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PITCH ACCENT AND VOWEL DEVOICING IN JAPANESE: A PRELIMINARY STUDY

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Introduction

It is well known that the devoicing of the close vowels /i, u/** in the Tokyo dialect of Japanese depends (in degree and frequency) on a number of conditioning factors, including, in addition to "surrounding voicelessness", speed of speech, the articulatory nature of contiguous segments, and whether or not the vowel in a neighboring mora is also devoiceable (potentially devoiced). Han (1962), in a spectrographic study of vowel devoicing, has confirmed another accepted observation (e. g. by Kindaichi 1958, p. 20) that devoiceability tends also to be correlated with whether such a vowel is phonologically accented or not. This interaction of a purely phonetic segmental process (devoicing) and a suprasegmental one (pitch accentuation) demands more detailed phonetic investigation. This paper attempts to formulate the empirical and theoretical questions that need to be asked, to describe some preliminary experiments on the subject, and to make a few speculative suggestions as to what sort of answers may eventually appear in response to the many new questions resulting from experimentation.

Collection of data

Several data bases were recorded on magnetic tape specifically for the investigation of vowel-devoicing phenomena related to accent placement. The main tape was made by asking nine informants native to the Tokyo-Yokohama area, five males and four females, whose age ranged from the mid-twenties to late forties, to read 56 sentences from cards at normal speed. Each card contained a single sentence, written in Japanese orthography (kanji and kana), and they were handed to the informants one at a time. The 56 sentences represented 14 different utterance types (listed just below)***, in four different orders (but ordered identically for each informant).

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**Other vowels are sometimes devoiced in very rapid speech, but that is not relevant here. (See e. g. Kindaichi 1958, p. 20.) It should also be noted that devoicing is in all cases relative, but may be analyzed binarily without distorting the essential facts.

***A note on transcription: here N stands for a moraic nasal, homorganic to any following consonant; C' for any palatalized C; ˥ for an underlying (phonological) accent unless otherwise noted; (˥) for an accent that is suppressable by rule (see below).

Kus'i to ka(ʔ)ita. 'He wrote (it as) 'comb'.'

Us'i to kaʔita. 'He wrote 'cow'.'

Has'i to ka(ʔ)ita. 'He wrote 'bridge'.'

Has'i to kaʔita. 'He wrote 'edge'.'

Haʔsʔiʔtoʔkaʔita. 'He wrote 'chopsticks'.'

Kutsu to kus'i to doʔtt'i ga yo(ʔ)i desu ka?
'Which is better, the shoes or the comb?'

Kus'i to kutsu to doʔtt'i ga yo(ʔ)i desu ka?
'Which is better, the comb or the shoes?'

SekitaʔN to tetsu to doʔtt'i ga taka(ʔ)i desu ka?
'Which is more expensive, coal or iron?'

Tetsu to sekitaʔN to doʔtt'i ga taka(ʔ)i desu ka?
'Which is more expensive, iron or coal?'

Us'i to umaʔ to doʔtt'i ga suki(ʔ)desu ka ?
'Which do you like better, cows or horses?'

Umaʔ to us'i to doʔtt'i ga suki(ʔ)desu ka?
'Which do you like better, horses or cows?'

Soko ni has'i to ka(ʔ)ite a(ʔ)ru no o mi(ʔ)te kaʔre wa sukkaʔri kaNgaeko(ʔ)Nde s'imatta.
'When he saw 'bridge' was written there, he became completely absorbed in thought.'

Soko ni haʔs'i to ka(ʔ)ite a(ʔ)ru no o mi(ʔ)te kaʔre wa sukkaʔri kaNgaeko(ʔ)Nde s'imatta.
'When he saw 'chopsticks' was written there, he became completely absorbed in thought.'

Soko ni has'i to kaʔite a(ʔ)ru no o mi(ʔ)te kaʔre wa sukkaʔri kaNgaeko(ʔ)Nde s'imatta.
'When he saw 'edge' was written there, he became completely absorbed in thought.'

This collection of data will be referred to as the hasi sentences because of the many occurrences of the minimal triplet /hasiʔ/ 'bridge', /haʔsi/ 'chopsticks', /hasi/ 'edge'.

