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On the Timing of the Sternohyoid Muscle Activity Associated with Accent in the Kinki Dialect

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1. Introduction

In this short report we will point out that the timing of pitch control by the sterno-hyoid (SH) muscle is not always fixed relative to the cricothyroid (CTh) activity. even when the same speaker pronounces the same type of utterance.

Unlike Tokyo Japanese. the Kinki dialect. which is spoken in a wide area including Kyoto and Osaka. distinguishes between words with a high accent and those with a low accent on their initial syllable. This distinction is phonologically lacking in Tokyo Japanese and is. consequently. characteristic of the Kinki dialect. In this dialect. a word group beginning with a low accent is marked. For example in the phrase *ane no tayori* "correspondence of an elder sister"[1]. *tayori* belongs to a group beginning with a low accent; thus, the initial syllable *ta* must always be pronounced at a lower pitch compared to the preceding *no* and following *yo* syllables (for the acoustic details about the Kinki accent. see Sugito[2]).

Sugito and Hirose[3] dealt with this marked accent and examined the activity of both the CTh and SH muscles to clarify the laryngeal mechanism underlying this accentual ontrast. They found that out of three female subjects. one speaker showed a reciprocal pattern of activity between these two muscles corresponding to the contrast in question. Another speaker also showed a similar. though not distinct. tendency of the pattern reciprocity. Recently, Kori et al.[4] describes a similar alternation of muscle activation for a speaker of Osaka Japanese. These observations in particular indicate that this accentual distinction is achieved by the SH in a rather consistent way which supports its active role in the fall of pitch. On the other hand. we have also noted some complicated gestures by this muscle in a number of other electromyographic (EMG) studies. Some of them apparently stem from segmental articulatory control. but it is also likely that they reflect how skillfully speakers use the SH muscle in pitch control. We recently were given an opportunity to make EMG recordings again from the speaker studied in Sugito and Hirose's experiment. The results were similar to those in the previous study. but we also found a major difference in the timing phase of the SH activity. The difference concerns the low accent.

2. Method

As mentioned, the subject was the same speaker in the previous study by Sugito and Hirose (referred to as Y.I.), who is a native of the Kinki area. Since their paper was published in 1978, there has been an interval of 13 years between our two experiments.

Here we will take up utterance tokens for the two-mora word *imi*, which is common to both speech samples. There are four possible accent types that are allowed in the Kinki dialect, because what is called the accent kernel further bears a distinctive function in word accent. Phonetically, the kernel is realized as an abrupt fall in pitch (for detailed Japanese phonology, see e.g. Vance[5]). According to the classification by Sugito, we will call each these type A (*i^mi*), type B (**imi^*), type C (**imi*) and type D (*imi*), respectively (we will use the symbols * and ^ hereafter to indicate the low accent and the accent kernel).

The subject was asked to read each word in the above order and to make 13 to 14 repetitions with a short pause between the tokens. EMG signals were derived from the CTh and the SH muscles, and recorded along with the audio signal on a PCM data recorder. The recordings obtained were digitized and transferred to a computer for further analysis (for the detailed procedure, see Simada et al.[6]).

3. High Accent

Figure 1 illustrates the full-wave rectified, integrated traces obtained from the CTh and the SH activity and compares single tokens of the words with a high accent. The word *i^mi* (type A) has the accent kernel on the first syllable and the word *imi* (type D) no kernel. Also shown in the right panel are the fundamental frequency contours of the tokens. Examining these two samples, we can first note a distinct pattern of SH activity. The SH muscle does not show any significant activity during the "pre-audio" phase, while the CTh has been activated ahead of the audio signal to raise its fundamental frequency. Second, the SH shows a large activity for the word *i^mi* with the accent kernel, which alternates with a gradually and then sharply decreased CTh activity; moreover, it is noteworthy that this SH activity begins to increase earlier than in the previous study (cf. Figure 3). On the other hand, the SH remains weakly active for the *imi* token with no kernel. Third, the CTh appears to be activated at its onset phase to a larger extent and earlier for the word with the kernel than that with no kernel. From these EMG findings we can account for the differences in pitch movement between *i^mi* and *imi*: that is, the pitch starts on a higher level, reaches a higher peak, and shows a sharp fall in the fundamental frequency for a type A word; vice versa for a type D word.

