

Pause and Hierarchical Structure in Sentence and Discourse

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Summary: There have been a number of studies on pause between constituents in a sentence (e.g. Grosjean, Grosjean and Lane 1979). However, pause between sentences has not been studied in detail. I propose the hypothesis that pause duration reflects the number of syntactic brackets between two words in hierarchical discourse structure (cf. Hinds 1979, Fox 1987, Polanyi 1988, Larson 1990). To prove the hypothesis, I analyzed Japanese radio news programs. An example discourse consists of 12 sentences. Pauses between two sentences are measured. The discourse is analyzed as a hierarchical structure. The numbers of brackets between two sentences (discourse brackets) are counted. The correlation coefficient between pause and the number of brackets is 0.49, some correlation. However, if we count brackets within a sentence as well as brackets between sentences, we get a better result. The correlation coefficient between pause and the number of brackets is 0.60, strong correlation. We conclude that both sentence structure and discourse structure affect pause duration. This study shows that there is hierarchical structure in sentence and discourse, and that there is some isomorphism between syntax and phonology, contrary to the generally accepted view.

1. Introduction

There have been a number of studies on pause between constituents in a sentence (e.g. Grosjean, Grosjean and Lane 1979). However, pause between sentences has not been studied in detail (cf. Couper-Kuhlen 2001). It has been argued that discourse has its internal structure especially by functional linguists (cf. Hinds 1979, Fox 1987, Polanyi 1988). In Section 1, I argue that sentences are merged by overt and covert conjunctions (cf. Larson 1990) to form discourse constituents such as paragraphs and chapters. In Section 2, I propose a hypothesis that the hierarchical structure of discourse and sentence is mapped onto prosodic structure by the boundary mapping rule, which interprets syntactic boundaries as prosodic boundaries. In order to prove the hypothesis, Japanese radio news is analyzed in Section 3. It is shown that the measured pauses between sentences highly correlates with the numbers of the boundaries between sentences.

2. Previous analyses of discourse structure

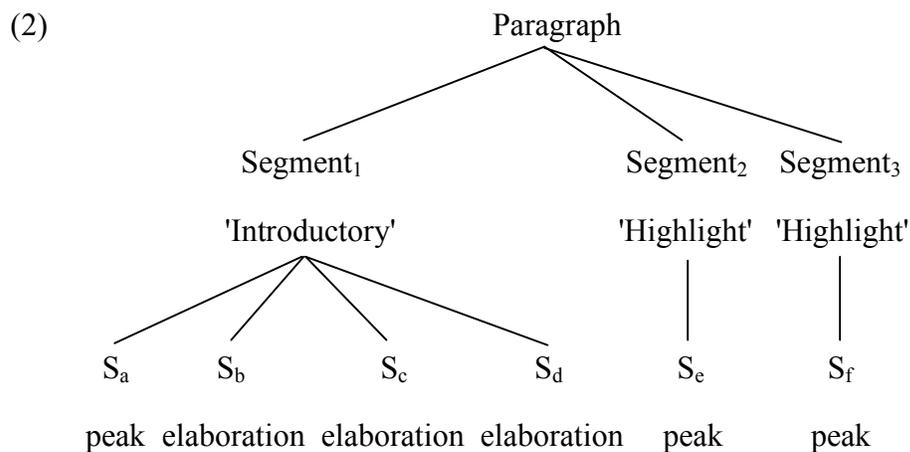
In this section, we will briefly review how discourse structure has been analyzed by functional and generative linguists. They have tried to analyze the structure by postulating constituents in discourse.

2.1 *N*-ary branching structure

First let us look at Hinds's (1979) analysis of the discourse (1).

- (1) FAMOUS ARTIST IWATA DIES AT 73 (Japan Times: 2/9/74)
- a. Sentaro Iwata, a celebrated artist and 1961 winner of the Medal of Honor with Purple Ribbon known for the sensuous illustrations of slim, kimono-clad women he did for periodicals, died of cerebral hemorrhage in Tokyo Tuesday.
 - b. He was 73.
 - c. He complained of a severe headache and nausea at about 8 p. m. Monday while working on magazine illustrations at his house in Shibuya Ward, Tokyo, and soon fell unconscious.
 - d. He was taken to the Keio University Hospital in Shinano-Machi, Tokyo, where he died at 10:35 a. m. Tuesday.
 - e. Born as the son of a printer in Asakusa, Tokyo, in 1901, Iwata became one of Japan's most popular illustrators when, at 25, he worked for the famous novel 'Ako Roshi' (The Tale of 47 Ronin) written by the late Jiro Osaragi.
 - f. In 1955, Iwata won the Kan Kikuchi Prize, an award for those having done outstanding work in art and journalism.

Hinds claims that the discourse has the internal structure shown in (2).



The syntactic tree (2) shows that the first four sentences S_a - S_d makes the first segment, which is combined with the other two segments to make a paragraph. In other words, a category can branch into more than two subcategories. Fox (1980) and Polanyi (1988) also propose similar n -ary branching structure for discourse.

2.2 Binary branching structure

In recent studies in generative syntax, it is assumed that a syntactic object is merged with another to make a larger object. Thus, the resulting structure must be binary branching, not n -ary branching. (cf. Kayne 1994, Chomsky 1995). Let us consider how we can represent the phrase structure above the

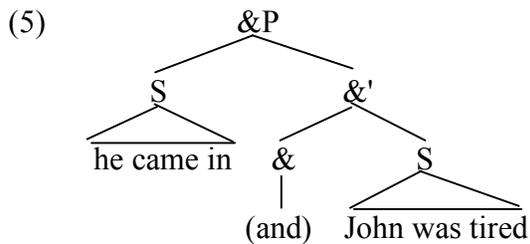
sentence in the minimalist framework. Larson (1990:594) discusses the following data on coreference:¹

- (3) a. *He came in and John was tired.
- b. *He came in. John was tired.

