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COMPREHENSION OF COMPLEMENT CONSTRUCTIONS IN JAPANESE*

Tazuko Uyeno**, Hiroshi Yamada***,
Hideo Hayashibe**** and Rieko Aoki*****

1. Introduction

Sentence comprehension involves the process of matching the given phonological sequence with its meaning. It is assumed that a hearer of a sentence follows the procedure of segmenting the serial input into most appropriate units in order to reconstruct the hierarchical structures to grasp its semantic contents. In the case of simple sentences, the identification of the relations among the constituents should be essential. Sentences which contain more than two clauses, such as complex or compound sentences, on the other hand, require additional processing such as recovery of clausal units and inter-clausal relations.

Our previous studies (Uyeno & Harada, 1975; Harada et al., 1976) revealed the following points which are closely related to our present study:

(1) Surface configurations, rather than underlying structures, directly affect sentence comprehension.
(2) Identification of clausal boundaries is crucial to sentence comprehension.
(3) Experimental results suggest existence of canonical forms in sentence comprehension processes.

The present study reports on an experimental study which aimed to clarify performance mechanism involved in the comprehension of complement constructions in Japanese in comparison with relative clause constructions, coordinate conjunction sentences and simple sentences. All sentence types used in the experiment are shown in Table 1.

In traditional terms, these sentences can be classified into three kinds: simple sentences (A. 1.), compound sentences (A. 2.) and complex sentences (B). Compound sentences may take either verb stem form or verb te-form in their non-final verbs; however, in our experiment only the te-form is employed. Complex sentences are subdivided into three types on the basis of the verb forms used in their subordinate clauses. Those sentences which carry tensed verb forms, marked by -ta in the stimulus sentences, in their subordinate clauses are here called "tensed, " which include B. I. 3 and B. II. Those sentences which carry verb forms without any tense marker in their subordinate clauses are called "tenseless, " which are further divided

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** Centre for Teaching of Japanese as a Foreign Language, The National Language Research Institute.
*** Department of Literature, Otsuma Women's University.
**** Research Institute for Education of Exceptional Children, Tokyo Gakugei University.
***** Graduate School of Education, International Christian University.

Table 1. Classification of Stimulus Sentences

A. Non-Subordinate Clause Constructions
   1. Simple Sentence (S)
   2. Coordinate Conjunction Sentence (CO)

B. Subordinate Clause Conjunction Sentence
   I. Complement Constructions
      1. Stem-Complement Constructions
         a. Causative Sentence (CA)
         b. Inchoative Sentence (IC)
      2. Te-Complement Constructions
         a. COME/GO Sentence (GO)
         b. GIVE/RECEIVE Sentence (GR)
         c. Desiderative Sentence (D)
      3. Tensed-Complement Constructions
         a. (Pseudo-) Cleft Sentence (CL)
         b. TO-Complement Sentence (TO)
         c. NO-Complement Sentence (NO)
         d. KOTO-Complement Sentence (KOTO)
   II. Relative Clause Constructions
      1. Center-Embedding Sentence (RCE)
      2. Left-Branching Sentence (RCL)

into those which use verb stem forms in their subordinate clauses (B. I. 1) and those which use verb te-forms in their subordinate clauses (B. I. 2). We called the former "stem-complement constructions" and the latter "te-complement constructions."

For each type of sentence in Table 1, an example sentence is given in the following:

S: Simple sentence

Sumisu-san wa sensyuu Sibuya no kissaten de Hanako-san ni kekkon o

Mr. Smith	last week	Shibuya	at coffee shop	Miss Hanako	marriage

moosikonda.

proposed

'Mr. Smith proposed marriage to Miss Hanako last week at a coffee shop in Shibuya.'

CO: Coordinate conjunction sentence

Guriin-san wa syuumatu ni Ikebukuro de tomodati ni atte hon o katta.

Mr. Green	last weekend	Ikebukuro	friend	met	a book	bought

'Mr. Green met his friend and bought a book at Ikebukuro last weekend.'

CA: Causative sentence
Sensee wa kodomo ni gonensee no toki kara teepu de eekaiwa o kikaseta.

teacher child fifth grade from by tape English conversation made listen

'The teacher made the child listen to English conversation by tape from fifth grade.'

IC: Inchoative sentence
Tyuusyoku-go Buraun-san wa nikai no kaigisitu de buka no hookokusyo o

after lunch Mr. Brown second floor conference room subordinate report

yomihazimeta.

started reading

'After lunch, Mr. Brown started to read a report from his subordinate in a conference room on the second floor.'

GO: COME/GO sentence
Kesa Kuraaku-san wa tikaku no biyooin de kami o setto-site kita.

this Ms. Clark nearby beauty parlor do hair came morning

'Ms. Clark had her hair done this morning at a nearby beauty parlor.'

GR: GIVE/RECEIVE sentence
Zyonson-san wa imooto ni rekisi no hon o yukkuri yonde ageta.

Mr. Johnson for sister history book slowly read gave

'Mr. Johnson read a history book slowly for his sister.'

D: Desiderative sentence
Sono toki watasi wa Zyeemusu-san kara sinsoo o higaisya ni tutaete
then I Mr. James from truth victim tell

hosikatta.

wanted

'I wanted Mr. James to tell the truth to the victim then.

RCE: Relative clause sentence with center embedding
Buraun-san wa nezumi ga yuube daidokoro de kazitta tiizu o suteta.

Mr. Brown rat last night at the kitchen gnaw cheese threw

'Mr. Brown threw away the cheese which a rat gnawed in the kitchen last night.'

RCL: Relative clause sentence with left branching
Doyoobi ni Hakone de marason ni sankasita Sukotto-san wa asi o itameta.

Saturday at Hakone marathon race entered Mr. Scott feet injured

'Mr. Scott, who had entered the marathon race at Hakone on Saturday, injured his feet. '

CL: (Pseudo)-cleft sentence
Asita kaigi de tyoosa no kekka o hookokusuru no wa Zyonson-san da

tommorow at meeting research result report Mr. Johnson

'It is Mr. Johnson who will report the results from the research at the meeting tommorow. '

TO: TO-complement sentence

Kinoo sensee wa dansi wa suugaku ga yoku dekiru to itta.

yesterday teacher boys mathematics well do said

'Yesterday, the teacher said that boys do well in mathematics. '

NO: NO-complement sentence
Teeraa-san wa tomodati ga butai de huramenko o odoru no o mita.

Mr. Taylor his friend on stage flamenco dance saw

'Mr. Taylor saw his friend dance flamenco on stage. '

KOTO: KOTO-complement sentence
Kootyoo wa kyoosi ga kyoositu de tabako o sutta koto o hinansita.

principal teacher in the classroom smoked criticized

'The principal criticized the teacher for smoking in the classroom. '

A description of the experiment using these sentences in oral reproduction task is given in section 2; results and discussion in section 3; and the summary in section 4. Grammatical descriptions of stimulus sentences and the list of the stimulus sentences are given as appendices.

2. Experiment

Subjects: 35 normal adults ranging from 20 to 33 years old (18 males and 17 females, mean age 26.4 years).

