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ON PITCH CONTOURS OF DECLARATIVE, COMPLEX SENTENCES IN JAPANESE*

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1. Introduction

Sentences in speech are characterized by segmental and suprasegmental components. When we comprehend these sentences, we must go through the process of reconstructing the given phonological sequence into hierarchical constructions to match the corresponding meaning. As a first step in clarifying the role of suprasegmental components in sentence comprehension, intonation patterns, especially pitch contours were examined using declarative sentences.

As is generally known, sentence final intonation represents the speaker's intention by designating the given sentence as declarative, interrogative, imperative, etc. (Hadding & Studdert-Kennedy, 1973, and Hakoda & Sato, 1978). In this study, we limited our scope to declarative sentences only in order to elucidate the relationship between pitch contours and complex sentence constructions.

The complex sentences examined were relative clause constructions and coordinate conjunction constructions. In addition to these, pairs of simple sentences spoken in succession were examined for comparison.

In the following 3 experiments, 3 male adult speakers of Standard Japanese (HH, Hj H, and SN) were employed as subjects, and a pitch recorder (Pitch Extractor HV-12) was used to extract pitch contours.

2. Experiment I

2.1. Test Sentences

In Experiment I, 3 kinds of test sentences were used: relative clause construction (RC), a pair of simple sentences uttered in succession (SS), and coordinate conjunction construction (CC). Both RC and CC consisted of 27 sentences, while SS consisted of 27 pairs of sentences. The following are examples of each type.

(1) RC: [[aruita]$_{S_1}$ anoko-ga koronda]$_S$
walked that child fell

That child who walked fell.

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(2) SS: [anoko-ga aruita]$_S$ [anoko-ga koronda]$_S$
that child walked that child fell

That child walked. That child fell.

(3) CC: [[anoko-ga aruite]$_{S_1}$ [anoko-ga koronda]$_{S_2}$]$_S$
that child walked that child fell

That child walked and that child fell.

RC contains two clausal units where the first clause aruita constitutes a relative clause, subordinate clause S_1, SS simply contains two independent sentences, and CC contains two coordinately conjoined clauses S_1 and S_2.

Three nouns and 9 verbs were chosen as lexical items for the test sentences (Table 1). They were classified according to lexical accent pattern: without marked pitch accent (F), with high pitch accent on the word initial mora (H), and with high pitch on the word medial mora (M). In Table 1, an accented mora is indicated by the mark ['] immediately following it.

Table 1: Lexical items used in the test sentences in Experiment I.

Accent pattern	Noun	Verb		
F	otona adult	koronda, fell	naita, cried	asonda played
M	e'nji kindergarten children	a'eta could meet	o'ita became old	ni'geta fled
H	ano'ko that child	aru'ita, walked	ugo'ita moved	kaku'reta hid

After constructing test items for RC, SS and CC using these words, each set of 27 test items were grouped into the 9 patterns shown in (4). For RC and CC, the same noun is used twice in one test item.

Test items given in examples (1), (2) and (3) belong to the MMF type in group 9 MMX. In the MMF sequence, the first M represents the accent pattern of the verb located before the clause boundary of a given test item, and the second M represents the accent pattern of the noun located after the clause boundary. F represents the accent pattern assigned to the sentence final verb. Therefore, MMF actually indicates the accent patterns of the final 3 lexical items in each sequence in (1), (2) and (3).

