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ABSTRACT

This paper adopts the activation spreading theory to explore how lexical items are accessed. Approximately 3300 errors from both public sources and ordinary conversation in Japanese are analyzed. Analyses suggest that there are two types of environment in which contextual lexical errors occur, and that these two types of environment correspond to two types of processing units. Adjacent elements may be an important processing unit at the syntactic and phonological level. (JP)

# Units of processing in sentence production —evidence from speech errors—

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## 1.Introduction

In the study of language production, it is one of the most alluring questions to investigate the nature of the mental lexicon. Although previous researches uncovered interesting properties about how lexical items are stored (cf. Fay and Cutler, 1977), little work has been done about how words are accessed during the processing in sentence production. The present paper adopts the activation spreading theory to explore the dynamic aspect of the mental lexicon, that is, how lexical items are accessed and how far the units of processing cover, using speech error data as evidence.

## 2.Data

Speech error is here defined as "involuntary derivation in performance from the speaker's current phonological, grammatical, lexical intention" (Boomer and Laver, 1973). Since Fromkin's influential paper(cf. Fromkin,1971), speech errors that occur in everyday speech have drawn considerable attention as evidence for the analysis of sentence production mechanism. Due to the difficulty of an experimental approach, a lot of papers on language production use speech errors as crucial evidence for their discussion (cf. Garrett,1975, Stemberger,1985, Levelt,1989). There are, however, limitation on the scope of speech error data. The data used in these studies have been exclusively collected from English and German. In this paper, the author will use speech error data collected from Japanese, which is considered to have different syntactic/phonological structures from those of English[1].

The data used in this paper come from the corpus that the author has

lected over nine years. It consists of about 3300 errors both from public sources (e.g.TV programs. radio broadcasts.etc.) and from ordinary conversation. Errors were written down on the cards immediately after the author noticed them with as much context as possible. Six hundred and eighty errors of the corpus were tape-recorded. It can help to decrease the slips of the ear and perceptual bias of the observer that is inherent risk in speech error collection.

Now let us look at the example of a phonological error in Japanese:

(1) In: kabe o yabut-ta
%m: N¦wall OBJ V¦break-AUX
%e: kabe->yabe s={ya}but-ta
%g: broke the wall

In the first line, speaker's intention of the utterance is represented in Roman alphabet. The second line is a morphemic translation of the intended utterance (see the list of abbreviations in Appendix). The third line indicates the target element and the intruding element, the former is on the left side of " ->" symbol and the latter is on the right side. The line also indicates the source of the error, i.e.the origin of the intruding element( "s=" in the line means "the source is..."). In this case, the intruding element is the first mora in yabut-ta, so that it is surrounded by curly brackets as shown in (1). The fourth line gives a whole translation of the Japanese sentence into its equivalent English sentence.

3.Word substitution error

Word substitution is a type of error in which one word is replaced by another. Let us observe some examples:

(2)a. In: anta tabako sute-ta
%m: N¦you N¦cigarette V¦throw-away -AUX
%e: tabako -> haizara "ashtray"

%g: you threw away a cigarette

b. In: piramiddo ni nobor-u
%m: N¦pyramid OBJ V¦climb-CGN
%e: piramiddo -> ejiputo "Egypt"
%g: climb the pyramid

c. In: soko no sennuki tot-te
%m: PRO¦there PTL N¦bottle-opener V¦pass-PTL
%e: sennuki->senhiki "ruler"
%g: pass me that bottle opener

Examples (2)a-c are called non-contextual word substitution where we cannot find the source in observed context. There are 346 instances in my corpus. This type of error is most plausibly interpreted as a selection error between words competing in the mental lexicon. and it is well known that the target word and the intruding word are related not only semantically. like (2)b. but also phonologically. like (2)c. Similarity between target word and intruding word are analyzed on the point of variables as follows:

Analysis of the target and the intruding word in non-contextual word substitution:

Table 1.

