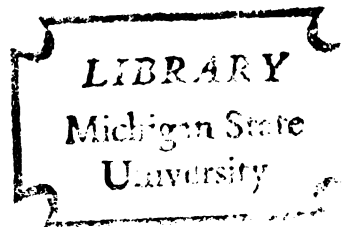


MEMORY FOR LINGUISTIC MATERIALS

Thesis for the Degree of Ph. D.
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SANDRA ELAINE GRAHAM
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This is to certify that the
thesis entitled

MEMORY FOR LINGUISTIC MATERIALS

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Sandra Elaine Graham

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ABSTRACT
MEMORY FOR LINGUISTIC MATERIALS

By
Sandra Elaine Graham

Two experiments were conducted to assess the effects of surface structure complexity and deep structure complexity on the recall of linguistic materials. It was hypothesized that surface structure complexity would influence short term memory (STM) in that more complex surface structures should require more time to be constructed in STM than less complex surface structures. The hypothesis was tested in a within subject design using two types of phrases which differed only in their surface structure complexity. An overflow test was employed on the assumption that the more complex phrases would require more analysis time and that fewer of the items following the phrase would then be recalled. The results showed no difference in recall of the phrases or in recall of the items which followed them.

A second hypothesis considered was that the complexity of the deep structure would influence short term retention of linguistic materials in that more complex deep structures would require more analysis time in a long term

Sandra Elaine Graham

memory access loop postulated to be present in STM, and thus require the surface structure input to be held longer in STM than would a sentence with a less complex deep structure. Deep structure complexity and presentation rate were manipulated in a between subject 2x2 factorial design using two types of sentences, which differed only in deep structure complexity, and presentation rates of two and four seconds. A 128 seconds number shadowing interference task was used between presentation of a sentence and recall. The results showed deep structure complexity but not presentation rate to have a significant ($p < .01$) effect on the number of sentences recalled. The results suggested that subjects were able to obtain the same number of words from the surface structure input for both types of sentences, but that for those sentences labeled as more complex, it was significantly more difficult to construct the deep structure and obtain the meaning of the sentence.

MEMORY FOR LINGUISTIC MATERIALS

By

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TABLE OF CONTENTS

	Page
LIST OF TABLES	iv
INTRODUCTION	1
EXPERIMENT I	9
Method	
Results and Discussion	
EXPERIMENT II	14
Method	
Results and Discussion	
GENERAL DISCUSSION.....	24
LIST OF REFERENCES	27
APPENDIX A Transformational history of noun phrases used in Experiment I.....	29
APPENDIX B Noun phrases and strings of words used in Experiment I	32
APPENDIX C Grammar pre-test for Experiment I	33
APPENDIX D Raw data Experiment I	34
APPENDIX E Surface and deep structures of Experiment II sentences	36
APPENDIX F Sentences used in Experiment II	38
APPENDIX G Mean number of errors per sentence in Experiment II	39
APPENDIX H Raw data Experiment II	40

1. *Journal of the American Medical Association*, 1997; 277: 1033-1038.

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LIST OF TABLES

Table	Page
1. Means and standard deviations for the number of sentences and the number of words recalled...	17
2. Means and standard deviations for the number of errors made by each condition	20
3. Percentages of the total errors of the various classes made by each condition	21

INTRODUCTION

The study of memory for linguistic materials has generally been an effort to demonstrate the psychological reality of the linguistic concepts of surface structure and deep structure. Toward this end a number of investigators have reported evidence which they feel demonstrate the influence of surface structure on sentence retention (Martin & Roberts, 1966; Martin, Roberts, & Collins, 1968; Roberts, 1968; and Wearing, 1970). These investigators have hypothesized a direct relationship between the ease of recall of a sentence and its surface structure complexity. "Yngve" numbers (Yngve, 1960; Martin & Roberts, 1966), which are the average of the number of left branches leading to a terminal element (word) in the phrase structure tree, have been used to assess the complexity of the surface structure. In general, the above investigators have found that the simpler the surface structure, the greater the probability of recalling the sentence. Martin and Roberts (1966), Perfetti (1969 a, b), and Wright (1969), however, have not been able to obtain the hypothesized relationship between surface structure complexity and sentence recall.