On the basis of parallelism between (3a) and (3b), Larson assumes the following:

- (4) a. Intrasentential anaphora between elements α , β depends on the relative hierarchical relations of α , β themselves; intrasentential anaphora between α , β depends on the relative hierarchical relations of the Ss containing α , β .
- b. Coordination structures fall under X-bar theory and have conjunctions as their heads.
- c. In their default form, discourses are extended coordinations.

Then (3a) and (3b) share the following phrase structure:



In (5), the second S merges with an overt or covert conjunction *and* to make a constituent &', which merges with the first S to make a discourse &P. Larson explains the disjoint reference in (3a) and (3b) with the constraint to the effect that “an S containing an R-expression cannot be c-commanded by an S containing a coreferential phrase.”

3. Asymmetrical discourse structure and boundary mapping hypothesis

3.1 Asymmetrical discourse structure

As Larson’s analysis of coreference in discourse seems to be on the right track, I assume that sentences are hierarchically structured into a binary branching tree as shown in (5).

Let us consider a simple example of a discourse consisting of four sentences:²

- (6) John came. He sang. Mary came. She danced. (The party went on and on ...)

As I argued in the last section, I assume that discourses are extended coordinations. Then the structure of the first and the second sentences in (6) is (7a), and that of the third and the fourth in (6) is (7b).³

¹ See Tokizaki (1995) for the discussion of coordinate structure and coreference.

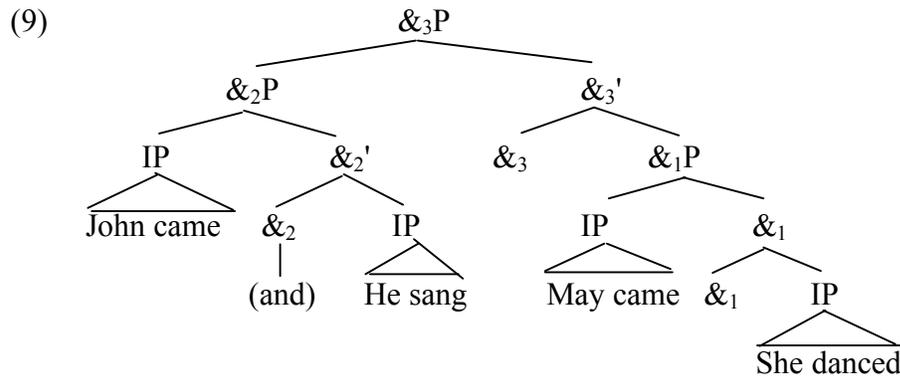
² See Tokizaki (1996) for discourse structure and coreference.

- (7) a. [_{&P} [_{IP} John came] [_{&'} & [_{IP} He sang]]]
 b. [_{&P} [_{IP} Mary came] [_{&'} & [_{IP} She danced]]]

Either of (7a) and (7b) makes a semantic unit, which might be called a paragraph. I propose that (7a) and (7b) are also combined by merging (7b) with a covert conjunction & and by merging the resulting &' with (7a), as shown in (8).

- (8) [_{&3P} [_{&2P} [_{IP} John came] [_{&2'} &2 [_{IP} He sang]]] [_{&3'} &3 [_{&1P} [_{IP} Mary came] [_{&1'} &1 [_{IP} She danced]]]]]

The tree diagram of (8) is shown in (9).



A covert conjunction combines a sentence with another to make a discourse constituent such as paragraph, which in turn is combined with another sentence or discourse constituent to make a larger discourse constituent. This merging process continues to apply until all the sentences in the whole discourse are combined to make a tree. We may call some intermediate constituents as sections or chapters.

3.2 Boundary mapping hypothesis

The theory of PF interface I have explored in Tokizaki (1999, 2000) involves boundary mapping and boundary deletion. I will call this approach boundary phrasing. Syntactic phrase structure is mapped onto phonological structure by the rule (10).

- (10) Interpret boundaries of syntactic constituents [...] as prosodic boundaries / ... /.

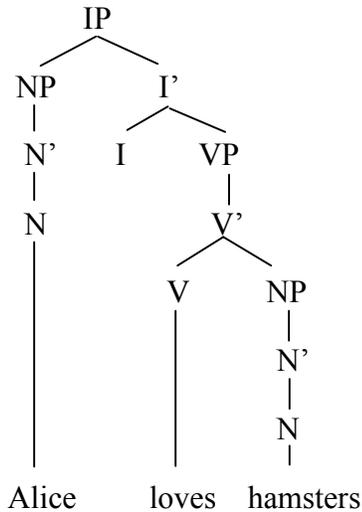
The rule (10) interprets boundaries of syntactic constituents as prosodic boundaries. I assume that this rule is one of the linearization rules that encode hierarchical syntactic structure as a sequence of words and pauses (see Kayne (1994) and Uriagereka (1998) for linearization). I assume the bare phrase structure in the sense of Chomsky (1995). For illustration, consider the following sentence:

- (11) Alice loves hamsters.

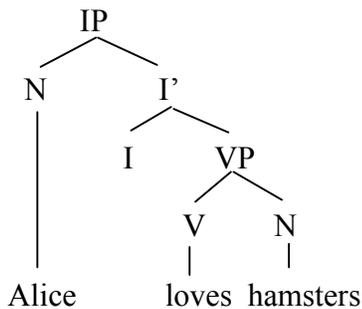
³ Here IP is Infl(ection) Phrase in syntax, not Intonational Phrase in phonology. Infl and its projection I' are not represented in (7) because of the convention (13) below.