(4)

1. FFX { FFF, FFH, FFM }	2. FHX { FHF, FHH, FHM }	3. FMX { FMF, FMH, FMM }
4. HFX { HFF, HFH, HFM }	5. HHX { HHF, HHH, HHM }	6. HMX { HMF, HMH, HMM }
7. MFX { MFF, MFH, MFM }	8. MHX { MHF, MHH, MHM }	9. MMX { MMF, MMH, MMM }

2.2. Purpose

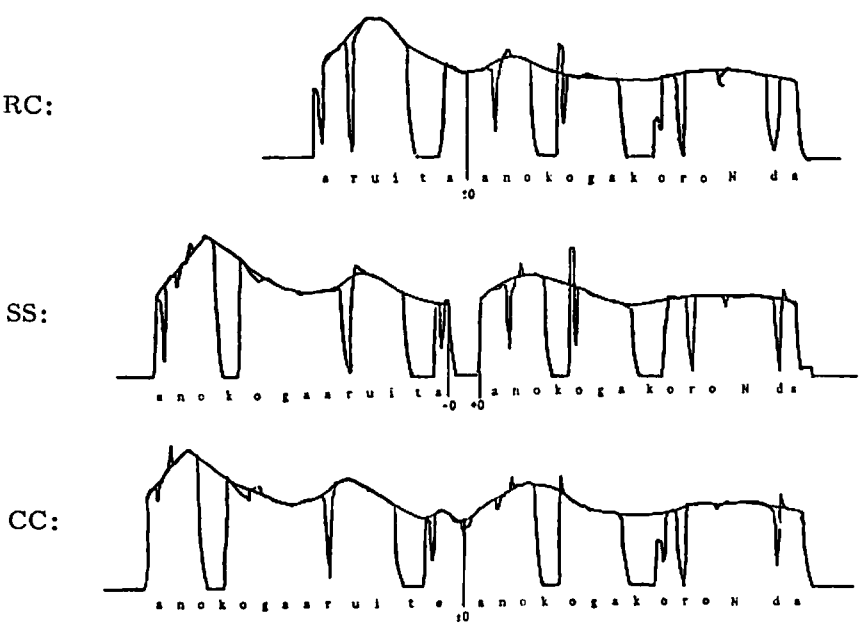
In Experiment I, an attempt was made to extract pitch contours characteristic of RC, SS, and CC, which were constructed using lexical items with the F, M, or H accent pattern.

2.3. Method

We asked the subjects to read the test sentences, and recorded them with a pitch recorder. The subjects were instructed to read each test item without any pauses, even in the case of SS.

The recorded pitch patterns were interpolated (Fig. 1).

Fig. 1. Interpolated pitch patterns (Sub:SN, HHX)



For measuring pitches, we set ±0 at a point where the clauses boundary was most likely to exist. In some cases, however, a pause was found at the clause boundary, as in SS in Fig. 1. In such a case, points -0 and +0 were set so as to eliminate the pause portion.

The pitch measurement was taken at intervals of 50 msec from point ±0 to ±1, 000 msec. Most of the test items were recorded within the span of ±1, 000 msec.

2.4. Results

On the basis of the pitch measurement of each test item, the 27 items of RC, SS and CC were classified into the 9 groups shown in (4). Then the mean values of the three pitch patterns were grouped together and plotted to get the mean pitch contour. Pitch contours in Fig. 2 are the mean pitch contours of the FFX pattern for RC, SS and CC, those in Fig. 3 are that of HHX, and those in Fig. 4 are that of MMX. They all belong to the same subject, SN . The vertical lines indicate the center point, ± 0.

Fig. 2. Mean pitch contours for RC, SS and CC in FFX (Sub:SN)

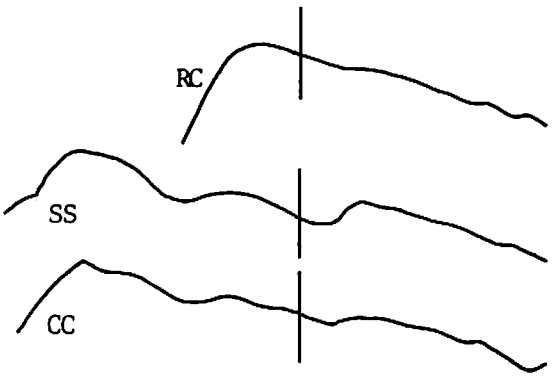


Fig. 3. Mean pitch contours for RC, SS and CC in HHX (Sub:SN)