Adding to this confusion are the studies which assess surface structure complexity in terms of number of

right-branches and number of self-embedded sentences contained in a sentence (Miller & Isard, 1964; and Foss & Cairns, 1970). These studies have found that the larger the number of right branches or self-embedded sentences, that is the more complex the surface structure, the more difficult it becomes for subjects to recall the sentence (number of words, meaning, and deep structure held constant. Foss and Cairns (1970) argued that increasing sentence complexity made it more difficult to rehearse and store linguistic materials. They also argued that linguistic materials which were not rehearsed and stored (unanalyzed) were forgotten more rapidly than materials which had been analyzed. Foss and Cairns tested this hypothesis by having subjects recall right-branching and self-embedded sentences, prefacing recall with a list of words which were to be recalled or read out loud. The reading or recall of the list of words was used to interrupt rehearsal of the sentence. Their results supported their hypothesis. Foss and Cairns concluded that when a sentence is heard/read it is first analyzed in terms of surface structure.

For the most part these above investigators have held that surface structure complexity alone would account for the observed differences in sentence memory. However, not all investigators agree with them. Mehler (1963), Savin and Perchonock (1965), Rohrman (1968), and Davidson (1969) have suggested that the likelihood of recall of a sentence

is directly related to the complexity of the deep structure. The index of complexity in all but Rohrman's study has been the number of transformations needed to transform deep structure into surface structure.

Rohrman (1968) used the complexity of the deep structure base as his complexity measure. He found that the ease of recall was directly related to the complexity of the deep structure base and was unaffected by surface structure complexity or number of transformations. However, Rohrman's results have been shown to be artificial by Rohrman (1970) and Paivio (1971). Rohrman (1970) upon further testing with his materials demonstrated that the transitive-intransitive dimension had been confounded with the complexity of the phrases in his previous study. His more complex phrases all contained transitive verbs while the less complex ones all contained intransitive verbs. When he controlled for deep structure complexity and varied the type of verb, intransitive phrases were recalled more often than transitive phrases. Paivio (1971) has shown that Rohrman's earlier results (1968) can also be accounted for in terms of imagery value. Rohrman's simpler phrases were higher in imagery value than his complex phrases.

Nevertheless, Mehler and Carey (1967) have reported results which do argue for the psychological reality of deep structure. Subjects were presented sentences which could be accurately heard only fifty percent of the time. Nine sentences which did not differ in deep structure or in

surface structure were presented to subjects for immediate recall. A tenth sentence was then presented which had the same surface structure as the preceding nine sentences but a different deep structure. The change in the deep structure of the final sentence was found to make its recall more difficult. These results suggest that a set for deep structure was established during the first nine sentences, and argue for the psychological reality of deep structure.

In all the above studies, surface structure and deep structure have been treated as if they were independent concepts, and as if only one could be involved in sentence memory. However, the model (Chomsky, 1957; 1965) in which these concepts were first suggested treats them as related subcomponents of the syntactic component. As such, surface structure and deep structure should be related in any attempt to account for sentence memory.

Miller and Chomsky (1963) have sketched a model of sentence memory which entails both surface structure and deep structure. They proposed that short term memory (STM) processes the surface structure of a sentence symbol by symbol as it is received and then transmits the resulting string to long term memory (LTM). In other words, in STM subjects construct the terminal phrase marker which corresponds to the surface structure and it is this phrase marker that is transmitted to LTM. The LTM contains a generative grammar of the language and determines the deep structure and hence the meaning of the string received from STM.

Neisser (1966) has proposed a model of cognition which postulates processes which are very similar to those of Miller and Chomsky. Neisser proposed a two stage model. The initial stage of perception or cognition is a short transient stage called iconic memory (for visual stimuli). During this initial stage of iconic memory an image of the visual input is constructed by the subject and briefly stored. This image is subject to rapid decay. If it is not processed by the next stage of active verbal memory, the information contained in the image is lost. (A similar process called echolic memory is postulated to handle auditory stimuli.)

The active verbal memory is the short term store where the information from the iconic image is synthesized into the cognitive counterpart of the physical stimulus and then rehearsed until the subject is required to reproduce the verbal stimulus. For the active verbal memory to carry out this synthesis it must have access to the long term store where the grammar of the language with its lexicon is stored. Otherwise, the reproduction would be merely a simple echo response.

Miller and Chomsky's proposal lends itself to the following interpretation in light of Neisser's model. Surface structure complexity should affect both iconic memory and active verbal memory. The more complex the surface structure, the more difficult it should be for subjects to form and hold the image in the iconic memory and to then

construct the surface structure. However, the effect of deep structure complexity is more complicated. The deep structure may be processed either directly by the LTM processes or through the active verbal memory's LTM loop. Which route is used is most likely controlled by the kind of task subjects are faced with. If subjects are required to store the information for distant future use, the active verbal memory could be by-passed. If, however, subjects are asked to recall the material within a brief period of time, the active verbal memory route most likely is used.