As Chomsky (1995:246) notes, “there is no such thing as a non-branching projection.” This is a consequence of the operation Merge, which combines two syntactic objects. Then the phrase structure of (11) is not the X-bar theoretic structure (12a) but the bare phrase structure (12b).

(12) a. [IP [NP [N' [N Alice]]] [I' I [VP [V' [V loves] [NP [N' [N hamsters]]]]]]]]



b. [IP [N Alice] [I' I [VP [V loves] [N hamsters]]]]



I also assume the following convention for invisible syntactic objects:⁴

(13) Phonologically null elements and the constituents made by merging them with other syntactic objects are invisible to phonological rules.

By “phonologically null elements” I mean the categories that have no phonetic features, such as PRO, Infl, and *v*. Given the convention (13), I and I' in (12b) are invisible to phonological rules. I is phonologically null, and I' is made by merging null I with VP. Note that IP is visible to phonological rules. It is made by merging N and I', neither of which is a phonologically null element. Thus, phonological rules can “see” only substantial parts of the bare phrase structure, which is shown in (14).⁵

⁴Nespor and Scorretti (1984) also argue that empty categories have no effect on the various PF rules.

⁵ If we assume VP-internal subject hypothesis as in (ia), the result is almost the same as (14) as shown in (ib) because the trace of subject and the VP are invisible.

(i) a. [IP [N Alice]_i [I' I [VP t_i [V' [V loves] [N hamsters]]]]]]]]

(14) [IP [N Alice] [VP [V loves] [N hamsters]]]

Following Chomsky (1995) and Collins (2002), I also assume that there are no labels in syntactic structure. With these assumptions, the mapping rule (10) applies to the “completely bare” phrase structure (15).

(15) [[Alice] [[loves] [hamsters]]]

The rule interprets the brackets in (15) and changes them into prosodic boundaries as in (16).

(16) // Alice /// loves // hamsters ///

The slashes in (16) show the basic disjuncture between words.

Here, let us review Selkirk’s (1984:314) Silent Demibeat Addition, which articulates the syntactic timing of a sentence.

(17) Silent Demibeat Addition

Add a silent demibeat at the end of the metrical grid aligned with

- a. a word
- b. a word that is the head of a nonadjunct
- c. a phrase
- d. a daughter phrase of S.

This rule applies to the sentence (18) to assign the silent demibeats (x) in (19).⁶

(18) [S [NP [N Mary]] [VP [V finished] [NP [her] [[AP [A Russian]] [N novel]]]]]

(19) x x x x

 x x x x x

 x xxx x x xx x x x x x x xxxxx

 Mary ↑ finished ↑ her Russian ↑ novel ↑

 (a,b,d) (a,b) (a) (a,b,c,d)

In (19), *Mary* is followed by three silent demibeats, because *Mary* is a word (17a), an argument (of VP) (17b), and a daughter of S (17d).⁷ Similarly, the other silent demibeats are assigned by (17).

b. [IP [N Alice] [V' [V loves] [N hamsters]]]

The only difference between (14) and (ib) is that the label of the constituent loves hamsters is VP in (14) and V' in (ib).

The difference disappears if we assume the label-free structure as in (15).

⁶ In (19), the stress beats (x) are assigned by other rule than Silent Demibeat Addition (17).

Notice that the Silent Demibeat Addition is different from the depth of boundaries and the branching depth in that it counts only the end of a constituent as shown in the second line of (17). Furthermore, Selkirk assumes the Principle of Categorial Invisibility of Function Words (PCI), whose effect is to make function words (e.g., determiners, auxiliary verbs, personal pronouns, conjunctions, prepositions, etc) invisible to rules of the grammar. PCI confines (17a) and (17b) of SDA to applying only to words of the categories N, V, A, Adv. These points might be good for describing the data, but at the same time they arouse questions in our mind. Why does SDA count only the end? Why are function words invisible to the rules of grammar? At least we need to know the reasons. Therefore I still assume the boundary mapping (10) which interprets all the syntactic brackets.

Now let us assume here that a prosodic boundary (/) is equivalent to a silent demibeat. Then the example (16) can be represented as (20).

(20) xx Alice xxx loves xx hamsters xxx

The silent demibeats represent the basic pause duration between words.

Let us go back to the discourse (6) and its structure (7), (8), and (9). The phrase structure in (8) or (9) is interpreted as a phonological representation as in (21).

(21) *//// John // came //// He // sang ////////// Mary // came //// She // danced /////*

In (21), there are four boundaries between *came* and *he*, and seven between *sang* and *Mary*. In other words, there are more boundaries after the end of a paragraph than the end of a sentence. One might argue that there are not so many boundaries after *danced* (six) as between *came* and *Mary* (seven). However, this mini discourse may well be followed by another mini discourse as in the following:

(22) John came. He sang. Mary came. She danced. The party went on and on

Then the second mini discourse has a number of syntactic brackets in front of it which are interpreted as prosodic boundaries as shown in (23).

(23) a. ... danced]]]]]]] &_4 [IP [DP [D The] [N party]] [VP [V went] [&P [ADV on] [&' [and] [ADV on]]]]]]]
 b. ... danced ////////// // The // party //// went /// on /// and // on ///// ...

In the example (23a), there are nine prosodic boundaries between *danced* and *the*. Thus, we can correctly predict more boundaries between larger discourse units such as paragraph and discourse. This is a welcomed result of the bare mapping theory.