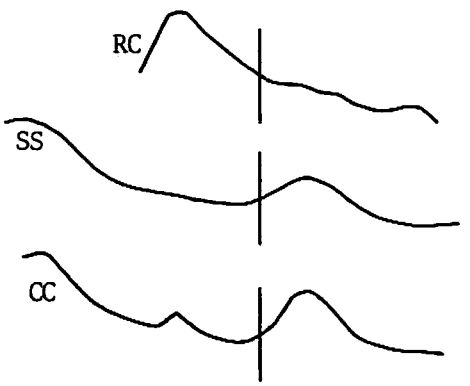
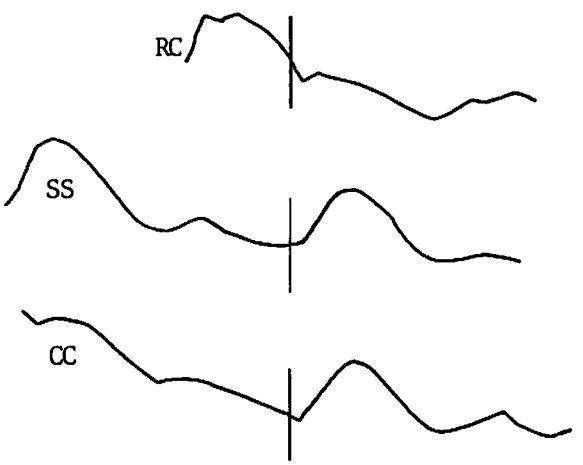


Fig. 4. Mean pitch contours for RC, SS and CC in MMX (Sub:SN)



The following figures (Figs. 5, 6 and 7) indicate the mean pitch contours of the 27 test items of RC, SS and CC as derived from the respective subjects.

Fig. 5. Mean pitch contours for RC, SS and CC (Sub: HjH)

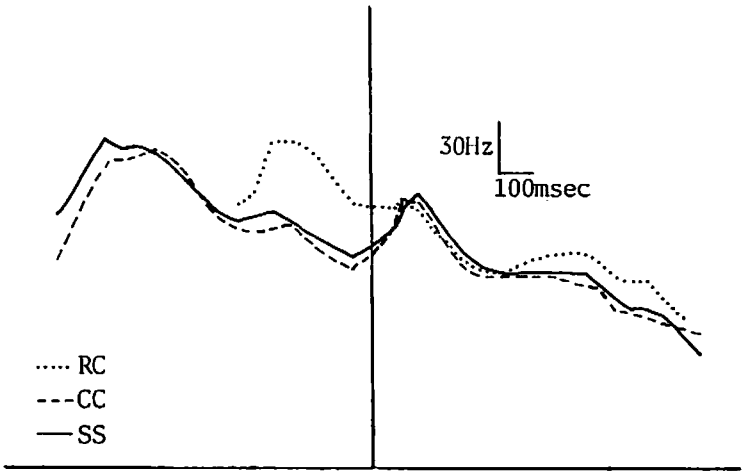


Fig. 6. Mean pitch contours of RC, SS and CC (Sub: SN)