Procedure: First, the subjects listened to the tape-recorded stimulus sentences one at a time, followed by additions of 3 figures plus 2 figures. Immediately after this, the subjects were to carry out the task of addition using pencil and paper, and then orally reproduce the sentence as accurately as possible. The tasks of addition were inserted in order to increase the memory load. All responses were tape-recorded.

Stimuli: Sentences were constructed of 7 simple phrases (i.e., bunsetu such as "noun+particle." Note that "complementizer+particle," e.g., "koto-o" or "no-o," was counted as one simple phrase.) As for complex sentences, the main clauses in the underlying structures were constructed of 3 simple phrases, and the subordinate clauses in the underlying structures were constructed of 4 simple phrases. Coordinate conjunction sentences were constructed of 5 simple phrases in the first clause and 2 simple phrases in the second clause. A total of 39 sentences (13 types, 3 each) were ar-

ranged randomly and were presented in the order listed in the appendices to half of the subjects, and in the reverse order to the other half. The example sentences are shown in the first section of this article.

3. Results and Discussion

3.1 Structure Preserving Responses and Meaning Preserving Responses

Table 2 shows the percentages of two kinds of responses for each stimulus sentence type obtained in the experiment: structure preserving responses, which we treat as correct responses, and meaning preserving responses. The former includes only the responses which maintained the same surface forms as the stimulus sentences, while the latter includes all the responses which preserved the same semantic contents as the stimulus sentences; thus, the latter include the former. The former are referred to as P-responses, and the latter as Q-responses. Q-responses, accordingly, include responses which exhibited movements of constituents but resulted in no semantic change from the stimulus sentences.

Table 2. Sentence types and percentages of P-responses, Q-responses and numbers of omitted phrases

SENTENCE TYPE	Percentages of P-responses (P)	Percentages of Q-responses (Q)	Numbers of Omitted phrases
S: Simple sentence	14.3%	39.0%	104
CO: Coordinate conjunction sentence	12.4	43.8	100
CA: Causative sentence	2.9	7.6	101
IC: Inchoative sentence	12.4	32.4	111
GO: COME/GO sentence	16.2	53.3	58
GR: GIVE/RECEIVE sentence	7.6	64.8	34
D: Desiderative sentence	22.9	55.2	54
RCE: Relative clause sentence with center-embedding	5.7	61.0	34
RCL: Relative clause sentence with left-branching	17.1	32.4	94
CL: (Pseudo-)Cleft sentence	23.8	45.7	91
TO: TO-complement sentence	24.8	37.1	59
NO: NO-complement sentence	28.6	47.6	43
KOTO: KOTO-complement sentence	38.1	66.7	21

The following is a list of sentence types arranged in the order of the increase of percentages in P-responses.

(4)	CA	RCE	GR	<	CO	IC	S	GO	RCL	<
	2.9	5.7	7.6		12.4	12.4	14.3	16.2	17.1	

D	CL	TO	NO	KOTO
22.9	23.9	24.8	28.6	38.1

When we divide the sentence types simply into those which have between 10% and 20% correct responses, from 20% to 30%, and from 30% up, sentence types D, CL, TO, NO and KOTO occupy the group which obtained more than or equal to 20% correct responses. All of these sentence types excepting D use the tense marker -ta in the complement clauses in the stimuli. Relative clause constructions also mark subordinate clauses with the tense marker, and RCL indicates the next higher percentage of correct responses to D. RCE, on the other hand, shows an extremely low percentage of P-response. From these, we may say that, in general, those sentence types which use tense markers in subordinate clauses resulted in the higher percentage of P-response.

The fact that RCE showed a low percentage of P-response in relative clause constructions seems to be due to its center-embedding constructions with a subordinate clause, independent of the matrix verb. (See APPENDIX 1.1) In RCE, the processing of the matrix sentence is interrupted in order to process the center-embedded relative clause, which is subordinate to a matrix noun phrase. Moreover, in the reproduction task, it is necessary to maintain the surface forms in memory along with performing processings. These should add complexity to the course of sentence processing, and thus resulted in a low percentage of P-responses.

Table 3 shows mean percentages of P-responses and Q-responses in the stimulus sentences grouped on the basis of "tensed" and "tenseless." As explained above, "tensed" includes all the tensed-complement sentences and relative clause constructions. "Tenseless" sentences are subgrouped into te-complement constructions (-te) and stem-complement constructions (-ϕ). Coordinate conjunction sentences are grouped with te-complement constructions. Percentages of P-responses and Q-responses in simple sentences are also cited for reference.

Table 3. Mean percentages of P-responses and Q-responses obtained by "tensed" and "tenseless" groups.

		Percentages of P-responses	Percentages of Q-responses
Tensed		23.0	48.4
Tenseless	-te	14.8	54.3
	-ϕ	7.7	20.0
Simple sentence		14.3	39.0

Statistically, t-tests given to P-responses indicated significant differences between "tensed" and "tenseless" sentences ($t=2.01$, $df=10$; $0.05<p<0.1$), and te-complement constructions and stem-complement construc-

tions ($t=2.4$, $df=8$; $0.01<p<0.05$).

T-tests given to Q-responses, on the other hand, showed no significant difference between "tensed" and "tenseless" ($t=0.55$, $df=10$; $p>0.1$), while te-complement constructions and stem-complement constructions were significantly different ($t=6.5$, $df=8$; $p<0.01$). In simple sentences, the percentage of Q-responses was close to the mean percentage of Q-responses obtained for all the "tenseless" sentences (36.7%).

Stem-complement constructions remain in remarkably low percentages both in P-responses and Q-responses. Between "tensed" and "tenseless," as pointed out before, there was a significant difference in P-responses, but there was no significant difference in Q-responses. In Q-responses, moreover, te-complement constructions achieved a higher percentage than the "tensed" group did. From these, we cannot find any correlation between correct responses and Q-responses. This is also true from the fact that no correlation was observed between correct responses and respective Q-responses as shown in Table 2. The fact that there exists no consistency between P-responses and Q-responses may suggest that the mechanism of sentence comprehension involved in maintaining the surface form of input sentences (for reproduction) is not the same as that involved in mere comprehension.

When we look at Q-responses, it is also possible to examine them in terms of logical forms underlying stimulus sentences, since we regard Q-responses as representations of semantic contents which the hearer grasped by listening to stimulus sentences.

Table 4 compares the mean percentages of Q-responses obtained by rearranging Q-responses by logical forms.

Table 4. Mean percentages of Q-responses in terms of logical forms.

Logical form	Sentnece type			Mean percentages of Q-responses
	Tensed	Tenseless		
		-te	-φ	
I [__P]and[__P]	RCL RCE	CO		45.7
II [__[__P]P]	KOTO NO TO	GR D	CA	45.5
III [____P.P]		GO	IC	42.9
IV [___P]	CL			42.1
	S			

Regardless of logical forms, mean percentages of Q-responses remain between 42% and 45%, where very little difference is observable. From this, we may say, in experiments such as we have conducted at least, the differences in logical forms do not directly affect sentence comprehension, especially the interpretation of semantic contents.

So far, we have examined P-responses and Q-responses. In 3.2 and 3.3 below, we will refer to movements and omission of constituents found in responses in general.

