

LANGUAGE UNIVERSALS: AUDITARY EVENT-RELATED POTENTIALS IN SPEECH DISCRIMINATION, ESPECIALLY BETWEEN AMERICANS AND JAPANESE

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Abstract: The report shows that the intonation of a sentence in speech in dicates a definite pattern according to the function of the sentence.An experiment was made to confirm that a listener understands the function of a sentence according to its intonation, using psychological and biological indications. In the experiment the subject was given the sound stimul us of a word with two kinds of intonation, typical and non-typical. The brain waves were recorded and auditory event-related potentials were studied. Four words representing sentence function were selected in both English and Japanese. Japanese and Americans were used as subjects. Analyzing the results of this experiment, the relation in speech discrimination between intonation and function of a language is discussed.

Keywords: Intonation Function Event-related
Speech Discrimination

1 EXPERIMENTAL PROCEDURE

Loudness of speech was set at the level of daily conversation.

1.1 word stimulus

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A one-or two-syllable word was selected, for two reasons: 1. to prevent the subject guessing sentence function from the sentence meaning, 2. to be precise in recording auditory event-related potentials.

The Japanese sound stimuli were recorded on tape in Japanese standard by a Japanese and

was heard by the Japanese subject. The Japanese words used were functionally classified: affirmative 'hai'; negative 'iie'; question 'nani', imperative 'yamete'. Each had two intonation patterns, typical and non-typical.(Table 1)

As English sound stimuli, words uttered by a subject born in New Zealand were used. English words were classified in the same way as in Japanese samples.(Table 2)

The subject was given the sound stimuli after an explanation of the differences in intonation. "Typical intonation pattern in daily conversation" or "non-typical" were made clear to the subject.

Table 1 Japanese Words (voice stimuli) and Time Duration

voice stimuli	intonation	time duration	change point	sound level
はい (yes)	level	170.4		63.0
	rising	154.0	(92.0)	62.0
いいえ (no)	falling	362.8	(162.0)	48.0
	level	354.8		53.0
なに (what)	rising	331.2	(80.0)	57.0
	level	324.8		54.0
やめて (stop)	level	434.0		61.0
	rising	772.4	(285.2)	60.0

*time:ms sound level: dB(A) peak level of stimulus

Table 2 English Words (voice stimuli) and Time Duration

voice stimuli	intonation	time duration	change point	sound level
yes	level	170.4		40.0
	rising	154.0	(280.0)	40.0
no	falling	362.8	(320.0)	37.0
	level	354.8		37.0
what	rising	331.2	(200.0)	40.0
	level	324.8		40.0
stop	level	434.0		39.0
	rising	772.4	(220.0)	39.0

*time:ms sound level: dB(A) peak level of stimulus

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1.2 Method of presenting oral stimuli and auditory event-related potentials

The experiment was made four times for each nationality (English, Japanese) and function. The presentation of the voice stimuli was random.

At each trial, words were presented with the typical and the non-typical intonation for 2-4seconds, 50 words at random.(100 times per trial) The auditory event-related response showing stimulus specificity on the spontaneous electroencephalogram was averaged as a trigger at time duration. We observed the electrical change appearing around potential time component P2 and N1 in general by making the initial moment of utterance the trigger point since the onset of utterance and of the physiological auditory recognition process are imprecise.

The two categories of utterance were presented at random and took twice as many average counts as usual (50 times).

This ability to discern the auditory stimulus and the mental concentration of the subject, the 30 measurements of auditory event-related response for one utterance were made within a proper period. (reference to material 1)

The utterance was given through headphones at normal sound level (peak 37-63dB(A)) to a subject sitting with his eyes closed.(Table 1, 2)

After the experiment we interviewed the subject about the listening conditions and any other problems. The record of auditory event-related potentials was made according to the 10-20 Electrode System of International Federation, from Cz, ear-lobe reference derivation (A1+2).

1.3 Subjects

The Japanese subjects were 2 males from Ehime and Fukuoka prefectures(students aged 21, 22, from Kinki University, Kyushu School) with normal hearing ability and normal verbal ability. They both speak in their local dialect in their home town but they speak in Standard Japanese on formal occasions and can also speak in simple English in daily conversation.