Agreement of grammatical category

| | |
|---|---|
| same | 334 (97%) |
| different | 12 ( 3%) |

Table 2

Agreement of accent pattern

| | |
|---|---|
| same | 264 (76%) |
| different | 84 (24%) |

%m: N¦I TOP N¦dog OBJ V¦go-with-PTL N¦walk OBJ V¦go-CGN
%e: inu->sanpo s={sanpo}
%g: I take a walk with my dog

c.In: kootya o non-de keeki o tabe-te
%m: N¦tea OBJ V¦take-PTL N¦cake OBJ V¦have-PTL
%e: tabe-te -> non-de s={non]-de
%g: Let's have a tea and some cake

d.In: fensu ni yozinobot-ta sentaa no hirota
%m: N¦fence OBJ N¦climb-AUX N¦center-outfielder PTL PN¦Hirota
%e: fensu->sentaa s={sentaa}
%g: center outfielder Hirota jumped at the fence

In (3)a, sensoo, which should have appeared in the next NP, is interpreted as the source, and it replaced the target word sekai. (3)a-d are, in fact, word substitution errors. But are they also selectional errors? One plausible explanation is that they occur when words are given an ordering after all lexical items are selected, i.e. they are ordering errors. We cannot exclude such an explanation by strong evidence. However, the analysis of the contextual word substitution errors on the same stand points as Table 1-4 suggests that they are selectional errors. Let us look at Table 5:

Table 5
The target and the source in contextual word substitutions
Agreement on: (N=99)

| grammatical category | accent pattern | number of morae | initial mora |
|---|---|---|---|
| 98 (99%) | 64 (65%) | 84(85)%[2] | 13 (13%)[3] |

Table 3

| Difference of the number of morae | |
|---|---|
| 0 | 209 (60%) |
| 1 | 103 (30%) |
| 2 | 24 ( 7%) |
| 3 or more | 10 ( 3%) |

Table 4

| Agreement of initial mora | |
|---|---|
| same | 145 (42%) |
| different | 201 (58%) |

It has been observed in the previous studies that the target word and the intruding word have semantic/pragmatic relations in some way (see Hotopf,1980). In addition, the results obtained in Table 1-4 suggest that two words are related both syntactically and phonologically. In other words, syntactic and phonological information as well as semantic information play an important role when lexical items are accessed in sentence processing.

It should be noted that there is another type of word substitution error:contextual word substitution. This is a type of word substitution in which we can find the source of the intruding word in surrounding context. Let us observe some examples:

(3)a. In: sekai no dokoka de sensoo ga
%m: N¦world PTL N¦somewhere PTL N¦war SUBJ
%e: sekai->sensoo s={sensoo}
%g: war (is taking place) somewhere in the world

b. In: boku wa inu o ture-te sanpo ni ik-u

What seems to be important in Table 5 is a high degree of agreement on grammatical category. It suggests that syntactic constraint on word selection is strong. In fact an error such as (4) rarely occur:

(4) In: siawase-na seikatu
%m: ADJN¦happy-CGN N¦life
%e: siawase-na -> seikatu-na s={seikatu}
%g: a happy life

In(4), noun replaced the stem of adjectival noun.

Now let us analyze contextual word substitution errors from a different point of view, which will be more crucial when we consider the unit of processing. It is interesting to examine the difference of structural environments in which errors occur. In (3)a, for example, it seems reasonable to assume that inu and sanpo, both of which are headnouns of adjacent NPs, were simultaneously accessed in some way. Types of structures in which contextual word substitutions occur are summarized in Table 6:

Table 6 Structures where contextual word substitutions occur

(N=99)

| | |
|---|---|
| Within phrases | 8[4] |
| Adjacent phrases | 26 |
| Between phrases | 6 |
| Adjacent basic clause[5] | 51 |
| Between basic clauses | 8 |

Results obtained in Table 6 seem to suggest that the intruding word does not pay attention to a clause boundary. Many researches have tried to delineate the unit of processing, and some of them proposed the unit that is smaller than surface clause (Ford,1982, Garrett,1975). Although we must agree that there is no single unit in sentence production, we will assume

that one unit is larger than basic clause, at least as a planning unit.