When the information is being stored for future use, the complexity of the deep structure should affect memory by making it more difficult to extract the information as the complexity increases. When the task requires subjects to use the active verbal memory route, deep structure complexity should affect memory for linguistic materials by increasing the analysis time in the LTM loop as the complexity of the deep structure increases. The increasing analysis time should necessitate holding the surface structure in the active verbal memory for increasing lengths of time because the surface structure is the information source for the analysis. When rehearsal is interfered with, the effect of deep structure complexity should become apparent.

The present study was intended to test two hypotheses generated by the Miller-Chomsky proposition and Neisser's model. First, surface structure complexity should have an effect on recall of linguistic materials when

presentation rates are fast because as the complexity of the surface structure increases, more time should be required by the active verbal memory to construct the surface structure prior to feeding it into the LTM loop. With short exposure times, less of the complex surface structure should be constructed and thus there would be less available information for the meaning analysis and subsequent recall. An overflow test (Epstein, 1969), which requires subjects to recall the critical material plus some extra items, was used to test this hypothesis on the assumption that if the more complex surface structure required more time for construction, then fewer of the additional items should be processed through the active verbal memory.

The second hypothesis proposed that the complexity of the deep structure should influence reproduction of linguistic materials when rehearsal of the surface structure input is interfered with shortly after exposure of the materials. A delayed recall task with a demanding intervening task was used on the basis of two assumptions. First, it was assumed that the nature of the task would require subjects to process the sentence via the LTM loop of the active verbal memory. Second, it was assumed that the deep structure of a simple sentence would be processed farther than that of a complex sentence by the time that the intervening task interfered with the subjects's ability to hold the surface structure input in the active verbal memory. Hence, recall of the

simpler sentence should be better. An interaction of presentation rate and deep structure complexity was predicted.

EXPERIMENT I

Method

Design and materials. The effect of surface structure complexity of noun phrases on the immediate recall of the phrases was tested in a within-subjects-design which varied the complexity of the surface structure of the noun phrases while holding the deep structure complexity constant. Noun phrases of the type, S (simple) "yellow growing lions" and C (complex) "yellow lions growing," which have the same deep structure and equal number of words in the surface structure but differ in surface structure complexity, were used. (See Appendix A for surface structure trees and derivational history of the noun phrases.) The ratio of the number of nodes in the surface structure phrase marker tree to the number of terminal elements ("words") was used to compare surface structure complexity of the noun phrases (Miller & Chomsky, 1963). Using this method, simple noun phrases have a 2.0 ratio while complex noun phrases have a 2.66 ratio. Twelve pairs of noun phrases were used with twelve random strings of eight words each which had Thorndike-
Large frequency ratings of A and AA (see Appendix B).

Procedure. Sixteen Michigan State University undergraduates from introductory psychology classes served as subjects in fulfillment of class requirements. Subjects

were first given a grammar pre-test. They were presented a list of 16 three-word-strings, half of which were sentences and half of which were noun phrases, on a single sheet of paper (see Appendix C). Next to each string was printed the words "sentence" and "phrase". For each string subjects were asked to indicate whether they thought the string was a sentence or a phrase by circling the appropriate word. This test was to assess any tendency on the part of the subjects to treat the noun phrases in Experiment I as sentences.

Following the pre-test, subjects were told that a three-word-phrase followed by eight words would be flashed on the screen. They were instructed to try to determine what the phrase was and to then determine as many of the words as they could. Emphasis was placed on retaining the phrase even if this reduced the number of words they could recall and on recalling the phrase before the words. In an effort to obtain recall in the desired order, phrase then string of words, subjects wrote their recall in booklets in which they were required to write the phrase on one page and then to turn to the next page to write the string of words.

The noun phrases were selected such that half of the subjects viewed six simple and six complex phrases with only one member of each of the twelve pairs being selected. The other half of the subjects viewed the six simple and six complex phrases which the other subjects had not seen. (That is, one group of subjects saw the phrase "yellow growling lions" while the other group saw the phrase "yellow lions

growling".) The noun phrases were presented in a random order on black and white slides printed in capital letters. The strings of eight words were also presented on slides, two words per slide. The slides were flashed at a two second rate using a slide projector which provided a one second effective viewing time per slide. Total time for each phrase + string was ten seconds. Subjects were given one minute for recall immediately following presentation of each phrase + string. After all the phrases had been presented subjects were asked to attempt a final recall of the phrases.

Results and Discussion

The mean number of correct responses to the grammar pre-test was 14.13 which was significantly better than chance performance, $t(15) = 5.31$, $p < .001$. Subjects were able to distinguish three-word-phrases from three-word-sentences. Hence, it seems reasonable to assume that they treated the three-word-strings of the experiment as phrases and not as sentences.