The American subjects were 2 males from Utah (missionaries aged 19, 20,) with normal hearing ability and normal verbal ability. They can manage simple Japanese conversation.

The subjects were given an explanation of the experiment procedures and of the voice stimuli, especially with respect to the two categories.

2 RESULTS

The results are shown in Figure 1-8. The components of auditory event-related potentials given by voice stimuli present rather different aspects to those from general stimuli.

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In English, when making voice stimuli, noise lasting around 150+50msec was observed before the onset of English utterance. In the auditory event-related response, this preliminary noise had generated false primary responses. Because of this we could not ascertain a precise primary response in English. But as we had no problem with the secondary response, affecting intonation patterns, we were able to use the given data in the experiment.

2.1 Affirmative function 'Hai' (Fig.1)
The auditory event-related response of 'yes' showed a negative peak and positive peak between 75--200mec as the primary response caused by sound level. But after that, Japanese subjects showed a tendency to decrease (N1-P2:3.129V) and delay (N1:16.5ms, P2:7.5ms) in amplitude and latency , while on the other hand, American subjects showed no clear peak.

2.2 Negative function 'Iie' (Fig.2)
Two Japanese subjects showed the counter response waves in typical and non-typical categories. American subjects, though showing different response waves, did not show the counter response waves in both categories.

2.3 Question function 'Nani' (Fig.3)
A phenomenon of the counter response waves was recognized in the question function 'what' in the same way as in negative function 'no'. American subjects showed a simple wave. The one showing a more simple wave had no difference in either category, typical or non-typical.

2.4 Imperative function 'Yamete' (Fig.4)
In 'stop', Japanese subjects showed a more simple wave compared with American subjects. Especially the part indicating the intonation difference(less than 290msec) showed a clear difference in the wave form.

2.5 Affirmative function 'yes' (Fig.5)
The primary response lasted about 250msec, while the secondary response was clearly recognized in 'yes', but the wave was in personally different form. The latency (about 40msec) was clearly recognized in both categories in the primary response of American subjects.

2.6 Negative function 'no' (Fig.6)
In the response of American subjects a clear primary response was recognized in the typical intonation pattern. On the other, it was not definite in the response of Japanese subjects. In the Japanese response the wave made up of basic rhythm (about 12Hz) caused by noise was

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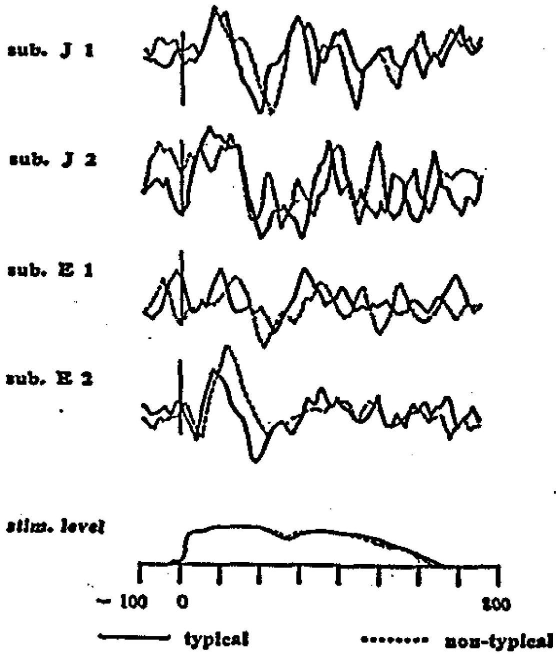

