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ABSTRACT

This study, the ninth in the series "Studies in the Phonology of Asian Languages," aims to analyze the phonological properties of the accentual system of Standard Colloquial Japanese on the basis of acoustic-phonetic data, especially data obtained through use of the sound spectrograph and pitch extractor. Chapters deal with functional distinctions among accent patterns, methods of acoustic-phonetic analysis, fundamental frequency and intensity as correlates of Japanese accent, and new conceptualizations for the phonological description of accent distinctions. Three transcription systems are used--phonetic, phonemic, and romanized. (Author/DD)

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STUDIES IN THE PHONOLOGY OF ASIAN LANGUAGES

IX

WORD ACCENT IN JAPANESE

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Preface

This study, Word Accent in Japanese, is the ninth report in the series Studies in the Phonology of Asian Languages. The following works have been published previously in this series.

Vol. 1 Korean Vowels, Han.
Vol. 2 Duration of Korean Vowels, Han.
Vol. 3 Acoustic Characteristics of Korean Stop Consonants, Han and Weitzman.
Vol. 4 Vietnamese Vowels, Han.
Vol. 5 Acoustic Features in the Manner-Differentiation of Korean Stop Consonants, Han and Weitzman.
Vol. 6 Complex Syllable Nuclei in Vietnamese, Han.
Vol. 7 Korean Affricates, Han and Ross.
Vol. 8 Vietnamese Tones, Han.

Parts of the present study were presented as a dissertation by Raymond Stanley Weitzman to the faculty of the Graduate School of the University of Southern California in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Linguistics, July 1969. His study was supported in part by an NDEA Title IV Fellowship; equipment and materials for the experiments were supplied by the Acoustic-Phonetics Research Laboratory which is financially supported by the Office of Naval Research under contract NR 049-183, Nonr 228(28).

Mieko S. Han

Los Angeles, California

February 1970

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INTRODUCTION

The aim of this study is to analyze the phonological properties of the accentual system of Standard Colloquial Japanese[1] on the basis of acoustic-phonetic data, especially data obtained through use of the sound spectrograph and pitch extractor.

Accent is herein regarded as a prosodic feature of Japanese which in its manifestation contributes to the characteristic melody of a Japanese utterance and is one of the features by which such an utterance is recognized as being the expression of a specific linguistic form in Japanese. Specifically, accent functions to differentiate lexical items. All Japanese utterances carry an identifiable accent pattern. Some utterances are recognized by native speakers as having the same pattern of accent, while others are recognized as having different patterns of accent. For example, the single-word utterances for 'god' and 'paper'

[1]Standard Colloquial Japanese is defined as the speech of educated persons native to Tokyo, which is the accepted standard for all of Japan.

(which in terms of segmental phonemes are identically analyzed as /kami/) are recognized by native speakers as being different linguistic forms by the fact that they possess contrastive patterns of accent. The fact that a difference in accent pattern contributes toward distinguishing linguistic forms constitutes the basis for regarding accent as a linguistically significant feature of the phonology of Japanese.

The nature of the system of accent distinctions in Japanese has been interpreted and understood in a number of different ways. The basic problem that scholars in this area have faced has been that of presenting a system of description which will adequately characterize the functional distinctions among the various accent patterns. How this problem has been solved by various scholars is discussed in Chapter I.

The distinctive character of a given accent pattern is correlated with certain acoustic properties of an utterance. The acoustic variations that mark a given accent pattern must, of course, be different in at least some respects from those found in utterances with different accent patterns. If this were not so, there would be no physical basis for accent as a linguistically functioning feature of the phonology of Japanese. Thus, an examination of the acoustic properties associated with accent reveals how accent is expressed in the utterances of Japanese.

Previous studies of Japanese accent have for the most part been done on the basis of auditory impression. This has resulted in certain types of analyses which, because of their subjective basis, fail to convey an accurate picture of the acoustic properties of accent. With the development of acoustic instruments, particularly the sound spectrograph and the pitch extractor, it has become possible to obtain accurate phonetic information concerning the physical basis of accent. By examining the data obtained from these instruments, one is led to a better understanding of accent phenomena in Japanese. Chapter II acquaints the reader with some of the methods, acoustic concepts, and techniques of acoustic-phonetic analysis.

An examination of the acoustic properties of Japanese accent is taken up in Chapters III-VI. Chapters III and IV deal with fundamental frequency as a correlate of Japanese accent. Chapters V and VI deal with intensity as a correlate of Japanese accent. Chapter VII describes a new conceptualization for the phonological description of accent distinctions, and discusses why previous approaches fail to describe adequately the nature of Japanese accent.

In this study three systems of transcription are used: (1) phonetic transcriptions which are enclosed by brackets

([ ]), (2) phonemic transcriptions which are enclosed by diagonal lines (//), and (3) romanized transcriptions of Japanese which are underlined, for example <u>kaki</u>. English words enclosed by single quotation marks are glosses for Japanese words.

CHAPTER I

BACKGROUND

Research in the field of Japanese accent has been quite active, with native Japanese scholars doing the bulk of the work. Hirayama Teruo[1] lists over 600 works dealing with Japanese accent written over the period from 1892 to 1957.[2] Since 1957 a considerable number of works have appeared on the subject. These works deal with such things as the phonetic properties, phonological significance, historical development, and dialectical varieties of Japanese accent.

Japanese scholars have long recognized the linguistic significance of accent in their language. As early as 1892 Yamada Bimyoo compiled a dictionary entitled Nihon Daijisho[3] [A Large Japanese Dictionary]. In this work

[1]In this work, the Japanese tradition of placing the surname first will be followed for Japanese names.

[2]Nihongo Onchoo no Kenkyuu [A Study of Japanese Accent] (Tokyo, 1957), pp. 645-670.

[3]Tokyo, 1892.

Yamada marked all the entries for accent according to a system described in an appendix in the dictionary.

The problem that faced Yamada as well as the scholars that followed him was one of developing a theory that was best suited to the facts of Japanese accent. Most scholars have regarded accent as something superimposed upon a syllable or sequence of syllables, forming distinctive patterns.

The Japanese syllable as far as linguistic function is concerned is more properly termed a mora. It consists of either a consonant plus a vowel (CV), a consonant plus the semivowel /y/ plus a vowel (CyV), a vowel alone (V), or a nasal or obstruent consonant plus phonemic length (C:).[4] These sequences form a basic unit of duration, which is called in Japanese an onsetsu.[5] Han has found that each mora has approximately the same actual duration under constant tempo conditions, and that there is a strong tendency for the segmental components of the unit to balance each

[4] Japanese has the following segmental phonemes: Consonants: /p/, /t/, /k/, /b/, /d/, /g/, /s/, /š/, /h/, /č/, /z/, /ǰ/, /m/, /n/, /ŋ/, and /r/. Vowels: /a/, /i/, /u/, /e/, and /o/. For details and discussion, see Mieko S. Han, Japanese Phonology (Tokyo, 1962), pp. 8-60.

[5] This expression means literally 'sound unit,' but because of its function can best be translated as 'mora.'

other to obtain roughly equal duration with neighboring moras.[6] Because of this tendency, the relative length of a Japanese utterance is describable in terms of the number of moras it contains. Thus, for example, both the word nippon (CVC:CVC:) 'Japan' (which to an English speaker sounds like a two-syllable unit) and the word sayonara (CVCVCVCV) 'good-bye' (which to an English speaker sounds like a four-syllable unit) have approximately the same duration or, in moraic terms, contain the same number of moras, namely four.

Just how important the moraic concept is for native speakers of Japanese is illustrated by the fact that the traditional forms of Japanese poetry have a meter that is based on the number of moras per line; for example the form of Waka poetry is distinguished from other poetic forms in that it is composed of five lines of 5, 7, 5, 7, 7 moras or a total of exactly 31 moras.

Japanese accent is functionally operative in an uninterrupted sequence of moras.[7] For every such sequence of a given moraic length there are a small fixed number of

[6] Han, pp. 63-81.

[7] An uninterrupted sequence of moras is one which is bounded by junctures, but contains no junctions within.

contrastive accent patterns. If a sequence of moras is interrupted by either an internal or terminal juncture, this results in two or more mora-sequences, and hence such an utterance is analyzable into two or more accent patterns.[8]

The limited number of accent patterns has long been recognized. One of the major problems that scholars studying Japanese accent have faced is that of developing some kind of conceptual framework that could serve as an adequate means of describing the phonological distinctions among these patterns. The two most prominent approaches to describing Japanese accent have been the pitch level approach and the accent kernel approach.

In the pitch level approach the accent patterns of Japanese utterances are described in terms of relative pitch levels. For every mora in an utterance, there is associated a relative pitch level. The particular sequence of pitch levels describes the accent pattern of the utterance. The number of pitch levels is dependent on the functional differences among the various accent patterns. In the

[8] Han, pp. 106-108.

literature on the subject, this number has varied from two to four or even five levels.

The first of such pitch level theories was that of Yamada Bimyoo. Yamada postulates two distinctive levels of pitch: even (Hei) and high (Koo). However, rather than describe each accent pattern in terms of sequences of these levels, he describes the patterns in terms of whether the pattern is a sequence of even levels throughout or whether a high pitch occurs followed by an even pitch in the sequence either actually or latently.[9] Thus, for example, Yamada recorded three contrastive patterns of pitch for two-mora words:

1. Even throughout (Zempei): Ex. hana 'nose'
2. First mora high (Ichijoo): Ex. hana 'girl's name'
3. Second mora high (Nijoo): Ex. hana 'flower'

In some respects Yamada's theory of Japanese accent more closely resembles the accent kernel approach than the level approach because of its manner of notation. (See section on accent kernel approach below.)

[9] See pp. 11-12 below.

A three-level theory of Japanese accent was introduced by Sakuma Kanae.[10] On the basis of a phonetic examination of Japanese accent, Sakuma concluded that more than two pitch levels must be used to account for the accent patterns. For example, he found that, contrary to Yamada's description, both the word for 'nose' and the word for 'flower' have a pitch rise from the first to the second mora, but that the pitch rise in hana 'flower' is greater than the pitch rise in hana 'nose'. This, in Sakuma's mind, called for the introduction of an additional pitch level. Accordingly, Sakuma describes the accent patterns for two-mora words as follows:

1. Low·mid: Ex. hana 'nose'
2. High·mid: Ex. hana 'girl's name'
3. Low·high: Ex. hana 'flower'

Thus, Sakuma describes the accent patterns as sequences of high, mid, and low pitch levels. In his system a high pitch can be followed only by another high pitch or a mid pitch; a low pitch is restricted to occurring only on the first mora of an utterance.

[10] See his works cited in the Bibliography, especially Nihon Onseigaku [Japanese Phonetics] (Tokyo, 1929), pp. 358-378, and Hyoojun Nihongo no Hatsuon-Akusento [The Pronunciation and Accent of Standard Japanese] (Tokyo, 1964), pp. 65-84.

A new two-level theory of Japanese accent was presented by Arisaka Hideyo.[11] Arisaka found that in normal pronunciation there is no difference in the actual accent pattern for such single-word utterances as hana 'nose' and hana 'flower.'[12] Arisaka noted that there is a latent difference between these words and words like them in the sense that when spoken as part of an utterance which includes certain postpositioned particles, such as wa and ga, which are subject markers, there is a difference in the overall accent pattern. Thus, the phrase hana ga with a low·high·low pitch pattern means 'the flower,' but with a low·high·high pitch pattern it means 'the nose.' Arisaka recognized that there

[11] See his works cited in the Bibliography.

[12] This has been confirmed by Han, pp. 112-115, who found that the distinction between such words as hana 'nose' and hana 'flower' in terms of pitch occurs only when the two words are presented together and a deliberate attempt is made to distinguish them. When only one of the words is spoken with a given pitch rise without any means of comparison, the responses of native speakers are ambiguous. A similar phenomenon also occurs in single-mora utterances. Usually such utterances are not contrastive in accent, but may be so distinguished in deliberate pronunciation. A more recent confirmation may be found in "Tookyoo Nihaku Gobidaka to Heiban Akusento-koo [Thoughts on Low-High and Even Accent Patterns in Two-Mora Words Spoken in Tokyo]" by Sugitoo Miyoko, Onseigakukai Kaihoo [Bulletin of the Phonetic Society of Japan], No. 129 (December 1968), pp.1-4.

is a fall in pitch after certain words when they are followed by a particle and that in other words such a fall in pitch does not occur, but he also recognized that this is unimportant in a phonological description of the distinctive accent patterns of utterances.[13] Arisaka's theory is generally supported by Kindaichi Haruhiko, who compiled an accent dictionary along the lines of Arisaka's approach.[14] Most scholars in Japan today appear to adhere to this approach.

Bernard Bloch in his article "Studies in Colloquial Japanese IV: Phonemics"[15] introduced a four-level pitch scheme for Japanese accent: a high pitch (/1/), a high-mid pitch (/2/), a low-mid pitch (/3/), and a low pitch (/4/). According to Bloch, these four phonemically different levels are necessary and sufficient for accounting for <u>all</u> observable pitch variations. To some extent Bloch seems to

[13]Such differences of course must be taken into account if one is concerned with the morphophonemic generation of an utterance. However, the linguistic function of an accent pattern in contributing to the contrasting of utterances is something worthy of study in its own right.

[14]<u>Nihongo Akusento Jiten</u> [A Japanese Accent Dictionary] (Tokyo, 1958).

[15]<u>Language</u>, XXVI (1950), 86-125. For views similar to Bloch's, see the works by Eleanor H. Jorden and Samuel E. Martin cited in the Bibliography.

intermingle some phonetic considerations in with phonemic considerations. Also, he uses these pitch levels to account for intonational and junctural features. In some cases his pitch notation contradicts some of the acoustic facts of pitch variations. According to his scheme, all moras with pitch phoneme /2/ are marked by writing an acute accent on the vowel of the mora. Unmarked initial and final syllables have the pitch phoneme /4/, and unmarked medial syllables have the pitch phoneme /3/. Thus, for example, kaki 'persimmon' is described as /44/ in pitch and kaki 'oyster' as /24/. From a phonetic point of view this description is inaccurate since a pitch rise occurs from the first to the second syllable of kaki 'persimmon' and since the pitch on the second syllable of the word for oyster is much lower than that on the second syllable of the word for persimmon.[16] From a functional point of view, an indication that a two-level pitch fall occurs in the word for oyster is not necessary, since the contrastive difference between the two words is a difference of pitch fall versus pitch rise.

In the level approach the accent patterns are looked upon as sequences of distinctive pitch levels. What

[16]See data in Chapter III.

distinguishes one accent pattern from another is represented by the different arrangements of these pitch levels in the sequence. On the other hand, the accent kernel approach has sought to describe the accent patterns in terms of the particular feature or features that make an accent pattern different from all other accent patterns in uninterrupted utterances of a given length.

Hattori Shiroo, the chief advocate of the accent kernel approach,[17] criticized the pitch level approach on two grounds: (1) the concept of an accent pattern is derived from the consideration of pitch alone and neglects other phonetic features such as intensity, duration, etc.,[18] and (2) portions of the sequences of pitch levels used to describe an accent pattern are not significant in distinguishing that pattern from other patterns.[19]

[17]Miyata Kooichi (see Bibliography) was the first to propose an accent kernel theory for Japanese, but his idea went unnoticed until it was taken up again by Hattori who refined it on the basis of phonemic principles unknown in Miyata's time.

[18]The question regarding the acoustic character of accent will be described in detail in Chapters III-VI.

[19]Gengogaku no Hoohoo [Methods in Linguistics] (Tokyo, 1961), pp. 240-275 and 360-367.

In place of the notion Akusento no kata (accent pattern), which Japanese scholars previously attributed to the pattern of pitch variations in sequences of moras, Hattori introduces the concept of Akusento-so (prosodeme), which is similar to the Akusento no kata in that it is something superimposed upon a sequence of moras. The Akusento-so, however, is more encompassing in that it is manifested not by pitch alone, as the Akusento no kata is said to be, but by other phonetic features as well.[20] Thus, Hattori believes, it is not proper to explain accent phenomena in terms of pitch levels alone, or any kind of levels for that matter.

To Hattori the significant feature of the prosodemes of the Tokyo dialect is the place where an abrupt and relatively large reduction of some kind occurs, from one mora to the next. This reduction can be manifested by such things as a fall in pitch and/or by a fall in intensity or force of articulation. Hattori calls this place of fall the accent kernel (akusento kaku) of the prosodeme. Thus, the distinctive features of a prosodeme are presence versus absence of

[20]Hattori, however, does not present any acoustic data to support this.

an accent kernel and the location of the accent kernel when present in the prosodeme. Using the symbol /⌝/ to mark the accent kernel, Hattori describes the accent in two-mora words as follows:

1. /00/: Ex. *hana* 'nose'
2. /0⌝0/: Ex. *hana* 'girl's name'
3. /00⌝/: Ex. *hana* 'flower'

Hattori, like Yamada and Sakuma, distinguishes three accent patterns for two-mora words, or, in general, n + 1 contrastive accent patterns for words n moras in length. (For a comparison of how these accent patterns of words up to four moras in length are described by the various scholars, see Table 1.1.)

Sakuma's system of accent patterns seems to be based on his belief that there is an actual physical difference between words like *hana* 'nose' and *hana* 'flower.' As mentioned above, however, most evidence seems to indicate that when these words are spoken normally as single utterances, there is no significant difference in their accent.

On the other hand, the system as set up by Hattori does not distinguish between, in Arisaka's terms, an actual or actualized accent pattern and a latent or potential accent pattern. Thus, any word that Hattori marks with an accent

TABLE 1.1

A COMPARISON OF THE PHONOLOGICAL DESCRIPTIONS OF ACCENT PATTERNS ACCORDING TO VARIOUS ACCENT THEORIES

	Accent Kernel Theory	Four Level Theory	Three Level Theory	Two Level Theory
Two-Mora Words				
Pattern 1	/00/ /00⌉/	/44/	/low-mid/ /low-high/	/low-high/
Pattern 2	/0⌉0/	/24/	/high-mid/	/high-low/
Three-Mora Words				
Pattern 1	/000/ /000⌉/	/434/	/low-mid-mid/ /low-high-high/	/low-high-high/
Pattern 2	/00⌉0/	/424/	/low-high-mid/	/low-high-low/
Pattern 3	/0⌉00/	/234/	/high-mid-mid/	/high-low-low/
Four-Mora Words				
Pattern 1	/0000/ /0000⌉/	/4334/	/low-mid-mid-mid/ /low-high-high-high/	/low-high-high-high/
Pattern 2	/000⌉0/	/4324/	/low-high-high-mid/	/low-high-high-low/
Pattern 3	/00⌉00/	/4234/	/low-high-mid-mid/	/low-high-low-low/
Pattern 4	/0⌉000/	/2334/	/high-mid-mid-mid/	/high-low-low-low/

kernel after the last mora of the word is not a description of the accent pattern of an actual utterance and thus not a phonological representation but a morphophonemic one. In the treatment of the actual accent patterns themselves and of how these patterns differ phonologically, the representation of a word that takes into account morphophonemic considerations is not of relevance. Therefore, as single-word utterances, hana 'nose' and hana 'flower' have the same accent pattern. This fact, however, does not vitiate the basic idea of the accent kernel theory, but only (1) forces a modification of it in regard to the number of accent patterns that need to be described by the theory and (2) places a restriction on the location of an accent kernel to any place except after the final mora of an utterance.

Generally, the theories of accent discussed above make little attempt to use acoustic phonetic data as supporting evidence. Mieko S. Han was one of the first investigators to gather, in a systematic way, acoustic phonetic data on Japanese accent and to use them as supporting evidence for a particular theory of accent.[21] Han's study was a

[21]Han, pp. 102-128. See also the works by Chiba, Doi, Kawakami, and Neustupny, cited in the Bibliography.

preliminary one, but it did show the usefulness of modern acoustic-phonetic techniques in the analysis of Japanese accent.

CHAPTER II

METHOD OF ANALYSIS

Methods of Acoustic-Phonetic Analysis

The various works discussed in Chapter I were mainly concerned with accent in terms of (1) the distinctive function it performs within the total structure of Japanese phonology, and (2) the means by which that function is described. Accent as a phonological feature has its realization in the speech act and, in fact, the only way to observe accent is through an examination of the spoken utterances of Japanese. Thus, a knowledge of the relationship between the physical character of an utterance and the accent pattern which it manifests is important for a thorough understanding of the character of accent distinctions. In characterizing the functional aspect of accent, one must recognize, for example, that the two words kaki 'oyster' and kaki 'persimmon' are phonologically distinctive as spoken utterances, but the physical basis for such a distinction can be known only through an acoustic analysis of the speech act associated with these two words.

The object of such an analysis, then, is to determine (1) what particular acoustic features of an utterance constitute the physical manifestations of a linguistic distinction, and (2) how the particular acoustic features function to make this distinction. The general procedure in an acoustic-phonetic analysis is to compare the acoustic properties of two sets of utterances which differ along some phonological dimension--in the case of this study, the dimension is accent--to see what acoustic feature or features are different and how they are different in the two sets of utterances. If a difference in a certain acoustic feature is consistently found between two phonologically different utterances, then the particular acoustic feature is said to be an acoustic correlate of the particular phonological distinction.

Acoustic Features

Voice fundamental frequency and intensity are the two acoustic features examined in this study as possible acoustic correlates of Japanese accent. The actual data on how these acoustic features relate to accent are examined in Chapters IV and V.

Voice fundamental frequency

Voice fundamental frequency is one of the inherent characteristics of speech sounds which are produced by the vibration of the vocal cords, such as in the production of vowels and voiced consonants. The term pitch has been used by many researchers as a synonym for fundamental frequency. This usage is followed in this study. Strictly speaking, however, pitch is a term to describe the subjective sensation of a sound that admits of rank ordering on a scale ranging from high to low. Thus, pitch is not an attribute of a sound per se, but a sensation evoked in a human listener by a sound stimulus. On the other hand, fundamental frequency of the two sounds, voiceless sounds which are aperiodic, and thus do not have a fundamental frequency, can also evoke pitch sensations in a human listener. For example, the voiceless alveopalatal fricative [š] sounds as if it is lower in pitch than the voiceless alveolar fricative [s].

Intensity

Intensity, like fundamental frequency, is a physical attribute of a sound and refers to the acoustic power of a sound; i.e., to the flow of energy per unit of time.

A considerable amount of variation takes place in the intensity of a sound. Since intensity is the flow of energy per unit of time, a number of different ways of measuring it are possible depending on the time unit chosen. A more detailed discussion of the various types of measures for intensity will be presented in Chapter V.

Intensity, like fundamental frequency, is directly proportional to subglottal pressure: the higher the subglottal pressure, the greater the intensity, <u>ceteris paribus</u>. On the other hand, intensity is inversely proportional to vocal cord tension: the greater the tension on the vocal cords, the smaller the value of intensity, <u>ceteris paribus</u>.[1] This is opposite in its effect to that of vocal cord tension on fundamental frequency, since the value of fundamental frequency is directly proportional to the vocal cord tension. Thus, it is possible for the fundamental frequency and intensity to be negatively as well as positively correlated.

[1]In effect, an increase in vocal cord tension will result in a lesser volume of air flowing through the glottis, since the vocal cords will not be blown as far apart by a given subglottal pressure, as they would be if the tension in the vocal cords were less.