While correct recall of the phrases was emphasized in the instructions, none of the subjects succeeded in recalling all of the phrases during the immediate recall task. The mean number of simple noun phrases recalled was 3.87 and the mean number of complex noun phrases recalled was 4.06. The difference was not significant, $t(15) = 0.306$, $p > .05$. That recall of the phrases, with eight seconds intervening between exposure and recall, was less than perfect may be due to interference with rehearsal of the phrase produced by

processing the words of the string.

The mean total number of words recalled after correct simple noun phrases was 14.0 and after correct complex noun phrases 11.5. The difference was not significant, $t(15) = 0.819$, $p > .05$. The mean number of phrases recalled on the final recall test was 0.93 for the simple noun phrases and 1.62 for the complex phrases. This difference was also not significant, $t(15) = 1.699$, $p > .05$.

The results of the present study do not permit the acceptance of the hypothesis that surface structure complexity affects the active verbal memory process. Both types of phrases were recalled equally well and had similar levels of recall for the strings of words. This failure to find a difference, on the one hand, suggests that for these pairs of phrases there was no difference in surface structure complexity. The findings, thus, do not necessarily mean that surface structure complexity does not influence memory for linguistic materials. Nor do they necessarily conflict with previous findings which have supported the hypothesis that surface structure complexity does influence the recall of linguistic materials. While these studies (Martin & Roberts, 1966; Martin, Roberts, & Collins, 1968; Roberts, 1968; and Wearing, 1970) have used exposure rates which have been as long or longer than the one employed in the present study, they have also used more complex linguistic materials: sentences as opposed to phrases. On the other hand, if the initial assumption that the phrases did differ in surface

structure complexity is retained, then there is no alternative but to reject the hypothesis and conclude that surface structure complexity does not influence reproduction of linguistic materials.

The evidence from the first experiment does not permit a choice to be made between these two positions. The results of the following study do permit some conclusions as to the appropriateness of transformational theory to memory for language materials.

EXPERIMENT II

The purpose of Experiment II was to assess the effect of deep structure complexity and presentation rate on sentence recall. The assumption was made that the delayed recall task would require subjects to process the sentence via the LTM loop of the active verbal memory rather than directly processing it in the long term memory because they were asked to attempt exact reproductions rather than to produce a sentence of similar meaning. Given that such an assumption holds, the hypothesis under consideration predicted that the deep structures of simple sentences would be processed farther than those of complex sentences by the time that the intervening task interfered with subjects' ability to hold the surface structure input in the active verbal memory and, thus, affect the ability of the subjects to reproduce the sentence. This hypothesis also assumes that the surface structure input must be held for the time required to analyze the deep structure or the analysis would be incomplete. This seems reasonable in that the surface structure is the only source of information input on which the analysis can be based.

Method

Materials and design. Two types of nine-word

sentences were used. Both had surface structures of equal complexity but varied in the complexity of the deep structure bases (see Appendix E). The complexity of the surface structures was measured by taking the ratio of the number of nodes in the surface structure phrase marker to the number of terminal elements ("words"). Both types of sentences had surface structure complexity ratios of 2.0. The complexity of the deep structures was measured by taking the ratio of the number of nodes in the deep structure base to the number of terminal elements (complex symbols) in the deep structure base. Sentences of the form, "The women baking the bread say it is good." (simple sentence - S), had a deep structure complexity ratio of 2.5. Sentences of the form, "The explorers mapping the island found rich buried treasure." (complex sentence -C), had a deep structure complexity ratio of 3.1. Thus, the latter sentence was more complex in its deep structure than the former sentence. Eight sentences of each type were constructed (see Appendix F).

Sentence type and presentation rate were manipulated in a 2x2 factorial-between-subjects design. The two sentence types were combined with presentation rates of two seconds and four seconds to yield four conditions to which subjects were assigned. In one condition, subjects were presented simple sentences for two seconds per sentence (Condition S-2). In a second condition, subjects were presented simple sentences for four seconds per sentence (Condition S-4). In a third condition, subjects were presented complex

sentences for two seconds per sentence (Condition C-2). In the fourth condition, subjects were presented complex sentences for four seconds per sentence (Condition C-4). All subjects were given two trials on each sentence.