A second group of sentences was recorded in the same way, with two or three randomized repetitions of each sentence type, by five male informants. These will be referred to as the mati kara sentences:

Matʔi kara desu. * 'It's from the town.'

Hanaʔ kara desu. 'It's from the flower.'

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*Here the underlying final accent on the particle is omitted; it does not surface because of the preceding accent within the minor phrase (see below).

Mit'i kara⌉ desu.	'It's from the street.'
Has'i⌉ kara desu.	'It's from the bridge.'
Hana kara⌉ desu.	'It's from the nose.'
Has'i kara⌉ desu.	'It's from the edge.'

Pitch accent

The phonology of pitch accent in Standard Japanese is assumed to be basically as described in McCawley (1968; n. d.), as well as in preceding Japanese works such as Hattori (1961), with the "accented" mora in the phonological word/phrase ultimately characterized by a perceptually significant drop in pitch between it and the following mora, and with all non-initial moras (if any) to the left of the accented one H: the basic contour is (L)HL. (The first mora is L if unaccented, with an exception involving long syllables (cf. Fujimura 1966b).) An important principle is that in a sequence of phonological accents, the first (leftmost) one predominates: completely so, within a phonological word/minor phrase (i. e. any accent on a post-nominal particle is "erased" if preceded by another), or relatively so, within a sequence of minor phrases (in this case whether later accents are eliminated or merely reduced depends on both speed and idiolect). (For a formal treatment, see McCawley 1968; also see Hattori 1961, Fujimura 1966b.)

The low-level phonetic manifestations of these contrastive pitch modulations are much more complex, mainly in the sense that pitch changes are "relative" along several different dimensions. The pitch within a minor phrase rises very slightly from the initial "low" and then falls gradually after the essential "steep drop" at the accent, to a point much lower than any initial phonological "low" L. (In an unaccented word, the pitch simply falls gradually after the second mora.) However, the total pitch drop within a word containing an accent is roughly confined to a certain number of semitones, no matter how long the word. (See Weitzman 1970 for details of these observations and others on word-internal pitch accent; also Hattori 1961 and Fujimura 1966a for general description of such phenomena. Fujisaki and Nagashima (1969) proposed a quantitative model for the pitch contour.)

Vowel devoicing

Han (1962) has studied the factors that make a single vowel more or less "devoiceable" (the term "devoiceable vowel" will mean a [+high] one in the appropriate immediate segmental context, C_0 __ $\left\{\begin{matrix} C_0 \\ \# \end{matrix}\right\}$, for devoicing to occur) and attempted to rank them in importance. In the data collected for the present study it was also clear that devoicing never occurs in the context # __ C_0, even though the vowel is "surrounded by voicelessness"; and word-final vowels appear to be less prone to devoicing than those followed by voiceless consonants.

It is generally recognized that devoicing may be foregone for stylistic or intonational reasons; compare, for example, the following utterances, given in their most likely forms, with an informal indication of the pitch contour:

Ko⌜ko ni ima⌝su.	'He's here.'
Ko⌜ko ni ima⌝su ka⌋?	'Is he here?'
Ko⌜ko ni ima(ʔ)su⌋?	'Is he here?'

In the third sentence, the question particle ka is omitted (which is possible in less formal speech) and a final-rising intonation is substituted--just as in English we may say

He is?

rather than using the normal "inverted" order of

Is he?

In such a rising-intonation situation, the last vowel is never devoiced. (Fujimura, personal communication.)

What then about accentual distinctions, involving segmental pitch assignment and on an entirely different structural level from sentence intonation? Are there situations in which an expected devoicing does not occur in an accented mora? This will be one of the main topics of investigation; but first let us review what Han concluded about the effects of accent or pitch on devoicing. A statement (1962, p. 27) to the effect that "high pitch" has a negative influence on devoicing is clearly too broad, as opposed to one that devoicing is significantly less likely to occur in a (phonologically) accented mora. But in any event such a restriction should not be attributed to "the effect of pitch on the vowels /i/ and /u/". Rather one must assume that if devoicing is foregone, it is for the sake of maintaining an accentual distinction: that the mechanism is in some sense similar to that operating in intonational cases. (The fact that H non-accented vowels are (very) occasionally voiced remains to be explained; the clear difference between devoicing frequencies in the accented and non-accented H cases has led to the above statement as a viable working hypothesis at the very least.)