4. Pause and structure in Japanese radio news

4.1 Data

To prove the hypothesis, I analyzed Japanese radio news programs. An example discourse consists of 12 sentences. The program was recorded on tape and dubbed as the accompanied MP3 file. Each pair of sentences is recorded as a sound file by PitchWorks. The end and the beginning of a sentence is

⁷ Somehow Selkirk (1984: 317) does not argue that (17c) applies to *Mary* in (19) in spite of the fact that it is assumed to be an NP as shown in (18).

marked with the cursor, and the duration between two sentences is measured by the software. For example, Figure 1 shows the sound file of the first sentence and the beginning of the second sentence. The duration of the rightmost blank in the top row is measured as 1493.5 ms.

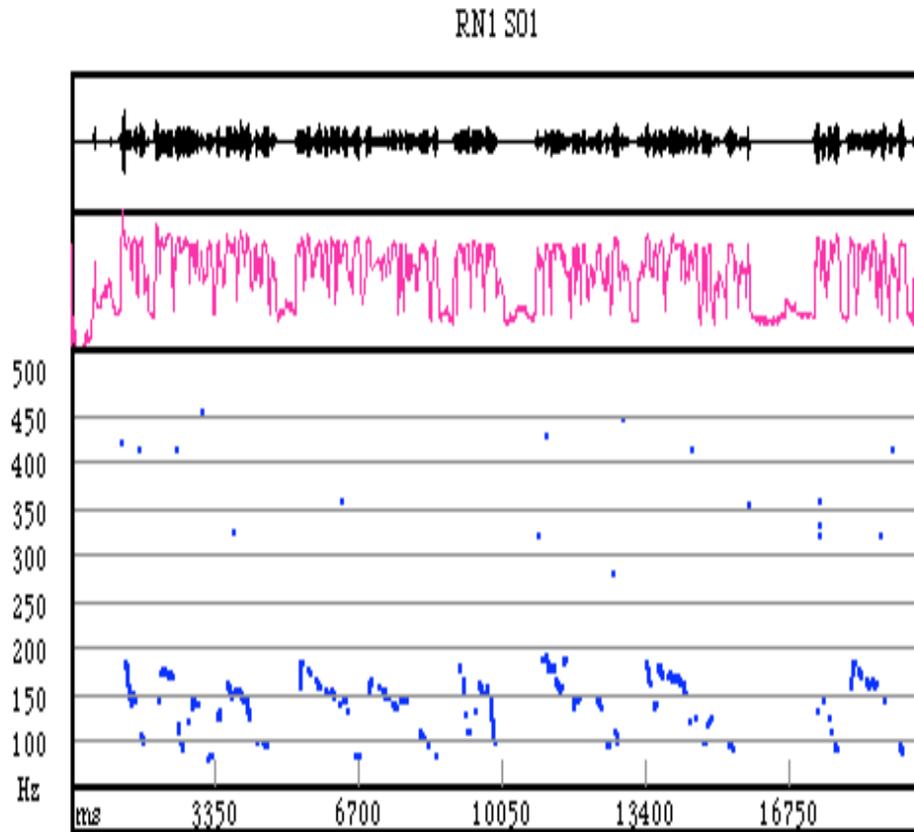


Figure 1 : PitchWorks sound file of S1-S2

The script of the news is shown in (24).

(24) (NHK Radio 1, 15:00-02, August 16, 2004)

S1. Kyoo gozen Kanagawa-ken Hatano-shi-no jinzai-haken-gaisha-no mae-de kono kaisha-no shachoo-to shain-ga san-nin-gumi-no otoko-ni osowarete hitori-ga karui kega-o shi, ginkoo-kara oroshita-bakari-no shain-no kyuryoo nisen nana-hyaku-man-en amari-no haitta baggu-o ubaware-mashita.

“In the morning today, the president and an employee of the company of convex of the temporary staffing agency in Hatano, Kanagawa Prefecture, were attacked by three men and were deprived of the bag that contained the salary for the employees, about 27 million yen, which they had just drawn from the bank.”

S2. Keisatsu-dewa gootoo-shogai-jiken-to-shite nigeta otoko-ra-no yukue-o soosa shite-imasu.

“The police are investigating the whereabouts of men who run away as a burglar injury event.”

- S3. Kyoo gozen kuji-sugi Hatano-shi Horinishi-no jinzai-haken-gaisha-no mae-de, kono kaishano shachoo, Ogawa Yoshihisa-san gojuu-ni-sai-to shain-no Suzuki Takahito-san sanjuu-nana-sai-no hutari-ga san-nin-gumi-no otoko-ni osoware-mashita.

“The president Ogawa Yoshihisa, 52 years old, and an employee Suzuki Takahito, 37 years old, were attacked by three men in front of the building of the temporary staffing agency at Horinishi, Hatano City at 9:00AM today.”

- S4. Otoko-ra-wa Suzuki-san-no kao-nado-o nagutte karui-kega-o saseta-ue, genkin oyoso nisen nana-hyaku go-ju man-en-no haitta tesage baggu-o ubatte joyosha-de toosoo shimashita.

“The men hit and injured Mr. Suzuki’s face lightly, deprived of the swagger bag of the cash about 27.5 million yen, and ran away by car.”

- S5. Keisatsu-no shirabe-ni yorimasu-to osowareta hutari-wa chikaku-no ginkoo-de shain-no kyuryoo-o oroshite, kaisha-no mae-de kuruma-kara orita-toki-ni osowareta-to iu koto-desu.

“According to the examination of the police, the two people were attacked when they stepped out of the car in front of the company after they withdrew the employee's salary from the nearby bank.”