Procedure. Twenty-eight Michigan State University undergraduates from introductory psychology classes served as subjects in fulfillment of class requirements. Subjects were assigned randomly to conditions with seven subjects per condition. Subjects were tested individually. Sentences were presented on a memory drum for either two or four seconds. After each sentence was exposed, subjects were asked to read aloud strings of random numbers which were presented on the drum at either the two or four second rate for 128 seconds. Each time the drum turned two lines of 18 numbers each appeared in the window and subjects were then asked to orally recall the sentence. Subjects were given a second complete trial on each sentence. Protocols were scored for the number of sentences correct, the total number of words correctly recalled, and the kinds of errors made.

Results and Discussion

The means and standard deviations for the number of sentences and total number of words recalled are presented in Table 1. The analysis of variance for number of correct sentences revealed significant effects due to deep structure complexity, $F = 8.65$, $df = 1/24$, $p < .01$, and trials, $F = 67.68$, $df = 1/24$, $p < .001$. Presentation rate did not have a significant effect nor were any of the

Table 1

Means and standard deviations for the number
of sentences and the number of words recalled.

Number of Sentences recalled			
Condition		Trial 1	Trial 2
S-2	M	3.86	6.00
	SD	2.29	1.31
S-4	M	3.57	6.86
	SD	1.68	0.97
C-2	M	0.86	4.57
	SD	0.99	2.61
C-4	M	2.14	5.71
	SD	1.36	1.96

Total Number of Words Recalled			
Condition		Trial 1	Trial 2
S-2	M	59.57	68.71
	SD	6.94	2.71
S-4	M	61.57	70.14
	SD	3.98	1.39
C-2	M	48.00	62.29
	SD	9.75	10.81
C-4	M	56.29	68.43
	SD	8.75	4.08

interactions significant. The analysis of variance for the total number of words recalled revealed significant effects due only to deep structure complexity, $F = 5.79$, $df = 1/24$, $p < .05$, and trials, $F = 107.30$, $df = 1/24$, $p < .001$.

The hypothesis that sentences with more complex deep structures take longer to be analyzed by the LTM loop of active verbal memory was supported. The results suggest that the intervening task interfered with subjects' ability to hold the surface structure input in active verbal memory while the deep structure was analyzed in the LTM loop. The more complex the deep structure the longer the analysis time required, and thus less of the complex sentence had been analyzed when subjects' rehearsal of the input was interfered with. The result was poorer recall of the complex sentences.

A main effect due to presentation rate was not found. It had been predicted that recall would be worse at the two second rate for both simple and complex sentences with the effect being more pronounced for complex sentences. Separate analyses of variance for both types of sentences indicated that there was no difference in the number of simple sentences recalled at either rate nor was there a significant difference in the number of complex sentences recalled at either rate. This suggests that subjects were able to process as much of the sentence as they could in two seconds with the additional two seconds possibly providing a brief rehearsal of the processed material.

The number of words correctly recalled were collapsed over presentation rate. The mean number of words recalled from simple sentences was 60.5 and 69.4 for Trial 1 and Trial 2, respectively. The mean number of words recalled from complex sentences was 52.1 and 65.3 for Trial 1 and Trial 2, respectively. On Trial 1, significantly more words were recalled from simple sentences than from complex sentences, $t(26) = 2.44$, $p < .025$. On Trial 2, the difference was not significant, $t(26) = 1.54$, $p > .05$.

These results indicate that subjects were able to determine more of the surface structure input of simple sentences on the first presentation than of the complex sentences. Subjects viewing simple sentences had more information on which to base their deep structure analysis which resulted in better recall of simple sentences on Trial 1. On Trial 2, subjects under all conditions were able to add to this initial information in the same amount. However, the difference in reproduction of correct sentences indicates that subjects were better able to analyze the deep structure of the simple sentences than of the complex sentences. This suggests that the deep structure of the more complex sentences required more time for analysis in the LTM loop of the active verbal memory.

In an attempt to clarify the above findings, the number and kinds of errors made were considered. The mean number of errors per condition are presented in Table 2. An analysis of variance revealed significant effects due to

Table 2
Means and standard deviations for the
number of errors made by each condition.

Condition		Trial 1	Trial 2
S-2	M	7.71	3.14
	SD	3.70	3.96
S-4	M	8.00	2.14
	SD	3.54	1.64
C-2	M	10.86	7.28
	SD	4.42	6.94
C-4	M	9.42	3.14
	SD	2.95	3.34

Table 3
Percentages of the total errors of the
various classes made by each condition.*

