryngeal EMG activities and F_0 contours was studied in three native speakers of the Kinki dialect.

It appears that there is a positive correlation between the pattern of CT activity and the raising and lowering of F_0, as often described in the previous literature. In addition, in two of the three subjects (Y. I. and M. M.), the activation of SH also seems to correlate with a descent in F_0. The onset of F_0 lowering is found to be after the CT peak and a little before the SH peak.

It was noted in Y. I. and M. M. that SH activity increases prior to the production of words of the low-start accent type. This result indicates that the difference between the low-start and high-start groups is based on a physiological mechanism.

The essential roles of the CT and SH in the Kinki dialect do not seem to be very different from their roles in the Tokyo dialect. However, the way these muscles are used may be different in the two dialects. The frequent use of the SH as well as CT in the production of the Kinki accent might help make possible the more complex accent types of the Kinki dialect, and might help distinguish the high-start and low-start groups. Further studies concerning these dialectal differences must be made on the activity patterns of these muscles.

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