4.Word and stem exchange error

Let us next consider another type of lexical speech error. Word exchange is a type of error in which two words in the utterance exchange their places. There are 22 word exchange errors in my corpus. Some typical examples of word exchange are:

(5)a. In: syokuba ni syokudoo ga na-i
%m: N¦place-to-work PTL N¦dining-hall SUBJ ADJ¦no-CGN
%e: syokuba->syokudoo syokudoo->syokuba
%g: there is no dining hall in my company

b. In: yubi ni mame ga deki-ta
%m: N¦finger PTL N¦corn SUBJ V¦have-AUX
%e: yubi->mame mame->yubi
%g: I had a corn on my finger

c. In: huro no ar-u apaato wa i-i
%m: N¦bath PTL V¦be-CGN N¦apartment TOP ADJ¦good-CGN
%e: huro->apaato apaato->huro
%g: an apartment with bathroom is good

d. In: genkan no doa o aker-u
%m: N¦entrance PTL N¦door OBJ V¦open-CGN
%e: genkan -> doa doa -> genkan
%g: open the front door

A similar type of error, stem exchange is an error in which two stems are misordered. There are 16 instances in my corpus. It should be noted that conjugated forms accomodated themselves to new environment in several

examples. Let us observe some examples as follows:

(7)a. In: kippu ka-u noni nara-n-de
%m: N¦ticket V¦buy-CGN PTL V¦form-a-line -CGN-PTL
%e: ka-u -> narabu nara-n-de -> kat-te
%g: form a line to buy tickets

b. In: nani ga okor-u ka wakar-i-mas-e-n
%m: WH¦what SUBJ V¦happen PTL V¦know-CGN-POL-CGN-NEG
%e: okor-u -> wakar-u wakar-u ->okor-i
%g: no one can tell what happens next

There are two exceptional stem exchange errors in my corpus shown in (8):

(8)a. In: kono sema-i heya
%m: ADN¦this ADJ¦small-CGN N¦room
%e: sema-i -> heya-i heya->sema
%g: this small room

b. In: atu-i natu
%m: ADJ¦hot-CGN N¦summer
%e: atu-i -> natu-i natu -> atu
%g: hot summer

In these errors, stem of adjective and the adjacent noun are misordered. Same-grammatical-category constraint is violated here. But it should be noted that two words involved in an error belong to the same NP and they are phonologically similar.

Now let us analyze word and stem exchange errors from the same stand point as we adopted in Table 5 and 6. Results obtained are shown in Table 7-10:

Table 7

Lexical properties of two words in word exchanges (N=22)

| Agreement on: | | | |
|---|---|---|---|
| grammatical category | number of morae | accent pattern | initial mora |
| 22(100%) | 17(77%) | 15(68%) | 4(18%) |

Table 8

Lexical properties of two words in stem exchanges (N=16)

| Agreement on: | | | |
|---|---|---|---|
| grammatical category | number of morae | accent pattern | initial mora |
| 13(81%) | 15(94%) | 11(69%) | 1(0.6%) |

Table 9

Structures in which word exchanges occur(N=22)

| | |
|---|---|
| Within phrases | 10 |
| Adjacent phrases | 9 |
| Between phrases | 0 |
| Adjacent basic clause | 3 |
| Between basic clause | 0 |

Table 10

Structures in which stem exchanges occur(N=16)

| | |
|---|---|
| Within phrases | 2 |
| Adjacebt phrases | 1 |
| Between phrases | 0 |
| Adjacent basic clause | 13 |
| Between basic clause | 0 |

The most striking difference between contextual word substitution and word

exchange is an environment in which two types of error occur. When word substitutions occur, the intruding word tend to pay no attention to the basic clause boundary. 59 out of 99 instances (60%) cross the boundary. Word exchanges, on the other hand, occur within a short range. "two adjacent phrases" seems to be the unit in which word exchanges occur, as shown in Table 9. An interesting observation can be made when we analyze the surface distance between the target and the source in two types of error. We measured the distance by the number of morae. For example, in (6)a, the intervening element is particle ni, so that the surface distance is counted as "1".

Table 11

The distance between the target and the source measured by the number of intervening morae

| | mean number |
|---|---|
| contextual word substitutions | 6.2 |
| word exchanges | 1.2[6] |

Result in Table 11 seems to suggest that the differences of structures in which two types of error occur correspond to the size of processing unit. Thus, we may assume two types of processing unit: word substitutions occur within far-sighted span which contains two basic clauses. Word exchanges, on the other hand, occur within short-sighted span which contains two adjacent phrases at the most. When we consider the nature of sentence production model, these facts must be explained in some way.