Instrumentation

In order to obtain data on the acoustic properties of fundamental frequency and intensity as they relate to accent, acoustic instruments which are capable (1) of extracting information about fundamental frequency and intensity from the speech signal and (2) of recording this information in a permanent way must be used. The sound spectrograph and pitch extractor are two instruments that make such an analysis possible.

Sound spectrograph

The spectrograph used in this study was a Kay Sona-Graph Model 6061A, an audio frequency analyzer that produces permanent graphic recordings of complex sound waves in the range of 85 to 8000 cycles per second. The spectrograph along with its Amplitude Display-Scale Magnifier accessory unit was used principally to gather information on the intensity values of utterances in order to determine the significance of intensity as a correlate of accent.

Pitch extracting and data recording system

The fundamental frequency data of the recorded utterances was obtained chiefly by means of a pitch extracting and data recording system.[2] This system consisted of a pitch extractor, a six-channel Galvanometer Amplifier unit, and an oscillograph.

Figure 2.1 is a block diagram of the pitch extractor component, showing the various stages of acoustic analysis that an input signal is subjected to in order to extract information about its fundamental component. An input signal passes through Stage I of the pitch extractor, where it is amplified, and then passes into Stage II, an adjustable low-pass filter. The filter has a negative slope of 24 db per octave. The frequency of the peak response is the variable parameter. By the proper adjustment of the filter it is possible to extract only the fundamental frequency component, while attenuating all other frequency components of the signal greater than the fundamental frequency. From the filter stage the signal passes through several stages of amplification and limiting whereby the signal is shaped into a rectangular waveform corresponding in frequency to that of the fundamental component. Stage IV differentiates the rec-

[2]The pitch extractor used in this study was designed and constructed for the Acoustic Phonetic Research Laboratory at the University of Southern California by the Office of Naval Research.

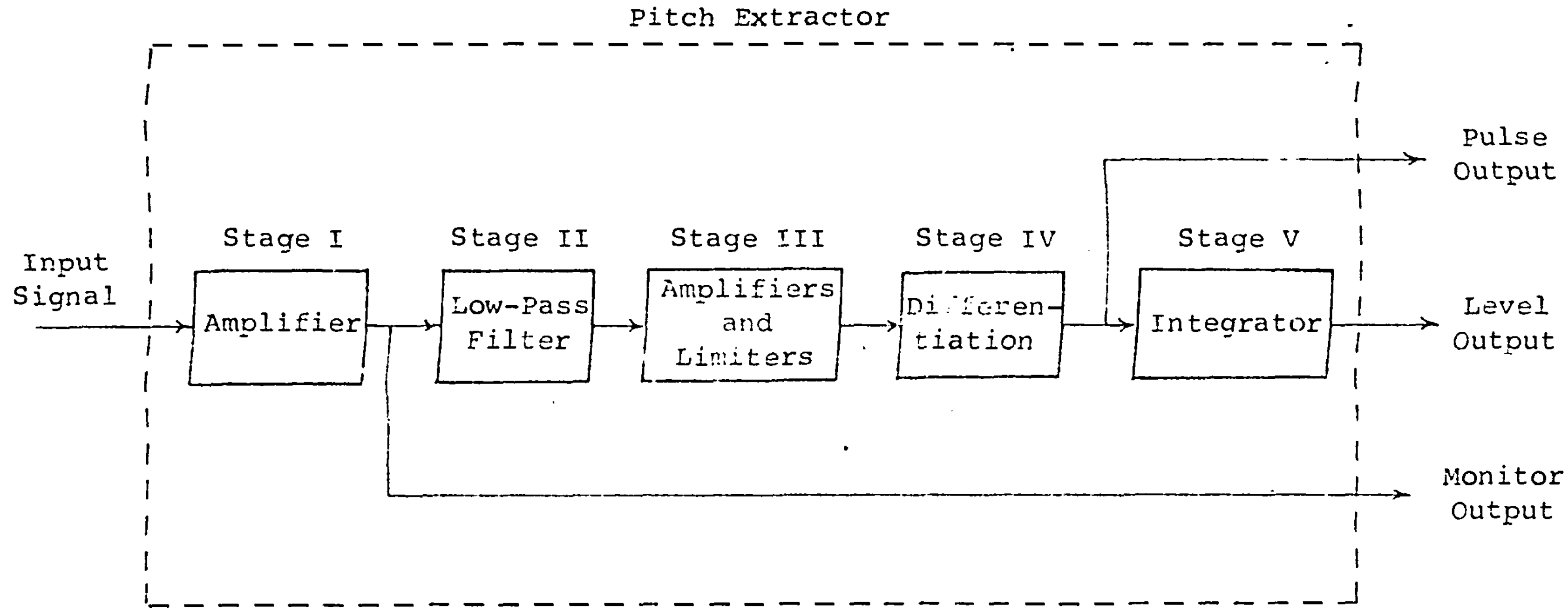


Fig. 2.1.--Block diagram of pitch extractor

tangular waveform to detect the transitions of the waveform; i.e., those points where the rectangular waveform rises and falls, and generates a uniform pulse for each transition. Stage V filters these uniform pulses to attenuate the high frequencies and form a smoothly varying DC voltage.

The pitch extractor has three outputs: (1) the Monitor Output, (2) the Pulse Output, and (3) the Level Output. The Monitor Output is simply an amplified version of the input signal. The pulses present at the Pulse Output mark the negative going transitions of the rectangular waveform derived from the fundamental frequency component. Thus, the time interval between each pulse represents the period of vibration of the fundamental frequency of the input signal. The Level Output is the smoothly varying DC voltage obtained from Stage V. This output varies in proportion to the variations that take place over time in the fundamental frequency of the input signal, and thus it serves as the primary source of information about the fundamental frequency. The relationship between the input signal's fundamental frequency component and the Level Output is linear over the range 60-500 cps.

The pitch extractor possesses a high sensitivity, so that any noise present at the input will cause some output level related to the average frequency of the noise. Generally, the noise does not interfere with the input signal, since it predominates only during silence. However, occasions do arise in which the noise level is high enough to interfere with the input signal, especially when the amplitude of the signal falls to a relatively low value.

From the pitch extractor all three outputs feed into a Honeywell Galvanometer Amplifier unit and from there into the oscillograph for the purpose of recording these outputs. The Galvanometer Amplifier unit is simply a set of six unity gain amplifiers and serves as buffer between the pitch extractor and the oscillograph.

The oscillograph used in this study is an eight-channel Honeywell Visicorder Model 906 provided with three types of galvanometers, which transfer current and voltage variations at the inputs to a photographic record. Each galvanometer has a different frequency response characteristic. The Monitor Output from the pitch extractor feeds into a Visicorder channel having a response of 0-2000 cps; the Pulse Output feeds into a Visicorder channel having a response of 0-270 cps; and the Level Output feeds into a Visicorder channel having a response of 0-900 cps. The Visicorder produces a visible display of each output simultaneously on photorecording paper.

Four selectable recording speeds are available on the Visicorder: 0.2, 1.0, 5.0, and 25.0 inches/second. In this study the recording speed was set at 5.0 inches/second. The displays produced at this speed are easy to read and have approximately the same time calibration as a spectrogram, making it possible to compare the Visicorder displays with spectrographic displays.

Besides the three channels necessary to record the pitch extractor outputs, a fourth channel on the Visicorder is used to provide a base line for the Level Output, from which displacement measurements can be made. In this way it is possible to calibrate the Level Output display so that a certain displacement of the Level Output from the base line represents a certain value of fundamental frequency.

Figures 2.2 and 2.3 present sample displays of the outputs from the pitch extractor. Figure 2.2 presents the Pulse, Monitor, and Level Output displays for three pure tones. In figure 2.2A the tone is 100 cps; in Figure 2.2B the tone is 150 cps; and in Figure 2.2C the tone is 200 cps. The recording speed for these displays was set at 25 inches per second in order to present a

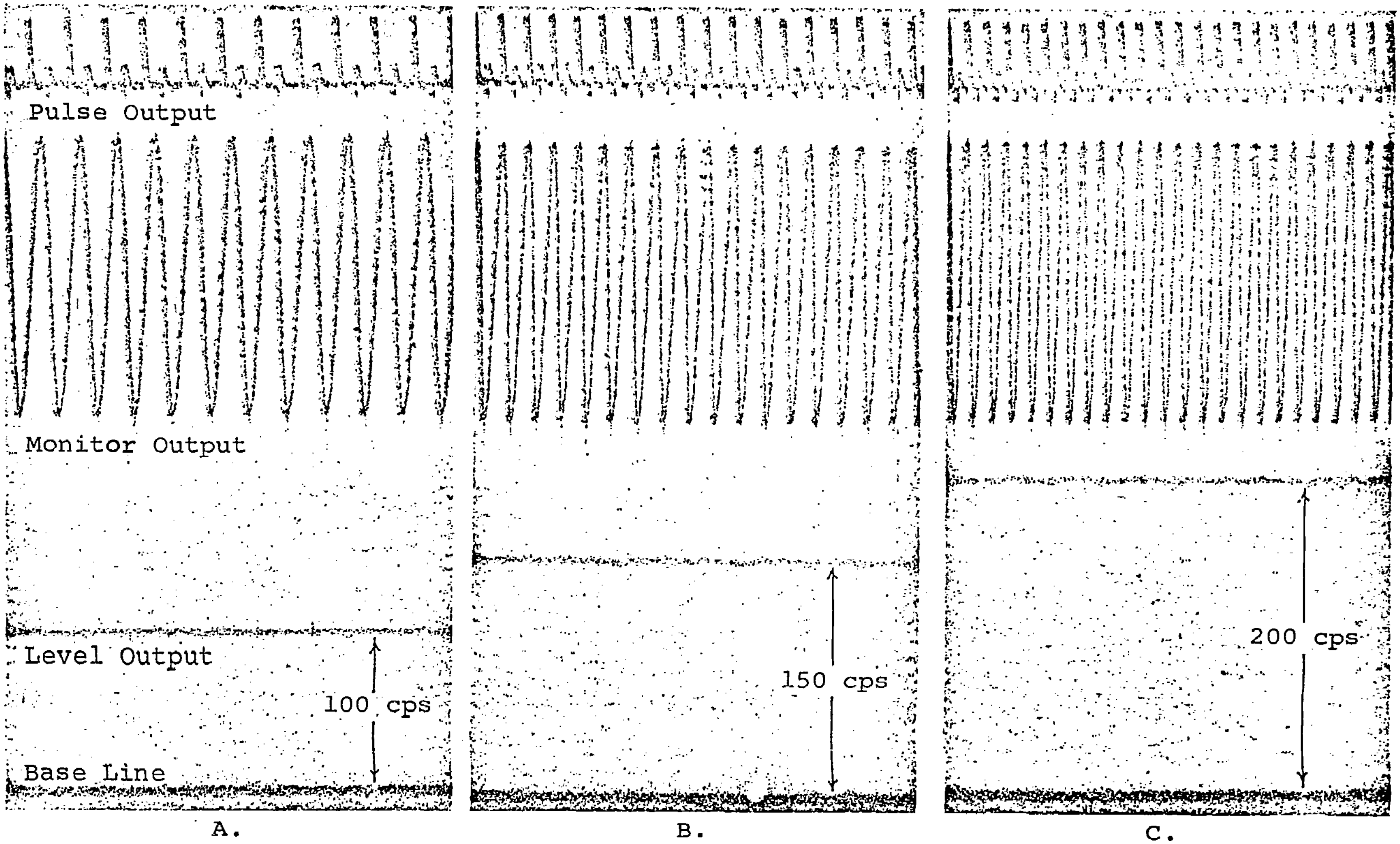


Fig. 2.2.--Pitch extractor displays of three pure tones

better resolution of the tones' waveforms. Figure 2.3 shows how the three pitch extractor outputs appear when the input to the pitch extractor is a complex speech waveform. The sample in this case is the word niwa 'two birds' as spoken by Informant 4. The displays in this figure were recorded at the normal speed of 5 inches per second.

The Level Output display is used to make fundamental frequency measurements, and the Monitor Output is used for the purpose of moraically segmenting the utterance. In some cases the Monitor Output is of little help in moraic segmentation, so spectrograms of the utterances can be used for this purpose.

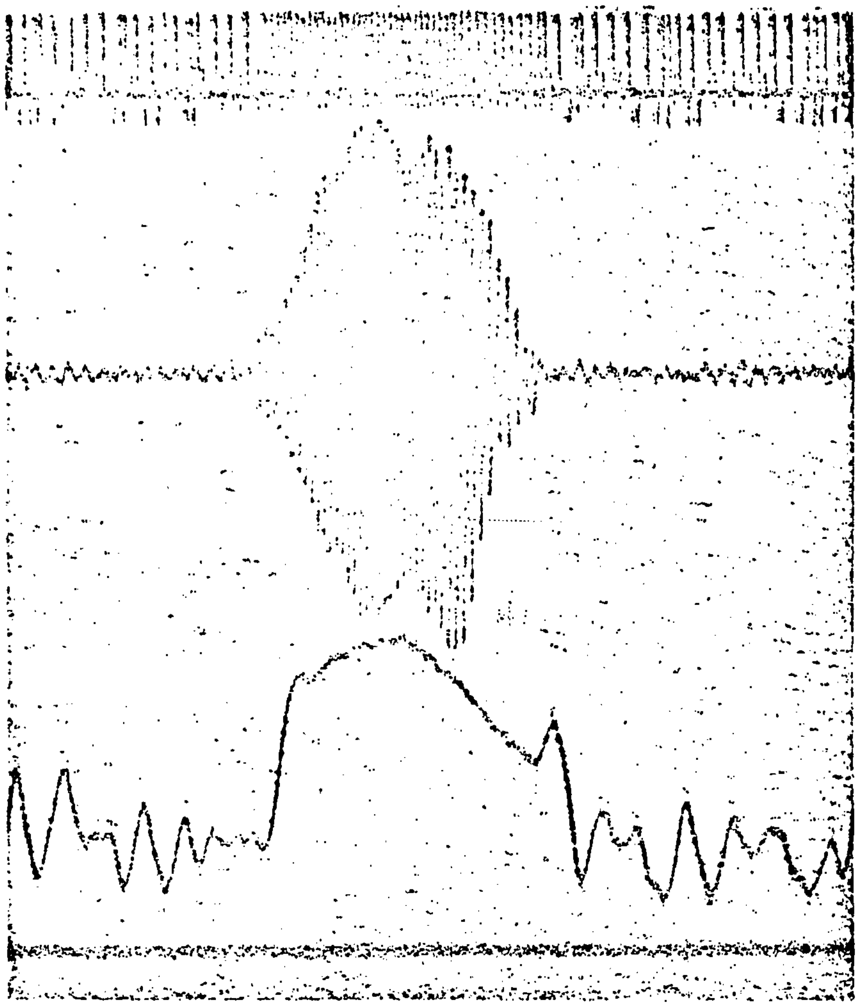


Fig. 2.3.--Pitch extractor display of the word niwa (Pattern 2 Accent) 'two birds' spoken by Informant 4.

CHAPTER III

FUNDAMENTAL FREQUENCY DATA

In order to discover how and to what extent the acoustic feature of fundamental frequency is used to make accent distinctions, experiments were conducted with the aid of the pitch extractor. The basic data for this study consisted of a total of fifty-eight words containing from two to four moras. All possible accent patterns of words n moras in length were equally represented. The number of words used for each two-mora word accent pattern was eight,[1] and the number of words used for each three-mora and four-mora word was six. The words used in this study as data for the accent patterns of two-mora words constituted minimal contrasts; i.e., these words differed only in their accent pattern and not in their segmental phonemes or in the tactic

[1]The corpus for Informant 1 of two-mora words with a Pattern 1 Accent consisted of only seven words, due to a recording error.

order of these phonemes. Such pairs of two-mora words are very abundant. However, phonological contrasts on the basis of accent alone in words three or more moras in length are either very rare or do not exist.[2]

In order to avoid making any judgment at this point as to the proper phonological description of the accent patterns, each distinctive accent pattern of a given moraic length was identified by a number. For example, the accent patterns in the words of four moras were identified as Pattern 1, Pattern 2, Pattern 3, and Pattern 4. (See Table 1.1 to see what this description corresponds to in terms of the accent theories discussed in Chapter I.)

The words were pronounced in citation form three times each by four native speakers of Standard Colloquial Japanese: Two female (Informants 1 and 2), and two male (Informants 3 and 4). The utterances of each informant were recorded in a soundproof booth on magnetic tape by an Ampex

[2]Although it is possible to find contrasts on the basis of accent alone between members of pairs of accent patterns, it is virtually impossible to find such contrasts among all accent patterns for words greater than or equal to three moras in length simultaneously. For example, it is very difficult to find three words three moras in length which have the same segmental constituency but differ from one another in accent.

Model 602 professional tape recorder at a speed of 7.5 inches per second, full track. Each recorded utterance was submitted to a fundamental frequency analysis by the pitch extractor.

For each accent pattern in words of two moras, the total sample size was twenty-four, and for each accent pattern in words of three and four moras, the total sample size was eighteen. Altogether, there was a total sample of 174 utterances for each informant available for examination. Some data also were collected on the accent patterns of words five and six moras in length and was used to check some of the conclusions reached on the basic data.

Measurement Procedures

The variations in fundamental frequency that take place within an utterance are continuous except where interrupted by gaps due to the presence of a voiceless segment. The continuous nature of fundamental frequency presents some difficulties in deciding how one should go about describing the variations in pitch that take place within an utterance. Since this study is concerned with fundamental frequency only to the extent that it correlates with accentual distinctions, it was decided to take only those measurements that would best reflect this correlation. A preliminary examination of the pitch data revealed that the changes in fundamental frequency from one mora to the next in a word seemed to express best the character of an accent pattern.

The next problem was to decide the point of measurement in each mora in order to determine the mora-to-mora changes in pitch. If the value of fundamental frequency remains unchanged throughout the duration of a mora, then there is no problem. In most cases, however, the value of fundamental frequency does not remain constant but often varies considerably within the duration of one mora. Here it was assumed that for every mora there is a target value for the fundamental frequency.

If the pitch rose or fell throughout a mora, it was assumed that the target pitch value for that mora was at the terminal point of the mora. In cases where the pitch rose and fell or fell and rose over the length of a mora, it was assumed that the target pitch value was at the point where the pitch was at a steady state; i.e., either at the peak of the initial rise or at the trough of the initial fall. These assumptions are somewhat arbitrary. Nevertheless, they led to pitch comparisons which clearly revealed the pitch differences among accent patterns.

The calibration scale for the pitch data on Informants 1 and 2 was 1/20th of an inch for every 10 cps. The measuring scale, contained 20 divisions to the inch. This allowed the measurement of fundamental frequency values to the nearest half of 10 cps. Therefore, the last digit of a measurement was either 5 or 0, and the true value of fundamental frequency was within ±5 cps of the measured value.

The calibration scale for the pitch data on Informants 3 and 4 was 1/20th of an inch for every 5 cps. Again a scale with 20 divisions to the inch was used in making the measurements. In measuring, an attempt was made to estimate the fundamental frequency value to the nearest one cycle. Because of the width of the pitch curve itself, which was about 1/20th of an inch, however, the true value of fundamental frequency was probably within about ±3 cps of the measured value.

Calculation of Frequency Changes

Since this study was primarily concerned with the relative changes of pitch that took place from mora to mora, a relative measure of frequency differences which would indicate, for example, that such relative changes as those from 300 cps to 150 cps and from 200 cps to 100 cps are the same, despite the fact that the absolute differences in frequency between these pairs are different, had to be found. The relative measure of pitch change selected for use in this study was the semitone.

The semitone is a logarithmic measure of pitch change. One semitone represents a change in frequency of about 6 percent. Thus, there are about 12 semitones per octave. The number of semitones may be calculated by the formula $s = 39.86 \log F2/F1$, where F2 is the higher frequency value and F1 is the lower frequency value. In order to determine the semitone value for each pitch change without making tedious calculations each time, a curve which related the frequency ratio F2/F1 directly to the semitone value was plotted (See Figure 3.1).

One semitone is about 20 times greater than the difference limen for pitch perception. However, this fact was not one of the considerations in selecting the semitone scale. Aural perception and linguistic perception, although not totally unrelated, comprise really separate perceptual modes. Aural perception is, strictly speaking, the capacity to recognize, to a certain degree, the difference in sounds along some acoustic continuum, while there is more than just an acoustic dimension involved

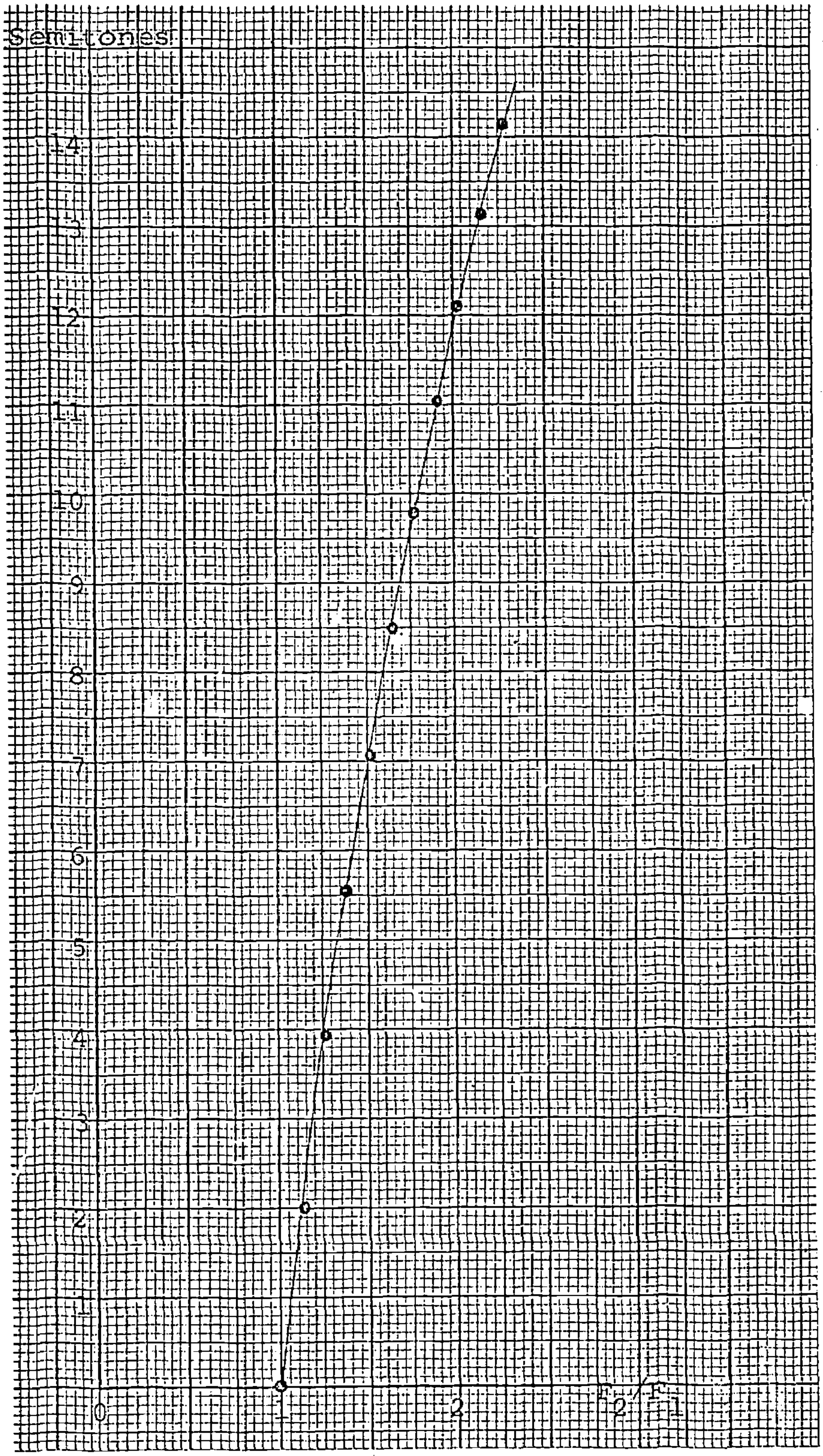


Fig. 3.1.--Conversion curve: frequency ratio to semitones

in the recognition of utterances, since they are also meaning-structured; i.e., expressions of linguistic forms.