Fig. 5 ERPs to "yes" in 4 subjects

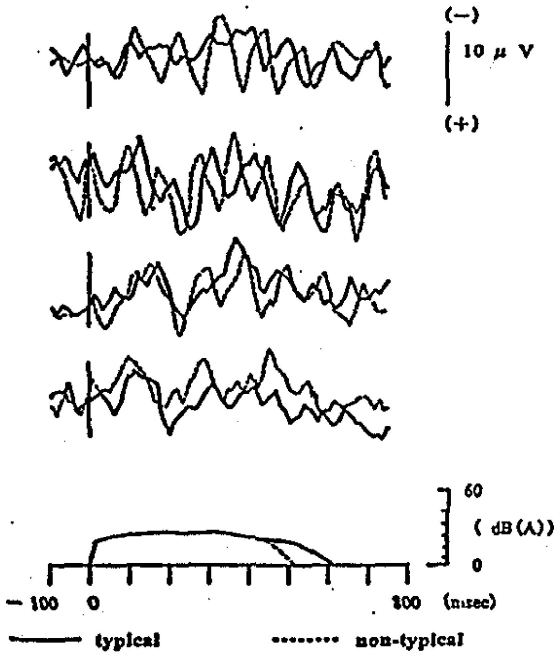

Fig. 6 ERPs to "no" in 4 subjects

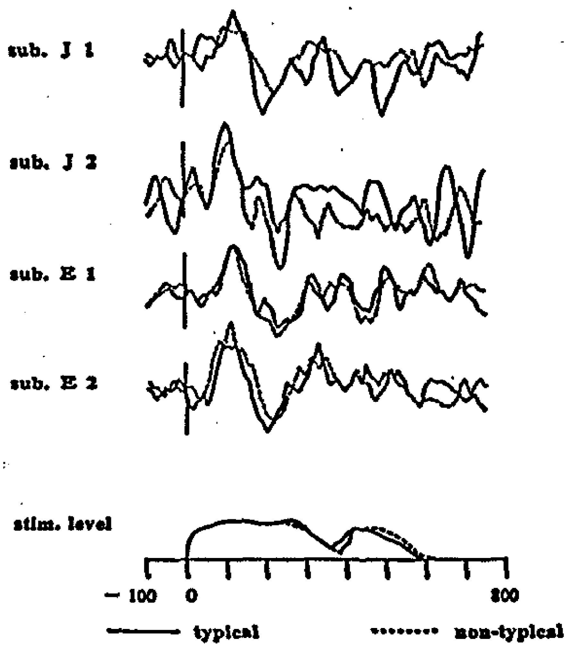

Fig. 7 ERPs to "what" in 4 subjects.

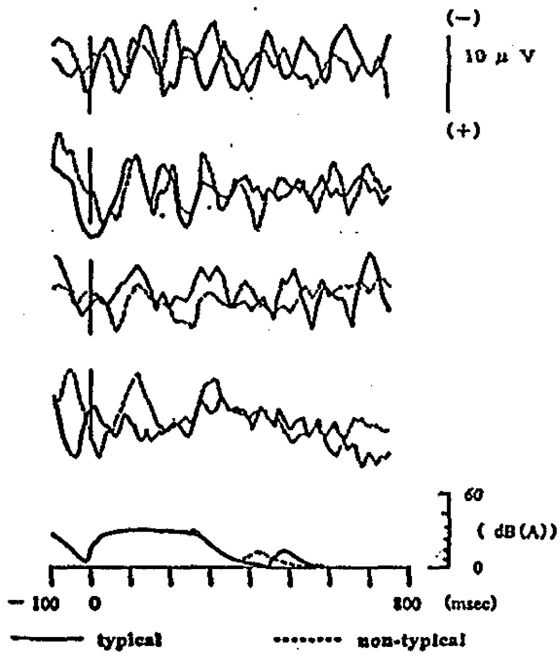

Fig. 8 ERPs to "stop" in 4 subjects.