3.2 Movements of Simple Phrases (Bunsetu)

Most responses, excepting correct responses, involved some movement of simple phrases. First, we will examine distance of movement and number of moved phrases.

Table 5 shows the number of moved phrases within a distance. Each distance indicates how far a simple phrase moved in the output sentences compared with the original position in the input sentence, regardless of direction.

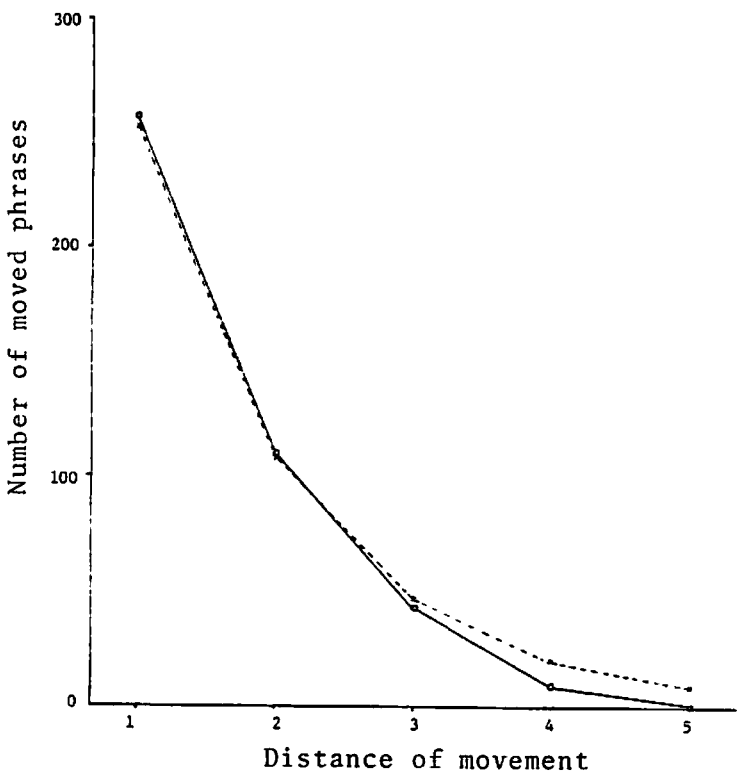
In the following input-output set (5), for example, we find the phrase yuusyoku-go in the response sentence two phrases away from the original position in the stimulus sentence. It is, then, treated as a case of distance 2.

(5) Stimulus: Buraun-san wa musuko ni yuusyoku-go.....
Response: Yuusyoku-go Buraun-san wa musuko ni.....

Table 5. Number and distance of moved phrases

Distance of movement	1	2	3	4	5	6
Number of moved phrases	257	110	43	9	0	0

Fig. 1 Number and distance of moved phrases



The solid line in Fig. 1. illustrates data given in Table 5. As it shows, the greater the distance, the fewer the movements, and no movement occurs at distance 5.

Suppose the probability of movement at distance 1 is k, the probability of movement at distance 2 is k^2, that at distance 3 is k^3, and so on. As far as distances 3, the result is well accounted for if we use 0.43 (number of moved phrases (110) at distance 2 ÷ number of moved phrases (257) at distance 3 = 0.43) as the probability.

Moreover, the number of moved phrases at distance 1, which amounts to 257, is very close to the number derived by multiplying the total number of stimulus sentences (1365) by 0.43^2 (=252.4).

In Fig. 1, the dotted line indicates the total number of stimulus sentences multiplied by 0.43^3 at distance 1, that by 0.43^4 at distance 2, and so on.

From these results, the following interpretation may be given. Suppose there is one possibility of movement in each stimulus sentence. When the probability of occurrence of movement at distance 1 is k and the probability of initiating the movement itself is also k, then the number of moved phrases n at distance d will be

$$n = N k^{d+1}$$

where N refers to the total number of stimulus sentences.

In our experiment, as mentioned above, the results were well accounted for when we take k = 0.43. When we look at distance 4 and beyond, we find greater gaps between the actual occurrences and the prediction. This could be due to certain characteristics of the stimulus sentences we employed.

The majority of stimulus sentences employed in the experiment are composites of two clauses. In most of the cases, clauses contain 4 or fewer simple phrases. Accordingly, when a phrase moves as far as distance 4, it may go beyond the clause boundary and result in alternation of semantic contents of the sentence. Probability of such movements should be less high than that of the movements arising within a clause boundary. Actual occurrence of the moved phrases at distance 4, therefore, must be less than the estimation, and no movement was found at distance 5 or more.

Next, we will look into the moved phrases in respect to their grammatical functions and direction in movement.

Attention is given to the following six types of phrases: time adverbials (TIME), locative adverbials (LOC), instrumental adverbials (INST), manner adverbials (MANNER), noun phrase + ni (N-ni), and noun phrase + o (N-o). Directions in movement are of two types: movements toward sentence-initial positions (forward), and toward sentence-final positions (backward).

Table 6 shows the total number of forward and backward movements for the six types of phrases.

Tables 7-12 and Figs. 2-7 indicate the percentages of moved phrases for each phrase type, respective of their positions held in stimulus sentences. The solid lines in Figs. 2-7 represent forward movements, and the dotted lines, backward movements.

Table 6. Grammatical function of moved segments and direction of movement

Grammatical function	Direction of movement (number)	
	Forward	Backward
TIME	234	45
LOC	81	17
INST	24	16
MANNER	11	19
N-ni	38	87
N-o	38	99

Fig. 2 Percentage of moved phrases and their positions in stimulus sentences: TIME

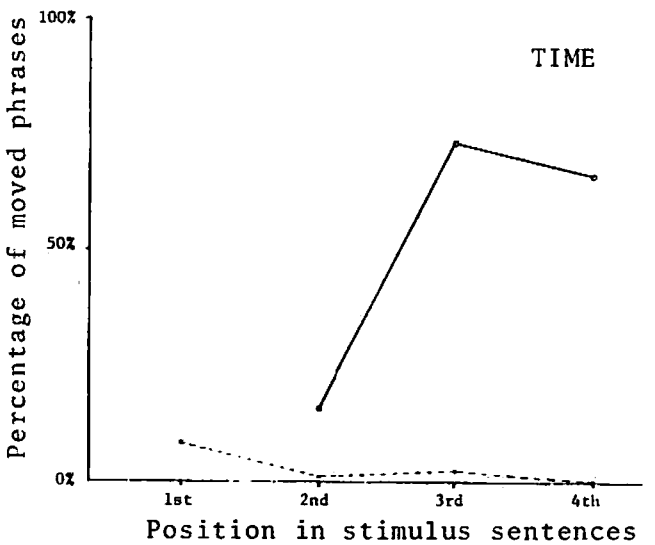


Table 7. TIME

Position in stimuli	Direction of movement (%)	
	Forward	Backward
1st		8.1
2nd	15.5	1.2
3rd	72.9	2.4
4th	65.7	0.0

Fig. 3 Percentage of moved phrases and their positions in stimulus sentences: LOC