Classes of errors		Conditions			
		S-2	S-4	C-2	C-4
Deletions	Trial 1	22.22	21.43	48.68	40.90
	Trial 2	18.18	6.67	23.53	36.36
Extraneous intrusions	Trial 1	38.88	33.93	28.95	28.79
	Trial 2	36.36	3.33	37.26	22.73
Experimental intrusions	Trial 1	18.52	16.07	6.58	16.67
	Trial 2	18.18	13.33	17.65	9.09
Tense	Trial 1	11.11	10.71	1.32	3.03
	Trial 2	13.64	20.00	5.88	9.09
Additions	Trial 1	7.41	3.57	0.00	0.00
	Trial 2	9.09	0.00	1.96	0.00
Structural changes	Trial 1	1.85	12.50	13.16	7.57
	Trial 1	4.55	26.66	13.73	22.73
Number	Trial 1	0.00	1.78	0.00	3.03
	Trial 2	0.00	0.00	0.00	0.00

*See Appendix H for raw data.

deep structure complexity, $F = 7.71$, $df = 1/24$, $p < .025$, and trials, $F = 18.24$, $df = 1/24$, $p < .001$. Presentation rate was again not a significant factor nor were any of the interactions significant. These results also indicate the effect of deep structure complexity on sentence memory as more complex sentences had more errors in recall than simple sentences. However, they do not clarify the previous findings in regard to the failure to find an effect due to presentation rate.

The percentages of the total errors made by each condition, which the classes of errors represent, are presented in Table 3. The errors were categorized into seven classes: deletions in which one or more words were missing from the sentence; extraneous intrusions which were the substitution of non-experimental words for words in the sentence; intrusions of experimental words from other experimental sentences into the sentence; tense which was a change in the tense of the sentence or any phrase; additions which were the addition of extra words to the sentence; structural changes which changed the structure of the sentence in some way other than through the addition of words; and number changes which were changes in the number of the nouns. (More than one error could occur per sentence with up to five errors being found in one sentence (see Appendix G).) Deletions and extraneous intrusions were the most prevalent types of errors made. This is in line with the previous findings. The higher percentages of deletions suggests incomplete acquisition of

information and analysis while the extraneous intrusions indicate attempts to "fill in" the blanks in the unfinished constructions. Experimental intrusions were also high. This is most likely due to confusion of sentences by the subjects. The sentences of each type being all structurally the same would easily permit substitution of words among sentences. without making them structurally impossible.

Generally, the results of this experiment indicate that deep structure complexity does affect the processing and subsequent recall of sentences. It is contended here that deep structure complexity influences reproduction of linguistic materials by influencing the amount of time needed for analyzing the sentence in the LTM loop of the active verbal memory. It should be pointed out that this is an observed effect for verbatim recall over a fairly short retention interval. Whether or not deep structure complexity would influence the recallability of linguistic materials that are initially processed for long term storage and use, is a question which cannot be answered from these data.

GENERAL DISCUSSION

The results of the present studies do not unequivocally support surface structure and deep structure factors in memory for linguistic materials. They do suggest that surface structure complexity will have little influence on subsequent reproduction of the materials if the structures are acceptable grammatical constructions. One major difference between the present study and studies such as Miller and Isard's (1964), who have found a surface structure effect, is that their complex surface structures, which resulted in lower recall scores, were also highly unacceptable although grammatical constructions. In the present study, the phrases used were grammatical and acceptable. Perhaps, then, in regard to surface structure, acceptability of the structure would be a better predictor than complexity.

The results also indicate that deep structure complexity will influence reproduction of linguistic materials. It is argued that this is done through the amount of time required for construction of the deep structure in a LTM loop. Addition of this long term memory loop may seem to complicate the active verbal memory unnecessarily as direct access to the LTM linguistic store is also postulated. However, without such a loop, any short-term reproduction (reproduction within the same experimental session) would have to be

considered echolic as no means of attaining meaning would be provided.

The question still remains, however, as to the psychological usefulness of concepts such as surface structure and deep structure. Something akin to these linguistic concepts must exist psychologically for the distinctions made by Chomsky in his well worn examples of syntactic ambiguity and syntactic paraphrase to be evident to speakers of human languages. The fact that such distinctions can be made by speakers is evidence to support the need for some kind of psychological structure which performs this function. Also arguing for a psychological counterpart of linguistic grammar (set of rules) is the variability and novelty found in language which can only reasonably be account for through the use of a set of rules - a grammar. The evidence on the development of language also suggests the necessity of a rule system.