Tables 3.1, 3.2, 3.3, and 3.4 present the fundamental frequency data on the sample utterances of Informants 1, 2, 3, and 4 respectively. Each table is subdivided according to the number of moras in words and the accent patterns on words of a given length.

Each table presents the following information:

1. A phonemic transcription of each word and an English translation.

2. The fundamental frequency value of every mora of every sample of a word as measured by the procedures described above. The letter M and a number identifies each mora and its position. Thus, M1 stands for the first mora of a word, M2 for the second mora of a word, and so on.

3. The relative value of fundamental frequency change from mora to mora in semitones. The letter M followed by a number, dash, and another number equal to the first number plus one identifies the change from one mora to the next. Thus, M1-2 identifies the change in pitch from the first mora to the second mora of a word, M2-3 identifies the change in pitch from the second to the third mora of a word, and so on. A pitch change with a plus (+) sign before it

indicates that the change is from a lower value of fundamental frequency to a higher value of fundamental frequency, and a minus (-) sign before a pitch change indicates that the change is from a higher value of fundamental frequency to a lower value of fundamental frequency.

TABLE 3.1

INFORMANT 1

PITCH DATA ON TWO-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps)		Mora to Mora Pitch Changes (in semitones)
	M1	M2	M1-2
/niwa/ 'garden'			
Rec. 1	240	255	+0.4
Rec. 2	240	255	+0.4
Rec. 3	235	240	+0.2
/kaki/ 'persimmon'			
Rec. 1	230	270	+2.9
Rec. 2	220	245	+1.7
Rec. 3	230	250	+1.4
/iši/ 'stone'			
Rec. 1	245	275	+2.5
Rec. 2	240	270	+2.0
Rec. 3	235	260	+1.6
/kama/ 'iron pot'			
Rec. 1	230	265	+2.5
Rec. 2	245	260	+0.8
Rec. 3	245	270	+1.6
/haši/ 'bridge'			
Rec. 1	250	280	+2.0
Rec. 2	250	285	+2.4
Rec. 3	250	280	+2.0
/asa/ 'linen cloth'			
Rec. 1	235	250	+0.9
Rec. 2	230	260	+2.1
Rec. 3	230	250	+1.4
/kami/ 'paper'			
Rec. 1	210	265	+4.0
Rec. 2	210	260	+3.1
Rec. 3	205	245	+3.2

PATTERN 2

	Mora Pitch Measurements (in cps)		Mora to Mora Pitch Changes (in semitones)
	M1	M2	M1-2
/niwa/ 'two birds'			
Rec. 1	290	160	-10.2
Rec. 2	290	160	-10.2
Rec. 3	290	170	- 9.2
/kaki/ 'oyster'			
Rec. 1	310	150	-13.2
Rec. 2	305	155	-10.6
Rec. 3	300	155	-10.6
/iši/ 'will power'			
Rec. 1	300	155	-10.6
Rec. 2	290	145	-12.0
Rec. 3	290	145	-12.0
/kama/ 'sickle'			
Rec. 1	295	175	- 9.1
Rec. 2	290	155	-10.8
Rec. 3	265	160	- 8.7
/haši/ 'chopsticks'			
Rec. 1	310	170	-10.4
Rec. 2	300	160	-10.9
Rec. 3	295	155	-11.1
/asa/ 'morning'			
Rec. 1	290	145	-12.0
Rec. 2	275	130	-12.9
Rec. 3	270	150	-10.5
/kami/ 'god'			
Rec. 1	270	155	- 9.6
Rec. 2	270	140	-11.4
Rec. 3	245	155	- 7.9
/ame/ 'rain'			
Rec. 1	290	160	-10.2
Rec. 2	285	130	-12.8
Rec. 3	270	165	- 8.5

PITCH DATA ON THREE-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps)			Mora to Mora Pitch Changes (in semitones)	
	M1	M2	M3	M1-2	M2-3
/riŋ:ŋo/ 'apple'					
Rec. 1	265	285	255	+1.1	-2.4
Rec. 2	265	280	245	+0.8	-2.4
Rec. 3	265	270	235	+0.2	-2.5
/saihu/ 'wallet'					
Rec. 1	265	275	220	+0.4	-3.9
Rec. 2	255	270	225	+0.8	-3.3
Rec. 3	235	260	210	+1.6	-3.7
/tabako/ 'cigarette'					
Rec. 1	230	260	210	+2.1	-3.7
Rec. 2	220	265	205	+3.3	-4.4
Rec. 3	215	250	195	+3.9	-4.3
/kan:na/ 'plane'					
Rec. 1	245	270	210	+1.6	-4.3
Rec. 2	230	260	230	+2.1	-2.1
Rec. 3	225	250	225	+1.7	-1.7
/kaeru/ 'frog'					
Rec. 1	250	265	215	+0.8	-3.7
Rec. 2	245	265	215	+1.3	-2.9
Rec. 3	240	265	220	+1.6	-3.3
/učiwa/ 'private'					
Rec. 1	220	250	195	+2.2	-4.3
Rec. 2	205	245	200	+3.8	-3.7
Rec. 3	215	245	195	+2.3	-4.0

PATTERN 2

	Mora Pitch Measurements (in cps)			Mora to Mora Pitch Changes (in semitones)	
	M1	M2	M3	M1-2	M2-3
/okaši/ 'sweets'					
Rec. 1	235	280	145	+3.2	-11.3
Rec. 2	225	270	160	+3.3	- 9.1
Rec. 3	210	255	165	+3.4	- 7.5
/mazui/ 'unsavory'					
Rec. 1	225	265	155	+2.9	- 9.3
Rec. 2	240	270	150	+2.0	-10.2
Rec. 3	225	265	155	+2.9	- 9.3
/nikuya/ 'meat market'					
Rec. 1	235	275	125	+2.9	-13.6
Rec. 2	235	260	145	+1.6	-10.1
Rec. 3	225	255	145	+2.1	- 9.8
/učiwa/ 'fan'					
Rec. 1	225	265	145	+2.9	-10.3
Rec. 2	215	255	150	+3.2	- 9.3
Rec. 3	230	255	155	+1.7	- 8.7
/takai/ 'high'					
Rec. 1	230	265	170	+2.5	- 7.6
Rec. 2	210	260	155	+3.8	- 8.4
Rec. 3	20[illegible]	235	150	+2.9	- 7.6
/kowai/ 'scary'					
Rec. 1	230	275	150	+3.3	-10.5
Rec. 2	240	265	155	+1.6	- 9.3
Rec. 3	235	260	140	+1.6	-10.7

PATTERN 3

	Mora Pitch Measurements (in cps)			Mora to Mora Pitch Changes (in semitones)	
	M1	M2	M3	M1-2	M2-3
/kan:na/ 'canna'					
Rec. 1	270	200	165	-5.2	-3.6
Rec. 2	255	200	155	-4.1	-4.4
Rec. 3	250	195	135	-4.3	-6.4
/kon:do/ 'next time'					
Rec. 1	295	175	120	-9.1	-6.5
Rec. 2	290	185	150	-7.6	-3.7
Rec. 3	275	170	135	-8.2	-4.0
/koŋ:ya/ 'tonight'					
Rec. 1	280	200	145	-5.9	-5.6
Rec. 2	290	190	155	-7.3	-3.7
Rec. 3	265	185	140	-6.2	-4.8
/hoŋ:ya/ 'bookstore'					
Rec. 1	295	195	130	-7.1	-7.0
Rec. 2	270	200	140	-5.2	-6.2
Rec. 3	270	185	140	-6.0	-4.8
/kaeru/ 'to return'					
Rec. 1	280	190	160	-6.7	-3.2
Rec. 2	265	180	140	-7.8	-4.3
Rec. 3	265	175	140	-7.1	-3.9
/sugata/ 'a form'					
Rec. 1	315	210	145	-7.0	-6.4
Rec. 2	320	200	160	-8.1	-3.9
Rec. 3	315	190	160	-8.8	-3.2

TABLE 3.1 (continued)

PITCH DATA ON FOUR-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/emːpitu/ 'pencil'							
Rec. 1	235	270	230	200	+2.5	-2.9	-2.5
Rec. 2	245	260	--[a]	215	+0.8	--	--
Rec. 3	240	255	--[a]	200	+1.7	--	--
/niŋːŋyoo/ 'doll'							
Rec. 1	225	245	205	185	+1.5	-3.2	-1.7
Rec. 2	230	255	220	200	+1.7	-2.6	-1.6
Rec. 3	225	250	210	175	+1.7	-3.2	-3.3
/doituŋo/ 'German language'							
Rec. 1	235	260	230	190	+1.6	-2.1	-3.4
Rec. 2	225	260	230	200	+2.5	-2.1	-2.5
Rec. 3	230	260	230	185	+2.1	-2.1	-3.8
/nihoŋːŋo/ 'Japanese language'							
Rec. 1	225	260	230	190	+2.5	-2.1	-3.4
Rec. 2	220	265	230	205	+3.3	-2.5	-2.0
Rec. 3	230	250	220	180	+1.7	-2.2	-3.7
/šimːbuŋː/ 'newspaper'							
Rec. 1	250	255	225	215	+0.2	-2.1	-0.7
Rec. 2	230	250	230	210	+1.3	-1.3	-1.6
Rec. 3	240	250	225	190	+0.6	-1.7	-3.1
/yookaŋː/ 'western-style building'							
Rec. 1	230	250	215	200	+1.7	-2.7	-1.2
Rec. 2	230	255	220	200	+1.7	-2.6	-1.6
Rec. 3	220	250	215	200	+2.2	-2.7	-1.2

[a] Vowel devoiced

PATTERN 2

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/kawaii/ 'cute'							
Rec. 1	250	290	235	150	+2.6	-3.8	- 7.7
Rec. 2	245	280	230	155	+2.4	-3.5	- 6.8
Rec. 3	245	280	215	140	+2.4	-4.5	- 7.3
/mijikai/ 'short'							
Rec. 1	240	280	240	150	+2.7	-2.8	- 8.1
Rec. 2	240	275	240	150	+2.5	-2.4	- 8.7
Rec. 3	235	260	230	130	+1.6	-2.1	- 9.9
/čiisai/ 'small'							
Rec. 1	280	300	240	130	+1.1	-3.9	-10.7
Rec. 2	265	300	240	135	+2.1	-3.9	-10.0
Rec. 3	260	295	245	140	+2.2	-3.3	- 9.7
/ookii/ 'large'							
Rec. 1	275	295	240	140	+1.2	-3.7	- 9.3
Rec. 2	280	295	235	130	+0.7	-3.9	-10.2
Rec. 3	275	300	235	125	+1.5	-4.2	-10.9
/seŋːsee/ 'teacher'							
Rec. 1	295	310	250	150	+0.7	-3.8	- 8.9
Rec. 2	280	295	260	160	+0.7	-2.1	- 8.4
Rec. 3	270	295	235	165	+1.5	-3.9	- 6.1
/mizuumi/ 'lake'							
Rec. 1	265	295	270	175	+1.7	-1.5	- 7.5
Rec. 2	240	285	260	150	+3.2	-1.6	- 9.6
Rec. 3	230	275	250	175	+3.3	-1.6	- 6.2

PATTERN 3

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/oteŋːki/ 'weather'							
Rec. 1	235	280	205	140	+3.2	- 6.6	-6.5
Rec. 2	230	270	190	160	+2.9	- 6.1	-3.2
Rec. 3	195	260	190	145	+4.9	- 5.4	-4.6
/jimuiŋː/ 'office worker'							
Rec. 1	235	290	175	130	+3.7	- 8.9	-5.2
Rec. 2	240	290	190	140	+3.4	- 7.2	-5.2
Rec. 3	240	295	190	130	+4.1	- 8.1	-6.5
/kuzukaŋo/ 'wastebasket'							
Rec. 1	215	300	175	135	+5.9	- 9.3	-4.5
Rec. 2	225	305	190	130	+5.2	- 8.1	-6.5
Rec. 3	220	305	175	125	+5.8	- 9.7	-5.9
/kinemːbi/ 'anniversary'							
Rec. 1	225	290	155	125	+4.4	-10.9	-3.8
Rec. 2	225	285	150	125	+4.0	-11.1	-3.3
Rec. 3	235	275	160	110	+2.9	- 9.4	-6.4
/ehaŋaki/ 'picture postcard'							
Rec. 1	240	290	175	135	+3.4	- 8.7	-4.5
Rec. 2	240	285	170	140	+3.2	- 9.0	-3.5
Rec. 3	240	280	175	120	+2.7	- 8.1	-6.5.
/nomimono/ 'a drink'							
Rec. 1	250	310	210	160	+3.8	- 6.7	-4.6
Rec. 2	260	295	200	160	+2.2	- 6.7	-3.9
Rec. 3	255	295	200	160	+2.5	- 6.7	-3.9

PATTERN 4

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/zuibuŋː/ 'very much'							
Rec. 1	280	205	130	120	-5.3	- 7.8	-1.3
Rec. 2	295	225	125	120	-4.1	-10.2	-0.6
Rec. 3	275	200	140	115	-5.5	- 6.2	-3.5
/homːbako/ 'bookcase'							
Rec. 1	280	185	140	120	-7.1	- 4.8	-2.8
Rec. 2	275	170	145	120	-8.2	- 2.9	-3.4
Rec. 3	270	175	150	130	-6.9	- 2.8	-2.5
/buŋːŋaku/ 'literature'							
Rec. 1	300	230	150	120	-4.5	- 7.3	-3.9
Rec. 2	280	230	140	130	-3.5	- 8.4	-1.2
Rec. 3	275	215	140	125	-4.2	- 7.3	-2.0
/oŋːŋaku/ 'music'							
Rec. 1	285	230	160	120	-3.8	- 6.3	-4.9
Rec. 2	280	230	155	125	-3.5	- 6.8	-3.8
Rec. 3	275	215	150	125	-4.2	- 6.2	-3.3
/geŋːkaŋː/ 'front door'							
Rec. 1	275	220	165	130	-3.9	- 4.9	-4.1
Rec. 2	270	225	145	125	-3.3	- 7.5	-2.6
Rec. 3	275	215	160	120	-4.2	- 5.1	-4.9
/yookaŋː/ 'bean jelly'							
Rec. 1	280	200	165	140	-3.5	- 3.4	-2.9
Rec. 2	290	250	170	140	-2.7	- 6.7	-3.4
Rec. 3	280	235	165	140	-3.2	- 6.2	-2.9

TABLE 3.2

INFORMANT 2

PITCH DATA ON TWO-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps)		Mora to Mora Pitch Changes (in semitones)
	M1	M2	M1-2
/niwa/ 'garden'			
Rec. 1	190	210	+1.6
Rec. 2	205	220	+1.2
Rec. 3	190	205	+1.4
/kaki/ 'persimmon'			
Rec 1	190	230	+3.4
Rec. 2	175	210	+3.3
Rec. 3	160	205	+4.3
/iši/ 'stone'			
Rec. 1	170	220	+4.5
Rec. 2	160	215	+5.1
Rec. 3	155	210	+5.2
/kama/ 'iron pot'			
Rec. 1	175	220	+3.9
Rec. 2	170	215	+4.0
Rec. 3	170	210	+3.8
/haši/ 'bridge'			
Rec. 1	175	230	+4.6
Rec. 2	180	220	+3.7
Rec. 3	165	220	+6.1
/asa/ 'linen cloth'			
Rec. 1	165	200	+3.4
Rec. 2	170	195	+2.5
Rec. 3	160	190	+3.1
/kami/ 'paper'			
Rec. 1	180	225	+3.9
Rec. 2	180	210	+2.8
Rec. 3	165	205	+3.8
/ame/ 'candy'			
Rec. 1	190	230	+3.4
Rec. 2	180	220	+3.7
Rec. 3	185	215	+2.6

PATTERN 2

	Mora Pitch Measurements (in cps)		Mora to Mora Pitch Changes (in semitones)
	M1	M2	M1-2
/niwa/ 'two birds'			
Rec. 1	240	140	-9.3
Rec. 2	240	165	-6.4
Rec. 3	245	150	-8.3
/kaki/ 'oyster'			
Rec. 1	255	145	-9.7
Rec. 2	240	145	-8.7
Rec. 3	225	140	-8.2
/iši/ 'will power'			
Rec. 1	230	145	-8.3
Rec. 2	225	145	-7.7
Rec. 3	225	150	-7.0
/kama/ 'sickle'			
Rec. 1	235	150	-7.4
Rec. 2	225	145	-7.7
Rec. 3	225	150	-7.0
/haši/ 'chopsticks'			
Rec. 1	250	150	-8.9
Rec. 2	235	150	-7.8
Rec. 3	225	145	-7.7
/asa/ 'morning'			
Rec. 1	230	145	-8.1
Rec. 2	225	150	-7.0
Rec. 3	220	150	-6.6
/kami/ 'god'			
Rec. 1	230	155	-6.8
Rec. 2	215	145	-6.8
Rec. 3	210	145	-6.4
/ame/ 'rain'			
Rec. 1	240	165	-6.4
Rec. 2	230	160	-6.2
Rec. 3	235	165	-6.1

PITCH DATA ON THREE-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps)			Mora to Mora Pitch Changes (in semitones)	
	M1	M2	M3	M1-2	M2-3
/riŋ:ŋo/ 'apple'					
Rec. 1	200	215	195	+1.2	-1.6
Rec. 2	190	205	200	+1.2	-0.2
Rec. 3	185	205	195	+1.7	-0.7
/saifu/ 'wallet'					
Rec. 1	195	215	205	+1.6	-0.7
Rec. 2	190	210	190	+1.6	-1.6
Rec. 3	185	205	185	+1.7	-1.7
/tabako/ 'cigarette'					
Rec. 1	190	225	205	+3.1	-1.6
Rec. 2	190	210	205	+1.6	-0.3
Rec. 3	185	200	190	+2.4	-0.7
/kan:na/ 'plane'					
Rec. 1	200	210	195	+0.7	-1.2
Rec. 2	190	210	180	+1.6	-2.7
Rec. 3	190	210	185	+1.6	-2.1
/kaeru/ 'frog'					
Rec. 1	210	215	195	+0.3	-1.6
Rec. 2	210	215	190	+0.3	-2.1
Rec. 1	200	205	185	+0.3	-1.7
/učiwa/ 'private'					
Rec. 1	190	220	205	+2.5	-1.2
Rec. 2	180	225	200	+3.9	-2.0
Rec. 3	180	215	190	+3.2	-2.1

PATTERN 2

	Mora Pitch Measurements (in cps)			Mora to Mora Pitch Changes (in semitones)	
	M1	M2	M3	M1-2	M2-3
/okaši/ 'sweets'					
Rec. 1	185	230	155	+3.8	- 6.8
Rec. 2	180	225	140	+3.9	- 8.1
Rec. 3	165	215	140	+4.5	- 7.3
/mazui/ 'unsavory'					
Rec. 1	190	230	150	+3.4	- 7.3
Rec. 2	190	215	140	+2.1	- 7.3
Rec. 3	175	195	130	+1.7	- 7.0
/nikuya/ 'meat market'					
Rec. 1	195	225	140	+2.5	- 8.1
Rec. 2	190	225	140	+3.1	- 8.1
Rec. 3	180	225	140	+3.9	- 8.1
/učiwa/ 'fan'					
Rec. 1	180	220	140	+3.7	- 7.2
Rec. 2	180	210	140	+2.8	- 7.0
Rec. 3	175	200	140	+2.4	- 6.1
/takai/ 'high'					
Rec. 1	190	230	165	+3.4	- 5.1
Rec. 2	185	225	160	+3.4	- 5.8
Rec. 3	180	210	150	+2.8	- 5.8
/kowai/ 'scary'					
Rec. 1	210	230	125	+1.6	-10.6
Rec. 2	195	215	145	+1.6	- 6.8
Rec. 3	200	215	130	+1.2	- 8.7

PATTERN 3

	Mora Pitch Measurements (in cps)			Mora to Mora Pitch Changes (in semitones)	
	M1	M2	M3	M1-2	M2-3
/kan:na/ 'canna'					
Rec. 1	235	170	130	-5.5	-4.5
Rec. 2	215	170	135	-3.9	-3.9
Rec. 3	215	160	130	-5.2	-2.0
/kon:do/ 'next time'					
Rec. 1	240	155	135	-7.7	-2.5
Rec. 2	230	160	130	-6.2	-2.0
Rec. 3	225	165	125	-5.8	-4.8
/koŋ:ya/ 'tonight'					
Rec. 1	240	165	125	-6.4	-4.8
Rec. 2	230	160	120	-6.2	-4.8
Rec. 3	225	170	135	-4.8	-7.0
/hoŋ:ya/ 'bookstore'					
Rec. 1	235	165	130	-6.2	-4.1
Rec. 2	230	170	135	-5.2	-3.9
Rec. 3	220	175	140	-3.9	-3.9
/kaeru/ 'to return'					
Rec. 1	245	155	135	-8.0	-2.4
Rec. 2	230	175	130	-4.5	-5.2
Rec. 3	220	165	135	-4.8	-3.7
/suŋata/ 'a form'					
Rec. 1	245	180	145	-6.4	-3.9
Rec. 2	250	185	150	-6.4	-3.6
Rec. 3	235	180	155	-4.5	-2.6

TABLE 3.2 (continued)

PITCH DATA ON FOUR-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/em:pitu/ 'pencil'							
Rec. 1	190	205	--[a]	180	+1.2	--	--
Rec. 2	185	200	--[a]	185	+1.3	--	--
Rec. 3	180	190	--[a]	175	+0.7	--	--
/niŋ:ŋyoo/ 'doll'							
Rec. 1	210	235	220	210	+2.0	-1.1	-0.7
Rec. 2	205	230	215	180	+2.0	-1.1	-3.2
Rec. 3	195	220	205	170	+2.0	-1.1	-3.3
/doltuŋo/ 'German language'							
Rec. 1	205	230	220	190	+2.0	-0.7	-2.5
Rec. 2	185	215	205	175	+2.6	-0.7	-2.9
Rec. 3	190	205	200	195	+1.2	-0.3	-0.3
/nihoŋ:ŋo/ 'Japanese language'							
Rec. 1	190	230	220	200	+3.4	-0.6	-1.6
Rec. 2	185	225	215	190	+3.4	-0.7	-2.1
Rec. 3	185	215	210	200	+2.6	-0.3	-0.7
/šim:buŋ:/ 'newspaper'							
Rec. 1	215	225	215	205	+0.7	-0.7	-0.7
Rec. 2	205	220	210	195	+1.2	-0.7	-1.1
Rec. 3	205	215	210	195	+0.7	-0.3	-1.1
/yookaŋ:/ 'western-style building'							
Rec. 1	215	230	215	205	+1.1	-1.1	-0.7
Rec. 2	195	220	210	195	+2.0	-0.7	-1.1
Rec. 3	200	215	205	190	+1.2	-0.7	-1.1