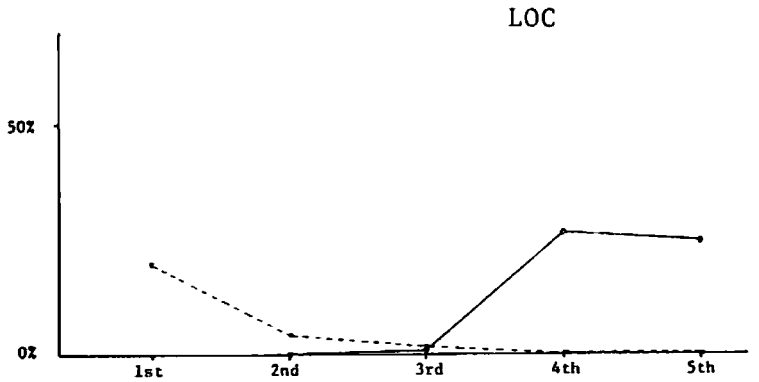


Table 8. LOC

Position in stimuli	Direction of movement (%)	
	Forward	Backward
1st		20.0
2nd	0.0	4.3
3rd	0.9	2.0
4th	26.3	0.0
5th	24.3	0.0

Fig. 4 Percentage of moved phrase and their positions in stimulus sentences: INST

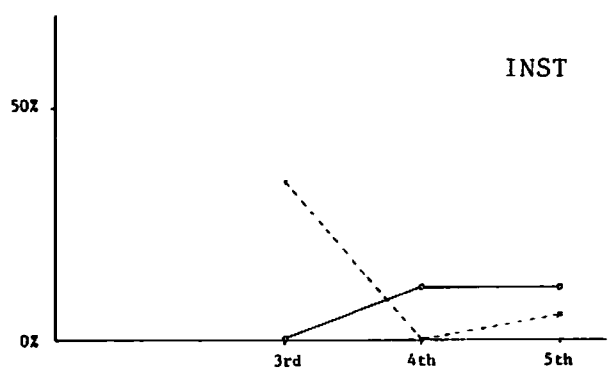


Table 9. INST

Position in stimuli	Direction of movement (%)	
	Forward	Backward
3rd	0.0	34.3
4th	11.4	0.0
5th	11.4	5.7

Fig. 5 Percentage of moved phrases and their positions in stimulus sentences: MANNER

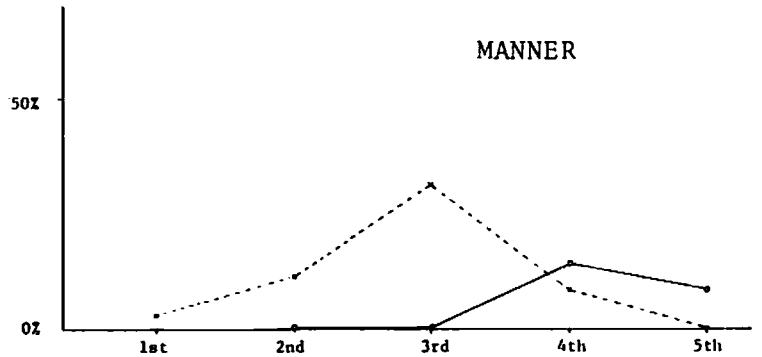


Table 10. MANNER

Position in stimuli	Direction of movement (%)	
	Forward	Backward
1st		2.9
2nd	0.0	11.4
3rd	0.0	31.4
4th	14.2	8.6
5th	8.6	0.0

Fig. 6 Percentage of moved phrases and their positions in stumulus sentences: N-ni

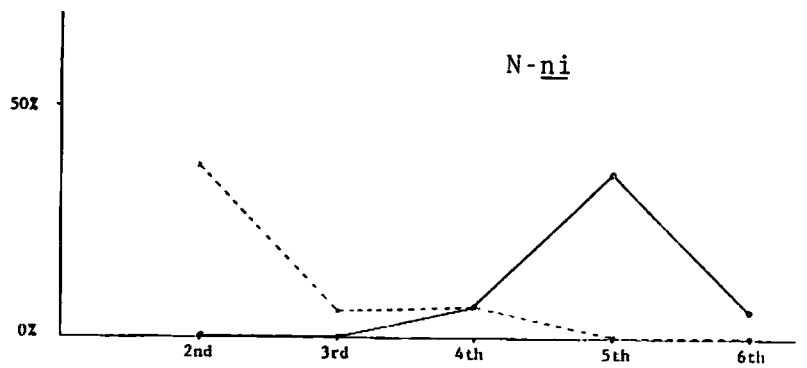


Table 11. N-ni

Position in stimuli	Direction of movement (%)	
	Forward	Backward
2nd	0.0	37.1
3rd	0.0	5.7
4th	6.7	6.7
5th	35.2	0.0
6th	5.7	0.0

Fig. 7 Percentage of moved phrases and their positions in stimulus sentences: N-o

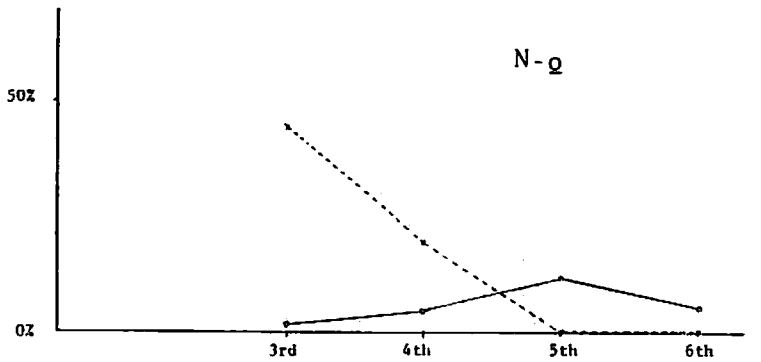


Table 12. N-o

Position in stimuli	Direction of movement (%)	
	Forward	Backward
3rd	1.4	44.3
4th	4.3	19.4
5th	11.4	0.0
6th	4.9	0.0

TIME, LOC and INST, in this order, tend to take forward movements, while N-o, N-ni and MANNER, in this order, tend to take backward movements (Table 6).

TIME shows a tendency to be in the 1st or 2nd position; LOC to be in the 2nd or 3rd positions; INST, MANNER or N-ni to be in the 3rd or 4th positions; and N-o to be in the 4th or 5th positions (Tables 7-12; Figs. 2-7).

From these results, we may decribe the canonical form of a subordinate clause as

$$\text{TIME} \quad \text{LOC} \quad \left\{\begin{matrix}\text{INST}\\ \text{MANNER}\\ \text{N-ni}\end{matrix}\right\} \quad \text{N-o} \quad \text{V}$$

when we take the fact into consideration that many of stimulus sentences located the verbs of subordinate clauses in the 5th or 6th phrasal position in a sentence.

3. 3 Omission of Simple Phrases

In many response sentences, we observed omission of simple phrases, which altered the semantic contents of the stimulus sentences. In this section, we will examine these phrasal omissions and discuss some grammatical characteristics of these phenomena.