- S6. San-nin-gumi-no otoko-wa izure-mo shinchoo-ga ichi-meetoru nanaju-ssenchi kurai-no gaikokujin-huude, kurumano-naka-ni taiki siteita nakama-no otoko-to-tomonni yonin-de nigeta-to iu koto-desu.

“They say that the three gangsters, looking like foreigners of about 170 centimeter tall, ran away with another who had waited in a car.”

- S7. Kono kaisha-dewa maitsuki onaji hi-ni kyuryoo-o oroshiteiru-to iu koto-de, keisatsu-dewa kooshita jijoo-o sitta-ue deno keikakuteki-na hankoo-to mite, gootoo-shogai-jeken-to-shite nigeta otoko-ra-no yukue-o soosa shite-imasu.

“This company withdraw the salary on the same day every month, and the police, assuming that this crime was well planned by those who know such circumstances, are investigating the whereabouts of the gangsters who ran away.”

- S8. Kawase-to kabu-desu.

“Here is an exchange and stock report.

- S9. Shu-ake-no Tokyo gaikoku kawase shijoo-no ensooba-wa senshoo-matsu-ni kurabete ichi-en nijuu roku-sen endaka doruyasu-no ichi-doru hyakujuu-en rokujuu nana-sen kara nanajuu ni-sen-to natte imasu.

“The yen exchange rate of Tokyo Foreign Exchange Market at the beginning of the week is one dollar to 110.67-72yen, that is, 1.26 yen up compared with the end of last week’s.”

S10. Ippoo, Tokyo kabushiki shijoo-no topikkusu, Toshoo kabuka shisuu-wa senshuumatsu-ni kurabete juu-nii-ten ichi-nana sagatte, senhachijuuon-ten rokuyon-to natte imasu.

“On the other hand, TOPICS, Tokyo Stock Price Index of the Tokyo stock market, falls by 12.17 compared with the end of last week’s 1084.64.”

S11. Mata nikkei heikin kabuka-wa senshuu-matsu-ni kurabete rokujuu kyuu-en sanjuu kyuu-sen yasui ichi-man roppyaku hachijuu nana-en hachijuu-ssen-to natte imasu.

“Moreover, Nikkei average is down by 69.39 yen to 10,687.81 yen compared with the end of last week’s.”

S12. Ijoo nyuusu-o otsutae shimashita.

“This is the end of the news.”

Pauses between two sentences (sec.) are shown in the second row in Table 1.

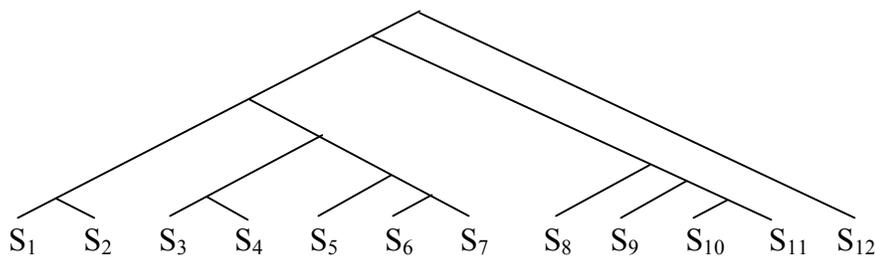
Position	S ₁ -S ₂	S ₂ -S ₃	S ₃ -S ₄	S ₄ -S ₅	S ₅ -S ₆	S ₆ -S ₇	S ₇ -S ₈	S ₈ -S ₉	S ₉ -S ₁₀	S ₁₀ -S ₁₁	S ₁₁ -S ₁₂
Pause	1.49	2.26	1.76	1.98	1.99	1.64	2.81	1.00	1.35	1.81	1.24

Table 1 : Japanese radio news

4.2 Analysis

The news consists of a report of a robbery and a report of the yen rate and stock prices. S₁ and S₂ are the outline of the robbery, and S₃-S₇ describe its details. S₃ and S₄ are the news facts and S₅-S₇ are the police reports. S₈ announces the start of the yen rate (S₉) and stock prices (S₁₀ and S₁₁). S₁₂ is the closing announcement. The discourse is analyzed as (25).

(25) [program [news [robbery [headline S₁ S₂] [detail [fact S₃ S₄] [police S₅ S₆ S₇]]] [rate&stock S₈ [rate S₉ [stock S₁₀ S₁₁]]]] S₁₂]



The numbers of brackets between two sentences (discourse brackets (DB)) are counted, which are shown in the fourth column in Table 2 below. The correlation coefficient between pause and the number of brackets (DB) is 0.49, some correlation.

However, if we count brackets within a sentence (SB) as well as brackets between sentences (DB), we get a better result as shown in the third column (DB+SB) in Table 2. The correlation coefficient between pause and the number of all the brackets (DB+SB) is 0.60, strong correlation.

Position	Pause(msec)	DB+SB	DB	SB
S1-S2	1493.5	6	0	6
S2-S3	2261.1	8	3	5
S3-S4	1763.2	5	0	5
S4-S5	1977.8	8	2	6
S5-S6	1993.7	5	1	4
S6-S7	1638.6	3	0	3
S7-S8	2811.2	9	5	4
S8-S9	1003.6	4	1	3
S9-S10	1352.2	4	1	3
S10-S11	1811.2	5	0	5
S11-S12	1293.9	8	4	4
S1-S12	correlation	0.60	0.49	0.31
S1-S11	correlation	0.79	0.76	0.29

Table 2 : Correlation between pause and the number of boundaries

In Table 2, I also show the correlation coefficient of S1-S11 as the bottom row. S12 is the closing announcement of the news and might well be excluded from the analysis. The correlation coefficient of S1-S11 between pause duration and the numbers of DB+SB is 0.79, very strong correlation.