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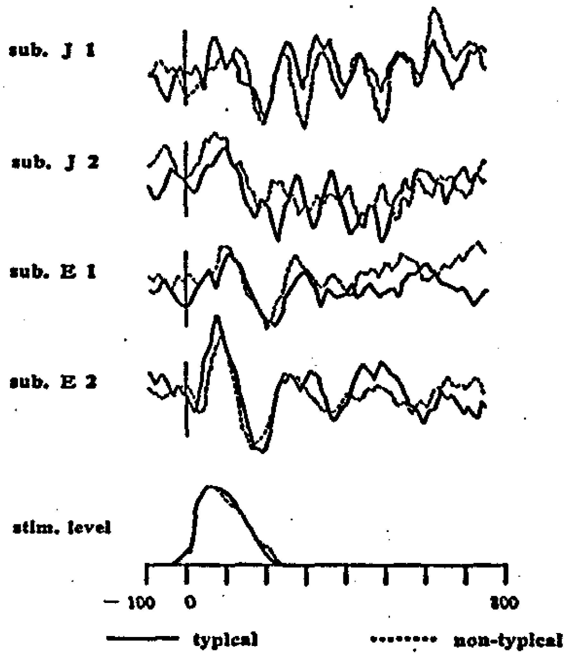

Fig. 1 ERPs to "hai" in 4 subjects

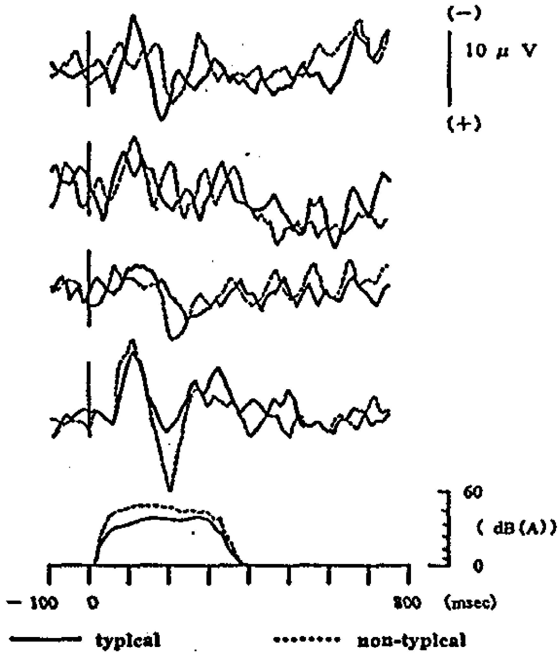

Fig. 2 ERPs to "iie" in 4 subjects

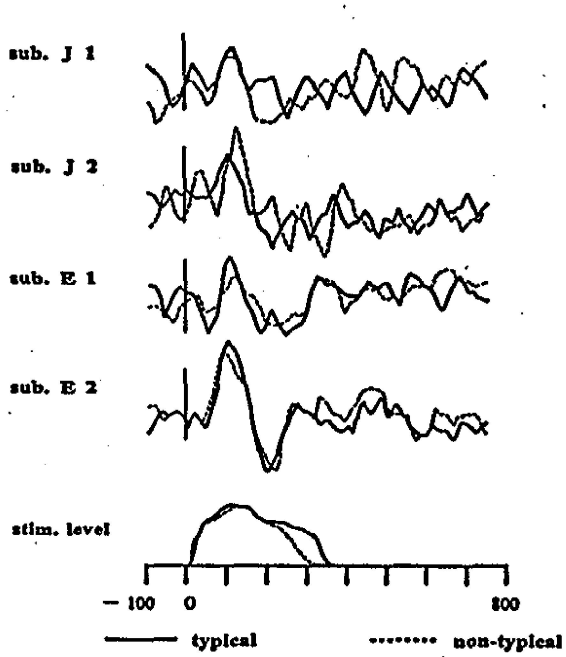

Fig. 3 ERPs to "nani" in 4 subjects

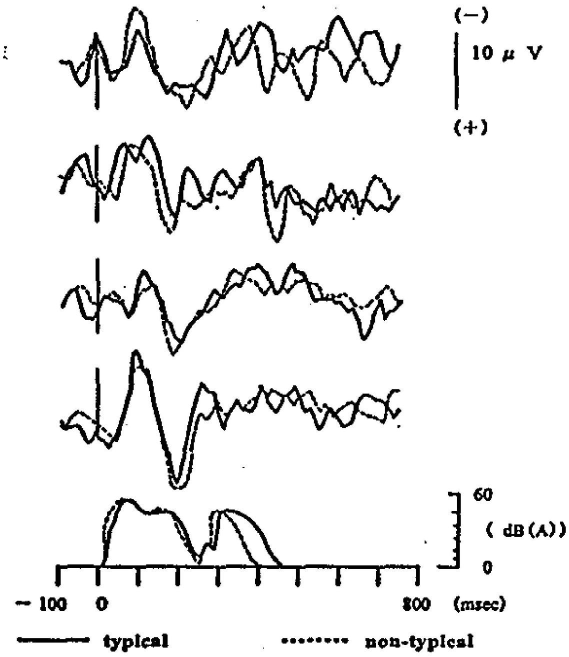

Fig. 4 ERPs to "yamete" in 4 subjects

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seen at the onset of the non-typical category.

2.7 Question function 'what' (Fig.7)

A clear primary response was recognized in 'what'. An almost identical wave was recognized in the part influenced by intonation except for one Japanese subject.

2.8 Imperative function 'stop' (Fig.8)

A clear primary response was not observed because it was affected by noise at its onset, but American subjects showed almost the same response in the part indicating the intonation difference. The wave marked by Japanese subjects was influenced by basic rhythm to almost the same degree as in the non-typical 'category of no'.

2.9 Differentiating the conditions of target utterances

After the experiment we interviewed the subjects and found that they couldn't keep their attention on the target utterances for as much as 100 times. In order to validate every function of our experiment , we consider we need a minimum of 30 times.

In differentiating target utterances, all the subjects reported that they could clearly differentiate every function of the utterances concerning the English typical categories. But concerning the Japanese typical categories, 'Iie' and 'Nani' were reported to be differently differentiated. This is caused by the influence of standard language on the local language the subjects use in daily life.

In our interview they reported that they could easily differentiate native language, while they had difficulty in differentiating the foreign language.

3 DISCUSSION

The primary response caused by the peak in sound level was clearly recognized.

We know that in discrimination of a simple sound stimulus the amplitude for the stimulus increases as the tension in a word increases, and decreases as the meaning of the target utterances is imprecise.2)

Concerning voice stimulus, discrimination is shown to decrease in amplitude and delay in latency, and decrease in N1-P2 amplitude compared with pure sound. This suggests a central signal-managing process.3)