An auditory analysis of the main bloc of tape-recorded sentences described earlier gave approximate figures on vowel devoicing in particular environments. As expected, all L devoiceable vowels (i. e. those that satisfy the above condition in an unaccented mora following C̥ at the beginning of a major phrase, or following an accent before a phrase boundary) were devoiced. Fewer than 2% of the H devoiceable unaccented (i. e. preaccentual) vowels were heard to have some voicing. More typically, they were heard as completely voiceless, as confirmed by spectrograms such as that showing /i/ in Figure 1. Accented vowels were however voiced much more frequently, 24% of the time in this listening test. Most often such voicing occurred toward the beginning of an utterance rather than later on, e. g. as in Figure 2, where the second /u/ is also devoiceable. Perhaps this is related to reduced subglottal pressure (which would make devoicing more natural) in the more rightward position. In any event, the optional nondevoicing occurred not only on morphemes which are members of a

Figure 1. Devoicing of phonologically H, non-accented /i/.

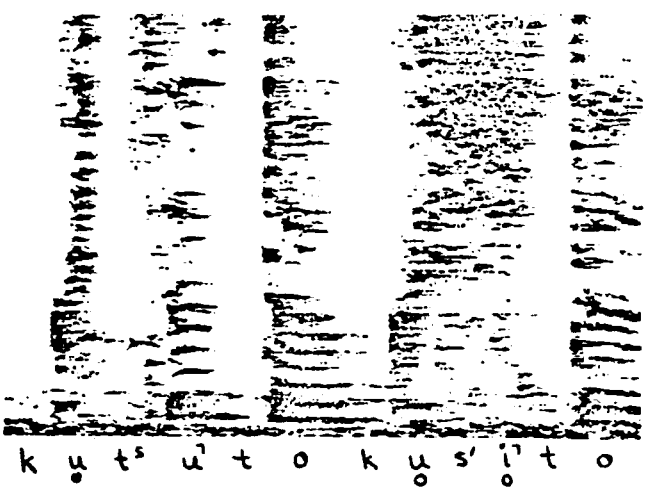

Figure 2. Optional non-devoicing of accented /u/ contrasted with devoicing of accented /i/.

segmentally homophonous pair, but also on others, implying that voicing was not being used in the experiment as a consciously or semi-consciously contrastive device on the lexical level. The accent and intonation cases are distinguished formally by the obligatory nature of the correlation between surface pitch and (non)devoicing in question intonation, whereas for accent the relation is an optional one. We might also make a functional distinction in terms of information load: in the accent case lack of voicing might possibly cause confusion (a point to be elaborated on later) but not always a straightforward "wrong" meaning.

Does this mean that one must claim a non-functional--purely phonological--explanation for the frequent voicing of accented devoiceable vowels? Such an explanation continues to be unavailable, nor does it seem necessary; rather functionalism and phonology appear to conspire. We may proceed on the assumptions that underlying (phonological) word accents tend to be realized, even if for no immediate contrastive purpose (not, certainly, a controversial assumption); that such a realization tends to occur in the most "normal" way (e. g. by a pitch drop at a certain point; but see below); and that the combination of these tendencies results in a certain amount of overriding of the phonological tendency to devoice.

Finally, with regard to the devoicing count, we may note that vowels in the environment C__CC, CC being a voiceless geminate, were devoiced as readily as between single voiceless consonants. This statement is confirmed by fiberscopic glottographic evidence presented in Sawashima (1969).