The analysis of sentence and discourse structure is shown in (26), where brackets ([...]) show the structure in a sentence (SB) and italicized brackets (*/ ... /*) show the structure above a sentence (DB).

- (26) S1. *////[[[Kyoo gozen] [[Kanagawa-ken Hatano-shi-no] [jinzai-haken-gaisha-no mae-de] [[kono kaisha-no [shachoo-to] [shain-ga]] [[[san-nin-gumi-no otoko-ni] [osowarete] [hitori-ga [karui kega-o shi]] [[ginkoo-kara [oroshita bakari-no]] [[shain-no kyuryoo] nisen nana-hyaku man-en amari-no]]] haitta baggu-o]] ubaware-masita]]]]]*
- S2. [Keisatsu-dewa] *[[[gootoo-shogai-jiken] [to-shite]] [[[nigeta] [otoko-ra-no] [yukue-o]] [[sosa] [shite-imasu]]]]]]/*
- S3. *///[[[Kyoo gozen kuji-sugi] [[Hatano-shi Horinishi-no] [[[jinzai-haken-gaisha Yuuingu-no] haitta tatemono-no mae-de] [[[kono kaisha-no shachoo] [[Ogawa Yoshihisa-san] [gojuu-ni-sai-to]] [[shain-no [Suzuki Takahito-san]] sanjuu-nana-sai-no] hutari-ga] [[san-nin-gumi-no otoko-ni] osoware-mashita]]]]]*
- S4. [Otoko-ra-wa] *[[[[Suzuki-san-no kao-nado-o] nagutte] [karui kega-o saseta-ue]] [[[genkin oyoso nisen nana-hyaku go-ju man-en-no] haitta tesage baggu-o] ubatte] [joyosha-de toosoo shimashita]]]]/*

- S5. /[[Keisatsu-no shirabe-ni] yorimasu-to] [[osowareta hutari-wa [[chikaku-no ginkoo-de] [[shain-no kyuryoo-o] oroshite]] [[kaisha-no mae-de] [[kuruma-kara orita toki-ni]] osowareta-to]] iu koto-desu]]
- S6. /[[San-nin-gumi-no otoko-wa] [izure-mo [shinchoo-ga [ichi-meetoru nanaju-ssenchi kurai-no gaikokujin-huude]]] [[[kurumano naka-ni [taiki siteita [nakama-no otoko-to]]] tomoni] [yonin-de nigeta-to]] iu koto-desu]
- S7. [[Kono kaisha-dewa [[maitzuki onaji hi-ni] [kyuryoo-o oroshiteiru-to]]] iu koto-de] [[keisatsu-dewa [[kooshita jijoo-o sitta ue deno] [keikakuteki-na hankoo-to]] mite]] [gootoo shogai jeken to-shite [[nigeta otoko-ra-no yukue-o] soosa shite-imasu]]]////
- S8. /[[Kawase-to kabu-desu]
- S9. /[[Shu-ake-no [Tokyo gaikoku kawase shijoo-no ensooba-wa]] [[[[senshuu-matsu-ni kurabete] ichi-en nijuu roku-sen endaka doruyasu-no] [ichi-doru hyakujuu-en rokujuu nana-sen kara nanajuu ni-sen-to]] natte imasu]]
- S10. /[[Ippoo [[Tokyo kabushiki shijoo-no [topikkusu Toshoo kabuka shisuu-wa]] [[[[senshuumatsu-ni kurabete] juu-nii-ten ichi-nana sagatte] [senhachijuuyon-ten rokuyon-to natte imasu]]]]]
- S11. [Mata [nikkei heikin kabuka-wa [[[[senshuu-matsu-ni kurabete] rokujuu kyuu-en sanjuu kyuu-sen yasui] ichi-man roppyaku hachijuu nana-en hachijuui-ssen-to] natte imasu]]]////
- S12. [Ijoo [nyuusu-o otsutae shimashita]]]/

Below are the tables of the correlation between pause duration and the number of boundaries between two adjacent sentences. The counted boundaries are (i) discourse and sentence boundaries (DB+SB) (Figure 2), (ii) boundaries in sentences only (SB) (Figure 3), and (iii) discourse boundaries only (Figure 4).