[a]Vowel devoiced

PATTERN 2

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/kawaii/ 'cute'							
Rec. 1	205	260	230	150	+4.1	-2.1	-7.3
Rec. 2	205	245	215	165	+3.2	-2.3	-4.5
Rec. 3	210	235	220	150	+2.0	-1.1	-6.6
/mijikai/ 'short'							
Rec. 1	210	230	210	140	+1.6	-1.6	-7.0
Rec. 2	200	230	205	140	+2.5	-2.0	-6.6
Rec. 3	200	230	195	125	+2.5	-3.0	-7.1
/čiisai/ 'small'							
Rec. 1	240	240	205	145	0.0	-2.8	-6.0
Rec. 2	240	240	205	150	0.0	-2.8	-4.5
Rec. 3	240	240	195	140	0.0	-3.7	-5.7
/ookii/ 'large'							
Rec. 1	205	235	200	145	+2.5	-2.9	-5.5
Rec. 2	215	220	190	145	+0.3	-2.5	-4.6
Rec. 3	210	225	200	155	+1.2	-2.0	-4.4
/seŋ:see/ 'teacher'							
Rec. 1	225	230	210	160	+0.3	-1.6	-4.6
Rec. 2	195	220	205	160	+2.0	-1.2	-4.2
Rec. 3	195	215	195	165	+1.6	-1.6	-3.1
/mizuumi/ 'lake'							
Rec. 1	205	240	220	165	+3.6	-1.4	-7.3
Rec. 2	190	240	220	165	+4.0	-1.5	-5.0
Rec. 3	190	235	220	160	+3.7	-1.1	-5.5

PATTERN 3

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/oteŋ:ki/ 'weather'							
Rec. 1	175	230	170	145	+4.6	-5.2	-2.9
Rec. 2	180	220	165	145	+3.9	-4.9	-2.4
Rec. 3	170	215	165	140	+4.0	-4.5	-2.9
/ǰimuiŋ:/ 'office worker'							
Rec. 1	210	255	150	145	+3.5	-9.2	-0.4
Rec. 2	210	250	160	140	+3.2	-8.1	-2.3
Rec. 3	200	240	150	145	+3.3	-8.1	-0.4
/kuzukaŋo/ 'wastebasket'							
Rec. 1	235	260	175	140	+3.8	-6.8	-3.9
Rec. 2	220	260	165	130	+3.1	-7.8	-4.1
Rec. 3	220	250	160	140	+2.3	-7.6	-2.3
/kinem:bi/ 'anniversary'							
Rec. 1	210	240	160	140	+2.4	-7.0	-2.4
Rec. 2	205	240	170	130	+2.8	-6.0	-4.5
Rec. 3	205	230	155	145	+2.0	-6.8	-1.1
/ehaŋaki/ 'picture postcard'							
Rec. 1	200	255	155	120	+4.2	-8.7	-4.4
Rec. 2	195	240	155	135	+3.7	-7.5	-2.5
Rec. 3	195	230	155	120	+3.1	-6.8	-4.4
/nomimono/ 'a drink'							
Rec. 1	200	240	170	140	+3.3	-6.0	-3.5
Rec. 2	200	235	170	150	+2.9	-5.6	-2.1
Rec. 3	195	225	165	145	+2.5	-5.3	-2.4

PATTERN 4

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/zuibuŋ:/ 'very much'							
Rec.[a] 1	270	170	155	140	-8.1	-1.6	-0.7
Rec. 2	250	170	155	140	-6.7	-1.6	-1.7
Rec. 3	250	165	145	130	-7.1	-2.3	-1.8
/hom:bako/ 'bookcase'[a]							
Rec. 1	--	--	--	--	--	--	--
Rec. 2	--	--	--	--	--	--	--
Rec. 3	--	--	--	--	--	--	--
/buŋ:ŋaku/ 'literature'							
Rec. 1	265	190	160	155	-5.8	-3.2	-0.4
Rec. 2	255	185	160	155	-5.5	-2.5	-0.4
Rec. 3	250	180	160	140	-5.1	-2.0	-2.3
/oŋ:ŋaku/ 'music'							
Rec. 1	240	190	160	155	-4.0	-3.2	-0.4
Rec. 2	250	185	160	140	-5.2	-2.5	-2.3
Rec. 3	230	185	155	130	-3.8	-3.2	-3.2
/geŋ:kaŋ:/ 'front door'							
Rec. 1	250	200	145	130	-3.9	-5.5	-1.8
Rec. 2	240	170	155	145	-6.0	-1.6	-1.0
Rec. 3	240	190	145	120	-4.0	-4.6	-3.4
/yookaŋ:/ 'bean jelly'							
Rec. 1	245	210	145	135	-2.8	-6.4	-1.1
Rec. 2	240	205	145	135	-3.0	-6.0	-1.1
Rec. 3	235	170	150	145	-5.6	-2.1	-0.4

[a]Mispronounced

TABLE 3.3

INFORMANT 3

PITCH DATA ON TWO-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps) M1	M2	Mora to Mora Pitch Changes (in semitones) M1-2
/niwa/ 'garden'			
Rec. 1	95	108	+2.4
Rec. 2	90	100	+1.7
Rec. 3	85	90	+0.8
/kaki/ 'persimmon'			
Rec. 1	100	108	+1.7
Rec. 2	102	107	+0.7
Rec. 3	99	99	0.0
/iši/ 'stone'			
Rec. 1	87	112	+3.2
Rec. 2	85	100	+4.1
Rec. 3	85	90	+0.8
/kama/ 'iron pot'			
Rec. 1	92	115	+3.9
Rec. 2	87	110	+3.9
Rec. 3	83	93	+2.0
/haši/ 'bridge'			
Rec. 1	--[a]	--[a]	--[a]
Rec. 2	92	105	+2.4
Rec. 3	89	90	+0.1
/asa/ 'linen cloth'			
Rec. 1	91	105	+2.5
Rec. 2	90	98	+1.5
Rec. 3	89	90	+0.1
/kami/ 'paper'			
Rec. 1	90	114	+5.5
Rec. 2	93	105	+2.0
Rec. 3	92	97	+0.7
/ame/ 'candy'			
Rec. 1	95	123	+4.5
Rec. 2	93	114	+4.8
Rec. 3	88	95	+1.3

[a]Mispronounced

PATTERN 2

	Mora Pitch Measurements (in cps) M1	M2	Mora to Mora Pitch Changes (in semitones) M1-2
/niwa/ 'two birds'			
Rec. 1	131	73	-10.1
Rec. 2	126	70	-10.2
Rec. 3	112	70	- 8.1
/kaki/ 'oyster'			
Rec. 1	132	74	-10.0
Rec. 2	128	75	- 9.3
Rec. 3	123	75	- 8.6
/iši/ 'will power'			
Rec. 1	134	80	- 9.3
Rec. 2	123	77	- 8.1
Rec. 3	126	78	- 8.3
/kama/ 'sickle'			
Rec. 1	129	74	- 9.6
Rec. 2	122	80	- 7.3
Rec. 3	115	76	- 7.2
/haši/ 'chopsticks'			
Rec. 1	133	82	- 8.4
Rec. 2	121	73	- 8.7
Rec. 3	120	80	- 7.0
/asa/ 'morning'			
Rec. 1	[illegible]	73	- 8.6
Rec. 2	127	79	- 8.2
Rec. 3	120	77	- 7.7
/kami/ 'god'			
Rec. 1	126	75	- 9.0
Rec. 2	125	87	- 6.3
Rec. 3	119	82	- 6.5
/ame/ 'rain'			
Rec. 1	132	75	- 9.8
Rec. 2	126	76	- 8.7
Rec. 3	110	74	- 6.9

PITCH DATA ON THREE-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps) M1	M2	M3	Mora to Mora Pitch Changes (in semitones) M1-2	M2-3
/riŋ:ŋo/ 'apple'					
Rec. 1	117	123	95	+0.7	-4.5
Rec. 2	105	117	80	+1.7	-6.5
Rec. 3	98	107	78	+1.5	-5.5
/saihu/ 'wallet'					
Rec. 1	90	110	85	+3.6	-4.2
Rec. 2	90	109	85	+3.3	-4.3
Rec. 3	85	107	82	+4.1	-4.7
/tabako/ 'cigarette'					
Rec. 1	89	112	90	+4.0	-3.9
Rec. 2	88	105	77	+3.3	-5.3
Rec. 3	82	98	75	+3.3	-4.5
/kan:na/ 'plane'					
Rec. 1	98	113	80	+2.5	-6.0
Rec. 2	93	103	80	+1.7	-4.4
Rec. 3	90	100	75	+1.7	-4.9
/kaeru/ 'frog'					
Rec. 1	102	110	88	+1.2	-3.9
Rec. 2	95	105	82	+1.6	-4.2
Rec. 3	92	100	80	+1.5	-3.9
/učiwa/ 'private'					
Rec. 1	90	110	83	+3.2	-4.8
Rec. 2	87	107	80	+3.7	-5.0
Rec. 3	85	100	72	+2.9	-5.8

PATTERN 2

	Mora Pitch Measurements (in cps) M1	M2	M3	Mora to Mora Pitch Changes (in semitones) M1-2	M2-3
/okaši/ 'sweets'					
Rec. 1	88	110	74	+3.9	-6.9
Rec. 2	82	111	72	+5.2	-7.4
Rec. 3	81	100	75	+3.7	-4.9
/mazui/ 'unsavory'					
Rec. 1	87	115	70	+4.8	-8.7
Rec. 2	88	113	70	+4.4	-8.2
Rec. 3	88	105	71	+3.3	-6.7
/nikuya/ 'meat market'					
Rec. 1	87	110	72	+4.0	-7.2
Rec. 2	86	115	70	+5.1	-8.7
Rec. 3	85	107	65	+5.8	-8.7
/učiwa/ 'fan'					
Rec. 1	90	115	69	+4.2	-9.0
Rec. 2	87	117	70	+5.2	-9.0
Rec. 3	88	113	68	+4.4	-8.8
/takai/ 'high'					
Rec. 1	98	122	80	+3.9	-7.2
Rec. 2	94	120	80	+4.2	-7.0
Rec. 3	92	112	77	+3.6	-6.5
/kowai/ 'scary'					
Rec. 1	93	113	75	+3.4	-7.0
Rec. 2	97	112	70	+2.5	-8.1
Rec. 3	90	105	70	+2.8	-7.0

PATTERN 3

	Mora Pitch Measurements (in cps) M1	M2	M3	Mora to Mora Pitch Changes (in semitones) M1-2	M2-3
/kan:na/ 'canna'					
Rec. 1	123	94	73	-4.6	-4.4
Rec. 2	118	87	70	-5.2	-3.9
Rec. 3	117	83	70	-6.0	-3.2
/kon:do/ 'next time'					
Rec. 1	122	77	70	-7.9	-0.7
Rec. 2	115	77	67	-7.0	-2.5
Rec. 3	110	72	63	-7.3	-2.4
/koŋ:ya/ 'tonight'					
Rec. 1	125	83	67	-7.0	-3.8
Rec. 2	120	82	75	-6.5	-1.5
Rec. 3	113	78	75	-6.4	-0.6
/hoŋ:ya/ 'bookstore'					
Rec. 1	115	82	73	-5.9	-2.0
Rec. 2	115	82	70	-5.9	-2.9
Rec. 3	110	82	65	-5.1	-4.0
/kaeru/ 'to return'					
Rec. 1	112	77	77	-6.4	0.0
Rec. 2	115	84	83	-5.5	0.0
Rec. 3	107	77	70	-5.8	-0.7
/suŋatn/ 'a form'					
Rec. 1	132	90	77	-6.6	-2.8
Rec. 2	125	95	67	-4.7	-6.1
Rec. 3	125	87	70	-6.2	-3.8

TABLE 3-1 (continued)

PITCH DATA ON FOUR-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/em:pitu/ 'pencil'							
Rec. 1	85	108	92	75	+4.1	-2.9	-3.7
Rec. 2	93	110	89	75	+3.7	-3.8	-3.2
Rec. 3	88	102	85	73	+2.6	-3.3	-2.6
/niŋ:ŋyoo/ 'doll'							
Rec. 1	103	110	89	70	+1.1	-3.8	-4.2
Rec. 2	91	109	83	70	+3.3	-4.6	-3.1
Rec. 3	93	100	81	65	+1.2	-3.7	-3.9
/doituŋo/ 'German language'							
Rec. 1	90	112	82	75	+3.9	-5.4	-1.5
Rec. 2	92	110	85	72	+3.3	-4.5	-3.1
Rec. 3	88	105	81	68	+3.3	-4.5	-3.2
/nihoŋ:ŋo/ 'Japanese language'							
Rec. 1	87	102	87	68	+2.9	-2.9	-4.3
Rec. 2	87	102	90	71	-2.9	-2.2	-4.1
Rec. 3	83	97	81	70	+2.8	-3.1	-2.5
/šim:buŋ:/ 'newspaper'							
Rec. 1	95	113	85	67	-3.2	-4.9	-4.1
Rec. 2	95	110	85	70	+4.6	-4.5	-3.4
Rec. 3	86	100	76	64	-2.6	-4.7	-3.2
/yookaŋ:/ 'western-style building'							
Rec. 1	99	115	84	69	-2.9	-5.5	-3.6
Rec. 2	98	113	84	70	+2.5	-5.2	-3.3
Rec. 3	90	106	77	65	+2.9	-5.5	-3.0

PATTERN 2

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/kawaii/ 'cute'							
Rec. 1	90	117	105	73	+4.5	-1.7	-6.3
Rec. 2	88	116	103	69	+4.[illegible]	-2.0	-7.0
Rec. 3	85	103	99	70	+3.4	-0.6	-6.1
/mijikai/ 'short'							
Rec. 1	88	115	93	68	+4.9	-3.9	-5.8
Rec. 2	91	121	95	70	+4.9	-4.1	-5.3
Rec. 3	[illegible]	113	98	70	+4.4	-2.5	-5.9
/čiisai/ 'small'							
Rec. 1	104	116	100	72	+1.8	-2.6	-5.8
Rec. 2	109	115	93	70	+0.8	-3.9	-4.9
Rec. 3	98	105	91	72	+1.2	-2.5	-3.8
/ookii/ 'large'							
Rec. 1	103	117	100	77	+2.2	-2.8	-4.5
Rec. 2	94	118	90	70	+4.6	-4.6	-4.3
Rec. 3	89	101	92	69	+3.7	-3.1	-4.9
/seŋ:sei/ 'teacher'							
Rec. 1	99	112	97	69	+2.1	-2.5	-5.4
Rec. 2	103	112	98	69	+1.5	-2.4	-6.1
Rec. 3	106	110	93	72	+1.7	-3.3	-4.4
/mizuumi/ 'lake'							
Rec. 1	102	146	117	78	+6.2	-3.9	-7.0
Rec. 2	93	141	115	78	+7.2	-3.7	-6.7
Rec. 3	90	135	112	73	+7.0	-3.3	-7.3

PATTERN 3

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/oteŋ:ki/ 'weather'							
Rec. 1	87	119	77	75	+5.5	- 8.7	-0.3
Rec. 2	83	120	77	73	[illegible]	- 7.6	-0.7
Rec. 3	91	114	75	75	+3	- 7.2	0.0
/jimuiŋ:/ 'office worker'							
Rec. 1	96	123	77	70	+4.2	- 8.1	-1.6
Rec. 2	90	120	75	69	+4.9	- 8.1	-1.4
Rec. 3	88	115	80	70	+4.5	- 6.3	-2.4
/kuzukago/ 'wastebasket'							
Rec. 1	97	130	80	68	+4.4	- 8.4	-2.9
Rec. 2	95	115	70	70	+6.2	-11.3	0.0
Rec. 3	90	123	75	65	+5.4	- 8.6	-2.5
/kinem:bi/ 'anniversary'							
Rec. 1	92	123	72	70	+5.1	- 8.2	-0.[illegible]
Rec. 2	95	120	78	71	+4.0	- 7.4	-1.[illegible]
Rec. 3	88	113	73	69	+4.3	- 7.5	-0.7
/ehaŋaki/ 'picture postcard'							
Rec. 1	90	118	68	68	+4.6	- 9.5	0.0
Rec. 2	88	118	73	67	+5.1	- 8.3	-1.5
Rec. 3	90	118	68	65	+4.6	- 9.5	0.6
/nomimono/ 'a drink'							
Rec. 1	101	150	95	77	+6.8	- 7.7	-3.7
Rec. 2	103	142	97	73	+5.5	- 6.5	-4.8
Rec. 3	92	137	92	75	+6.9	- 6.9	-3.7

PATTERN 4

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/zuibuŋ:/ 'very much'							
Rec. 1	115	92	73	66	-3.9	-4.0	-1.6
Rec. 2	117	95	[illegible]	[illegible]	-3.7	-4.0	-1.2
Rec. 3	115	90	72	67	-4.2	-3.9	-1.2
/hom:bako/ 'bookcase'							
Rec. 1	123	73	62	62	-9.2	-2.9	0.0
Rec. 2	120	78	65	64	-7.4	-3.3	0.0
Rec. 3	116	75	65	65	-7.5	-2.5	0.0
/buŋ:ŋaku/ 'literature'							
Rec. 1	127	83	70	70	-7.3	-3.1	0.0
Rec. 2	130	80	74	70	-8.4	-1.3	-0.7
Rec. 3	117	81	80	72	-6.4	0.0	-1.7
/oŋ:ŋaku/ 'music'							
Rec. 1	127	89	70	70	-4.2	-4.1	0.0
Rec. 2	120	85	79	70	-6.5	-1.2	-2.1
Rec. 3	115	85	75	70	-5.2	-2.1	-1.2
/geŋ:kaŋ:/ 'front door'							
Rec. 1	118	85	64	63	-5.2	-3.7	0.0
Rec. 2	110	83	65	63	-4.8	-4.2	-0.4
Rec. 3	108	83	70	63	-4.5	-3.1	-1.7
/yookaŋ:/ 'bean jelly'							
Rec. 1	121	85	65	63	-6.2	-4.6	-0.4
Rec. 2	117	85	65	63	-5.5	-4.6	-0.4
Rec. 3	113	79	63	62	-6.2	-3.9	0.0

TABLE 3.4

INFORMANT 4

PITCH DATA ON THREE-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps) M1	M2	Mora to Mora Pitch Changes (in semitones) M1-2
/niwa/ 'garden'			
Rec. 1	133	148	+1.7
Rec. 2	140	147	+0.7
Rec. 3	133	136	+0.3
/kaki/ 'persimmon'			
Rec. 1	126	145	+2.5
Rec. 2	122	137	+2.0
Rec. 3	115	120	+0.7
/iši/ 'stone'			
Rec. 1	117	142	+3.4
Rec. 2	120	140	+2.8
Rec. 3	110	130	+3.0
/kama/ 'iron pot'			
Rec. 1	120	147	+3.7
Rec. 2	123	142	+2.5
Rec. 3	120	135	+2.0
/haši/ 'bridge'			
Rec. 1	117	147	+3.9
Rec. 2	122	143	+3.9
Rec. 3	123	123	0.0
/asa/ 'linen cloth'			
Rec. 1	133	140	+0.7
Rec. 2	126	138	+1.6
Rec. 3	114	129	+2.1
/kami/ 'paper'			
Rec. 1	123	150	+3.5
Rec. 2	125	140	+2.0
Rec. 3	120	130	+1.3
/ame/ 'candy'			
Rec. 1	145	164	+2.1
Rec. 2	132	155	+2.9
Rec. 3	136	147	+1.3

PATTERN 2

	Mora Pitch Measurements (in cps) M1	M2	Mora to Mora Pitch Changes (in semitones) M1-2
/niwa/ 'two birds'			
Rec. 1	169	108	- 7.7
Rec. 2	166	105	- 7.9
Rec. 3	161	100	- 8.2
/kaki/ 'oyster'			
Rec. 1	147	105	- 5.8
Rec. 2	146	105	- 5.7
Rec. 3	143	--[a]	--[a]
/iši/ 'will power'			
Rec. 1	157	95	- 8.7
Rec. 2	157	96	- 8.5
Rec. 3	149	102	- 6.5
/kama/ 'sickle'			
Rec. 1	163	94	- 9.5
Rec. 2	163	100	- 8.5
Rec. 3	147	94	- 7.7
/haši/ 'chopsticks'			
Rec. 1	154	107	- 6.3
Rec. 2	153	109	- 5.9
Rec. 3	152	95	- 8.1
/asa/ 'morning'			
Rec. 1	155	78	-11.9
Rec. 2	150	91	- 8.6
Rec. 3	153	83	-10.6
/kami/ 'god'			
Rec. 1	160	115	- 5.7
Rec. 2	155	93	- 8.8
Rec. 3	143	85	- 9.0
/ame/ 'rain'			
Rec. 1	169	90	-10.9
Rec. 2	166	92	-10.2
Rec. 3	156	98	- 8.0

[a]Vowel devoiced

PITCH DATA ON TWO-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps) M1	M2	M3	Mora to Mora Pitch Changes (in semitones) M1-2	M2-3
/riŋ:ŋo/ 'apple'					
Rec. 1	142	148	134	+0.6	-1.6
Rec. 2	138	140	125	+0.1	-1.9
Rec. 3	136	142	118	+0.6	-3.3
/saihu/ 'wallet'					
Rec. 1	150	152	139	+0.1	-1.5
Rec. 2	146	150	125	+0.3	-3.3
Rec. 3	141	142	122	0.0	-2.6
/tabako/ 'cigarette'					
Rec. 1	130	155	130	+3.2	-3.2
Rec. 2	127	142	120	+1.9	-3.1
Rec. 3	116	140	117	+3.4	-3.3
/kan:na/ 'plane'					
Rec. 1	150	157	125	+0.7	-3.9
Rec. 2	145	148	125	+0.2	-3.1
Rec. 3	135	136	117	0.0	-2.6
/kaeru/ 'frog'					
Rec. 1	143	147	138	+0.3	-0.9
Rec. 2	144	145	125	0.0	-2.6
Rec. 3	135	140	127	+0.5	-1.6
/učiwa/ 'private'					
Rec. 1	129	150	140	+2.6	-1.1
Rec. 2	129	150	128	+2.6	-2.9
Rec. 3	124	137	125	+1.6	-1.5

PATTERN 2

	Mora Pitch Measurements (in cps) M1	M2	M3	Mora to Mora Pitch Changes (in semitones) M1-2	M2-3
/okaši/ 'sweets'					
Rec. 1	120	160	110	+4.9	- 6.4
Rec. 2	123	160	105	+4.5	- 7.3
Rec. 3	120	150	100	+3.9	- 7.0
/mazui/ 'unsavory'					
Rec. 1	140	163	90	+2.7	-10.2
Rec. 2	139	160	77	+2.5	-12.1
Rec. 3	138	158	105	+2.5	- 7.0
/nikuya/ 'meat market'					
Rec. 1	137	145	97	+0.8	- 7.0
Rec. 2	132	165	95	+3.9	- 9.6
Rec. 3	129	140	87	+1.3	- 8.3
/učiwa/ 'fan'					
Rec. 1	143	163	95	+2.3	- 9.4
Rec. 2	136	165	80	+3.4	-12.0
Rec. 3	135	157	85	+2.6	-10.7
/takai/ 'high'					
Rec. 1	133	160	90	+3.3	-10.0
Rec. 2	132	162	67	+3.7	-15.3
Rec. 3	138	152	100	+1.6	- 7.2
/kowai/ 'scary'					
Rec. 1	146	165	77	+2.1	-13.1
Rec. 2	148	158	100	+1.1	- 8.0
Rec. 3	139	155	95	+1.7	- 8.5