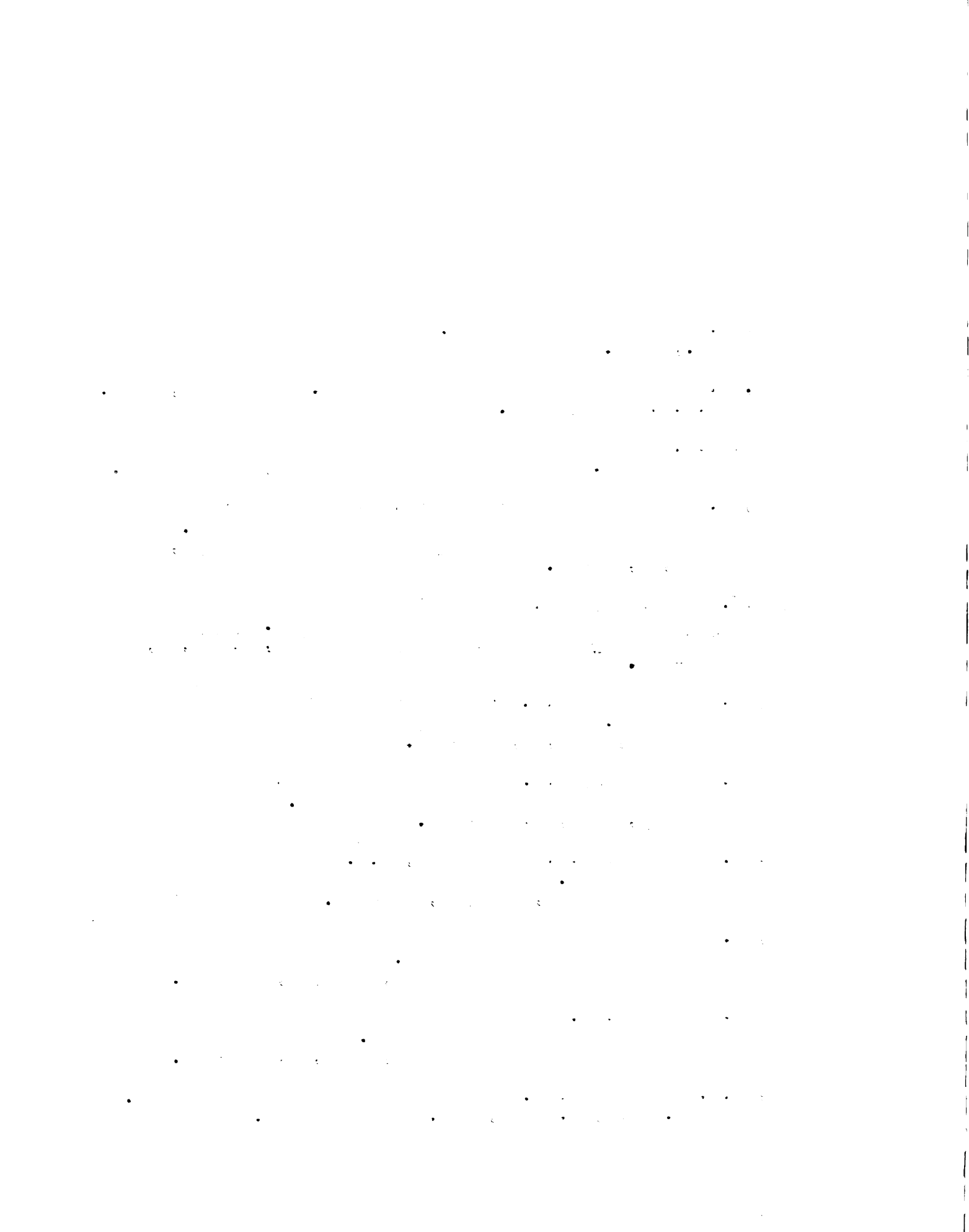
All these pieces of evidence point to the need for a psychologically real grammar which in some way conforms to the Chomskian grammar. Why then are the results of studies of the psychology of grammar so contradictory and unclear? Perhaps the answer lies in the fact that for the most part the study of language has concentrated on syntax. While the surface structure and deep structure components may be necessary, it may not be possible to understand and observe their functioning as purely syntactic entities. Indeed, as syntactic entities they may not exist

psychologically but only have existence when considered in regard to their influence on the meaning of linguistic utterances. Thus, it would seem necessary to understand the semantic system - how meanings are acquired and stored - before the existence and influence of such structures can adequately be assessed.