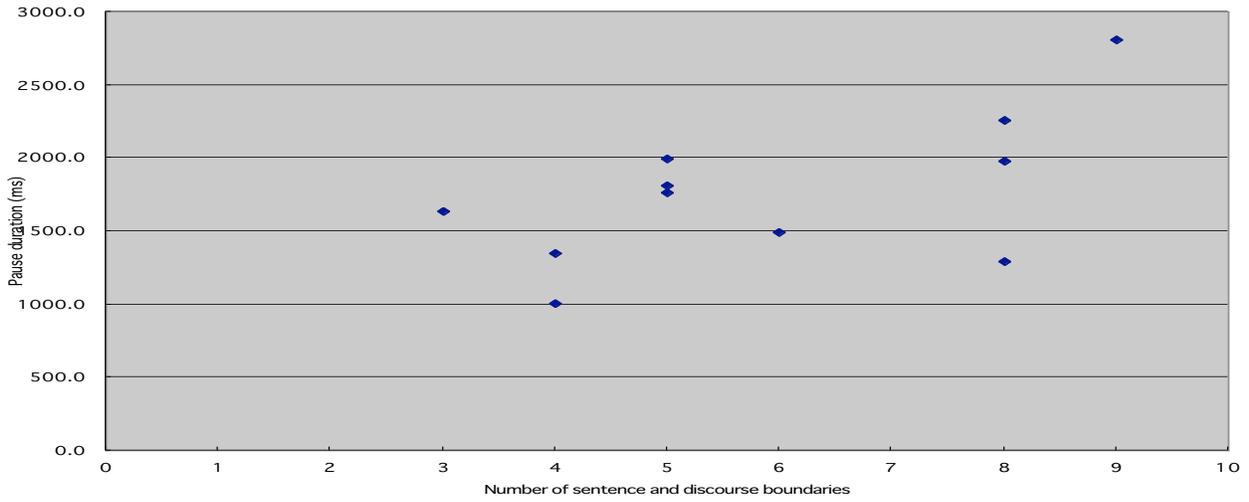


Figure 2: Pause and the number of discourse and sentence boundaries (DB+SB)

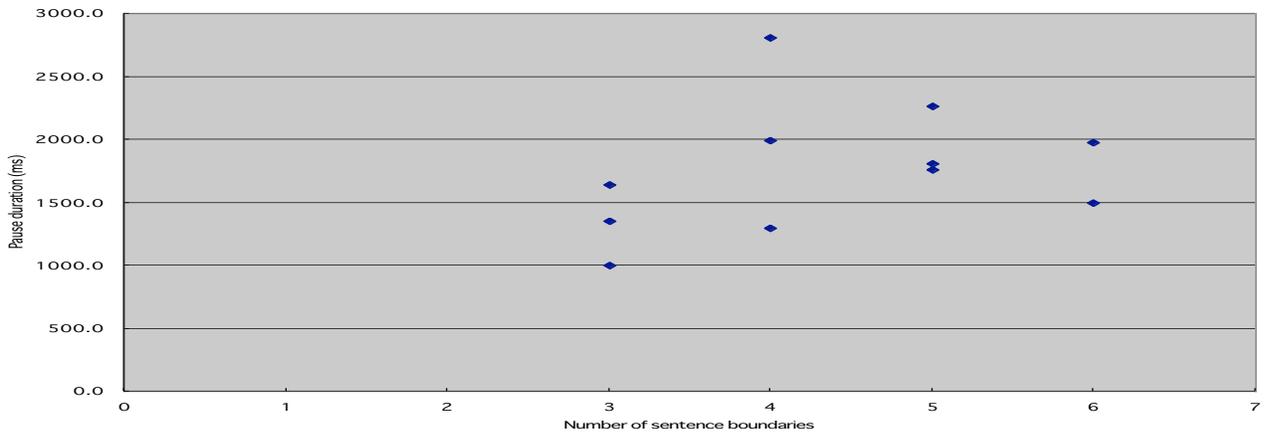


Figure 3: Pause and the number of sentence boundaries (SB)

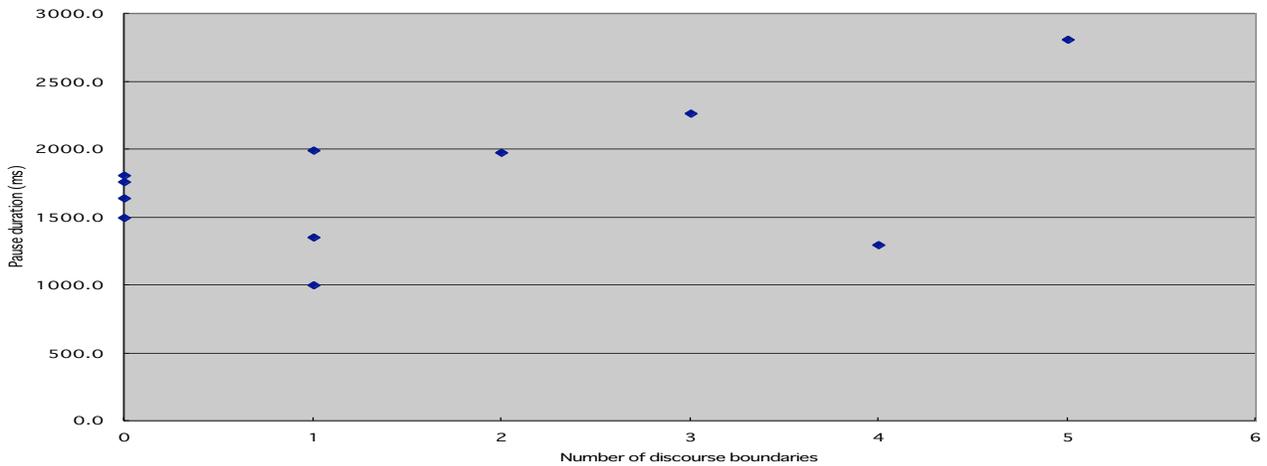


Figure 4: Pause and the number of discourse boundaries (DB)

The numbers of DB+SB in Figure 2 shows stronger correlation with pause duration than those of SB in Figure 3 and those of DB in Figure 4.

The correlation coefficients in Table 2 and dispersion in Figure 2-4 give support to the hypothesis that both syntactic boundaries in sentence and boundaries of discourse structure are interpreted as phonological disjuncture.

I analyzed three more news discourse as well as the news presented above (News 1). The results are summarized in Table 3.⁸

	DB+SB	DB	SB
News 1	0.60	0.49	0.31
News 2	0.33	0.52	-0.10
News 3	0.38	0.36	0.25
News 4	0.54	0.20	0.45
Average	0.46	0.39	0.23

Table 3 : Correlation efficient between pauses and the number of brackets in four news

The average of correlation efficient between pauses and the number of discourse and sentence boundaries (DB+SB: 0.46) is higher than that between pauses and the number of discourse boundaries (DB: 0.39) and that between pauses and the number of sentence boundaries (SB: 0.23). This result confirms the hypothesis that both syntactic boundaries in sentence and boundaries of discourse structure are interpreted as phonological disjuncture.