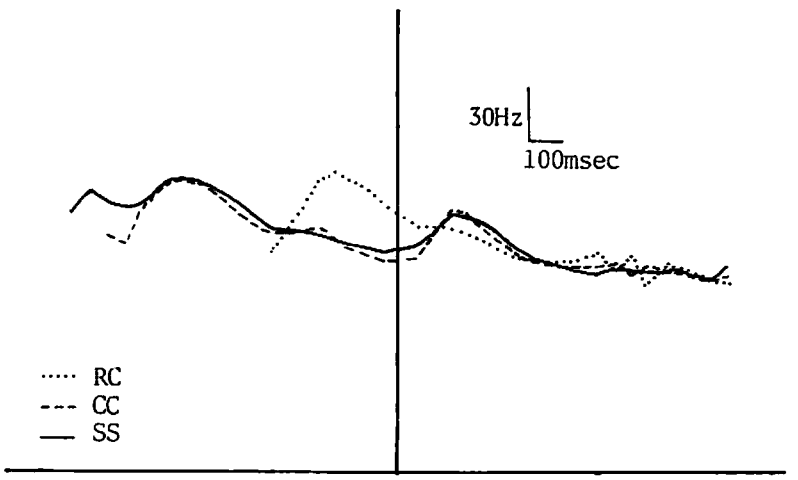
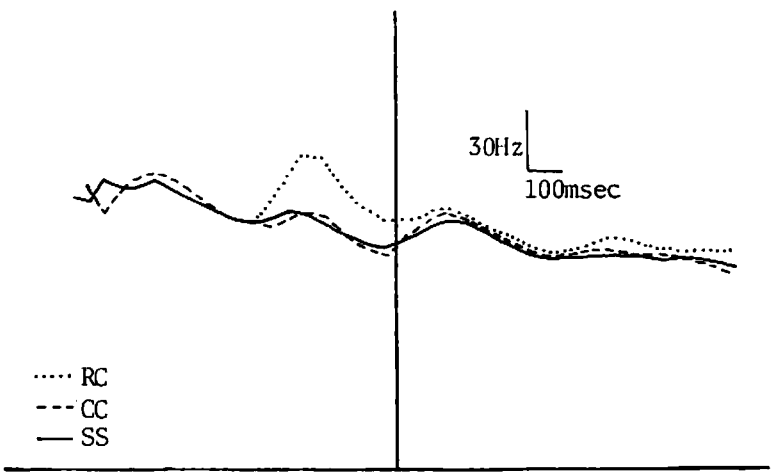


Fig. 7. Mean pitch contours of RC, SS and CC (Sub:HH)



The results illustrated in Figs. 2-7 support the following:

(a) Pitch contours may differ according to the lexical accent pattern involved; they form curves within the approximate limit of 100-200 Hz.
(b) In all test items, the pitch curve rises at the onset of the utterance and falls toward the end of the utterance.
(c) In RC, the pitch curve rises at the onset of the utterance and then rises again slightly, right after the clause boundary. However, the curve in general, gradually falls toward the end of the utterance. As explained in 2.1., the utterance initial verb in RC constitutes a relative clause. When we compare the pitch curve of the verb in RC with that of the corresponding verbs in SS and CC, the RC pitch curve is remarkably higher.
(d) Between SS and CC, no remarkable difference was found. In SS, the pitch curve rises again at the sentence initial of the succeeding sentence, while in CC, it rises again at the clause initial of the succeeding clause.

At this stage, it was not certain whether the high pitch curve was characteristic of a relative clause or of a clause being located in the utterance initial position. In order to examine this question, we conducted the second experiment.

3. Experiment II

3.1. Test Sentences

In Experiment II, two types of relative clause constructions, left-branching (RCL) and center-embedding (RCC), and the same pairs of simple sentences (SS) given in Experiment I were used. The examples of each type follow.

(5) RCL: [[ototoi naita]$_{S_1}$ otona-ga waratta]$_S$
day before yesterday cried adult laughed

The adult who cried day before yesterday laughed.

(6) RCC: [otona-ga [naita]$_{S_1}$ otona-o waratta]$_S$
adult cried adult laughed

An adult laughed at the adult who cried.

(7) SS: [otona-ga naita]$_S$ [otona-ga waratta]$_S$
adult cried adult laugh

An adult cried. An adult laughed.

Three nouns, 3 adverbs and 12 verbs were chosen as lexical items for test sentences (Table 2). They were classified according to lexical accent patterns, F, H and M. In Table 2, "Verb 1" is an utterance medial verb, and "Verb 2" is an utterance final verb.

Table 2. Lexical items used in the test sentences in Experiment II.