PATTERN 3

	Mora Pitch Measurements (in cps) M1	M2	M3	Mora to Mora Pitch Changes (in semitones) M1-2	M2-3
/kan:na/ 'canna'					
Rec. 1	160	132	77	-3.4	- 9.3
Rec. 2	158	128	92	-3.7	- 5.7
Rec. 3	150	127	95	-3.1	- 5.1
/kon:do/ 'next time'					
Rec. 1	168	113	97	-6.9	- 2.5
Rec. 2	165	110	95	-7.0	- 2.6
Rec. 3	153	105	92	-6.4	- 1.6
/koŋ:ya/ 'tonight'					
Rec. 1	156	121	87	-4.4	- 5.7
Rec. 2	157	123	97	-4.2	- 4.1
Rec. 3	155	120	78	-4.4	- 7.6
/hoŋ:ya/ 'bookstore'					
Rec. 1	168	130	85	-4.4	- 7.3
Rec. 2	165	130	75	-4.1	- 9.5
Rec. 3	153	125	65	-3.7	-11.3
/kaeru/ 'to return'					
Rec. 1	158	150	105	-0.7	- 6.1
Rec. 2	158	140	104	-2.0	- 5.7
Rec. 3	145	129	98	-2.0	- 4.7
/suŋata/ 'a form'					
Rec. 1	170	138	97	-3.7	- 6.1
Rec. 2	165	135	95	-3.7	- 6.1
Rec. 3	170	125	98	-5.3	- 7.3

TABLE 3.4 (continued)

PITCH DATA ON FOUR-MORA WORDS

PATTERN 1

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/em:pitu/ 'pencil'							
Rec. 1	146	160	148	113	+1.6	-1.1	-4.6
Rec. 2	150	159	125	124	+0.8	-4.1	0.0
Rec. 3	151	168	130	120	+1.7	-4.4	-1.4
/niŋ:ŋyoo/ 'doll'							
Rec. 1	140	162	145	133	+2.5	-1.9	-1.4
Rec. 2	148	160	139	125	+1.3	-2.5	-1.7
Rec. 3	146	155	135	120	+0.8	-2.5	-2.0
/doituŋo/ 'German language'							
Rec. 1	150	170	140	126	+2.1	-3.4	-1.7
Rec. 2	155	168	135	125	+1.2	-3.9	-1.4
Rec. 3	143	153	132	120	+1.1	-2.6	-1.6
/nihoŋ:ŋo/ 'Japanese language'							
Rec. 1	140	167	147	128	+3.2	-2.3	-2.5
Rec. 2	135	160	137	123	+3.1	-2.9	-1.7
Rec. 3	129	153	145	118	+3.2	-0.7	-3.7
/šim:buŋ:/ 'newspaper'							
Rec. 1	152	167	150	135	+1.6	-1.7	-1.7
Rec. 2	155	163	140	120	+0.7	-2.6	-2.6
Rec. 3	145	152	132	112	+0.7	-2.5	-2.9
/yookaŋ:/ 'western-style building'							
Rec. 1	150	160	138	132	+1.0	-2.9	-0.7
Rec. 2	146	163	135	132	+1.9	-3.3	-0.3
Rec. 3	140	149	121	117	+1.0	-3.8	-0.4

PATTERN 2

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/kawaii/ 'cute'							
Rec. 1	138	150	138	102	+1.5	-1.4	-5.2
Rec. 2	128	153	135	105	+3.3	-2.1	-4.3
Rec. 3	127	148	133	100	+2.6	-1.8	-4.9
/mijikai/ 'short'							
Rec. 1	150	177	150	105	+3.1	-3.0	-6.2
Rec. 2	143	175	152	95	+3.7	-2.5	-8.1
Rec. 3	152	175	148	95	+2.5	-3.1	-7.6
/čiisai/ 'small'							
Rec. 1	172	172	148	95	0.0	-2.7	-7.6
Rec. 2	172	172	140	102	0.0	-2.7	-5.5
Rec. 3	163	163	131	102	0.0	-3.8	-4.3
/ookii/ 'large'							
Rec. 1	[illegible]	177	155	115	+1.5	-2.4	-5.2
Rec. 2	162	172	142	106	+0.8	-3.4	-5.1
Rec. 3	165	170	140	105	+0.4	-3.4	-4.9
/seŋ:see/ 'teacher'							
Rec. 1	165	175	150	90	+0.8	-2.8	-9.0
Rec. 2	162	164	148	85	+0.1	-1.6	-9.6
Rec. 3	157	160	137	100	+0.2	-2.8	-5.4
/mizuumi/ 'lake'							
Rec. 1	130	170	155	105	+4.5	-1.6	-6.8
Rec. 2	136	165	152	110	+3.4	-1.4	-5.7
Rec. 3	140	163	145	105	+2.0	-2.0	-5.6

PATTERN 3

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/oteŋ:ki/ 'weather'							
Rec. 1	132	170	135	106	+3.2	-4.0	-4.2
Rec. 2	125	171	125	107	+5.4	-5.4	-2.9
Rec. 3	110	165	130	96	+7.0	-4.1	-5.2
/jimuiŋ:/ 'office worker'							
Rec. 1	150	180	130	107	+3.3	-5.6	-3.4
Rec. 2	150	180	123	98	+3.3	-6.5	-4.0
Rec. 3	148	176	120	100	+3.2	-6.5	-7.3
/kuzukaŋo/ 'wastebasket'							
Rec. 1	168	182	122	105	+1.3	-6.9	-2.9
Rec. 2	152	174	125	110	+2.5	-5.8	-2.1
Rec. 3	150	173	115	100	+2.5	-7.0	-1.8
/kinem:bi/ 'anniversary'							
Rec. 1	163	175	112	100	+1.2	-7.5	-1.8
Rec. 2	160	175	115	90	+1.5	-7.2	-4.2
Rec. 3	153	170	110	100	+1.7	-7.5	-1.7
/ehaŋaki/ 'picture postcard'							
Rec. 1	127	178	127	110	+5.9	-5.9	-2.5
Rec. 2	135	183	132	110	+5.2	-5.7	-3.9
Rec. 3	125	170	117	105	+5.3	-6.4	-1.7
/nomimono/ 'a drink'							
Rec. 1	150	177	122	95	+3.0	-6.4	-4.2
Rec. 2	135	170	130	100	+3.9	-4.5	-4.5
Rec. 3	140	172	127	92	+3.7	-6.2	-5.6

PATTERN 4

	Mora Pitch Measurements (in cps)				Mora to Mora Pitch Changes (in semitones)		
	M1	M2	M3	M4	M1-2	M2-3	M3-4
/zuibuŋ:/ 'very much'							
Rec. 1	184	152	112	96	-3.4	-5.2	-2.8
Rec. 2	177	137	107	95	-4.3	-4.3	-2.0
Rec. 3	163	133	100	90	-3.7	-4.9	-1.7
/hom:bako/ 'bookcase'							
Rec. 1	175	156	112	95	-2.0	-5.7	-3.1
Rec. 2	172	152	118	86	-2.1	-4.4	-5.5
Rec. 3	170	143	110	95	-3.2	-4.5	-2.6
/buŋ:ŋaku/ 'literature'							
Rec. 1	178	130	100	100	-5.4	-4.5	0.0
Rec. 2	180	130	104	92	-5.6	-3.9	-2.1
Rec. 3	168	121	103	95	-5.7	-2.9	-1.3
/oŋ:ŋaku/ 'music'							
Rec. 1	175	131	110	107	-4.9	-3.2	-0.3
Rec. 2	168	143	112	107	-3.7	-4.2	-0.7
Rec. 3	163	142	105	105	-2.5	-5.2	0.0
/geŋ:kaŋ:/ 'front door'							
Rec. 1	180	155	115	105	-2.6	-5.2	-1.6
Rec. 2	175	152	115	106	-2.5	-4.7	-1.4
Rec. 3	165	130	105	102	-4.1	-3.8	-0.4
/yookaŋ:/ 'bean jelly'							
Rec. 1	170	147	98	95	-2.5	-7.0	-0.4
Rec. 2	180	140	100	100	-4.3	-5.9	0.0
Rec. 3	180	140	102	99	-4.3	-5.5	-0.4

CHAPTER IV

FUNDAMENTAL FREQUENCY AS AN ACOUSTIC CORRELATE OF JAPANESE ACCENT

The data presented in Chapter III reveal that the amount and direction of change in fundamental frequency from mora to mora in single-word utterances help distinguish one accent from another and help characterize the melody of a particular accent.

Two-Mora Words

Table 4.1 presents the average values of fundamental frequency change from the first to the second mora in the data for Pattern 1 and Pattern 2 of two-mora words.

These data clearly show that differences in fundamental frequency distinguish the two accent patterns. In Pattern 1 the pitch rises from the first to the second mora,[1] and in

[1] A few cases occur where there is no change in pitch from the first to the second mora in Pattern 1 words.

Pattern 2 the pitch always falls from the first to the second mora. This difference is illustrated in Figure 4.1, which compares pitch displays of the words /kama/ (Pattern 1) 'iron pot' and /kama/ (Pattern 2) 'sickle' as spoken by Informant 2.

The data reveal no cases where a fall in pitch occurs in words with Pattern 1, nor where a rise in pitch occurs in words with Pattern 2.

TABLE 4.1

AVERAGE CHANGES OF FUNDAMENTAL FREQUENCY IN TWO-MORA WORDS

(IN SEMITONES)

	Informant 1 M1-2	Informant 2 M1-2
Pattern 1	+ 1.9	+3.5
Pattern 2	-10.7	-7.5
	Informant 3 **M1-2**	**Informant 4** **M1-2**
Pattern 1	+2.2	+2.1
Pattern 2	-8.8	-8.2

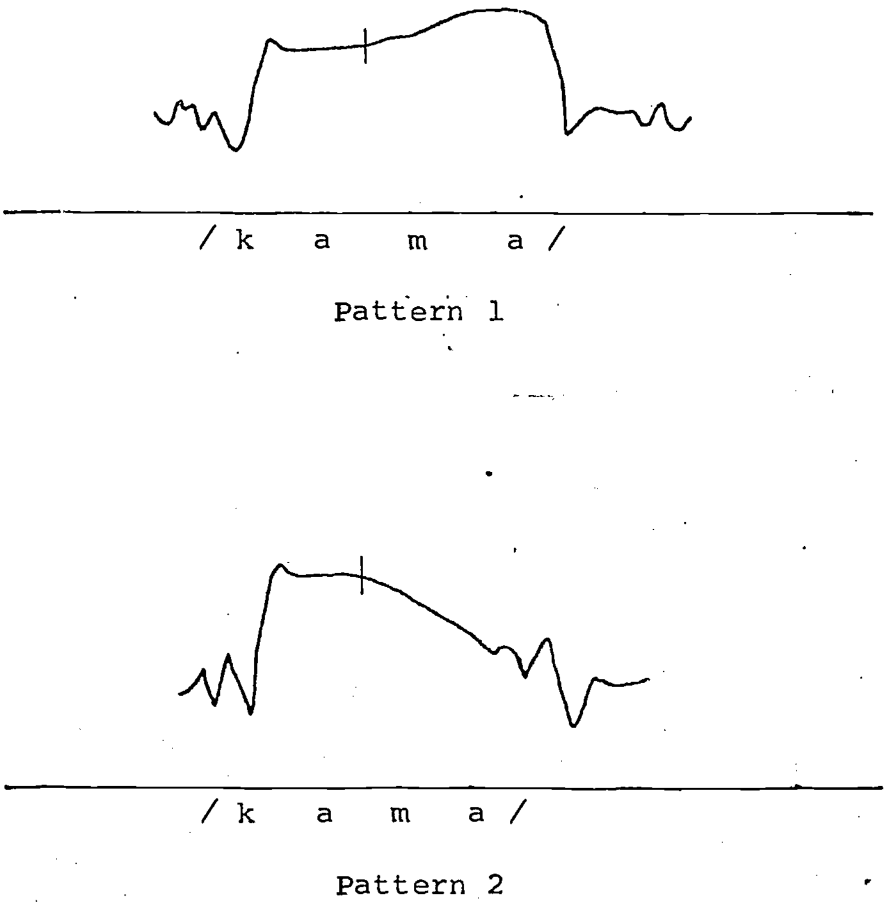


Fig. 4.1.--Sample pitch displays of the words /kama/ (Pattern 1 Accent) 'iron pot' and /kama/ (Pattern 2 Accent) 'sickle' as spoken by Informant 2. (Vertical striations mark moraic boundaries.)

Three-Mora Words

Table 4.2 presents the average values of fundamental frequency change from the first to the second and from the second to the third mora in Patterns 1, 2, and 3 of three-mora words.

TABLE 4.2

AVERAGE CHANGE OF FUNDAMENTAL FREQUENCY IN THREE-MORA WORDS (IN SEMITONES)

	Informant 1		Informant 2	
	M1-2	M2-3	M1-2	M2-3
Pattern 1	+1.8	-3.4	+1.7	-1.4
Pattern 2	+2.7	-9.6	+2.9	-7.3
Pattern 3	-6.8	-4.8	-5.7	-3.9
	Informant 3		**Informant 4**	
	M1-2	M2-3	M1-2	M2-3
Pattern 1	+2.6	-4.7	+1.0	-2.4
Pattern 2	+4.1	-7.6	+2.7	-8.8
Pattern 3	-6.1	-2.5	-4.1	-6.0

The distinction between Pattern 3 as compared with Patterns 1 and 2 definitely appears to be that the pitch always falls by some amount from the first to the second mora in Pattern 3, while a rise in pitch occurs from the first to the second mora in Patterns 1 and 2. The pitch fall from the second to the third mora in Pattern 3 does not seem to be distinctive, since no words which have a pitch fall from the first to the second mora contrast. Nevertheless, the pitch fall from the second to the third mora in Pattern 3 does seem to be necessary in the total characterization of the pattern.

In the data for Informants 1, 2, and 3, the greatest pitch fall in Pattern 3 occurs from the first to the second mora and averages about 6 semitones or half an octave. This is reversed in the data for Informant 4 where the greatest fall in pitch in Pattern 3 occurs from the second to the third mora. Apparently it does not matter whether the greatest amount of fall is from the first to the second mora or from the second mora to the third mora as long as some fall in pitch occurs from the first to the second mora. Figure 4.2 presents a sample pitch display of the word /kaeru/ 'to return' as spoken by Informant 3, as an

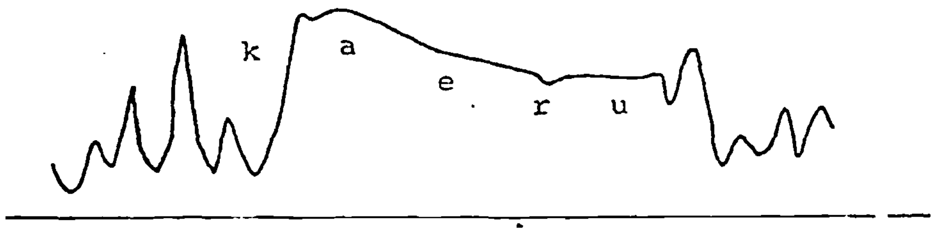
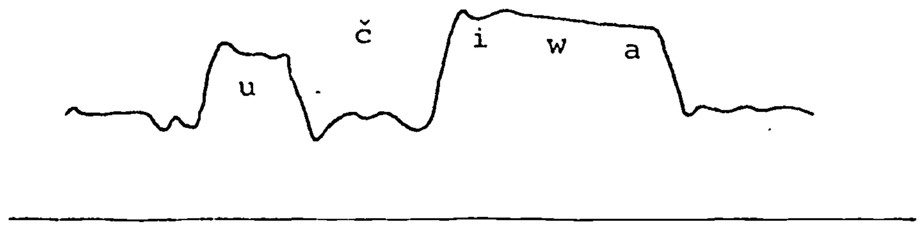


Fig. 4.2.--Sample pitch display of the three-mora word /kaeru/ (Pattern 3 Accent) 'return' as spoken by Informant 3.

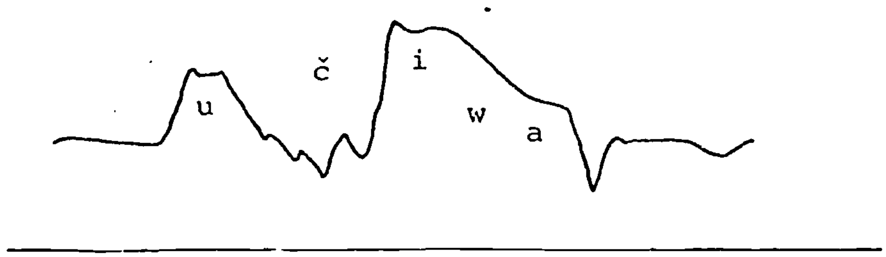
example of the fundamental frequency contour associated with Pattern 3 of three-mora words.

Comparing Pattern 1 and Pattern 2, the distinguishing feature seems to be the difference in the amount of pitch fall from the second to the third mora. The pitch drop in Pattern 2 is about one-half an octave greater on the average than the pitch drop in Pattern 1 for Informants 1, 2, and 4. Figure 4.3 shows the difference between a sample of the word /učiwa/ 'private,' which has a Pattern 1 accent, and a sample of the word /učiwa/ 'fan' which has a Pattern 2 accent. In the data for Informant 3, however, the difference in the amount of pitch fall between a Pattern 1 accent and a Pattern 2 accent does not appear to be very great. The pitch drop in Pattern 2 for Informant 3 is only about 3 semitones or one-fourth an octave greater on the average than the pitch drop in Pattern 1. Yet a clear distinction exists between the minimal pairs for these patterns /učiwa/ (Pattern 1) 'private' and /učiwa/ (Pattern 2) 'fan' when spoken by Informant 3. This is illustrated in Figure 4.4.



Pattern 1

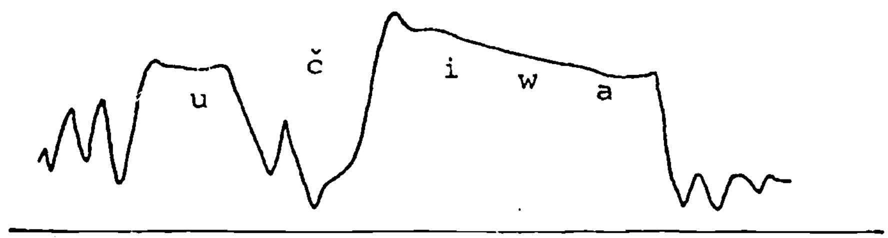
'private'



Pattern 2

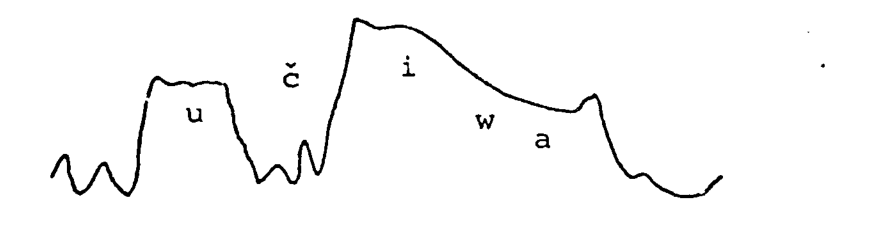
'fan'

Fig. 4.3.--Comparison of Accent Patterns 1 and 2 of three-mora wrods as spoken by Informant 2.



Pattern 1

'private'



Pattern 2

'fan'

Fig. 4.4.--Comparison of Accent Patterns 1 and 2 of three-mora words as spoken by Informant 3.

Four-Mora Words

Table 4.3 presents the average values of fundamental frequency change from the first to the second, from the second to the third, and from the third to the fourth mora in Patterns 1, 2, 3, and 4 of four-mora words.

TABLE 4.3

AVERAGE CHANGES OF FUNDAMENTAL FREQUENCY IN FOUR-MORA WORDS (IN SEMITONES)

	Informant 1			Informant 2		
	M1-2	M2-3	M3-4	M1-2	M2-3	M3-4
Pattern 1	+1.7	-2.4	-2.3	+1.7	-0.7	-1.4
Pattern 2	+1.9	-3.1	-8.1	+1.9	-2.1	-5.5
Pattern 3	+3.8	-8.0	-5.1	+3.3	-6.8	-2.6
Pattern 4	-4.5	-6.2	-3.0	-3.7	-4.5	-1.4

	Informant 3			Informant 4		
	M1-2	M2-3	M3-4	M1-2	M2-3	M3-4
Pattern 1	+3.0	-4.2	-3.3	+1.6	-2.7	-1.8
Pattern 2	+3.7	-3.0	-5.6	+1.7	-2.5	-6.2
Pattern 3	+5.0	-8.1	-1.6	+3.5	-5.9	-3.2
Pattern 4	-5.9	-3.1	-0.9	-3.7	-4.5	-1.4

Patterns 1, 2, and 3 in four-mora words are similar in that the pitch rises form the first to the second mora, but differ in the degree and manner of the fall in fundamental frequency that takes place after the second mora. First, all of the data indicate that Pattern 1 is generally differentiated from Patterns 2 and 3 by a difference in the total amount of pitch fall that takes place from the second to the fourth mora. In the data for Informants 1, 2, and 4, the average total pitch fall in Pattern 1 is something less than one-half an octave, while the average total pitch fall in Patterns 2 and 3 is something more than two-thirds an octave. This difference in the amount of pitch fall is much the same as the difference in pitch fall between Pattern 1 and Pattern 2 of three-mora words. The only exception seems to occur in the data for Informant 3 where there is relatively little difference in the average total fall in pitch between Pattern 1 and Pattern 2 and 3.

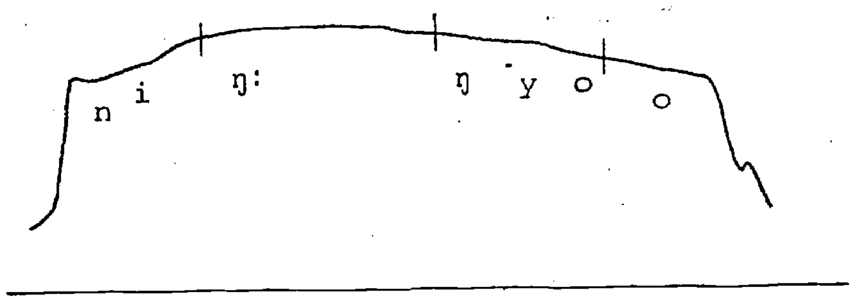
Another feature of the fundamental frequency variations also seems to contribute to the distinction between Pattern 1 and Patterns 2 and 3. In the data for Informant 3, the pitch fall from the second to the third mora and the pitch fall from the third to the fourth mora each contribute about equally, on the average, to the total fall in pitch. The fall from the second to the third mora constitutes about 56 percent of the total fall and the fall from the third to the fourth mora constitutes about 44 percent of the total fall. On the other hand, the pitch fall from the second to the third, and the pitch fall from the third to the fourth mora in Patterns 2 and 3 contribute unequally to the total amount of pitch fall. In the data for Informant 3, the pitch fall in Pattern 2 from the second to the third mora and from the third to the fourth mora constitute 35 percent and 65 percent of the total fall respectively, while the pitch fall in Pattern 3 from the second to the third and from the third to the fourth mora constitute 83 percent and 17 percent of the total fall respectively. Similar differences are seen also in the data for Informant 1, but not in the data for Informants 2 and 4. Generally there appears to be some interplay between the total amount of the pitch fall and the contribution of each mora to mora fall in distinguishing Pattern 1 from Patterns 2 and 3. Just which one of these features is the most significant appears to depend on the idiolect of the speaker.