4.3 Discussion

Before we conclude, let us consider how brackets are placed at the end of a sentence. In general, the longer the sentence is, the more brackets it has at its end.⁹ Compare the following two sentences:

- (27) a. [John came.] [...
 b. [John [came home.]] [...

In (27a) *came* merges with *John* and gets one bracket at its right. In (27b), *home* merges with *came* and then the resulting constituent merges with *John*. The two merging processes give two brackets at the right of *home*.

⁸ News 2-4 have almost the same length and discourse structure as News 1, consisting of a news topic followed by a rate and stock report. The news scripts are spoken by different announcers (News 2 on Aug 16, News 3 on Aug 17, News 4 on Aug 18, 2005). The unwelcome result in News 2 might also be ascribed to the fact that it has citation of a person's comments ranging over two sentences.

⁹ This is true in languages with right branching structure. Japanese is sometimes called left branching language, but it also has right branching structure. For example, it has VP to the right of the subject NP which branches into an object and a verb.

This is also the case with discourse boundaries. Consider the following schematic example discourses:

- (28) a. [S₁ S₂] [...
b. [S₁ [S₂ S₃]] [...

In (28a) S₂ merges with S₁ and gets one bracket at its right. In (28b) S₃ merges with S₂ and then the resulting discourse constituent merges with S₁. The two merging processes give two discourse brackets at the right of S₃. Thus, in right branching sentence and discourse structure, more merging processes make more brackets at the end of the resulting constituent. Therefore, the longer a constituent is, the longer the pause after it.

Note that the brackets before a constituent affect the pause duration between it and the preceding constituent. Consider the following examples, which have left branching structure:

- (29) a. ...] [Mary danced.]
b. ...] [[Mary Smith] danced.]
- (30) a. ...] [S₁ S₂]
b. ...] [[S₁ S₂] S₃]

In (29a) and (30a), the first word or sentence merges with the second and gets one bracket. In (29b) and (30b), the first word or sentence merges with the second, and then the resulting constituent merges with the third. The two merging processes give two brackets before the first object. Thus, a left branching constituent has more boundaries at its left as it gets longer.

This prediction seems to be correct as we see the fact that the largest number of brackets between two sentences in the discourse (26) is nine between S₇ and S₈, that is, four sentence brackets and five discourse brackets.

5. Conclusion

To conclude, both sentence structure and discourse structure affect pause duration between two sentences. We have seen that pause duration can be predicted by means of mapping from hierarchical structure of sentence and discourse onto prosodic structure with prosodic boundaries, which can be translated into silent demibeats. This study shows that there is hierarchical structure in sentence and discourse, and that there is some isomorphism between syntax and phonology, contrary to the generally accepted view.

References

CHOMSKY N. (1995), *The Minimalist Program*, Cambridge, MA, MIT Press

COLLINS C. (2002), Eliminating labels, in Epstein S & Seely D. (eds.), *Derivation and Explanation in the Minimalist Program*, Malden, MA, Blackwell, 42-64

- COUPER-KUHLEN, E. (2001), Intonation and discourse: Current views from within, in Shiffrin D, Tannen D. & Hamilton H. (eds.), *The Handbook of Discourse Analysis*, Maldon, MA, Blackwell, 13-34
- FOX B. (1987), *Discourse Structure and Anaphora*, Cambridge, Cambridge University Press
- GROSJEAN F., GROSJEAN L. & LANE H. (1979), The pattern of silence: Performance structures in sentence production, *Cognitive Psychology* 11, 58-81
- HINDS J. (1977), Paragraph structure and pronominalization, *Papers in Linguistics* 10, 77-99
- KAYNE R. (1994), *The Antisymmetry in Syntax*, Cambridge, MA, MIT Press
- LARSON R. (1990), Double objects revisited: Reply to Jackendoff, *Linguistic Inquiry* 21, 589-632
- NESPOR M. & SCORRETTI M. (1984), Empty elements and phonological form, in Guéron J, Obenauer H-G. & Pollock J-Y. (eds), *Grammatical Representation*, Dordrecht, Foris, 223-235
- POLANYI L. (1988), A formal model of the structure of discourse, *Journal of Pragmatics* 12, 601-638
- SELKIRK E. (1984), *Phonology and Syntax: The Relation between Sound and Structure*, Cambridge, MA, MIT Press
- TOKIZAKI H. (1995), Teimeishiku-shouou-to senteki-junjo (Definite NP anaphora and linear order, *Bunka-to Gengo* 28:2, Faculty of Foreign Languages, Sapporo University, 1-21
- TOKIZAKI H. (1996), Danwa-ni-okeru shouo-to kaiso-kouzo (Anaphora and hierarchy in discourse), *Sapporo Daigaku Sogo-Ronso* 2, Sapporo University, 47-60
- TOKIZAKI H. (1999), Prosodic phrasing and bare phrase structure, *Proceedings of the North East Linguistic Society* 29, Volume one, Amherst, GLSA, University of Massachusetts, 381-395
- TOKIZAKI H. (2000), Syntax-phonology mapping and the length of constituents, *University of Pennsylvania Working Papers in Linguistics* 7, vol. 1, 275-286
- URIAGEREKA J. (1998) *Rhyme and Reason: An Introduction to Minimalist Syntax*, Cambridge, MA, MIT Press