Pitch accent strategy

Examination of Japanese pitch accent reveals several distinct phonetic strategies that are used to manifest or interpret the phonological accent on a devoiced vowel. The first of these cannot be expected to be effective in all cases, as it is heavily context-dependent. When a phonologically H vowel is devoiced in Japanese, there is no phonetic evidence of any indication of high pitch (in fact, there is some fiberscopic evidence (low position of the glottis) as to why such a vowel might be perceived as uttered on a low pitch (Fujimura 1971), but only for non-accented H vowels). Suppose we had a sequence of moras /#MM̄M/, whose phonological pitches would be /LHL/. If the vocalic nucleus in the middle mora were devoiced, this would result in L?L, presumably unacceptable as a monophrasal sequence in Japanese, as it lacks the post-initial rise. The listener should automatically resolve this phonetic paradox by assigning an accent to the second mora; there is no other possibility, given the low-pitched first and third moras. Similarly, an initial sequence ?L with voiceless first mora would be interpreted as /#M̄M/.

Such a partial deletion of the pitch contour might however result in some confusion if it occurred in a context like /#MMM̄M/, or /LHHL/, with the third mora voiceless. Then it would be unclear, if this mora were perceived as pitchless, whether the accent really fell on the second or the third mora. More generally, accent drop on M>2 would leave the position of the phonological accent in doubt. There appears in fact to be some evidence that such a situation could lead to a phonological reanalysis, moving the accent leftward one mora. Consider the following partial paradigm for Japanese adjectival inflections, with the phonetic pitch drops marked by ¬:

accented	/na⌝ga/	'long'	/atara⌝si/	'new'
present	naga⌝i		ataras'i⌝i	
adverbial	na⌝gaku		atara⌝s'iku	
past	na⌝gakatta		atara⌝s'i̥katta	
unaccented	/kura/	'dark'	/yasasi/	'easy'
present	kurai		yasas'ii	
adverbial	kuraku		yasas'iku	
past	kura⌝katta		ya⌝sas'i̥katta	

The boxed form is analyzed as either /yasasi⌝katta/ or /yasa⌝sikatta/ (e. g. see McCawley n. d., p. 8 and Kindaichi 1958, respectively). This suggests the possibility of a phonological leftward shift (to /yasa⌝sikatta/), probably encouraged by levelling pressures from the paradigm (cf. /atara⌝sikatta/).*

The second--and much more common--way that accented devoiced vowels remain accented is for the pitch drop to move to the right far enough to fall on a voiced segment. It is important to note here that the normal horizontal placement of the pitch curve, on a completely voiced sequence, is not nearly as simple as the phonological analysis suggests, and the introduction of devoicing produces additional effects that must be sorted out from the normal phonetic variations, idiolectal as well as universal. For example, a word /#M̄M/ will typically have a rising pitch on the first mora (i. e. this is the realization of /#H/); the steepest pitch drop may sometimes not occur until the second mora, when the first is accented.** (More precisely, it may occur not between the ends of the first and second moras, but rather between the ends of the second and third.) There is considerable individual variation in timing in this respect. Weitzman's (1970) measurements of semitone differences between moras (pp. 42-49, 53, 59) showed that for several of his informants, the steepest pitch fall in initial-accent three- and four-mora words was on the post-accented mora (in the sense defined just above)*** There were no devoiceable vowels in accented position in his experimental data.

If the accented vowel is voiceless, the pitch lag is exaggerated even further than usual, until it may appear that the accent has shifted rightward one mora. (In Figure 3, note the much higher pitch of /to/, and the steeper fall on /ka/, following a voiceless vowel, than where there is no devoicing.) Experimental measurements indicate that the shift really is

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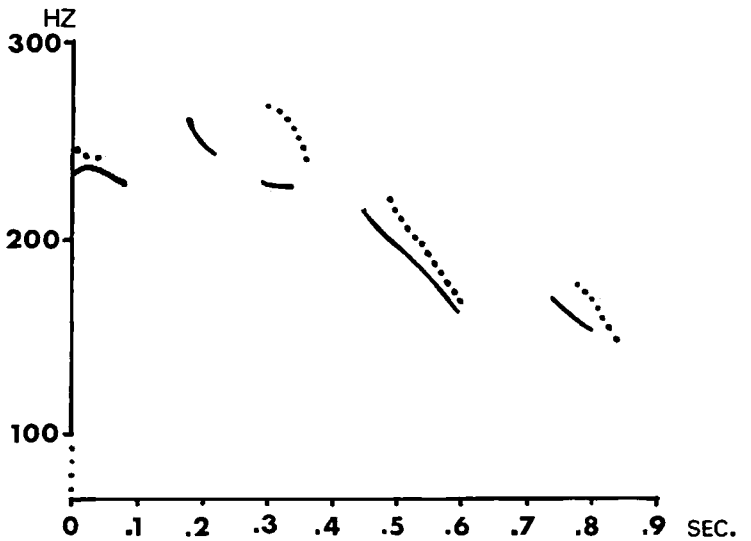
*Unfortunately the issue is complicated by the existence of another accepted form /yasasi⌝i/. I have not been able to find any unambiguous examples; apparently all such adjectives have two patterns like this.