The waves of the native language are easy to resemble in each subject, and those of the foreign language are difficult. The clear delay in latency in the primary response was recognised in both categories with American subjects. This shows evidence that a subject can easily

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differentiate in his own language. In the primary response in English, not only intonation difference but the response to the right timing of an utterance or a sound level can be analyze.

In vague discriminations, two phenomena were observed:

(1) A basic rhythm caused by noise at the onset as seen by Japanese subjects in the foreign language appears.

(2) After the secondary response the rhythmic wave slows.

In Japanese 'Hai' and 'Nani' the counter phenomenon was observed, but this is a natural result because it accords with the intonation pattern in the daily life of the subjects.

In response to 'Nani', American subjects showed a rather simple wave, the cause of which we could not clarify. This suggests a possibility that it works as the strongest factor in intonation in question function, since the response of alternative 'what' is clear.

A delay in latency in the primary response 'yes' was seen, but it showed no change in amplitude. This also suggests that even a slight difference at the onset of a voice stimulus involves information analysis in the discrimination of function.

Though the experiment did not include long sentences, there are clues to understanding of sentence functions in daily conversation: sound levels of each word, its intonation and its duration are closely related; in the typical intonation category the intonation of just one word makes sentence functions clear.

4 CONCLUSION

To relate sentence function and the intonation pattern at the end of its sentence, we studied the components of auditory event-related potentials by using affirmative 'Hai' and 'yes', negative 'Iie' and 'no', question 'Nani' and 'what' and imperative 'Yamete' and 'stop' as target utterances.

We conclude that:

(1) The relation between time sequence and voice sound, sound level, intonation suggests a key for understanding sentence function.

(2) Even a single intonation of a word may enable us to understand the sentence function.

(3) The influence of native language and foreign language on discrimination of intonation is an important factor in language understanding.

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