The data indicate that Patterns 2 and 3 have little difference in the total fall in pitch. However, as mentioned in the last paragraph, the amount of pitch fall in these accents from the second to the third and from the third to the fourth mora is unequally distributed. In Pattern 2 the pitch fall from the second to the third mora amounts on the average to 26 percent (Informant 1), 28 percent (Informant 2), 35 percent (Informant 3), and 29 percent (Informant 4) of the total fall in pitch, while in Pattern 3 the pitch fall from the second to the third mora amounts to 61 percent (Informant 1), 72 percent (Informant 2), 83 percent (Informant 3), and 65 percent (Informant 4) of the total fall in pitch. Thus, the fall in pitch from the second to the third mora in Pattern 3 contributes about twice as much to the total fall as the fall in pitch from the second to the third mora in Pattern 2. On the other hand, the pitch fall in Pattern 2 from the third to the fourth mora amounts on the average to 74 percent (Informant 1), 72 percent (Informant 2), 65 percent (Informant 3), and 71 percent (Informant 4) of the total fall in pitch, while the pitch fall in Pattern 3 from the third to the fourth mora amounts on the average to 39 percent (Informant 1), 28 percent (Informant 2), 17 percent (Informant 3), and 35 percent (Informant 4) of the total pitch fall. Thus, the fall in pitch from the third to the fourth mora in Pattern 2 contributes about twice as much to the total fall as the pitch fall from the third to the fourth mora in Pattern 3.

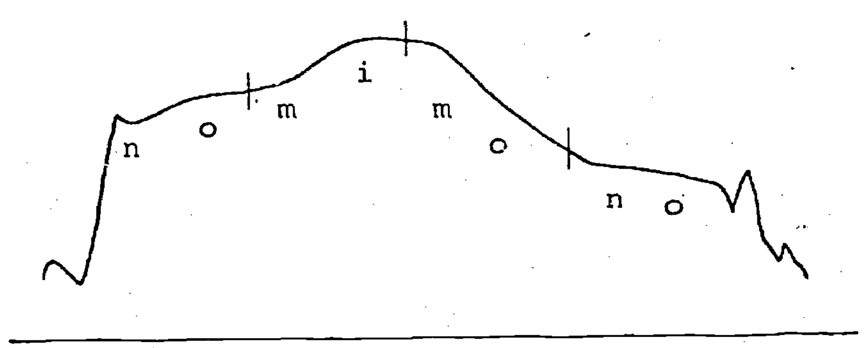
Clearly then, Pattern 2 and Pattern 3 differ in that the greatest amount of fall occurs from the third to the fourth mora in Pattern 2, while the greatest amount of fall occurs from the second to the third mora in Pattern 3. Since the total amount of fall in Patterns 2 and 3 is about the same, this generally means that the pitch fall from the second to the third mora in Pattern 3 will be greater than that in Pattern 2 and conversely, that the pitch fall from the third to the fourth mora in Pattern 3 will be less than that in Pattern 2. The pitch differences between Patterns 1, 2, and 3 can be seen in Figure 4.5, which presents sample pitch displays of the words /niŋ:ŋyoo/ (Pattern 1) 'doll,' /nomimono/ (Pattern 2) 'drink' and /mizuumi/[2] (Pattern 3) 'lake' as spoken by Informant 1.

Pattern 4 clearly differs from the other three patterns in that the pitch falls from the first to the second mora in this pattern, while the pitch rises in the others. Thus, Pattern 4 in four-mora words differs from the other accent patterns of words of the same length in the same way that

[2]Phonetically [midzuumi].

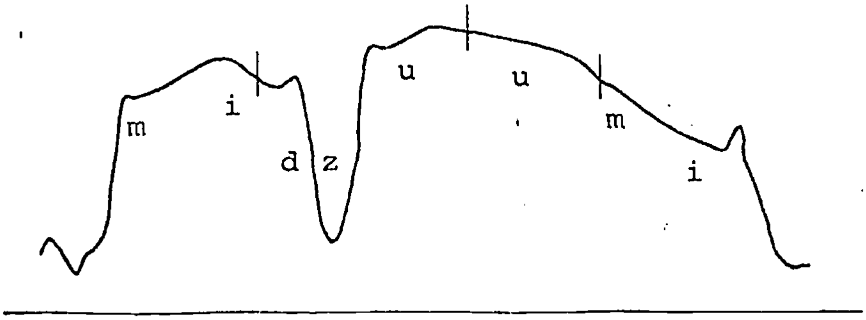


A. Pattern 1

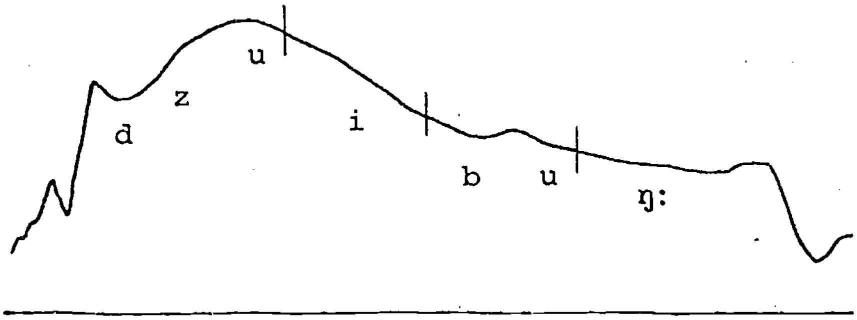


B. Pattern 2

Fig. 4.5.--A comparison of sample pitch displays of four-mora words with different accent patterns. (Vertical striations indicate moraic boundaries.)



C. Pattern 3



D. Pattern 4

Fig. 4.5.--Continued

Pattern 2 differs from Pattern 1 in two-mora words and Pattern 3 differs from Patterns 1 and 2 in three-mora words. Again the remainder of the fall in Pattern 4 does not seem to be particularly significant except in the total characterization of Pattern 4, since no contrasts occur among four-mora words with a pitch fall from the first to the second mora. Figure 4.5 illustrates the difference between Pattern 4 and the other three accent patterns for four-mora words.

Besides the above observations on how pitch functions to distinguish the contrastive accents, some observations can also be made in regard to the nature of the pitch rise and pitch fall in the accent patterns of single-word utterances in Japanese.

Pitch Rise

An examination of the pitch rise data on Pattern 2 of three-mora words and Pattern 3 of four-mora words (See Tables 4.2 and 4.3) reveals that the amount of pitch rise is about twice that of the other patterns which have a pitch rise from the first to the second mora. At first glance this feature of these two accent patterns seems to have something to do with the fall in pitch from the second to the third mora, which is appreciably greater than the comparable fall in the other patterns. However, further examination reveals that the first two moras in all word samples for Pattern 2 of three-mora words and Pattern 3 of four-mora words are (C)VCV, while in other accent patterns, the first two moras are (C)VV and (C)VN:,[3] as well as (C)VCV. In order to see if the segmental constituency of the first two moras had any influence on the amount of pitch rise, all word samples of three and four moras with a pitch rise from the first to the second mora were classified according to whether their first two moras consisted of (C)VCV, (C)VV, or (C)VN:. The three and four-mora words with a (C)VCV... pattern which have a Pattern 2 or Pattern 3 accent respecttively[4] were kept apart from the other words with a (C)VCV... pattern. Table 4.4 presents the calculated average value and range of the pitch rise for each set.

The sample size is fairly small, so it is not possible to state that any difference in the averages is statistically significant. Nevertheless, the data in Table 4.4 does suggest that the reason for a greater pitch rise in

[3]The symbol N: stands for a moraic nasal

[4]These words are denoted by (C)VCV⌉.

Pattern 2 of three-mora words and Pattern 3 of four-mora words lies in the difference in the segmental constituency of the moras over which the pitch rise occurs.

TABLE 4.4

AVERAGE VALUE AND RANGE OF PITCH RISE FROM THE FIRST TO THE SECOND MORA (IN SEMITONES)

	Informant 1			Informant 2		
	Sample Size	Average	Range	Sample Size	Average	Range
(C)VN:	18	+1.2	0.2-2.5	18	+1.3	0.3-2.0
(C)VV	18	+1.5	0.4-2.5	18	+1.1	0.0-2.6
(C)VCV	18	+2.6	1.6-3.9	18	+3.0	1.6-4.1
(C)VCV⌉	36	+3.6	1.6-5.9	36	+3.6	1.2-4.9

	Informant 3			Informant 4		
	Sample Size	Average	Range	Sample Size	Average	Range
(C)VN:	18	+2.3	0.7-4.6	18	+0.8	0.0-2.5
(C)VV	18	+2.4	0.8-4.6	18	+0.7	0.0-2.1
(C)VCV	18	+4.2	2.8-7.2	18	+2.9	1.6-4.5
(C)VCV⌉	36	+4.6	2.5-6.9	36	+3.1	1.1-7.0

The table shows that the pitch rise on the moraic patterns (C)VN: and (C)VV tends to be somewhat less than that on the moraic pattern (C)VCV or (C)VCV⌝. In fact, cases occur where no pitch change at all occurs from the first to the second mora with the pattern (C)VN: or (C)VV. There is little difference between the pitch rise in (C)VCV and (C)VCV⌝ on the average. Thus, it would appear that the greater pitch rise in Pattern 2 of three-mora words and Pattern 3 of four-mora words, as compared with the pitch rise from the first to the second mora on the other accent patterns, is not as much related to the relatively abrupt fall in pitch from the second to the third mora following the rise as it is to the segmental constituency of the two moras on which the rise takes place. Apparently the pitch rise that takes place between two moras with the segmental constituency (C)VCV is about twice as great as the pitch rise taking place between two moras with the constituency (C)VV or (C)VN:.

Pitch Fall

In all the data that were examined in this study, the mora with the highest value of fundamental frequency is either the first or second, and the pitch always falls after this value. As noted earlier, certain words of a given length seem differentiated in accent by the total amount of pitch fall that takes place within them. Thus, for example, among three-mora words, Pattern 1 differs from Pattern 2 in that the pitch does not fall in the former to the extent that it does in the latter; and among four-mora words, Pattern 1 differs from Patterns 2 and 3 in a similar manner. Those words which have accent patterns where the total amount of pitch fall is relatively small, I shall henceforth call atonic words, and their accent patterns where the total amount of pitch fall is relatively great, I shall henceforth call tonic words, and their accent patterns tonic accents. Thus, Pattern 1 of two-, three-, and four-mora words are atonic, while Pattern 2 of two-mora words, Patterns 2 and 3 of three-mora words, and Patterns 2, 3, and 4 of four-mora words are tonic.

An interesting feature of tonic accent patterns is that the amount of the fall in these patterns is roughly the same no matter what the length over which the fall takes place. Table 4.5, which compares the average value of the total fall in all tonic words of a given length with the average value of the total fall of all atonic words of the same length, illustrates this feature of tonic words.

TABLE 4.5

COMPARISON OF THE AVERAGE TOTAL PITCH FALL IN TONIC AND ATONIC WORDS (IN SEMITONES)

	Two-Mora Words	Three-Mora Words	Four-Mora Words
A. Tonic Words			
Informant 1	-10.7	-10.5	-12.8
Informant 2	- 7.5	- 8.4	- 8.4
Informant 3	- 8.8	- 8.1	- 9 4
Informant 4	- 8.2	- 8.8	- 9.2
B. Atonic Words			
Informant 1	---	- 3.4	- 4.7
Informant 2	---	- 1.4	- 2.1
Informant 3	---	- 4.7	- 7.5
Informant 4	---	- 2.4	- 4.5

Table 4.5 demonstrates that in tonic two-mora words, where the fall occurs over both moras, the amount of the pitch fall is about as great as in tonic words where the fall occurs over three or four moras. This feature of tonic accent patterns is further confirmed by some data that were available on tonic words of five and six moras in length. Evidently there is some relatively fixed range of pitch fall in tonic words, amounting to between two-thirds and four-thirds octaves. The amount of the pitch fall apparently depends on the idiolect of the speaker.

Table 4.5 also gives some indication that the total pitch fall that occurs in atonic words is somewhat variable and increases with an increase in word length. This is especially the case in the data for Informants 2, 3, and 4. A check of data available on atonic accent patterns in words five and six moras in length seems to confirm this. Since the amount of pitch fall in tonic words is relatively constant, the apparent increased fall in longer atonic words suggests that the difference in pitch fall between tonic and atonic words decreases as word length increases, indicating that there may be some limit to the functional importance of the total amount of the pitch fall in distinguishing atonic from tonic accent patterns. More data will have to be examined, however, before any definite conclusion can be made.

CHAPTER V

INTENSITY DATA

The recordings of two-mora words made by the four informants were used to examine the possible correlation of intensity with accentual distinctions. Out of the eight pairs of two-mora words, six pairs were selected for analysis. Three of these pairs consisted of words whose mora constituents contained the same vowel ([a] or [i]). The other three pairs consisted of words whose mora constituents contained different vowels: The first mora containing [a] and the second mora containing [i]. The former three pairs were chosen because they allowed an examination of intensity changes under the same vowel quality conditions. The latter three pairs were chosen because they allowed an examination of intensity changes under different vowel quality conditions. These words with the particular vowels [a] and [i] were chosen, since under the same glottal conditions [a] and [i] represent extremes in vowel intensity, because of differences in the size and shape of the vocal tract in producing these sounds.[1] Intensity displays were made of these utterances with the aid of the spectrograph and its Amplitude Display-Scale Magnifier accessory unit.

Problems in Measuring Intensity

Since speech is so variable, there are naturally a number of ways to characterize intensity or speech power. Fletcher[2] lists six possible measures for intensity:

1. Instantaneous speech power: the rate at which sound energy is being radiated at a given instant
2. Average speech power: The total speech energy radiated divided by the total duration of the utterance
3. Mean speech power: the average speech power over each one-hundredth of a second period
4. Syllabic speech power: the maximum value of mean speech power which is reached in a syllable
5. Phonetic speech power: the maximum value of mean speech power for a vowel or consonant

[1]See Chiba and Kajiyama, pp. 82-88.

[2]Speech and Hearing in Communication (New York, 1953), pp. 68-69.

6. Peak speech power: the maximum value of instantaneous speech power within a given segment of speech

All of these measures of intensity are available for use in acoustic phonetic work. But not all of them are necessarily applicable in examining intensity as an acoustic correlate of some phonological distinction such as accent. Since this study is concerned with comparing intensity differences from one mora to the next, only moraic speech power,[3] phonetic speech power of the vowel in each mora, or peak speech power of the mora seem applicable. Each of these peak measures may be compared from mora to mora. Peak speech power, although a good measure for mora to mora comparison, is not a very practical one, since most intensity measuring devices, like the sound spectrograph's Amplitude Display-Scale Magnifier unit, do not measure the speech power of a sound at each instant in its duration, but rather measure the mean speech power values of a sound over its entire duration. This leaves only the moraic speech power and phonetic speech power as intensity measures. Since the vowel is usually the most powerful sound in a mora, it will

[3]Analogous to syllabic speech power, moraic speech power is defined as the maximum value of mean speech power which is reached in a mora.

often be the case that moraic speech power and phonetic speech power are identical.

Another possible measure is the total area under the intensity curve within the time interval it takes to utter a sound. This area is not, strictly speaking, an intensity measure, but is conceptually equivalent to the total energy contained in a speech segment and roughly proportional to it.[4] An interesting feature of this measure is that it combines the features of intensity and duration into a single measure. Since the subjective quality of loudness is dependent acoustically on both intensity and duration, the area measure is, to some extent, the acoustic correlate of loudness.

For the purpose of this study, I decided to select the measures of phonetic speech power of the vowel in each mora, as well as the area measure of vowel intensity. I did this because, as far as I know, no acoustic measure involving intensity has as yet been proposed in the study of intensity

[4] The area under the curve is conceptually equivalent to energy only if the output of the intensity measuring device is proportional to the intensity or the input signal. Furthermore, since intensity is usually measured in decibels, the area measure is proportional to the relative total energy of the speech segment.

as a correlate of accent, and because both of these measures seem worthy of examination.

Measurement Procedures

The phonetic speech power value in decibels of each vowel in a word was measured to the nearest 0.5 decibel. In some cases the intensity curve fell throughout the duration of the segment. When this phenomenon occurred, the intensity at the beginning of the vowel segment was measured. The ratio of the phonetic speech power of the first vowel (V_1) to that of the second vowel (V_2) in each word-token was calculated to the nearest tenth, along with the average of this ratio for all three tokens of each word. Also calculated was the overall average value of this ratio for the following sets of words: (1) those with a Pattern 1 accent which have either [a] or [i] in both moras, (2) those with a Pattern 2 accent which have either [a] or [i] in both moras, (3) those with a Pattern 1 accent which have [a] in the first mora and [i] in the second mora, and (4) those with a Pattern 2 accent which have [a] in the first mora and [i] in the second mora. A ratio greater than 1.0 indicates that the phonetic speech power of V_1 is greater than that of V_2 by the amount of the ratio. On the other hand, a ratio less than 1.0 indicates that V_2 is greater than V_1 by an amount equal to the reciprocal of the ratio. Table 5.1 presents the data on phonetic speech power and vowel intensity ratios for Informants 1, 2, 3 and 4. Values in parenthesis are interpolated values.

Since there was no direct means available for measuring the area under the intensity curve of a vowel, such as a planimeter, the area had to be estimated by making approximations--one too small and one too large--and then by averaging these values. This was done first by tracing the intensity curves onto graph paper with grid lines laid out 10x10 to the 1/2 inch. Thus, each square formed by the grid lines had an area of 0.0025 square inches. Counting the total number of whole squares within the boundaries formed by the intensity curve of the particular segment being measured gave the minor (too small) approximation of the area in question. Counting the minimum number of whole squares that could totally encompass the intensity curve gave the major (too large) approximation of the area. The sum of major and minor approximations was divided by two. This calculation gave the average of the two

TABLE 5.1

PHONETIC SPEECH POWER MEASUREMENTS OF VOWELS

(in Decibels)

INFORMANT 1

Pattern 1

	/iši/ 'stone'			/asa/ 'hemp'			/kama/ 'iron pot'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	12.0	13.0	0.9	19.0	23.5	0.8	11.0	22.0	0.5
Rec. 2	14.0	17.0	0.8	32.5	24.5	1.3	22.5	20.5	1.1
Rec. 3	9.0	11.5	0.8	14.0	24.0	0.6	18.0	15.0	1.2
Average			0.8			0.9			0.9

	/kami/ 'paper'			/kaki/ 'persimmon'			/haši/ 'bridge'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	20.5	9.5	2.2	21.5	7.0	3.1	25.0	12.5	2.0
Rec. 2	18.5	11.0	1.7	16.0	7.0	2.3	21.5	8.5	2.5
Rec. 3	9.5	8.0	1.2	13.5	10.0	1.3	23.0	14.0	1.6
Average			1.7			2.2			2.0

Pattern 2

	/iši/ 'volition'			/asa/ 'morning'			/kama/ 'sickle'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	18.0	4.0	4.5	23.5	13.0	1.8	(35.0)[a]	15.0	2.3
Rec. 2	22.0	7.0	3.1	21.0	19.0	1.1	30.0	17.0	1.8
Rec. 3	15.5	8.0	1.9	34.0	14.0	2.3	26.5	14.5	1.8
Average			3.2			1.7			2.0

	/kami/ 'god'			/kaki/ 'oyster'			/haši/ 'chopstick'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	33.0	2.5	13.2	26.0	5.5	5.2	22.0	7.0	3.1
Rec. 2	24.0	3.0	8.0	32.0	6.0	5.3	27.0	6.0	4.5
Rec. 3	32.0	3.0	10.7	24.0	3.5	6.9	23.0	9.0	2.6
Average			10.6			5.8			3.4

[a]Interpolated value

INFORMANT 2

Pattern 1

	/iši/ 'stone'			/asa/ hemp'			/kama/ 'iron pot'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	27.0	15.0	1.8	22.0	25.0	0.9	28.5	24.5	1.2
Rec. 2	25.0	15.0	1.7	34.0	24.0	1.4	23.0	21.0	1.1
Rec. 3	24.5	16.0	1.5	27.0	24.5	1.1	24.0	24.0	1.0
Average			1.7			1.1			1.5

	/kami/ 'paper'			/kaki/ 'persimmon'			/haši/ 'bridge'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	25.0	17.0	1.5	22.5	27.5	0.8	25.5	18.5	1.4
Rec. 2	23.5	16.0	1.5	20.0	25.5	0.8	24.0	18.0	1.3
Rec. 3	26.0	17.0	1.5	23.5	23.5	1.0	30.0	18.5	1.6
Average			1.5			0.9			1.4

Pattern 2

	/iši/ 'volition'			/asa/ 'morning'			/kama/ 'sickle'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	28.0	15.0	1.9	(40.0)[a]	20.5	1.9	26.5	19.0	1.4
Rec. 2	29.0	20.0	1.4	(40.0)[a]	21.0	1.9	29.0	16.0	1.8
Rec. 3	25.0	20.5	1.2	26.5	22.0	1.2	28.0	23.0	1.2
Average			1.5			1.7			1.5

	/kami/ 'god'			/kaki/ 'oyster'			/haši/ 'chopstick'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	28.5	17.5	1.6	29.0	23.0	1.3	(39.0)[a]	20.5	1.9
Rec. 2	28.5	11.0	2.6	(38.0)[a]	23.0	1.6	31.0	23.0	1.3
Rec. 3	25.5	13.0	2.0	27.0	20.0	1.3	29.5	19.0	1.6
Average			2.1			1.4			1.6

[a]Interpolated value

INFORMANT 3

Pattern 1

	/iši/ 'stone'			/asa/ 'hemp'			/kama/ 'iron pot'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	15.5	22.0	0.7	13.5	32.0	0.4	18.5	18.0	1.0
Rec. 2	12.5	25.0	0.5	13.0	26.0	0.5	18.5	14.5	1.1
Rec. 3	11.5	23.5	0.5	12.0	20.0	0.6	18.5	13.0	1.4
Average			0.6			0.5			1.2

	/kami/ 'paper'			/kaki/ 'persimmon'			/haši/ 'bridge'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	19.0	16.5	1.2	18.0	26.0	0.7	--[a]	--[a]	--
Rec. 2	18.5	13.5	1.4	17.0	22.0	0.8	19.5	23.0	0.8
Rec. 3	19.0	15.5	1.2	16.5	18.5	0.9	16.5	18.5	0.9
Average			1.3			0.8			0.9

[a]Mispronounced

Pattern 2

	/iši/ 'volition'			/asa/ 'morning'			/kama/ 'sickle'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	23.0	17.0	1.4	23.0	21.0	1.1	28.0	14.0	2.0
Rec. 2	22.5	17.0	1.3	22.0	13.0	1.7	27.5	11.0	2.5
Rec. 3	25.5	15.0	1.7	24.0	12.0	2.0	31.5	15.5	2.0
Average			1.5			1.6			2.2

	/kami/ 'god'			/kaki/ 'oyster'			/haši/ 'chopstick'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	28.0	14.5	2.1	28.5	19.0	1.5	32.0	12.0	2.7
Rec. 2	25.0	13.5	1.9	23.5	15.5	1.5	22.5	9.5	2.4
Rec. 3	21.5	9.0	2.4	24.5	14.0	1.8	23.0	6.0	3.8
Average			2.1			1.6			3.0

INFORMANT 4

Pattern 1

	/iši/ 'stone'			/asa/ 'hemp'			/kama/ 'iron pot'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	15.0	24.0	0.6	15.5	(36.0)[a]	0.4	23.0	19.5	1.2
Rec. 2	13.5	21.0	0.6	16.0	(36.0)[a]	0.5	19.0	18.0	1.1
Rec. 3	12.5	20.0	0.6	14.5	30.0	0.5	20.0	18.5	1.1
Average			0.6			0.5			1.1

	/kami/ 'paper'			/kaki/ 'persimmon'			/haši/ 'bridge'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	21.0	23.5	0.9	9.5	24.5	0.4	15.0	22.5	0.7
Rec. 2	17.5	23.0	0.8	12.0	24.5	0.5	17.0	20.5	0.8
Rec. 3	19.0	18.0	1.1	14.5	25.0	0.6	12.0	22.5	0.5
Average			0.9			0.5			0.7

Pattern 2

	/iši/ 'volition'			/asa/ 'morning'			/kama/ 'sickle'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	26.5	15.0	1.8	21.5	34.0	0.6	27.0	16.5	1.5
Rec. 2	28.5	18.0	1.6	21.0	34.0	0.6	24.0	12.5	1.9
Rec. 3	27.0	10.5	2.6	18.5	30.0	0.6	20.5	11.0	1.9
Average			2.0			0.6			1.8

	/kami/ 'god'			/kaki/ 'oyster'			/haši/ 'chopstick'		
	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2	V_1	V_2	V_1/V_2
Rec. 1	29.5	16.0	1.8	24.0	15.5	1.5	26.0	16.0	1.6
Rec. 2	23.5	14.5	1.6	27.0	15.0	1.8	24.0	12.0	2.0
Rec. 3	33.5	14.0	2.4	20.5	19.0	1.1	23.0	6.0	3.8
Average			1.9			1.5			2.5

[a]Interpolated value

and a fair approximation of the relative area under the curve.[5]

The relative area values of each vowel segment of the utterances were measured, and the ratio of the area of V_1 to that of V_2 was calculated for each word token. As with the phonetic speech power ratios, the average of the area ratios for all three samples of each word was calculated, as well as the overall average of the ratios for each set of words. Like the phonetic speech power ratios, an area ratio greater than 1.00 indicates that V_1 is greater than V_2 by the amount of the ratio, and an area ratio less than 1.00 indicates that V_2 is greater than V_1 by an amount equal to the reciprocal of the ratio. Table 5.2 presents these measurements for Informants 1, 2, 3, and 4.