**For a recent discussion see Hattori 1975.

***However, such a form is always distinguishable (ceteris paribus) from one with the accent one mora to the right, phonologically (see Hattori 1975). This is not true in the cases discussed immediately below, involving a voiceless vowel.

about a full mora, as it is heard to be by native speakers. * The shift has attained the status of a phonological rule in the generic sense at least in some cases. ** McCawley (1968, pp. 153-154), for instance, gives a rule for right-shift within adjectives and verbs. The normal forms for the



—— has'i to kaita

···· has'i to kaita

Figure 3. F_0 of pitch contours showing accent shift due to vowel devoicing.

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*Sugito (1971) mentions the steep drop on /to/ in such cases, and notes that it begins at the height attained on the preceding accented vowel when it is voiced, but she does not equate this result with an accent shift. Comparison of the spectrograms for

Ka're wa hasika' da to omou. 'I think he has the measles.'

Ka're wa hasi' kara o'rita. 'He came down off the bridge.'

with voiceless [i̥] in /...hasi.../ in each case shows no significant difference in the pitch contour with respect to /...ka.../: in the second sentence the accent is shifted onto the particle /kara/ (see further discussion below).

**Forms like itsu'tsu, in free variation with i'tsutsu /itsu'tsu/ 'five', seem to be heard but not spoken of. This particular example was unintentionally provided by a linguist lecturing on Japanese accent patterns.

adverbial form of accented adjectives, and past form of accented verbs, are represented respectively by

ta⌝kaku	'high'	ta⌝beta	'ate'

In forms like

t'ika⌝ku	'near'	tasuke⌝ta	'helped'

the accent moves rightward in the adverbial and past, since the stem-penultimate vowel is devoiced.

The same phenomenon is seen in nouns, but is much more difficult to illustrate because there are no inflectional alternations (justifying a "phonological rule") and derivational alternations are only sporadic. We have e. g. [kika⌝i] 'machine, device', along with an observation in Kindaichi's accent dictionary (pp. 9-10) that nouns of this form (which usually without the devoicing environment have initial accent) tend to have the accent one mora rightward of the voiceless (in Tokyo) mora. Such a statement can only have the status of a distributional fact; there is no justification for setting up a synchronic underlying */ki⌝kai/, for example. The accent shift has been lexicalized, if we can even say it ever occurred in any real sense.

The examples which have not received much attention in the literature are those in which the accent shifts across a morpheme boundary. We have already seen this for the minor phrase /hasi⌝ to/ 'the bridge'; it is also possible for/ hasi⌝ kara⌝/ ⟶ has'i kara 'from the bridge', a particularly interesting case since this provides a fourth phonetic pitch pattern for /kara⌝/: it is ka⌜ra in isolation; kara after an unaccented noun; and kara normally after an accented noun (e. g. /hana⌝ kara⌝/ ⟶ ha⌜na⌋kara). Sentences #1 and 4 in the mati kara recording invariably showed such a shift; they were phonetically

Mat'i ka⌋ra desu.	Has'i ka⌋ra desu.

In contrast with this case, McCawley (n. d., p. 8; he also claims no accent shift for /___kara⌝/) notes that there is no accent shift onto suffixes like /-katta/ 'adjective past'. I have observed devoicing of the accented vowel preceding /-katta/ e. g. [ya⌜sas'ikatta] above) and consequent partial deletion of the pitch contour, as an alternative to not devoicing the vowel. The accent here comes from McCawley's proposed preaccented /-⌝katta/. One possible interpretation of such cases is that accent shift due to devoicing cannot occur across an underlying accent. However, if we are seeing here the workings of a phonological rule, then the rule must include further restrictions, as yet unclear. For example, there is never any shift (though there is devoicing of the /i/)in /futi⌝ saN/ 'Mr. /Ms. Fuchi'; there is no surface high pitch at all in this phrase, when the vowel is devoiced.