Accent Pattern	Noun	Adverb	Verb 1			Verb 2
F	otona adult	ototoi day before yesterday	naita, cried	koronda fell	asonda played	waratta laughed
H	e'nji kinder-garten children	a'rutoki walked	a'eta, could meet	ni'geta, fled	o'kita got up	ka'ita wrote
M	ano'ko that	anoto'ki that time	aru'ita walked	ugo'ita, moved	kaku'reta hid	osa'eta caught

Both RCL and RCC consisted of 9 sentences, and SS of 9 pairs of sentences. Each test item was formed using only lexical items of the same accent pattern.

3.2. Purpose

The purpose of Experiment II was to examine the pitch contours of RCL and RCC, and compare them with that of SS.

3.3. Method

The same instructions were given to the subjects as in Experiment I. The recording of the pitch contours, methods for interpolations and pitch measurement also followed the same procedure as in Experiment I.

3.4. Results

On the basis of the pitch measurement of each test item, the mean pitch values of 9 test items for RCL, RCC and SS, respectively, were plotted to get the mean pitch contours (Figs. 8, 9 and 10).

Fig. 8. Mean pitch contours of RCL, RCC and SS (Sub: HjH)

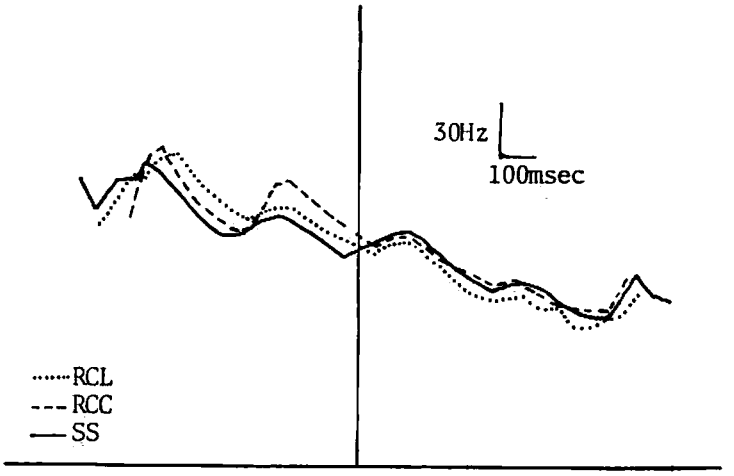


Fig. 9. Mean pitch contours of RCL, RCC and SS (Sub:SN)

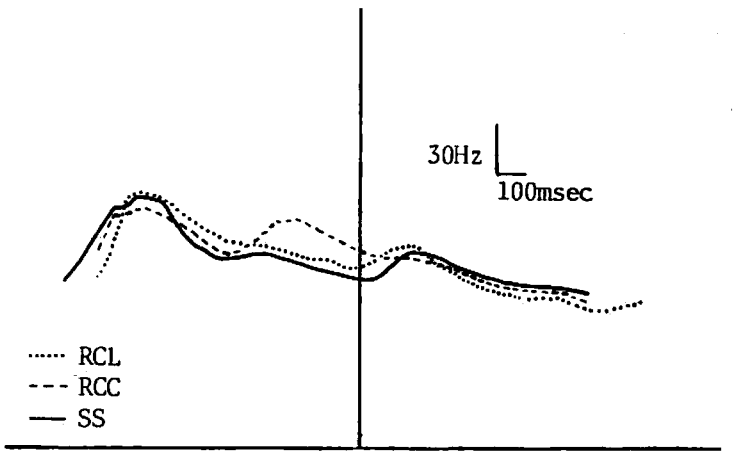
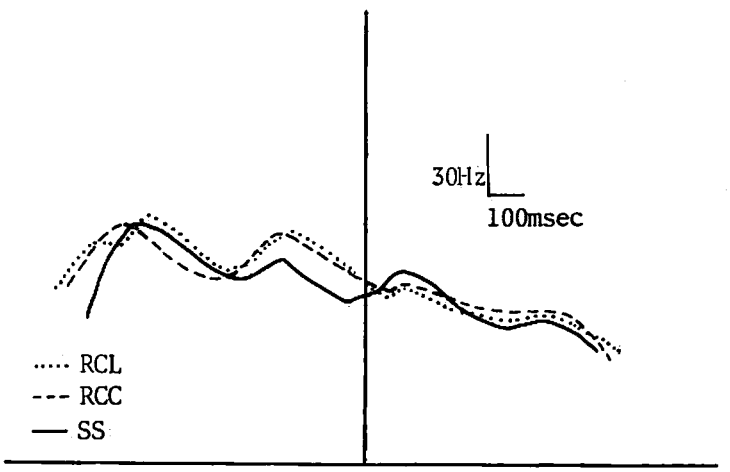