[5]The actual estimated area can be found by multiplying this number by the area of a single square, but since this is a constant factor throughout all the measurements, it need not be performed, unless one is concerned with absolute values rather than relative ones.

TABLE 5.2

AREA MEASUREMENTS

INFORMANT 1

Pattern 1

	/iši/ 'stone' V_1	V_2	V_1/V_2	/asa/ 'hemp' V_1	V_2	V_1/V_2	/kama/ 'iron pot' V_1	V_2	V_1/V_2
Rec. 1	48.5	38.0	1.3	99.5	103.5	1.0	52.5	105.0	0.5
Rec. 2	57.5	50.0	1.1	120.0	104.0	1.1	86.0	101.0	0.9
Rec. 3	48.0	48.0	1.0	63.5	92.5	0.7	90.5	73.0	1.2
Average			1.1			0.9			0.9

	/kami/ 'paper' V_1	V_2	V_1/V_2	/kaki/ 'persimmon' V_1	V_2	V_1/V_2	/haši/ 'bridge' V_1	V_2	V_1/V_2
Rec. 1	80.5	42.0	1.9	79.5	33.5	2.4	93.0	43.5	2.1
Rec. 2	84.5	36.0	2.3	80.0	25.5	3.1	102.5	30.5	3.4
Rec. 3	50.5	32.0	1.6	54.5	35.0	1.6	97.5	43.0	2.3
Average			1.9			2.3			2.6

Pattern 2

	/iši/ 'volition' V_1	V_2	V_1/V_2	/asa/ 'morning' V_1	V_2	V_1/V_2	/kama/ 'sickle' V_1	V_2	V_1/V_2
Rec. 1	68.0	14.5	4.7	105.5	44.0	2.4	133.5	53.5	2.5
Rec. 2	77.5	28.0	2.8	94.5	67.0	1.5	134.5	49.5	2.7
Rec. 3	64.5	31.0	2.1	139.0	45.5	3.1	105.5	53.5	2.1
Average			3.2			2.2			2.4

	/kami/ 'god' V_1	V_2	V_1/V_2	/kaki/ 'oyster' V_1	V_2	V_1/V_2	/haši/ 'chopstick' V_1	V_2	V_1/V_2
Rec. 1	142.5	12.0	11.9	106.5	20.0	5.3	65.5	33.5	2.0
Rec. 2	129.0	12.0	10.7	122.0	23.0	5.4	107.0	19.0	5.6
Rec. 3	128.5	10.0	12.9	108.0	14.5	7.4	74.5	26.0	2.9
Average			11.8			6.0			3.5

INFORMANT 2

Pattern 1

	/iši/ 'stone' V_1	V_2	V_1/V_2	/asa/ 'hemp' V_1	V_2	V_1/V_2	/kama/ 'iron pot' V_1	V_2	V_1/V_2
Rec. 1	119.5	88.0	1.4	119.0	176.0	0.7	123.5	163.5	0.8
Rec. 2	83.5	59.0	1.4	124.5	166.5	0.7	113.5	150.5	0.7
Rec. 3	86.5	58.0	1.5	117.0	154.0	0.8	113.0	134.0	0.8
Average			1.4			0.7			0.8

	/kami/ 'paper' V_1	V_2	V_1/V_2	/kaki/ 'persimmon' V_1	V_2	V_1/V_2	/haši/ 'bridge' V_1	V_2	V_1/V_2
Rec. 1	165.5	111.5	1.5	118.0	123.5	1.0	122.5	89.5	1.4
Rec. 2	135.5	110.5	1.2	106.5	117.0	0.9	107.5	76.0	1.4
Rec. 3	145.0	88.5	1.6	112.5	97.0	1.2	133.0	74.5	1.8
Average			1.5			1.0			1.5

Pattern 2

	/iši/ 'volition' V_1	V_2	V_1/V_2	/asa/ 'morning' V_1	V_2	V_1/V_2	/kama/ 'sickle' V_1	V_2	V_1/V_2
Rec. 1	99.5	53.0	1.9	165.5	80.5	2.1	126.0	58.0	2.2
Rec. 2	111.0	62.0	1.8	191.0	87.5	2.2	132.0	59.0	2.2
Rec. 3	114.5	56.0	2.0	144.0	73.5	2.0	133.5	83.5	1.6
Average			1.9			2.1			2.0

	/kami/ 'god' V_1	V_2	V_1/V_2	/kaki/ 'oyster' V_1	V_2	V_1/V_2	/haši/ 'chopstick' V_1	V_2	V_1/V_2
Rec. 1	142.0	49.5	2.9	146.5	38.5	3.8	149.5	61.5	2.4
Rec. 2	170.0	41.0	4.1	188.5	53.5	3.5	132.0	70.0	1.9
Rec. 3	123.5	39.5	3.1	116.0	36.0	3.2	123.5	53.0	2.3
Average			3.4			3.5			2.2

INFORMANT 3

Pattern 1

	/iši/ 'stone' V_1	V_2	V_1/V_2	/asa/ 'hemp' V_1	V_2	V_1/V_2	/kama/ 'iron pot' V_1	V_2	V_1/V_2
Rec. 1	43.0	103.0	0.4	63.0	106.5	0.6	73.5	70.0	1.0
Rec. 2	43.0	93.0	0.5	53.0	84.5	0.6	54.0	75.5	0.7
Rec. 3	44.5	88.5	0.5	56.5	71.0	0.8	61.5	68.5	0.9
Average			0.5			0.7			0.9

	/kami/ 'paper' V_1	V_2	V_1/V_2	/kaki/ 'persimmon' V_1	V_2	V_1/V_2	/haši/ 'bridge' V_1	V_2	V_1/V_2
Rec. 1	83.5	93.5	0.9	71.5	89.5	0.8	--[a]	--[a]	--
Rec. 2	67.5	62.0	1.1	72.0	79.5	0.9	48.0	75.5	0.6
Rec. 3	75.0	78.5	1.0	45.0	54.0	0.8	56.0	39.0	1.4
Average			1.0			0.8			1.0

Pattern 2

	/iši/ 'volition' V_1	V_2	V_1/V_2	/asa/ 'morning' V_1	V_2	V_1/V_2	/kama/ 'sickle' V_1	V_2	V_1/V_2
Rec. 1	90.0	54.0	1.7	104.5	56.0	1.9	96.0	44.0	2.2
Rec. 2	92.0	51.5	1.8	107.0	34.5	3.1	115.0	27.5	4.2
Rec. 3	94.5	44.0	2.1	102.0	34.5	3.0	108.0	43.0	2.5
Average			1.9			2.6			3.0

	/kami/ 'god' V_1	V_2	V_1/V_2	/kaki/ 'oyster' V_1	V_2	V_1/V_2	/haši/ 'chopstick' V_1	V_2	V_1/V_2
Rec. 1	122.5	46.0	2.8	113.5	68.0	1.7	123.0	29.5	4.2
Rec. 2	112.5	38.5	2.9	89.5	39.0	2.3	95.5	25.0	3.8
Rec. 3	93.0	22.0	4.2	91.0	33.5	2.7	88.5	13.5	6.6
Average			3.3			2.2			4.9

[a]Mispronounced

INFORMANT 4

Pattern 1

	/iši/ 'stone' V_1	V_2	V_1/V_2	/asa/ 'hemp' V_1	V_2	V_1/V_2	/kama/ 'iron pot' V_1	V_2	V_1/V_2
Rec. 1	36.5	116.5	0.3	61.0	163.0	0.4	69.5	87.5	0.8
Rec. 2	34.5	115.5	0.3	65.0	122.5	0.5	48.5	107.0	0.5
Rec. 3	24.0	83.0	0.3	42.5	119.5	0.4	44.5	87.0	0.5
Average			0.3			0.4			0.6

	/kami/ 'paper' V_1	V_2	V_1/V_2	/kaki/ 'persimmon' V_1	V_2	V_1/V_2	/haši/ 'bridge' V_1	V_2	V_1/V_2
Rec. 1	87.0	131.5	0.7	42.0	121.0	0.3	50.5	96.0	0.5
Rec. 2	103.5	129.0	0.8	42.5	124.0	0.3	61.0	86.0	0.7
Rec. 3	65.0	92.0	0.7	47.5	102.5	0.5	48.5	84.5	0.6
Average			0.7			0.4			0.6

Pattern 2

	/iši/ 'volition' V_1	V_2	V_1/V_2	/asa/ 'morning' V_1	V_2	V_1/V_2	/kama/ 'sickle' V_1	V_2	V_1/V_2
Rec. 1	98.0	49.0	2.0	78.5	106.5	0.7	79.0	71.5	1.1
Rec. 2	173.5	45.0	3.7	76.0	96.0	0.8	113.5	59.5	2.3
Rec. 3	117.0	36.5	3.2	79.0	75.0	1.0	88.5	42.0	2.1
Average			3.0			0.9			1.8

	/kami/ 'god' V_1	V_2	V_1/V_2	/kaki/ 'oyster' V_1	V_2	V_1/V_2	/haši/ 'chopstick' V_1	V_2	V_1/V_2
Rec. 1	99.5	64.5	1.5	91.5	41.0	2.2	97.5	48.5	2.0
Rec. 2	126.5	68.5	1.9	122.0	36.0	3.4	111.0	39.0	2.9
Rec. 3	126.0	54.5	2.3	87.5	66.5	1.3	91.5	19.5	4.7
Average			1.9			2.3			3.2

CHAPTER VI

INTENSITY AS AN ACOUSTIC CORRELATE OF JAPANESE ACCENT

Phonetic Speech Power

The intensity data in Chapter V reveals that there is a great deal of variation in the phonetic speech power (PSP) values for a single informant. However, such variations are not too important. What is important is whether there is a relative difference in the PSP ratios between words with one accent pattern and those with another. If this difference is consistent within the data for one informant and from informant to informant, then there is a clear indication that intensity is indeed an acoustic correlate of accent.

Table 6.1A presents a comparison of the average PSP ratios and of the range of PSP ratios for each informant in Pattern 1 words and Pattern 2 words which have the vowel [a] or [i] in both moras. This table indicates the existence of a difference in intensity correlated with a difference in

TABLE 6.1

A COMPARISON OF THE AVERAGES AND RANGES OF PHONETIC SPEECH POWER RATIOS OF TWO-MORA WORDS

6.1A
WITH [a] OR [i] IN BOTH MORAS

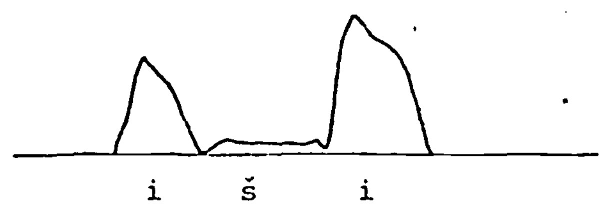
		PSP Ratio Average	Range of PSP Ratios
Informant 1			
	Pattern 1	0.9	0.5-1.3
	Pattern 2	2.3	1.1-4.5
Informant 2			
	Pattern 1	1.3	0.9-1.8
	Pattern 2	1.5	1.2-1.9
Informant 3			
	Pattern 1	0.7	0.4-1.4
	Pattern 2	1.7	1.1-2.5
Informant 4			
	Pattern 1	0.7	0.4-1.2
	Pattern 2	1.5	0.6-2.6

6.1B
WITH [a] IN THE FIRST MORA AND [i] IN THE SECOND MORA

		PSP Ratio Average	Range of PSP Ratios
Informant 1			
	Pattern 1	1.9	1.2-3.2
	Pattern 2	6.0	2.6-13.2
Informant 2			
	Pattern 1	1.3	0.8-1.5
	Pattern 2	1.7	1.3-2.6
Informant 3			
	Pattern 1	1.0	0.7-1.4
	Pattern 2	2.2	1.5-3.8
Informant 4			
	Pattern 1	0.7	0.4-1.1
	Pattern 2	2.0	1.1-3.8

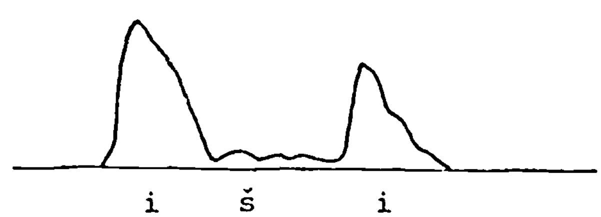
accent in the data for Informants 1, 3, and 4. The data for these informants indicate that the value of PSP is greater on the average in the vowel of the first mora than the vowel of the second mora in words with Pattern 2 accent, and that in words with Pattern 1 accent the value of PSP is less in the vowel of the first mora than in the vowel of the second mora. (See Figure 6.1 for a specific illustration of this difference.) Nevertheless, these averages only tell part of the story; the data on the ranges of PSP ratios indicate that there is some degree of inconsistency in the use of intensity in making accent distinctions, as shown by the overlapping of the ranges of PSP ratios between words with Pattern 1 accent and words with a Pattern 2 accent. For example, in one case for Informant 1 and Informant 3, the PSP ratio was 1.1 in both a word of Pattern 1 accent and a word of Pattern 2 accent, and in three cases for Informant 4 the PSP ratio was 0.6 in both a word of Pattern 1 accent and a word of Pattern 2 accent.

Besides these inconsistencies in the use of intensity as a correlate of accent by single informants, the data indicates that one informant (Informant 2) does not seem to use intensity at all as a correlate of accent. In the data for Informant 2, the average of the PSP ratios in both types



(stone)

A. Pattern 1



(volition)

B. Pattern 2

Fig. 6.1.--A comparison of the intensity curves of Pattern 1 and Pattern 2 Accent as spoken by Informant 3.

of words is about the same and is greater than 1.00. For example, compare the intensity displays in Figure 6.2 of the word tokens /iši/ (Pattern 2) 'volition' and /iši/ (Pattern 1) 'stone' as spoken by Informant 2.

The same type of inconsistency occurs in the average PSP ratios of words with Pattern 1 and Pattern 2 accents which have the vowel [a] in the first mora and the vowel [i] in the second mora (see Table 6.1B). Two informants (Informants 3 and 4) make a fairly clear distinction in intensity associated with a difference in accent, yet in both cases there is some overlapping even in this small amount of data.

As noted in Chapter V, the intensity of [a] and [i] will be quite different because of the difference in the size and shape of the vocal tract in producing these sounds, given the same values of subglottal pressure and vocal cord tension. It is interesting to note, however, that the data for Informants 2, 3, and 4 indicate that some type of compensation in subglottal pressure and/or vocal cord tension takes place to keep the intensity of the vowels [a] and [i] approximately the same in identical environments. On the other hand, in the data for Informant 2 no such compensation seems to take place. For example, a comparison of the average PSP values for the second mora of the words /kama/ 'sickle' and

(stone)

A. Pattern 1

(volition)

B. Pattern 2

Fig. 6.2.--A comparison of the intensity curves of Pattern 1 and Pattern 2 Accent as spoken by Informant 2.

/kami/ 'god' as spoken with a Pattern 2 accent by Informant 1 reveals a difference of about 13 db between them; this compares with only a difference of 5.5 db in the data for Informant 2, and a difference of 1.5 db in the data for Informants 3 and 4. This great intensity difference between [a] and [i] as spoken by Informant 1 in identical environments results in the PSP ratios in words with [a] in the first mora and [i] in the second mora being much higher than they are in words in which the vowel in both the first and second mora is either [a] or [i]. On the other hand the intensity difference between [a] and [i] in identical environments is much less for Informants 2, 3, and 4, so that the average PSP ratios in words with [a] in the first mora and [i] in the second mora are about the same as those in words which have either [a] or [i] in both moras. It is not exactly clear what this means concerning intensity as a correlate of accent, since one of the Informants who makes such an intensity compensation (Informant 2) does not appear to use intensity to manifest accent distinctions, while the other two informants do use intensity in this way to some extent.

Although the amount of data presented here is small, it indicates that intensity as measured by phonetic speech power is not consistently associated with a difference in accent patterns. This is quite different from the evidence presented in Chapters III and V concerning fundamental frequency as a correlate of accent. In this case it was found that differences in fundamental frequency are consistently associated with differences in accent.

Area Measure

Table 6.2A presents a comparison for each informant of the average value and range of area ratios of words with a Pattern 1 accent and words with a Pattern 2 accent which have either [a] in both moras or [i] in both moras. This table reveals a somewhat better correlation between intensity area differences and accent differences. Even the data for Informant 2 shows on the average a clear distinction between Pattern 1 accent words and Pattern 2 accent words. Yet even in the case of area ratios there is some overlap and near overlap in the value of the area ratios for the two accent patterns.

This overlapping or near overlapping of values also is observed in the area ratios for words with [a] in the first mora and [i] in the second mora (see Table 6.2B). Furthermore, as in the case of the PSP ratios, the data on

TABLE 6.2

A COMPARISON OF THE AVERAGES AND RANGES OF AREA RATIOS FOR TWO-MORA WORDS

6.2A

WITH [a] OR [i] IN BOTH MORAS

		Average of Area Ratio	Range of Area Ratio
Informant 1			
	Pattern 1	1.0	0.7-1.3
	Pattern 2	2.0	1.5-4.7
Informant 2			
	Pattern 1	1.0	0.7-1.5
	Pattern 2	2.0	1.6-2.2
Informant 3			
	Pattern 1	0.9	0.4-1.0
	Pattern 2	2.5	1.7-4.2
Informant 4			
	Pattern 1	0.5	0.3-0.8
	Pattern 2	1.9	0.7-3.7

6.2B

WITH [a] IN THE FIRST MORA AND [i] IN THE SECOND MORA

		Average of Area Ratio	Range of Area Ratio
Informant 1			
	Pattern 1	2.3	1.6-3.4
	Pattern 2	7.1	2.0-12.9
Informant 2			
	Pattern 1	1.3	0.9-1.8
	Pattern 2	3.0	1.8-4.1
Informant 3			
	Pattern 1	0.9	0.6-1.4
	Pattern 2	3.5	1.7-6.6
Informant 4			
	Pattern 1	0.6	0.3-0.8
	Pattern 2	2.5	1.3-4.7

Informant 1 show that the average area ratio for Pattern 1 words with the [a] in the first mora and [i] in the second mora is close to the average area ratio for Pattern 2 words with [a] or [i] in both moras.

These observations suggest that the area lying under the intensity curve of the vowel in each mora is a better acoustic correlate of Japanese accent than the intensity itself, as measured in terms of the phonetic speech power of the vowel in each mora. However, even this measure is not as consistently correlated with accent as fundamental frequency. To the extent that some degree of correlation exists, both intensity and the area of the intensity curve may be said to contribute to the acoustic quality of accent. Nevertheless, both these measures seem to be secondary cues, since even when they are not well correlated with accent distinctions, there are differences in fundamental frequency that are so correlated.

CHAPTER VII

A PHONOLOGICAL INTERPRETATION OF JAPANESE ACCENT

If all that was required for a linguistic description of Japanese accent was the recognition of each phonologically distinct accent pattern, the accent pattern of an uninterrupted utterance of a given length could be represented simply by a number (as done in Chapters III-VI) in its phonological transcription. Such a description, however, would overlook the fact that two accent patterns may differ from a third accent pattern in the same way and be different from each other in another way. For example, as shown in Chapter IV, two (Patterns 1 and 2) of the three accent patterns of three-mora words are alike in that a pitch rise (or no pitch change) occurs in both from the first to the second mora and that this pitch rise contrasts with the pitch fall that occurs from the first to the second mora in three-mora words with a Pattern 3 accent. On the other hand Pattern 1 contrasts with Pattern 2 in the amount of pitch fall from the second to the third mora.

These relationships between various accent patterns must be accounted for within the total phonological structure of Japanese. To do this, some sort of conceptual framework or theory must be postulated which explicitly describes these relationships. At the same time such a theory must account for the fact that each accent pattern can be characterized only in terms of the totality of relationships among its constituent parts and distinguished from all other accent patterns because its totality of relationships is unique.

One clue as to the nature of Japanese is that it normally can be observed only in utterances two or more moras in length. Normally no accentual distinctions are observed in utterances only one mora in length. These observations strongly suggest that accent phenomena in Japanese is susceptible to a phonotactic analysis. On such a basis each accent pattern is conceived of as a number of units linearly ordered. The way in which these units are ordered serves both to express the unique quality of each accent pattern, and to express the phonological differences and similarities between accent patterns. Thus, a given accent pattern may be thought of as a string of tactic units which differs from other such strings by its length (the number of units in the string) and by the order in which the units are arranged on the string.