5.Sound exchange error

Before considering sentence production model, let us see another type of exchange error called sound exchange. There are 104 instances of sound

exchanges in my corpus. Typical examples are given as follows:

(8)a. In: bootakatobi
%g: N¦pole-jump
%e: bootakatobi -> bootakabito

b. In: teisyukanpaku
%m: N¦domineering husband
%e: teisyukanpaku -> teisyupankaku
%g: domineering husband

c. In: daisan keihin
%m: N¦third N¦Tokyo-Yokohama
%e: keihin -> heikin
%g: the third Keihin highway

d. In: anzenunten
%m: N¦safe driving
%e: anzenunten -> unzenanten

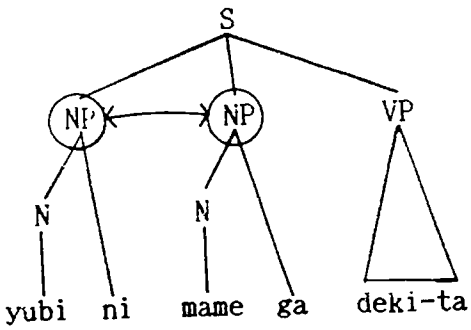
(8)a can be analyzed as a mora exchange error. (8)c and (8)d represent segment exchanges: consonant exchange and vowel exchange respectively. While (8)b, which is rather common, can be analyzed either as a mora exchange or a consonant exchange because two morae involved in the error have identical vowel. Previous researches of sound exchange error uncovered the major characteristics of Japanese sound exchanges (see Kamio and Terao,1986, Terao,1988). They are briefly summarized as follows: Japanese sound exchanges occur (i)in one and the same word (ii)between adjacent syllable (iii)in content word.[7] Among these, let us close look at (ii). Table 12 represents the environments in which sound exchanges occur:

Table 12

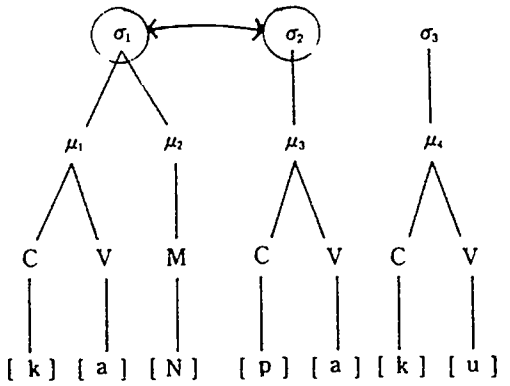
| the number of intervening syllables between two exchanged elements | (N=104) |
|---|---|
| 0 | 82 (77%) |
| 1 | 15 (15%) |
| 2 | 3 ( 5%) |
| 3 or more | 3 ( 3%) |

Table 12 clearly shows that the most common structure in which sound exchanges occur is "between adjacent syllables". This reminds us the result obtained from the analysis of word exchange error. Although these two types of error occurred at the different level, they show an interesting parallelism in environment in which they occur. This parallelism is illustrated in Fig.1.

Fig. 1




syntactic structure in which word exchanges occur



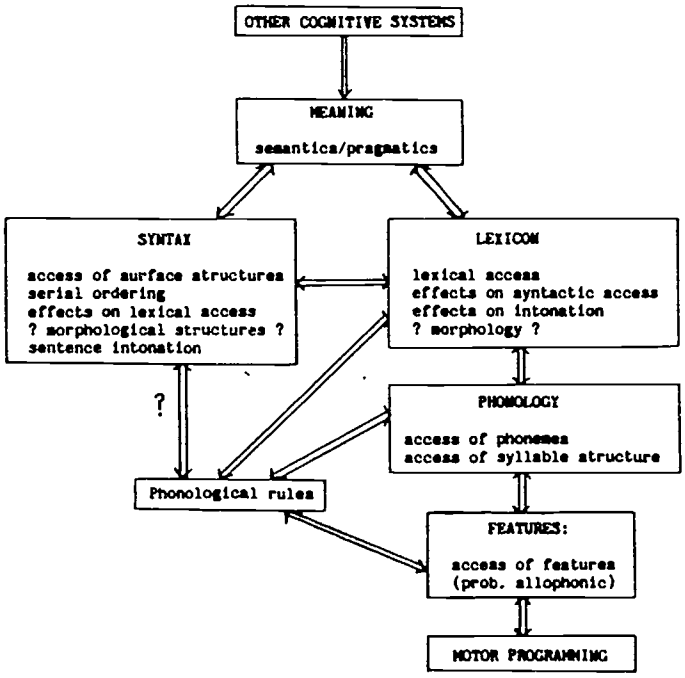

phonoiogical structure in which sound exchanges occur

We cannot explain why this parallelism arises. But the analysis of sound exchanges again suggests that "adjacent element" may be the basic processing unit in sentence production.