Accent shift and lexical distinctions

The main body of data described above was used in an attempt to determine what effect accent shift has on perceptual identification of phrases like /hasi to ka⌝ita/ 'he wrote (it as) 'edge'' and /hasi⌝ to ka⌝ita/ 'he wrote (it as) 'bridge'', a minimal pair for which one would expect (phonetically)

something like

has'i to kaita

has'i to kaita or has'i to kaita

(Tracings of the ninth harmonic for all three hasi forms, produced by the same speaker, are contrasted in Figure 4.) The alternative in the latter case depends on whether or not the second accent appears as the main accent of a separate phonological phrase. Such a possibility predicts that the pitch curves, in those cases where the speaker assumes a phrase boundary before the verb, would be similar for 'bridge' and 'edge'.

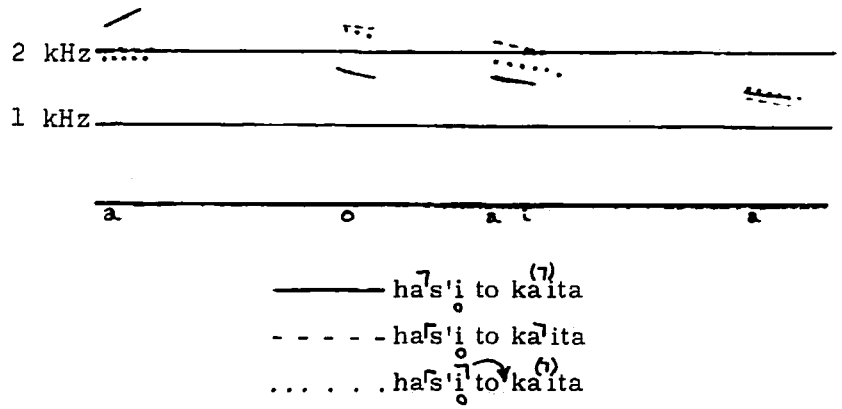

Figure 4. Normal pronunciation of three minimally distinctive sentences. (Tracings of ninth harmonic.)

To determine the actual facts, a forced-choice test was given to (approximately) the same group of informants who had provided the original data. They were each asked to listen to their own recordings of the 56 sentences (24 of which contained some occurrence of 'bridge', 'edge', or 'chopsticks', embedded in either a "long" (sentences #12, 14, 13) or a "short" (#3, 4, 5) context), and then to one or two identical recordings by other informants. An answer sheet for each test was provided, with the three forms of hasi written in kanji (橋, 端, 箸) as column headings. The listener was directed to check the appropriate column (a total of 24 checks) each time he heard hasi.

In all, 29 tests were given using this procedure. The score on 'chopsticks' was perfect, and the error rates for 'bridge' (b) and for 'edge' (e) were comparable, by all listeners, for any given set of utterances (any given speaker). The error rates were computed, therefore, for the data listened to by several informants, on the assumption that these figures indicate the clarity of the articulatory (accentual) distinctions made by a given speaker. They fall naturally into three categories: essentially no confusion (approximately 0-1 errors out of 16 possible for b:e distinctions); some confusion (about 3-4 errors); and considerable difficulty (4-6 errors). There were slightly more errors in the "long" context than in the "short" one (34 vs. 24), but there is no obvious significance in this difference.