4. Low Accent

In contrast to the words with a high accent, low-accented **imi^* (type B) and **imi* (type C) both showed a burst of SH activity around the onset phase of the audio (Figure 2). This finding had already been described in the previous paper and interpreted as a manifestation of the low accent on the initial syllable. However, we can point out two

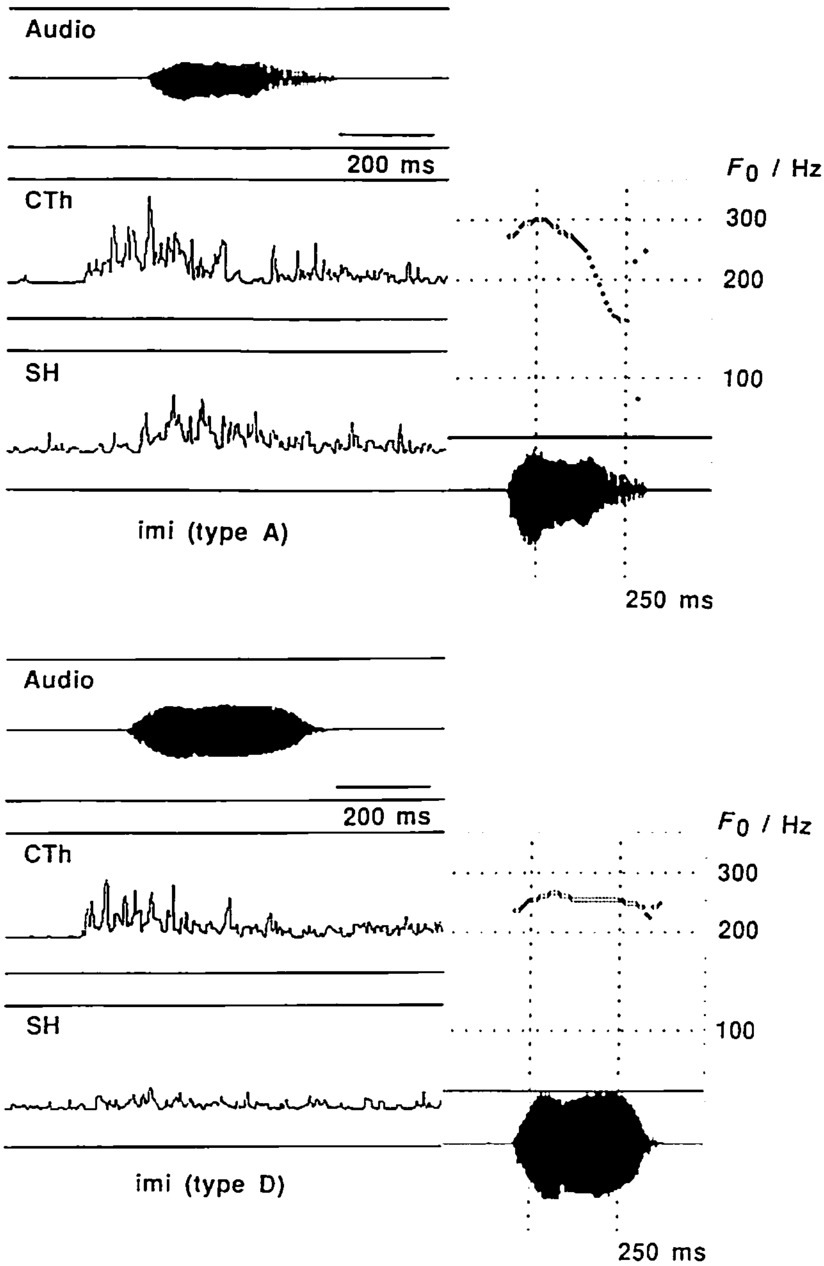

Figure 1. Audio and integrated EMG traces from the CTh and the SH for tokens of *imi* beginning with a high accent. Type A has the accent kernel, but type D does not. Shown in the right panel are the fundamental frequency contours of the tokens.