The number of units in the string corresponds to the length in moras of the utterance. In order for the arrangement of the units to be of any significance, there must be at least two distinct units composing the string, otherwise two strings could only be compared by their length.

In pitch level theory, the value of pitch in one mora compared with the value of pitch in neighboring moras constitutes the basis for describing accent distinctions. This, however, leads to inconsistencies. For example, in the two-level theory, a Pattern 1 accent for three-mora words is described as low•high•high. Does this mean that the two high pitches are high with respect to the pitch on the first mora? If the answer is yes, then this description does not agree with the phonetic facts, since the third mora may be as low if not lower in pitch than the first mora. Figure 7.1 illustrates this feature of pitch change in three-mora words with a Pattern 1 accent (see also Table 4.2). If the high in the third mora is supposed to be interpreted as high with respect to the high in the second

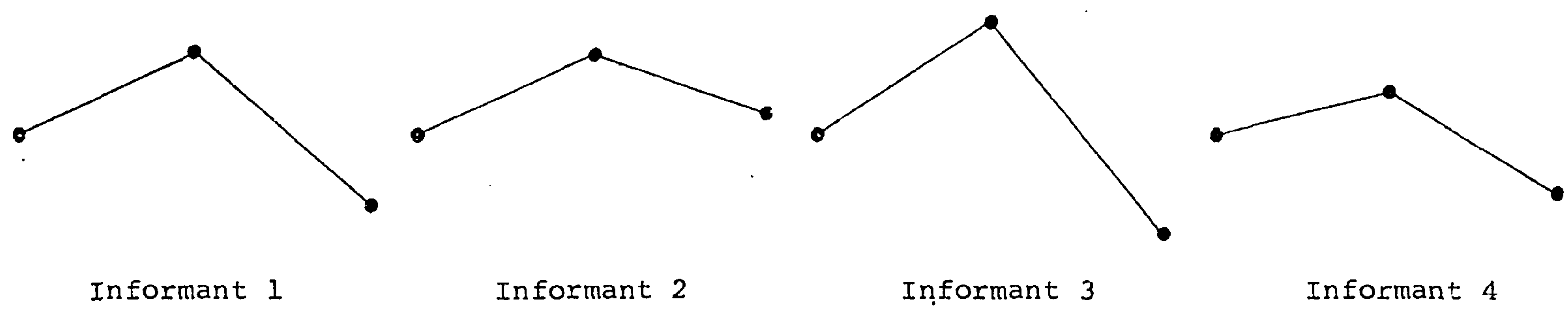


Fig. 7.1.--Graphical representation of average mora to mora relative pitch changes in three-mora words with a Pattern 1 Accent. (1 semitone = 1/4 inch vertically.)

mora, then assigning the value high to the third mora is inappropriate, since the pitch on the third mora is not observed to be higher than the pitch on the second mora in any of the data. Yet in the case of a Pattern 2 accent of a three-mora word, which is described in the two level system as high•low•low, the low pitch on the third mora is both lower than the high pitch on the first mora and lower than the low pitch on the second mora. Thus, there is an inconsistency in the relative relations between high and low pitch.

Since the pitch on the final mora of a three-mora word with a Pattern 1 accent is actually lower than that of the second mora and about as low as or lower than that of the first mora, it might be more appropriate to call it low pitched. The problem here is that the sequence low•high•low is used to describe Pattern 2, where the pitch on the third mora is actually lower than that in the first mora. The only way to resolve this problem and still preserve a pitch level conceptualization is to introduce a third pitch level and call it mid. Thus, Pattern 1 could be represented by the pitch sequence mid•high•mid, Pattern 2 by mid•high•low, and Pattern 3 by high•mid•low. This would solve the problem of representing the accent patterns of three-mora words, but it will not be adequate for describing the pitch levels in words four or more moras in length, because even greater pitch variations occur in these words. This is graphically illustrated in Figure 7.2, which shows the average relative pitch changes in the four different accent patterns of four-mora words. The pitch level theory cannot account for these pitch changes without multiplying the number of pitch levels and, in doing so, reducing its usefulness as a system for the representation of distinctive accent patterns.

The great flaw in the pitch level theory is its equivocation in what it tries to describe--the actual phonetic manifestation of accent distinctions or the functional contrasts involved in these distinctions. This equivocation leads to the inconsistency discussed above, for when one considers the functional similarities and differences in accent patterns, the phonetic basis for them is largely irrelevant. For example, the differences in pitch change from the second to the third mora in three-mora words that signal a functional difference in the accent pattern of these words are not in themselves important to the phonological structure of Japanese; what is important phonologically is that a functional difference does exist and, therefore, that some abstract conceptual system must be employed to

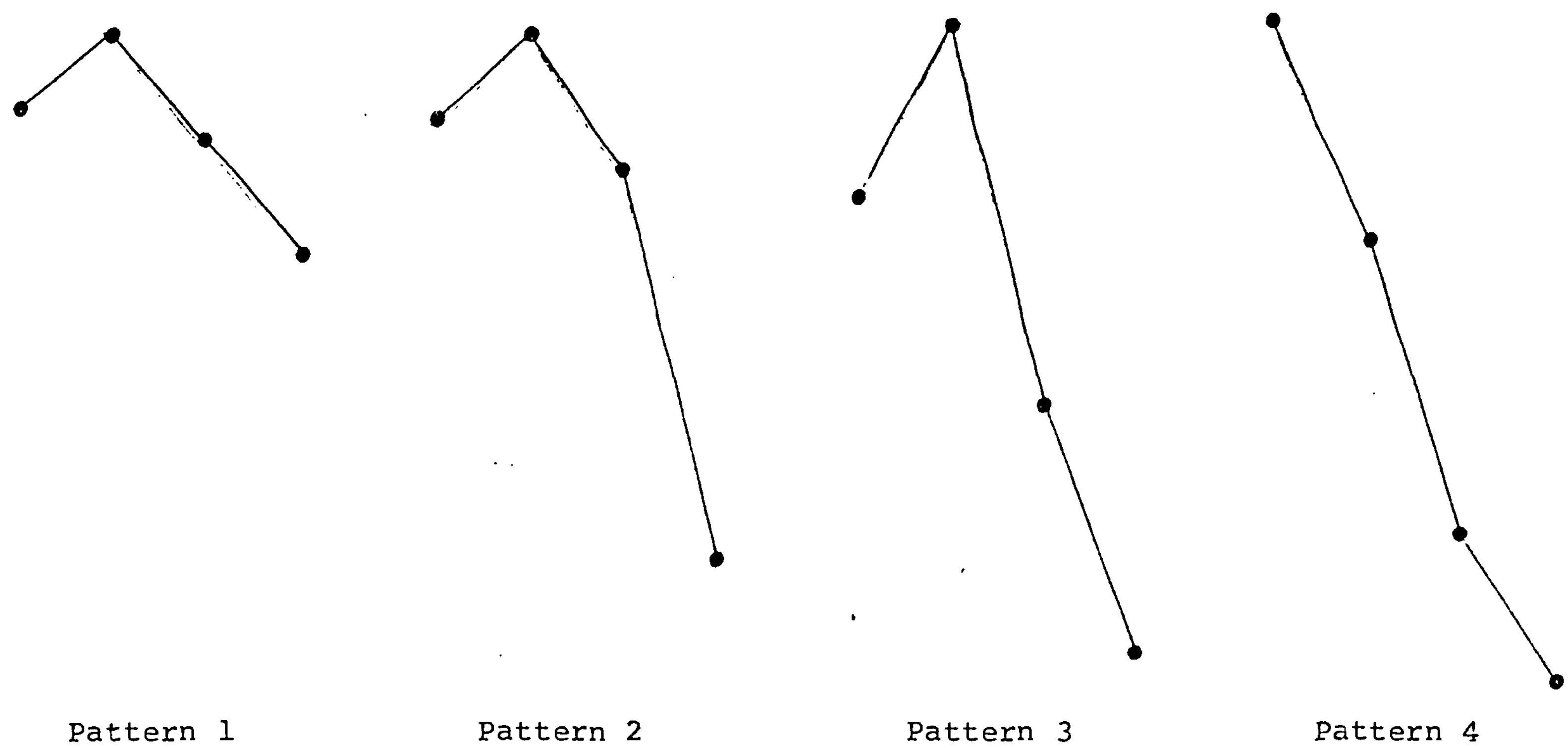


Fig. 7.2.--Average relative pitch changes in the four different accent patterns for four-mora words spoken by Informant 1. (1 semitone = 1/4 inch vertically.)

describe it. The pitch level theory cannot be considered adequate as a phonological description of Japanese accent, because it relies on the phonetic aspects of accent distinctions to describe the functional contrasts and actually defines its functional units in phonetic terms.

The pitch level theory recognizes and tries to take into account that one accent pattern may be partially like and partially different functionally from another accent pattern. This does not seem to be well recognized in the accent kernel theory. The accent kernel theory attempts only to describe how an accent pattern is different from another in terms of (1) the presence or absence of a single feature and (2) the location of this feature in an utterance. This feature, the accent kernel, describes an abrupt change from one mora to the next in the prosodic pattern of an utterance caused by an abrupt pitch fall or some other downward change. However, one cannot regard the accent kernel as the only significant feature, for in doing so, one overlooks the fact that the accent kernel acquires its phonological significance only in contrast with some other feature. For example, the accent kernel theory describes the word <u>kaki</u> 'oyster' as having an accent kernel between the first and second mora, and describes the word <u>kaki</u> 'persimmon' as lacking an accent kernel between the first and second moras. Nevertheless, the lack of an accent kernel in the latter word is just as significant as the presence of an accent kernel in the former word, since this lack contributes to the phonological distinction between the two words.

While on the surface the accent kernel theory seems to postulate only one unit for the description of accent, it implicitly postulates at least two units, since the place(s) where no accent kernel occurs is just as significant for the distinction of an accent pattern as the accent kernel. As noted earlier, an accent pattern is characterized by the totality of relationships that exist among its constituent parts and is distinguished from all other accent patterns by the uniqueness of this totality. Since the accent kernel theory concentrates on only one feature, it cannot describe the full uniqueness of an accent pattern.

While the pitch level approach takes into consideration the phonotactic nature of Japanese accent, it fails to realize that the significance of the phonotactic units used to describe an accent pattern lies in how they are arranged and not in the phonetic features that manifest the accent pattern; i.e., one unit compared to another unit is meaningful only as a comparison of two units occupying different positions in a string. For this reason, these units may be referred to as tactic phonemes:[1] the term phoneme indicating that they are part of the phonological system and the term tactic indicating the dimension of their significance within the system.

For Japanese it is necessary and sufficient to postulate only two tactic phonemes, which are represented in this study as /A/ and /B/. These two phonemes permute in certain ways to form strings representing the accent patterns of single-word utterances.

The accent data in Chapter III above indicate that the accent patterns of words n moras in length could be classified into those in which a pitch fall occurs from the first to the second mora and those in which no pitch fall occurs from the first to the second mora. This acoustic difference signals a functional contrast. The postulated tactic phonemes can express this contrast as the sequence //BA...//[2] versus the sequence //AB...// respectively. Thus, for

[1]Phonemes which are only tactically significant have also been called suprasegmental phonemes and secondary phonemes.

[2]A transcription enclosed by double slant lines indicates a phonotactic representation.

example, the sequence //AB...// is a partial phonological representation of Pattern 1 of two-mora words, Patterns 1 and 2 of three-mora words, and Patterns 1, 2, 3 of four-mora words, while the sequence //BA...// is a partial phonological representation of Pattern 2 of two-mora words, Pattern 3 of three-mora words, and Pattern 4 of four-mora words. In fact the sequences //AB// and //BA// are necessary and sufficient for representing Pattern 1 and Pattern 2 of two-mora words respectively.

Considering the words of three or more moras, those that begin with the sequence //BA...// are not further differentiated as far as accent is concerned. In terms of pitch patterns, this means that for words n moras in length, there is only one accent pattern which contains a fall in pitch from the first to the second mora. On the other hand those words beginning with the accentual sequence //AB...// turn out to be further differentiated in accent. In terms of fundamental frequency, this differentiation appears to be made on the basis of the total amount of pitch fall from the second to the last mora in a word and on the basis of the contribution of each mora to mora fall after the second mora. (See the discussion on pp. 60-63.)

The fundamental frequency data on Pattern 2 of three-mora words show that the pitch falls from the second to the third mora by a much greater amount than in Pattern 1 of three-mora words.[3] The tactic system characterizes the two patterns by transcribing Pattern 1 as //ABB// and Pattern 2 as //ABA//; i.e., the representation of the difference is expressed by the sequence //-BB// versus the sequence //-BA//. Since Patterns 2 and 3 are noncontrastive in the total amount of pitch fall (i.e., the total amount of pitch fall is about the same in both),[4] the terminal tactic phoneme will be the same in each. Thus, //BAA// is the transcription for Pattern 3.

In four-mora words the fundamental frequency data show that Pattern 1 differs from Pattern 2 and 3 by the total amount of pitch fall from the second to the last mora,[5] just as Pattern 1 differs from Pattern 2 and 3 of three-mora words. Continuing the same procedure of description, the sequence //ABBB// characterizes Pattern 1, //ABBA// characterizes Pattern 2, and //ABAA// characterizes Pattern 3.

[3]See Chapter IV, p. 56.

[4]See Chapter IV, pp. 53-56.

[5]See Chapter IV, pp. 59-61.

These representations for the three accent patterns show that all of them are noncontrastive from the first to the second mora, that Patterns 1 and 2 are similar also in that they are noncontrastive from the second to the third mora but are contrastive in their accent pattern from the third to the fourth mora, and that Pattern 3 is contrastive with Patterns 1 and 2 in the accent pattern from the second to the third and from the third to the fourth mora but noncontrastive with Pattern 2 in the amount of pitch fall from the second to the fourth mora. In terms used in Chapter IV, Patterns 2 and 3 are tonic accents, while Pattern 1 is atonic.[6] The sequence //BAAA// characterizes Pattern 4, showing that it differs from Patterns 1, 2, and 3 in that it contains a pitch fall from the first to the second mora, while the others do not, but is similar to Patterns 2 and 3 by being a tonic accent. Table 7.1 presents the various representations of accent patterns in words two to four moras in length.

[6]As a matter of fact, it is now possible to define a tonic accent as any accent that terminates in /A/ and an atonic accent as any accent that terminates in /B/.

TABLE 7.1

PHONOLOGICAL REPRESENTATIONS OF THE ACCENT PATTERNS IN WORDS TWO TO FOUR MORAS IN LENGTH

	Two-Mora Words	Three-Mora Words	Four-Mora Words
Pattern 1	//AB//	//ABB//	//ABBB//
Pattern 2	//BA//	//ABA//	//ABBA//
Pattern 3	--	//BAA//	//ABAA//
Pattern 4	--	--	//BAAA//

There are, however, certain limitations placed on the joining of /A/ and /B/ to form sequences: (1) in the first two positions of a sequence, either /A/ is followed by /B/ or /B/ is followed by /A/, no matter what the length of the word, and (2) if the sequence //BA// occurs anywhere in a string, the remainder of the string will be filled by /A/s. Thus, neither /A/ nor a sequence of /A/s is permitted between two /B/s, although either /B/ or a sequence of /B/s is permitted between two /A/s.

It should also be noted that Patterns 1 and 2 of two-mora words, Patterns 1 and 3 of three-mora words, and Patterns 1 and 4 of four-mora words are maximally contrastive in the sense that the position of each unit within one pattern is just the opposite of the position of each unit within the other pattern. The differences among other patterns or these patterns and others are something less than this.

The particular pitch value or intensity value associated with /A/ and /B/ is dependent on their positions in a string describing a given accent pattern. In other words, it is the nature of the accent pattern itself which defines its phonetic properties. The individual units themselves are conceived simply to describe the unique phonological character of each accent pattern and to indicate the phonological relations that exist among the various accent patterns. Figure 7.3 illustrates the average variations in fundamental frequency associated with sequences of /A/ and /B/.

The accent theory proposed above does not seem to suffer from the inadequacies of the other theories, mainly because it is more abstractly conceived, because it tries to take into account all contrastive features, and because it does not try to define its theoretical entities in terms of any phonetic notions, such as pitch levels. The theory

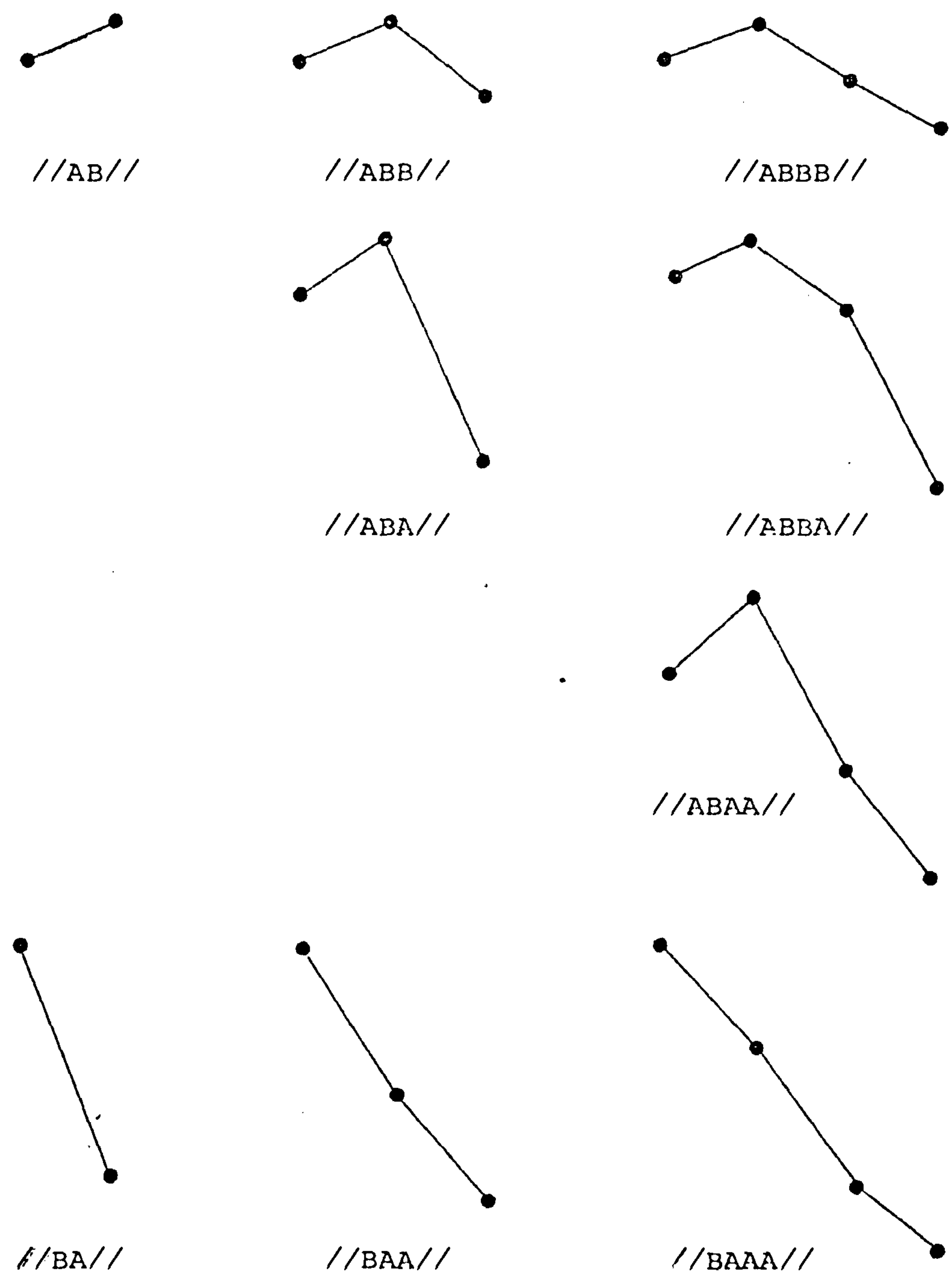


Fig. 7.3.--Average relative pitch changes in the accent patterns of words two to four moras in length spoken by Informant 1 and their corresponding phonological representations. (1 semitone = 1/8 inch vertically.)

only tries to express, in terms of sequences of tactic phonemes, the unique character of each accent and the phonological relations that exist among the various patterns.

SUMMARY

This study has attempted to present an analysis of the acoustic phonetic basis of accent distinctions and to offer a new phonological conceptualization of accent in Japanese.

In order to determine the acoustic correlates of Japanese accent two experimental studies were carried out. One was to determine the nature and extent of fundamental frequency as an acoustic correlate of accent, and the other was to determine the nature and extent of intensity as an acoustic correlate of accent.

The data on fundamental frequency revealed that a difference in fundamental frequency was consistently correlated with a difference in accent.

1. In single-word utterances of two or more moras, a rise in fundamental frequency versus a fall in fundamental frequency from the first to the second mora may serve to distinguish accent patterns.

2. Single-word utterances of equal length in which the pitch falls from the first to the second mora are not further contrasted in accent. Thus, for every word of n moras, there is one and only one accent pattern in which the pitch falls from the first to the second mora.

3. Single-word utterances of the same length n, where $n \geq 3$, and where there is pitch rise from the first to the second moras, may be differentiated by accent in n-1 ways. Pitch contributes to distinguishing these n-1 patterns in two ways: (1) by the total amount of pitch fall, and (2) by the percentage amount a given fall in pitch from one mora to the next contributes to the total pitch fall in the utterances.

The data on intensity as measured by the phonetic speech power of the vowel in a mora were highly equivocal. No clear and consistent correlation was found between intensity and accent. The area under the intensity curve yielded a better correlation with accent, but even in this case the correlation was not as clear and consistent as that of fundamental frequency.

As a result of the observations made in the acoustic analysis of accent, a new phonological interpretation of Japanese accent is proposed in which each accent pattern is described in terms of sequences of two tactic or suprasegmental phonemes /A/ and /B/. These phonemes are functional only as part of a sequence describing a given accent pattern, and cannot be defined individually in terms of any specific phonetic feature. Rather it is the nature of the accent pattern itself which defines its phonetic properties and not the individual units conceived to describe the unique phonological character of each accent pattern and to indicate the phonological relations that exist among the various accent patterns.

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13. ABSTRACT

This study presents an acoustic-phonetic and phonological analysis of Word Accent in Japanese. Two experiments are carried out in order to determine the nature and extent of fundamental frequency and intensity as acoustic correlates of accent. Fundamental frequency data on single-word utterances were obtained using a pitch extractor and oscillograph. Measurements of the target value of fundamental frequency in each mora of a word were made, and the relative mora-to-mora changes in fundamental frequency were calculated in semitones. Intensity data were obtained through an intensity-time analysis using a sound spectrograph. Measurements were made of (1) the phonetic speech power in each vowel and (2) the area under the intensity-time curve of each vowel within an utterance.

The data reveal that a difference in fundamental frequency is consistently correlated with a difference in accent. Words of n moras have n different accent patterns. No clear and consistent correlation was found between intensity and accent; though the area under the intensity curve yields some correlation with accent. As a result of these findings, a new interpretation is proposed in which each accent pattern is described in terms of contrastive sequences of two phonemes with functional significance at the phonoactic level of analysis.

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14. KEY WORDS	LINK A		LINK B		LINK C	
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Word Accent						
Pitch						
Intensity						
Japanese						