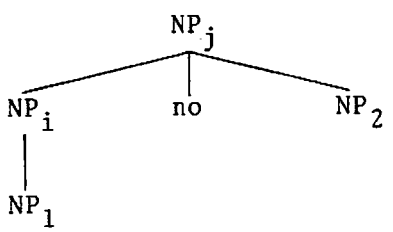
In the third column of Table 2 the numbers of omitted phrases for each

stimulus type are contrasted with their respective percentages in P-responses. It is obvious, here, that the number of omitted phrases and the percentage of P-responses for each stimulus type are not necessarily in correlation. As was already examined in section 3.1, structural differences in the stimulus sentences directly affect P-responses. We may say, therefore, that structural differences in the stimulus sentences are not the main factors for phrasal omission.

Simple phrases such as adverbials and modifying phrases, which do not play central roles in grammatical constructions, tend to be easily omitted, when compared with simple phrases that function as a subject or an object of the sentence. Among adverbial phrases, time adverbials (TIME) and locative adverbials (LOC), and among modifying phrases, noun phrases in the form of "noun + no" (N-no) have a strong tendency toward being omitted. From these, we can assume that the grammatical functions played by simple phrases are important factors in phrasal omissions.

Detailed examination of TIME, LOC and N-no phrases revealed the following. There were 35 subjects, and 39 stimulus sentences were given to each subject. The number of TIME, LOC and N-no phrases used in the stimulus sentences are 31, 21 and 23, respectively. Therefore, it could be expected to have 1085 (31 x 35) of TIME, 735 (21 x 35) of LOC and 805 (23 x 35) of N-no, if there were only P-responses or Q-responses. In Table 13, the expected occurrences of these phrases and their omissions in the data are compared. In the table, N-no, among others, shows a remarkably strong tendency toward omission. This may be due to the structural reason it holds; N-no in N_1 no N_2 noun phrase constructions does not play as important a role in grammatical relations as N_2 does being the main constituent in the construction. Thus, N_1 does not play a crucial role in the underlying semantic structure. The reason stated, however, is not unique to N-no. It is also applicable to TIME and LOC. To explain the peculiarity of the omission of the N-no phrase, it would be necessary to point out its structural uniqueness, namely, that it is dominated by the same category NP as is illustrated below:

(5)



Suppose a certain procedure which processes any NP. This procedure must be recursively used to process NP_i while it is processing NP_j. As is pointed out in Chomsky (1965), this "recursive use of a certain procedure" would have something to do with the peculiar behavior of N-no in omission.

Dividing the grammatical functions into the major functions (subject, object and predicate) and marginal ones (adverbials and modifiers) presupposes the degree of strength of the relation between the predicate and other phrases. In other words, the major functions noted above have an indispensable relation to the predicate, while the marginal functions do not. Grammatically speaking, the predicate has the selectional restrictions on the major functions, but not on the marginal.

Table 13. Number and percentage of omitted phrases of each grammatical function

	Expected occurrence (f)	Deleted (d)	d/f 100
TIME	1085	108	10.0
LOC	735	117	15.9
N-no	805	167	20.7
Subject	1785	43	2.4

According to the discussion, we can point out the following two factors which take part in the omission of the phrases:

i) The recursive use of a certain procedure

ii) The grammatical function of the phrase, i.e., major vs. marginal.

As for ii), it is interesting to note that there are two types of adverbials. TIME and LOC are typical examples of adverbials which do not have strong relation to predicates. The so-called "manner" adverbials are typical examples of adverbials which have strong relation to the predicate. Yukkuri 'slowly' (6), hijooni 'extremely' (3), huto 'suddenly' (2), yoku 'quite well/often' (4), yatto 'barely' (1) are the manner adverbials used in the stimulus sentences. The figures in parentheses indicate the number of omissions. Compared with TIME and LOC, the number of omissions for MANNERS is remarkably small. This can also be explained by ii).

The above discussion offers a rather clear view of the sentence comprehension process. First of all, we may say that the processing of a clause is carried out focusing on the simple phrases which bear the major functions. More concretely, the simple phrases with major functions are put on the template, which is arranged in the form of the canonical form. After that, the simple phrases with marginal functions are related to the items on the template. Thus, if the given surface sentence is processed linearly, the items which are not put on the template must be stacked, and have more chance of being omitted.

4. Summary

4.1 The percentage of structure-preserving responses (P-responses) is lower than that of meaning-preserving responses (Q-responses). For P-responses, the verb forms in subordinate clauses, whether they are with tense marker (-ta) or not (-te, -ϕ), affect crucially.

Q-responses are not in correlation with P-responses. This implies that differences in the surface forms of stimulus sentences do not strongly affect semantic interpretation. Differences in logical forms underlying stimulus sentences also do not directly control semantic interpretation.

From these points, it is clear that the mechanism involved in mere semantic interpretation of a sentence is different from that involved in the semantic interpretation maintaining input surface configurations.

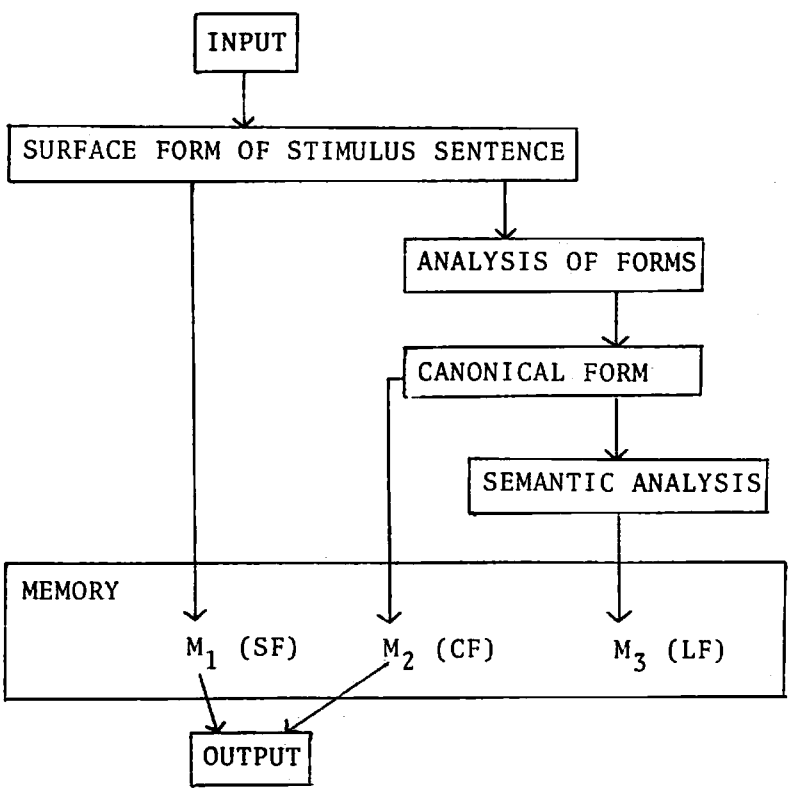
4.2 In sentence reproduction, movement of simple phrases occurs more frequently in shorter distances. The direction of movements differs with the grammatical function of each phrase, and seems to indicate sentential

positions where each phrase should be located. These tendencies suggest the use of canonical form in both sentence comprehension and reproduction processes.