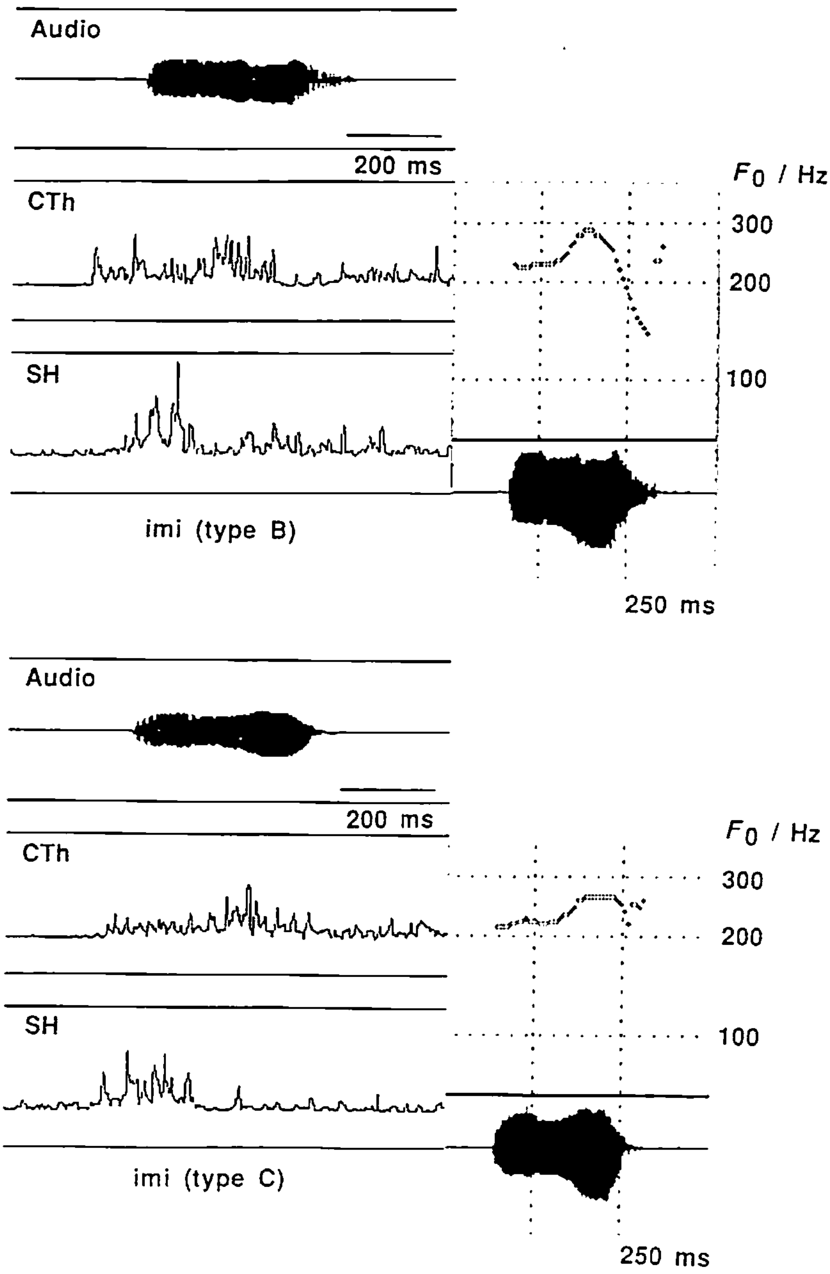

Figure 2. The same traces as in Figure 1 for tokens of *imi* beginning with a low accent.

important differences between the two experiments. First, in the present study, the SH burst occurred earlier than the audio but still lasted until after the onset of the audio. This is in sharp contrast to the previous result that the SH activity at issue had become still already before the audio onset. Second, the CTh was not markedly suppressed during this initial phase. Indeed, its level of activity was lower than the one at the later stage, which contributes to a pitch rise from the first to the second syllable of the word. However, we cannot regard it as being extremely low.

5. Discussion

These findings indicate that the SH here behaves with a timing different from that in the previous experiment. For comparison, we present a sample adapted from Sugito and Hirose's paper (Figure 3). When we compare the SH behaviors for the low accent with the corresponding pitch contours, we see that the SH control in the present experiment accounts better for the pitch movements in terms of timing: the initial burst lasts until it alternates with the abrupt increase in CTh activity, and it accordingly appears to cause a flat segment of pitch. Problematic is the simultaneous occurrence of CTh activity during this phase, which was not observable in the previous study. Examing other samples of the type B tokens, we noted the CTh activity at issue for most of the tokens, though there were also a couple of samples with a subtle, weak activity as seen in the lower trace of Figure 3. It is not unnatural for the SH to be simultaneously activated with the CTh, because both muscles never form a pair of antagonists to each other anatomically. If we accept the view that the SH is associated with falling pitch, we can interpret our findings as follows: the SH functions in the present experiment to weaken the pitch-raising effect of the CTh muscle.