As far as the direction of the errors goes, of the 58 errors made (12.5% of potential b:e confusions), b was heard as e (i.e. the accent was heard too far to the right) in 35 cases, and e as b in 23. (Half of the latter errors were based on a single speaker, however.) The reason for the former kind of confusion is frequently obvious from an inspection of the relevant spectrograms (see e.g. the tracings in Figure 5 of a consistent confusion):

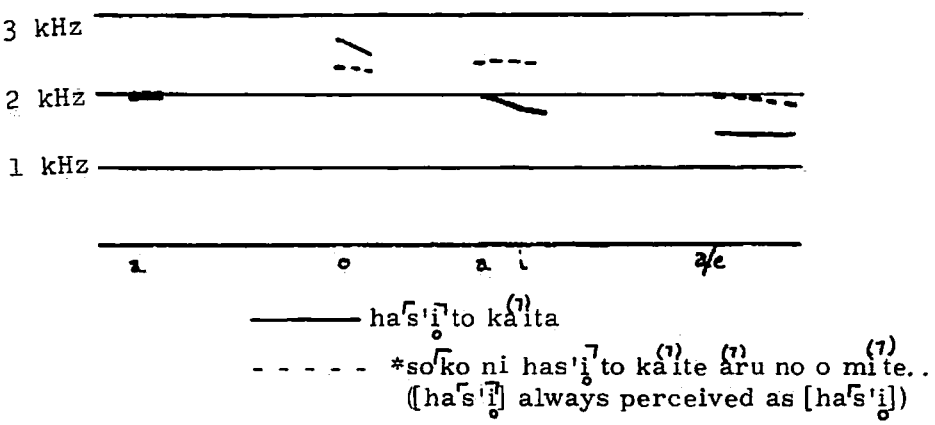

Figure 5. Sentence in which /hasi⌝/ 'bridge' (dotted line) is perceived as /hasi/ 'edge', compared with normal utterance of 'bridge' (solid line). (Tracings of ninth harmonic.)

the pitch is too high on /...ka.../ not to be taken as a signal of the accent for the minor phrase, i.e. a correlate of (unaccented) /hasi/ 'edge', particularly if the listener does not anticipate a phrase boundary before the verb. Since most discrimination responses were correct, we may assume that most of the sentences were originally produced without phrase boundaries; in this case b would never be confused with e. It is in those few cases of b with a phrase boundary following it that we would expect confusion with e (a b → e error), or rather confusion with e not followed by a phrase boundary (since no-phrase-boundary is the usual case).

For the "leftward", or e → b, perception errors, a slightly different mechanism may be assumed. First we note that the pitch contours for the e sentences with or without an intended phrase boundary are almost identical, so we may expect the listeners to have some difficulty in interpreting the speaker's syntactic intentions in this respect. (Nor can we easily find the phrase boundary cues on a spectrogram.) In those cases in which the listener hears or thinks he hears a phrase boundary cue after e, he could be expected to waver between this choice and b with a phrase boundary, and be right about half the time. It is notable that for those few speakers who generated many e → b listening errors, there were also many b → e errors; and the existence of phrase boundary cues is a prerequisite for both kinds of error. On the other hand, sporadic phrase boundary cues generated by a given speaker could be expected to cause somewhat more b → e errors than e → b ones, which again corresponds to the data.

Summary and conclusions

There are various strategies available enabling a speaker of Standard Japanese to avoid the undesirable effect (loss of a meaning distinction) of devoicing accented devoiceable vowels, although devoicing is simply foregone in this environment much more often than on non-accented devoiceable vowels. (The situation is partially comparable to that of obligatory voicing of a devoiceable vowel in question-final position, with rising intonation.) One possibility is to omit any pitch change in the vicinity of the accented mora; in this case the accent location may sometimes be inferred from a following low pitch, while in other cases the context may result in theoretical or practical ambiguity of the accent placement, and it may be interpreted as shifted one mora to the left.

The more common case is rightward movement of the steep pitch drop, either in a systematic manner (as seen in certain adjectives and verbs, where the accent is moved a full mora rightward off a voiceless mora) or as a non-obligatory but extremely probable phonetic (apparently) process, as illustrated in the phonetic accent shift off of final-accented nouns onto a following particle. In this situation, other attributes of the phrasal pitch contour may lead to confusion, in a given minimal pair situation and for certain speakers only. In certain classes of cases, accentual distinctions are preserved despite the accent shift, and despite the resulting identical 'HL' sequences. It hardly needs emphasizing that these cases are among the many in which a contrast is achieved through variation fairly far removed from the segments actually being contrasted.

Acknowledgments

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