4.3 Omission of simple phrases in sentence reproduction varies with the grammatical function and structural restrictions of each phrase. In terms of grammatical functions, adverbials show a strong tendency toward omission. Structurally, noun-modifying noun phrases (N-no) tend to be easily omitted. In both cases, these phrases do not play central roles syntactically or semantically. Omission of these phrases, consequently, does not decisively affect the basic organization of the sentences.

4.4 A model of sentence comprehension and reproduction processes is proposed below on the basis of our experimental results.

Fig. 8 Processes of sentence comprehension and reproduction



where M:memory, SF:surface form, CF:canonical form, LF: logical form.

Sentence processing, in the model, follows arrows time-wise. In actual processes, analyses in different steps, such as analysis of forms and semantic analysis, may take place simultaneously. In memory, M_1 preserves the surface sentence form of the input sentence, M_2 the canonical form, and M_3 the logical form. In sentence reproduction, such as experimented here, output sentences are directly produced from M_1 and M_2. M_1 can be regarded less effective than M_2. In the experiment, output sentences solely from M_1 result in P-responses, and those from M_1 and M_2 in Q-responses. Movements and omission of phrases may be taken as products in the course of analysis of forms.

In this model, little attention has been paid to sentence reproduction mechanism. The model would be more appropriate if detailed sentence production mechanism were included. Elucidation of such mechanisms is left for future studies.

APPENDIX 1. Grammatical Descriptions of Stimulus Sentences

1.1. Complex sentences in Japanese

In this appendix, we will provide a brief explanation of each sentence type and the norms of classification employed in this experiment. As was noted in section 1, the purpose of this experiment is to clarify the process of complex sentence comprehension. Therefore, we must first define the notion of "complex sentence."

The notion "complex sentence" is purely a grammatical one, and to define it, we must define the notion of "subordinate clause" beforehand.

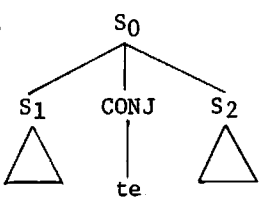
(1) The Subordinate Clause

Given a P-marker where the clauses S_M and S_C are its constituents, S_C is called a "subordinate clause" of S_M (or S_C is subordinate to S_M) if and only if S_C is a constituent of S_M and S_M contains any major categories (such as VP, NP, AP, PRED, etc.)other than S.[1]

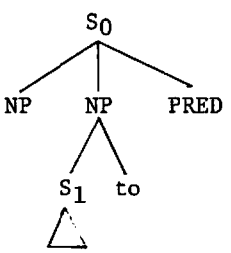
According to this definition, S_1 and S_2 are subordinate clauses in diagram (2a), where neither S_1 nor S_2 contians the other. Thus the subordinate relation never holds between them. Furthermore, neither S_1 nor S_2 is subordinate to S_0 because S_0 contains no mojor category other than S. Notice that CONJ (conjunction) is not a mojor category but a grammatical one. Contrary to (2a), S_1s in (2b) and (2c) are subordinate clauses because each is contained in S_0 and S_0 also contians major categories (such as NP and PRED).

Diagram (2a) is the P-marker of the coordinate construction and is called a "compound sentence" in traditional grammars. (2b) is a p-marker of a complement construction, and (2c) a typical relative construction.

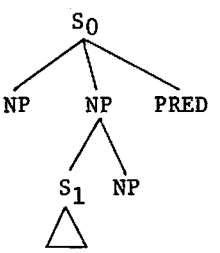
(2) a.



b.



c.



The complex sentence is defined as follows;

(3) The Complex Sentence

The sentence which contains a subordinate clause as its constituent is called a complex sentence.

By definition (3), (i)the complement sentence, construction, (ii)the relative clause construction, and (iii) the sentence construction which involves the adverbial clause have complex sentence structure. In this experiment, however, only (i) and (ii) are taken up.

The following sentence will be a typical example of the complement construction:

(4) Tanaka-san wa [Ookawa-san wa subarasii yakusha da] to omotta.
Mr. Tanaka Mr. Ookawa marvelous actor is that thought
'Mr. Tanaka thought that Mr. Ookawa was a marvelous actor.'

In sentece (4), the part in parentheses itself could be an independent sentence and describes the content of the "thinking." Syntactically speaking, it functions as the object of the verb omou (omotta in (4) is the verb (omou)+past-tense form (-ta) form), and thus it is not a mere subordinate clause but an essential grammatical unit in a sentence (functioning in most cases as the subject or the object of the sentence), we call it a "complement sentence" and the sentence which involves a complement sentence as a "complement (sentence) construction."

The Japanese sentences which are analyzed as complement constructions in a generative-transformational grammar can be classified into three types in terms of their sufrace forms:

(5) Complement Constructions
  a. Tensed-complement construction: the verb of the complement sentence is in the finite form.
  b. te-compelment construction: the verb of the complement is in the VERB-STEM +te form.
  c. Stem-complement construction: the verb of the complement is in the VERB-STEM form

Sentence (4) is a typical example of the tensed-compelment construction. In sentence (4), the particle to which precedes the verb omotta functions as the indicator of the complement sentence and is thus called the "complementizer." Japanese grammar is considered to have several complementizers, and among them -to, -koto and -no are considered to be the most general ones. We have, therefore, classified the tensed-complement constructions into three types in terms of these most general complementizers:

(i) To-complement construction
(ii) Koto-complement construction
(iii) No-complement construction

The most fundamental grammatical characteristics of these complement types is that their choice is dependent on the choice of verb in the main clauses. That is, the information of which complement type the construction has must be attributed to the lexical information of the main verb. Thus we consider that the information in question is governed by the main verb.

Contrary to the complement construction, whether or not the construction may involve a relative clause is independent of the choice of the main verb. This can be the most effective norm for differentiating the complement construction from the relative clause construction.

We have already found taht the tense marker attached to the predicate of the subordinate clause plays a significant role in the process of sentence comprehension (Uyeno & Harada, 1975 ; Harada et al., 1976 ; Uyeno et al., 1977, 1978) This suggests that the surface differences in the complement constructions noted above would affect the sentence comprehension process. This is the reason why we take up the classification of sentence types shown in TABLE 1 in the text.

It is worth noting here that linguistic factors which work saliently in the domain of liguistic performance are mostly indifferent to the domain of linguistic competence. For example, the linguistic analysis of relative clause constructions pays little attention to the left-branching/center-embedding difference. Contrary to linguistic analysis, it is widely accepted that the left-branching/center-embedding difference greatly affects the sentence comprehension (Chomsky, 1965, §2 of Chapter 1 ; Harada et al., 1976). In the same way, surface forms of the complement constructions (in Japanese) are not crucial to their linguistic analysis. But the information of the surface forms of the complement constructions could, as the im-

portance of the tense marker in the relative clause comprehension suggests, affect sentence comprehension greatly. Furthermore, we should have known various grammatical characteristics of each construction to clarify the factors which play the crucial role in its comprehension. We will briefly summarize the grammatical characteristics of each stimulus sentence in the following.