Another problem with interpreting the difference in SH control is its origins during the process of speech production. Where does it stem from? Does it come from the process of planning motor commands for utterances, or is it from some peripheral control independent of intention? We do not have any definitive data to answer these questions. However, it is likely that the superior center of language scans the peripheral speech organs before a speaker sets out to utter something. The center thereby is able to know in advance about the current state of these organs in order to achieve the utterance goals successfully.

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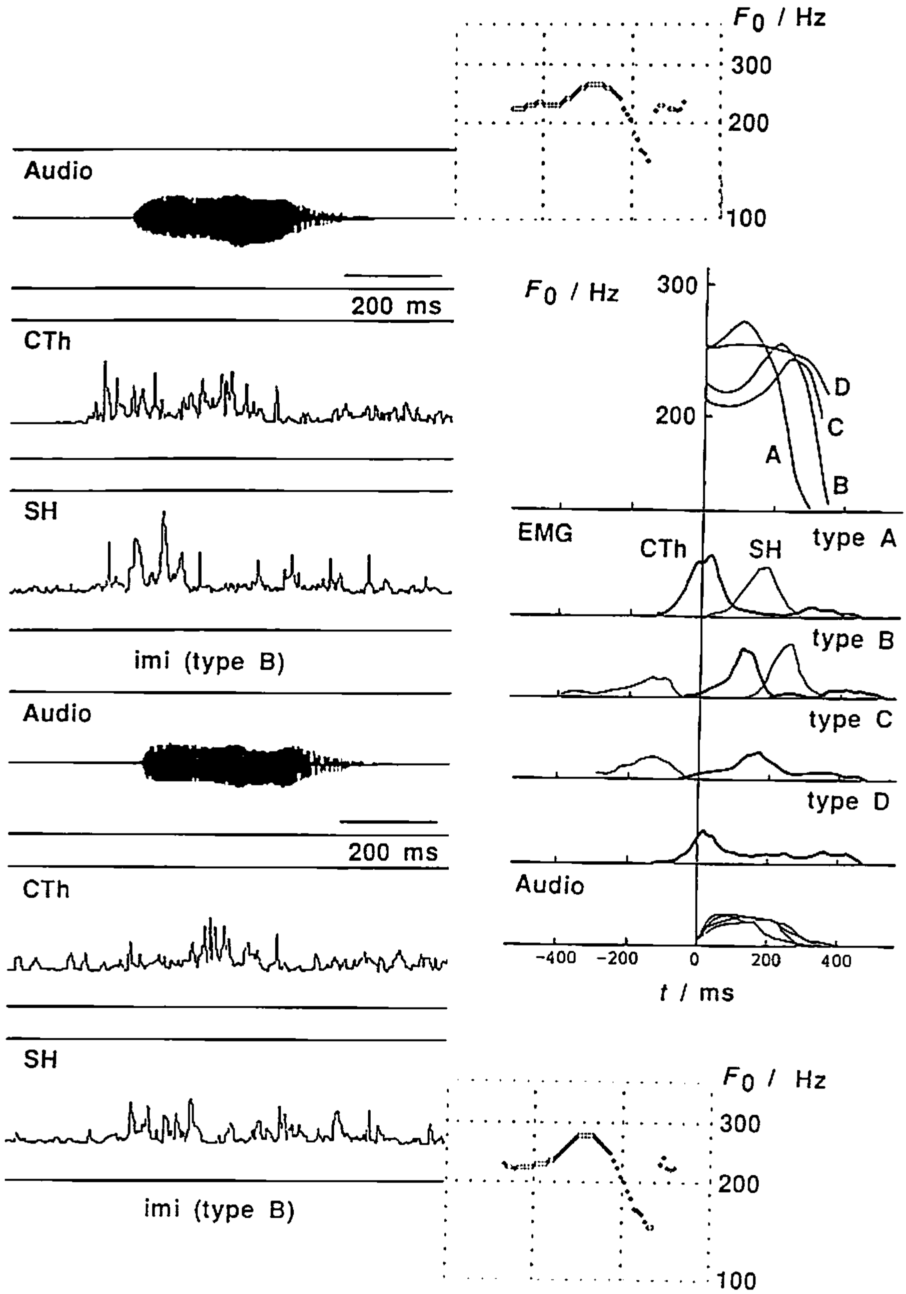

Figure 3. Other two tokens of type B *imi^. Compare these with Sugito and Hirose's results as shown in the right panel, where heavy lines represent CTh and light ones SH activity.

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