Fig. 10. Mean pitch contours of RCL, RCC and SS (Sub:HH)



Although we found some individual differences among pitch contours, in general, we can state the following:

(e) In all cases, the pitch curves rise at the onset of the utterance and fall toward the end of the utterance.
(f) In SS, the initial portion of the succeeding sentence is characterized by a rising pitch curve.
(g) In RCC, pitch curves which characterize the center-embedded relative clauses rise almost as high as pitch curves at the onset of utterance, then gradually fall toward the end.
(h) In RCL, the left branching relative clauses are characterized by rising pitch at the clause initial, as well as the onset of the utterance, which falls toward the clause boundary. The pitch contours then slightly rise again at the beginning of the main clause.

The pitch contour of RCL in Fig. 10, however, does not follow the patterns of RCL exhibited in Figs. 8 and 9. Rather, it resembles the pitch contour of RCC demonstrated by the subject. This fact may be due to a misinterpretation of the given RCL test items (as RCC) by the subject, because of the underlying ambiguity. Sentence (5), for example, can be ambiguous in two ways because it contains an adverb in a sentence initial position;

(8) RCL: [[ototoi naita] $_{S1}$ otona-ga waratta] $_{S}$
day before yesterday cried adult laughed

The adult who cried the day before yesterday laughed.

(9) RCC: [ototoi [naita] $_{S_1}$ otona-ga waratta] $_{S}$

The adult who cried laughed the day before yesterday.

In order to find out whether or not the inconsistency of RCL pitch contours mentioned above is due to different interpretations of the given sentence constructions, we conducted Experiment III.

4. Experiment III

4.1. Test sentences

The 9 test sentences given as RCL in Experiment II were all used in Experiment III. The interpretations of the test sentences, however, are given in two ways: RCL and RCCAd. In RCL, the relative clause S_1 is left-branching, whereas in RCCAd, the relative clause S_1 is center-embedded, as shown in (10) and (11).

(10) RCL: [[ototoi koronda] $_{S_1}$ otona-ga waratta] $_{S}$
day before yesterday fell adult laughed

The adult who fell the day before yesterday laughed.

(11) RCCAd: [ototoi [koronda]$_{S_1}$ otona-ga waratta]$_S$

The adult who fell laughed day before yesterday.

4.2. Method

The same procedure was followed as in Experiments I and II.

4.3. Results

On the basis of the pitch measurement for each of the test sentences, the mean pitch values of RCL and RCCAd were plotted to obtain the respective mean pitch contours (Figures 11, 12 and 13).

Fig. 11. Mean pitch contours of RCL and RCCAd (Sub: HjH)

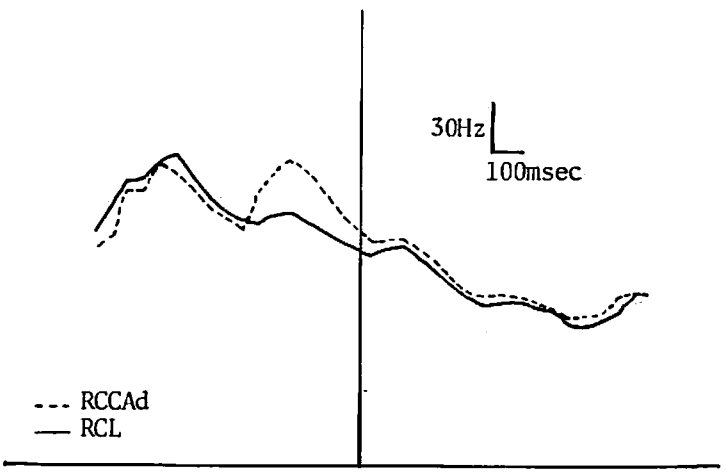


Fig. 12. Mean pitch contours of RCL and RCCAd (Sub: SN)