6.Interactive Activation Model

We can now return to the problem of how lexical items are accessed. The present analysis of some types of speech error data so far has uncovered two problems that sentence production model must explain. They are summarized as follows: (i) the model must explain the similarity between the tareget and the source. As shown in Table 5 and 6, they are related phonologically, syntactically, as well as semantically.[8] (ii) the model must explain the difference between the structures in which contextual word substitutions and word exchanges occur. In order to explain these facts, the present paper adopts the Interactive Activation Model.[9] The general structure of the model is illustrated in Fig.2.

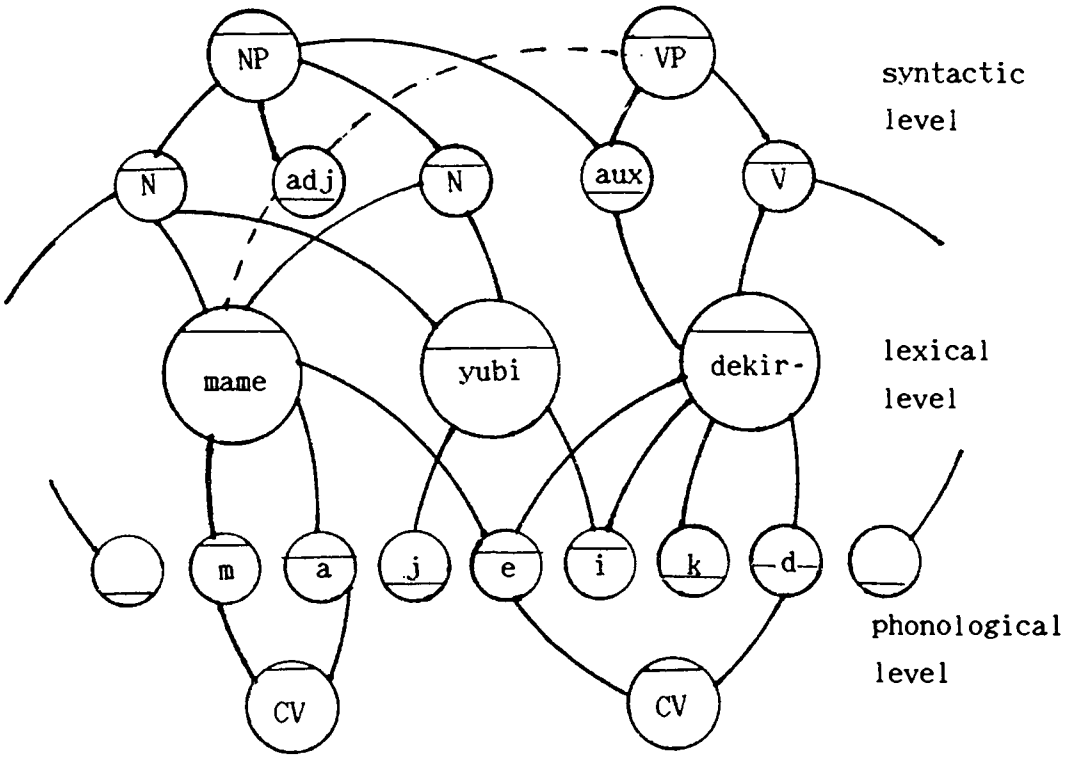
Fig 2. General structure of the model (from Stemberger,1985)




A lot of bi-directional arrows (" <=> " symbol in Fig.2) represent the major characteristics of this model. They guarantee that activation, a basic

driving force of the model. can spread not only to lower levels but also to higher levels. It is assumed that many processings on different levels are carried out in parallel fashion. Note that the influential models in previous studies have linear ordering between levels (See Garrett.1975. Levelt,1989). The advantages of bi-directional activation are discussed later. Let us look at the model in detail. The basic elements are units and links. Units in each level are linked each other like neural-network. Example of an interactive activation network of three levels(syntactic, lexical, phonological) is shown in Fig.3.