1.2. Grammatical Characteristics of Stimulus sentences [2]

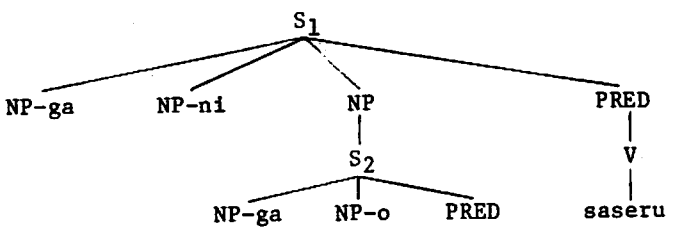
A.1 Simple Sentence: Omitted

A.2 Coordinate Conjunction Sentence

The coordinate conjunction sentences taken up in this experiment have two clauses (S_1 and S_2 : see (2a)). The verb in S_1 must have -te-form in the surface. In the underlying structure of these constructions, S_1 and S_2 have the identical NP, and the identical NP in S_2 must be deleted in the surface.

B.I.1.a Causative Sentence

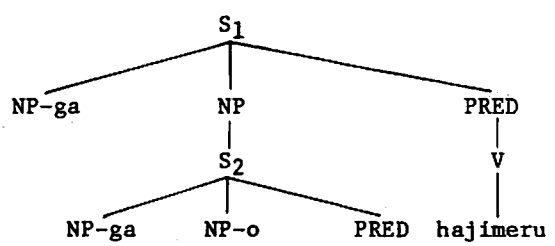
It is generally agreed that there are two types of causative construction, o-causative and ni-causative, but it is also true that there are some debates on the underlying structure of these constructions (Kuroda, 1965 ; Inoue, 1976, p.67-75). We will assume the following structure:



In this underlying structure, NP-ni in S_1 and NP-ga in S_2 must be identical. A notable characteristic of this construction is its semantic complexity. Syntactically, S_2 funcitons as the object of the verb saseru, but the meaning of S_2 supplies indispensable meaning to the causative verb. This suggests the reason why the verb saseru cannot be the independent verb in a simple sentence. We can say that S_1 and S_2 in the causative construction are strongly tied compared with other complement constructions.

B.I.1.b Inchoative Sentence

The following diagram shows the underlying structure of the inchoative sentence:



In this structure, NP-ga in S_1 must be identical to Np-ga in S_2. Semantically, inchoative verbs such as hajimeru are the element expressing aspect and thus are considered to be a modifier-like element to the predicate of S_2.

B.I.2.a COME/GO Sentence

The underlying structure configuration of this sentence type is equivalent to that of B.I.1.b. The difference is that the verb of COME/GO sentence is realized as a -te-verb form, and that of an inchoative sentence, a verb stem form.

B.I.2.b GIVE/RECEIVE Sentence

The underlying configuration of a GIVE/RECEIVE sentence is equivalent to that of causative sentence, but the identy condition is totally different. In the construction (V=ageru), NP-ga in S_1 and NP-ga in S_2 must be identical. This might have some relevance to the difficulty of sentence comprehension.

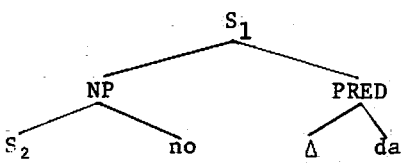
B.I.2.c Desiderative Sentence

We assume the underlying structure of the desiderative sentence (V= hoshii) has the equivalent configuration to that of B.I.1.b except the matrix verb. In this construction, the subject of S_1 must not be identical to the subject of S_2. Moreover, this construciton has a peculiar grammatical constraint: the subject of S_1 (PRED=hoshii) must be in the first person.

B.I.3.a (Pseudo-)Cleft Sentence

In Japanese Grammar, there is no construction corresponding to the English cleft sentences.

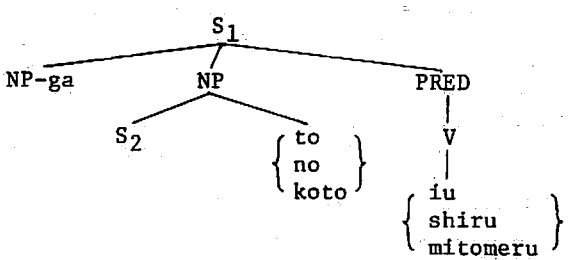
We assume the Japanese (pseudo-)cleft sentence has the following underlying structure:



Cleft sentence formation applies to the underlying structure, and lifts any element in S_2 except the verb to the position of Δ. The Characteristic of a cleft sentence is that although the surface form has two predicates, semantically it has only one proposition. This suggests that the comprehension of the cleft sentence is much easier than the normal complement constructions.

B.I.3.b To-complement Sentence
B.I.3.c No-complement Sentence
B.I.3.d Koto-complement Sentence

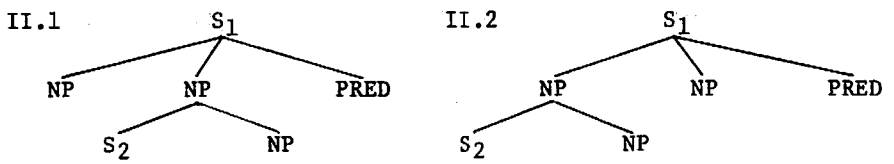
The underlying structures of these complement constructions can be diagramed as follows:



As was noted before, the choice of complementizers depends on the main verb. One of the main factors of this choice is the so-called "factivity" of the verb. Non-factive verbs take the to complementizer. To-complement construction has one more peculiar characteristic. That is, subject-raising transformation can apply to the to-complement construction as in [Taroo wa, Hanako ga baka da to omotta] = [Taroo wa, Hanako o baka da to omotta]
There is no identity condition on these complement construcions.

B.II.1 Relative Clause Construction:Center-Embedding Sentence
B.II.2 Relative Clause Construction:Left-Branching Sentence

The relative clause construction is one of the adnominal constructions in which the noun phrase is modified by the preceding clause. A relative clause can be added to any noun phrase in a sentence.



In diagram II.2, relative clause (S_2) appears at the left-most position in the sentence. We will call this construction the "left-branching" sentence. In II.1, an NP which is not the element of the relative clause comes in front of S_2. We will call this structure the "center-embedding"sentence. Although this difference has no meaning in the grammatical analysis of relative clauses, it might take a crucial role in the study of sentence comprehension (Chomsky, 1965, § 2 of Chapter 1 ; Harada et al., 1976).

In Japanese, there are some other adnominal clause constructions. The distinguishing feature of relative clauses from other adnominal construction is that in the relative clause construction, the relative clause must have an NP identical to its head.

1.3 Sentence Structure and Logical Form

We assume that the process of sentence comprehension is the conversion of the surface sentence to its semantic representation. Thus what we think is the semantic representation is a very important problem. We basically follow the proposal of generative grammar and assume that the semantic representation is described in a certain form of logical proposition. We will call it a "logical form"(LF). The recent generative literature primarily adopts the so-called λ-(lambda-)notation for the logical form, but we adopt a kind of reversed Polish notation with a slight modification because the Japanese sentence has almost the equivalent sequence of NP and PRED to the reversed Polish notation.[3]

What type of logical notation we adopt is not an important issue here. The important point is to ask whether it is necessary to adopt a certain kind of logical form in the description of the meaning of a sentence. For the answer to this question, see Chomsky's papers cited in note 3. In our foregoing researches, we have proposed that we must assume some mechanism of clause separation, the existance of template, etc., in the process of sentence perception. All of these implicitly assume that in the output of the sentence perception mechanism, which is considered to be the semantic representation of the sentence, the clause is an indespensable unit. Therefore it is natural to assume that the logical proposition, which corresponds to the clause in the syntactic description, is the unit of the semantic representation. Needless to say, the logical form does not express

the whole semantic information borne in the sentence. But this does not force us to abandon the adoption of logical form in the semantic description.