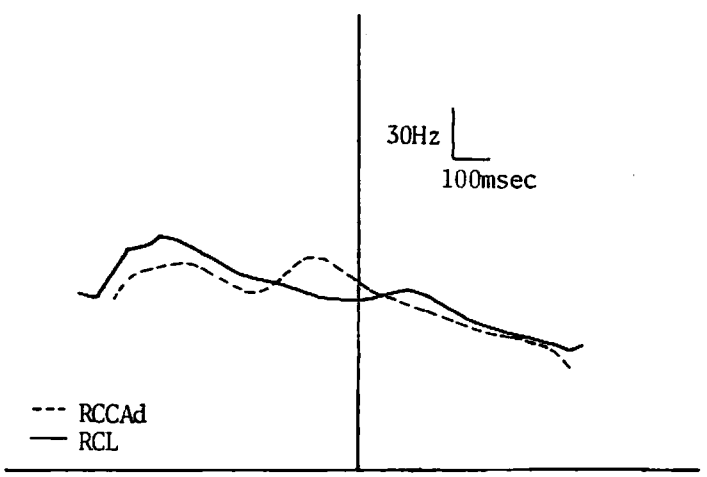
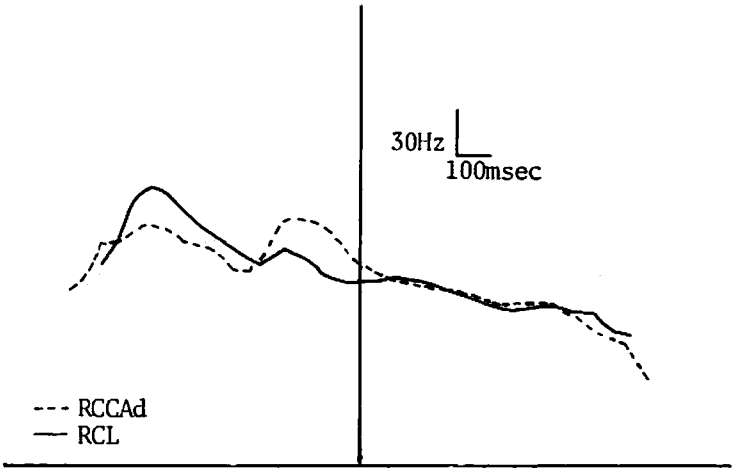


Fig. 13. Mean pitch contours of RCL and RCCAd (Sub:HH)



Leaving a side some individual differences in pitch contours, we observed the following:

(i) Pitch contours of RCL are characterized by a high rise in pitch at the onset of the utterance, declining gradually toward the end of the utterance.

(j) Pitch contours of RCCAd are characterized by a high rise in pitch at the onset of the utterance and by a repeated high rise in the relative clause. After the clause boundary, the contour declines gradually toward the end of the utterance.

Summary

The results obtained in Experiments I, II and II ((a)-(j)) can be summarized as follows:

i. The pitch contour of a declarative sentence rises at the onset of an utterance and gradually declines toward the end.
ii. Pitch curves rise at the clause initial. This is interpreted as a function of pitch contour which identifies a clause boundary.
iii. The results obtained from experiment III reveal that a structually ambiguous complex sentence is disambiguated by difference in pitch contour.

Pauses, which were omitted in this study, and the effect of pitch contours on the perception of sentences are important problems which remain to be examined.

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