Fig. 3 Example of a neural-network




It should be noted that each unit has its characteristic level to which it returns when not being activated. Horizontal lines in the units represents its resting level. As Stemberger(1985' pointed out, the resting level

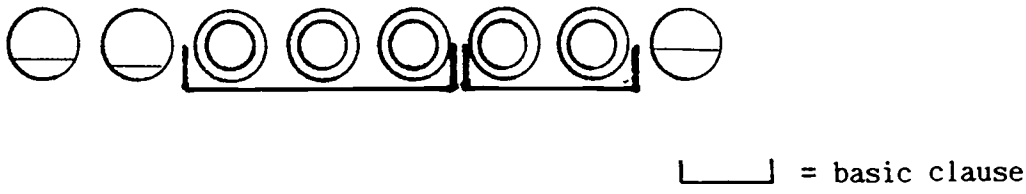
varies from very low level to very high level. The basic driving force of the system is activation. When the speaker intends to say something, relevant units in each level including targets are activated in parallel fashion. Activation spreads from one unit to another through the links. In normal case, the target unit is highly activated and "the rich gets richer" principle operates to win against competing units. After being accessed, the activation level returns to its resting level ( The author calls this mechanism "cool down"). But when some noise arise, errors are supposed to occur. Stemberger(1985) argues three sources of noise:they are (i) random variation of resting level, (ii) frequency effect, (iii) feedback from other levels. Although discussion about causation of speech errors is interesting (See Levelt,1989), it is beyond the scope of this paper. Let us now examine how this model explain two problems mentioned earlier.

Interactive activation model can explain the relationship between the target and the source in non-contextual word substitution errors shown in Table 1-4. Since units in lexical level are linked with units in syntactic level and phonological level, they are reinforced syntactically and phonologically. As a result, the target and the competing units tend to have many properties in common. The model can also account for malapropisms, in which the target word is replaced by another existing word that is related phonologically but not semantically. Malapropisms are explained as a result of a strong feedback from the phonological level.

Now let us turn to the problem (ii). Taking the existence of contextual word substitutions into consideration, we can hardly assume that access of one lexical item proceed to the next only when the present target had gone to the next level.[10] It is natural to assume that the lexical level has several highly activated units at a time.d It is also reasonable to assume that the number of the highly activated units are limited, because the processing must proceed with very high speed. Here, we must remember the result obtained from Table 6. Table 6 shows that the environment in which contextual word substitutions occur is limited to two basic clause. So we can assume that the highly activated units which can take a "reserved seat"

must be the units that can appear within following two basic clauses. We may also assume that the scope of planning for the processing is two basic clauses. They are illustrated in Fig.4.

Fig.4 Highly activated units in the scope of processing.



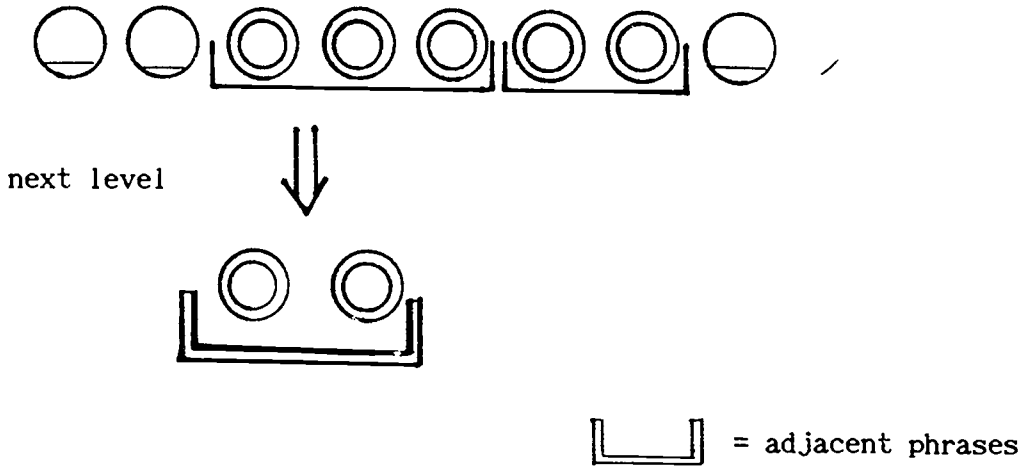

In Fig.4. " ◎ " symbol represents the highly activated unit. At this stage, syntactic feedback seems stronger than phonological one because selection of words in syntagmatic relation is more relevant than selection of words in paradigmatic relation.[11] Note that noun - verb intrusion rarely occur in contextual word substitutions. It is also interesting to note that exceptional word substitution errors, which Terao(1989) calls "semantic source error", can be taken as evidence for this stage. This is a type of error in which (semantic) rivals of unit A replaced unit B. Observe some instances:

(9)a. In: zyooban-sen no naka de tabako sut-te-ru hito ga i-ta
%m: N¦Zyoban-line PTL N¦inside PTL N¦cigarette V¦smoke-PTL-AUX N¦man SUBJ V¦be-AUX
%e: tabako -> densya "train" s={Zyooban line}
%g: (I) saw a man smoking in the train of Zyooban line

b. In: sugoku kiniit-teiru kyoku da
%m: ADV¦very V¦like-AUX N¦song-AUX
%e: kyoku -> suki "ADN¦like" s={kiniit-teiru}
%g: this is my favorite song

Let us next consider word exchanges. As we have seen in the previous chapter, word exchanges apparently occur in relatively small environment,that is, within adjacent phrases. We can explain the difference of environment without conflict, if we adopt the interactive activation model. We assume that word exchanges occur when the processing proceed from the access stage to the next stage. We also assume that this "adjacent phrase" structure is related to the "cool down" process. In other words, the highly activated units in lexical level is available, or still "hot" until the target in the adjacent phrase is accessed. Let us look at Fig.5:

Fig.5 "Hot" units in processing.




Suppose that the intended ordering was A-B-C-D, and B was mistakenly accessed first. Then A lost his "seat". But it is possible that A is accessed next and appear in the position B because A is still available even when adjacent phrase is processed. Thus the output would be B-A-C-D, a typical exchange error. If D was accessed first, then the output would be D-B-C-D because A is "cool" when proper D is accessed. In this case, D can appear twice because the distance between A and D is large enough for D to be activated again. In sum, contextual word substitutions occur when highly

activated words are represented in the lexical level, and the scope of this stage is two basic clauses. Word exchanges, on the other hand, occur when words are accessed and are sent to the next level, the scope of the processing at this stage is adjacent phrases.

## 7.Conclusion

The present study will be concluded by summarizing the major findings: (i) There are two types of environment in which contextual lexical errors occur. (ii) These two types of environment correspond to two types of processing units. And interactive activation model can explain difference of the unit of processing. (iii) "adjacent elements" may be a important processing unit both in syntactic and phonological level. This question should be explored in a future study.

## NOTES

[1] It is widely agreed that Japanese is a non-configurational language syntactically, and moraic language phonologically.

[2] Differnce of one mora is included

[3] It should be noted that the agreement of initial morae was relatively low. But it does not seem to indicate that contextual word substitutions are ordering errors. If they were purely ordering errors, then the instance such as "*ik-u o sanpo ni ture-te", in which verb replaced noun,would be observed more frequently.

[4] Seven out of eight instances were errors between modifying word and a headnoun linked with particle no.

[5] Basic clause is here defined as the clause with one predicate

[6] Most of the intervening elements were one particle

[7] Garrett argues the characteristics of sound exchange in English. According to Garrett(1975), they occur (i)in adjacent words, (ii)within a phrase, and (iii)in content words. Apparently, sound exchanges in Japanese occur in relatively small unit. But the detailed analysis should be made in a future study.

[8] Semantic analysis is beyond the scope of this paper. But Terao(1989) argues that malapropisms, semantically unrelated word substitution, rarely occur in Japanese.

[9] The basic concept of the model is carried over from Stemberger(1985), and Dell(1988).

[10] The next level is assumed to be an execution level.

[11] The terms "syntagmatic" and "paradigmatic" are used in the sense of glossematics

## Appendix: a list of abbreviations

(These abbreviations are used in CHAT sytem)

Main line

In: intended utterance

Sub-line

%m: morphemic translation

| | |
|---|---|
| %e: | error line contains the target and the source |
| " " | translation of the intruding word |
| %g: | glosses |

Grammatical category

| | |
|---|---|
| N | noun |
| V | verb |
| AUX | auxiliary verb |
| ADJ | adjective |
| ADV | adverb |
| ADJN | adjectival noun |
| PTL | particle |
| CGN | conjugation |
| POL | polite form |
| NEG | negation |
| PN | proper noun |

Grammatical relation

| | |
|---|---|
| SUBJ | subject |
| OBJ | object |

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