We will briefly explain how we set up logical form of each sentence type in the experiment.

We basically consider that single clause in the syntactic description corresponds to a single proposition in LF. We enclose a proposition with brackets,and indicate the predicate of the proposition with P. In our discussion, it is enough to indicate the skeletal structure of the proposition. Thus we do not describe the terms of the predicate. Therefore, a logical form of a sentence is described as [P]. As was noted before, a complement sentence is a required element for the verb, and thus the proposition which corresponds to the complement sentece is expressed as the term of the predicate in the proposition. Therefore, we assume the following notation for the logical form of the complement construction as far as we assume the matrix verb be the predicate: [[P]P]. We assume the logical form to the COME/GO sentence and inchoative sentence as [P.P]. As noted before, verbs of COME/GO and inchoative can be considered as a marginal element in the semantic representation. The fact that these constructions always have the identity conditon between the matrix and complement subjects indirectly support this analysis.

Semantically, a cleft sentence has a single proposition in LF, thus it is equivalent to that of the simple sentence. In the coordinate conjunction and the relative constructions, each clause corresponds to a proposition. They do not function as the term of the predicate,and thus we connect the propositions by the Boolean operator AND. LF should be in the form: [P]&[P]. This is similar to Ross's analysis of the relative clause in that the underlying structure of the relative clause is equivalent to that of the coordinate conjunction (Ross, 1967).

Consequently, we can classify the stimulus sentences in (6), using the forms of their LFs.

(6) I. [P]&[P]: Coordinate Conjunction Sentence, Relative Clause Constructions
II. [[P] P]: Compelment Constructions except in III below
III. [P.P]: COME/GO Sentence, Inchoative Sentence
IV. [P]: Simple Sentence, Cleft Sentence

Notes: 1. For the notion of Major Categories, see Chomsky (1965), p.74.
2. For more detailed explanations, see Inoue (1976).
3. For adopting the logical form to the semantic representation, see Chomsky (1977b), Chapter 6, especially p.145ff. He uses the term "semantic representation" rather differently from us. See also the papers in Chomsky (1977a). See Sag (1976) for the use of lambda-notation in the linguistic analysis. See Mizutani (1970) and Katz and Postal (1964) for the reversed Polish notation.

APPENDIX 2. List of Stimulus Sentences

ORDER	TYPE	SENTENCES
1.	CO	Guriin-san wa kinoo Ginza de eega o mite suteeki o tabeta.
2.	S	Sumisu-san wa sensyuu Sibuya no kissaten de Hanako-san ni kekkon o moosikonda.
3.	CL	Sensyuu gakkoo do kanozyo kara no raburetaa o otosita no wa Kuraaku-san da.
4.	D	Ano toki watasi wa keekan ni doroboo o sonoba de tukamaete hosikatta.
5.	RCE	Buraun-san wa nezumi ga yuube daidokoro de kazitta tiizu o suteta.
6.	KOTO	Miraa-san wa okusan ga sinsya o roon de kau koto o mitometa.
7.	CA	Sensee wa kodomo ni gonensee no toki kara teepu de eekaiwa o kikaseta.
8.	GR	Zyonson-san wa imooto ni rekisi no hon o yukkuri yonde ageta.
9.	TO	Keekan wa huto Howaito-san ga hannin ni kaodati ga niteiru to omotta.
10.	GO	Hiruyasumi ni Paamaa-san wa buturi no repooto o tosyokan de kaite kita.
11.	NO	Teeraa-san wa tomodati ga butai de huramenko o odoru no o mita.
12.	CL	Kinoo Yoyogi-eki no hoomu de ani ni atta no wa Adamusu-san da.
13.	RCL	Sensyuu syuttyoosaki de kaze o hiita Zyeemusu-san wa kaisya o yasunda.
14.	CA	Sukotto-san wa itoko ni ikkagetu-kan tadade keesanki no soosa o narawaseta.
15.	IC	Kinoo Mittyeru-san wa yatto keesatu ni ziken no sinsoo o hanasi hazimeta.
16.	KOTO	Kootyoo wa kyoosi ga kyoositu de tabako o sutta koto o hinan-sita.
17.	RCE	Miraa-san wa okusan ga kinoo baagen de katta yoohuku o hometa.
18.	GR	Howaito-san wa musuko ni gunkan no puramoderu o yuushokugo kumitatete yatta.
19.	S	Teeraa-san wa suiyoobi ni kuruma de obasan to roppongi no disko ni itta.
20.	D	Sono toki watasi wa Zyeemusu-san kara sinsoo o higaisya ni tutaete hosikatta.

21. TO Kinoo sensee wa dansi wa suugaku ga yoku dekiru to itta.

22. D Hontoo wa watasi wa Mittyeru-san kara ronbun no matigai o sitekisite hosikatta.

23. CO Guriin-san wa syuumatu ni Ikebukuro de tomodati ni atte hon o katta.

24. GO Kesa Kuraaku-san wa tikaku no biyooin de kami o settosite kita.

25. CL Asita kaigi de tyoosa no kekka o hookoku suru no wa Zyonson-san da.

26. CO Paamaa-san wa gozentyuu ni bunbooguten de syorui o kopiisite zimusyo ni todoketa.

27. S Adamusu san wa kinoo tomodati no baiku o tonari no hee ni butuketa.

28. RCL Doyoobi ni Hakone de marason ni sankasita Sukotto-san wa asi o itameta.

29. GR Kinoo Sumisu-san wa kozukai o inaka no hahaoya ni okutte agera.

30. GO Gozentyuu ni Buraun-san wa ekimae no yuubinkyoku de sokutatu o dasite kita.

31. TO Zyeemusu-san wa dooryoo ni syatyoo ga asita hikooki de kaeru to tutaeta.

32. CA Adamusu-san wa tomodati ni sensyuu syakaika no repooto o zyuumai kakaseta.

33. NO Paamaa-san wa seerusuman ga sinsya no atukaikata o setumeesuru no o kiita.

34. RCE Howaito-san wa kodomo ga sensyuu yama de kowasita kamera o syuurisita.

35. RCL Kooen o asa hayaku inu to sanposita Zyonson-san wa saihu o hirotta.

36. KOTO Miraa-san wa Nihongo no keego ga hizyoo ni muzukasii koto o satotta.

37. IC Tyuusyokugo Buraun-san wa nikai no kaigisitu de buka no hookokusyo o yomi hazimeta.

38. NO Kuraaku-san wa tomdati ga sengetu huyuyama de soonansita no o sitta.

39. IC Hookago Teeraa-san wa tonari no kyoositu de siken no ayamari o naosi hazimeta.

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