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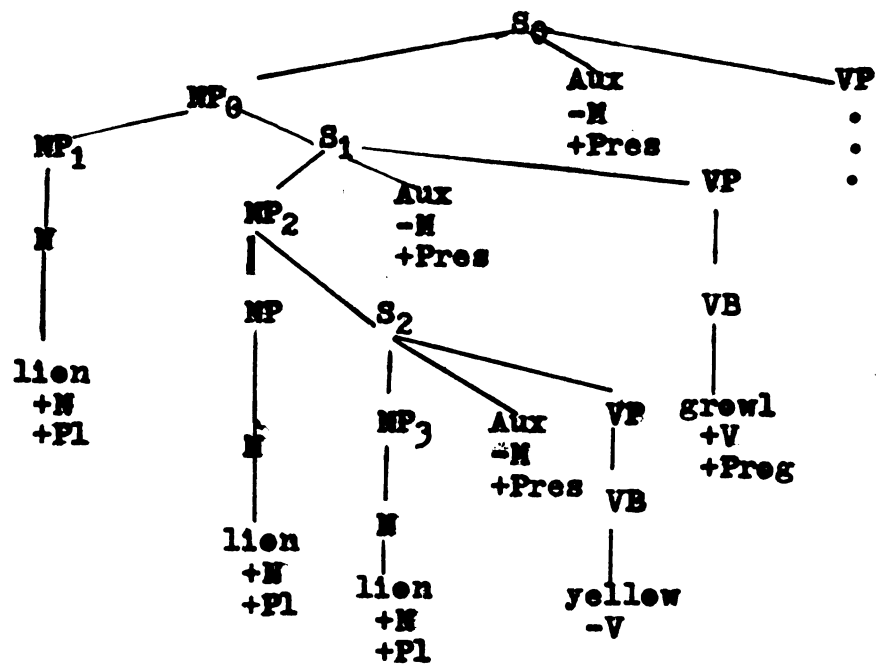
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APPENDICES

APPENDIX A

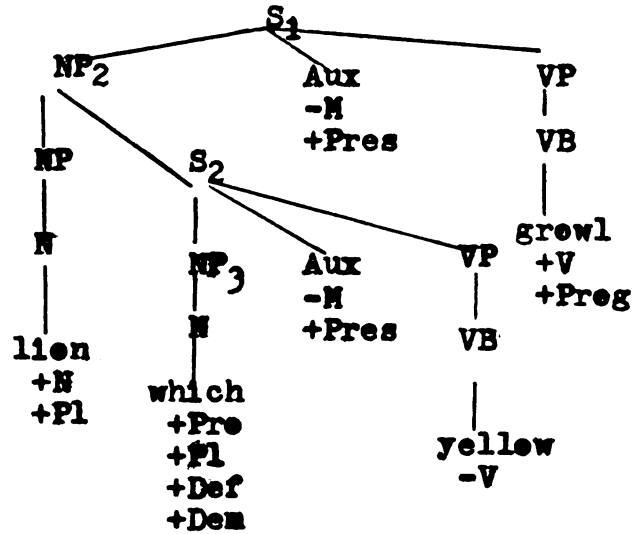
Transformational history of noun phrases used in Experiment I.

Example: yellow growling liens; yellow liens growling

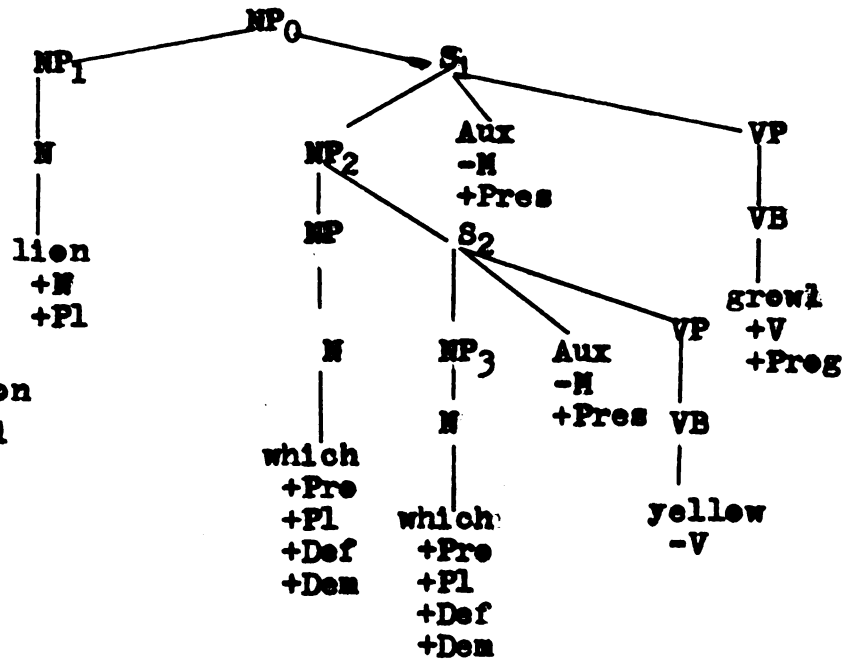


Deep Structure

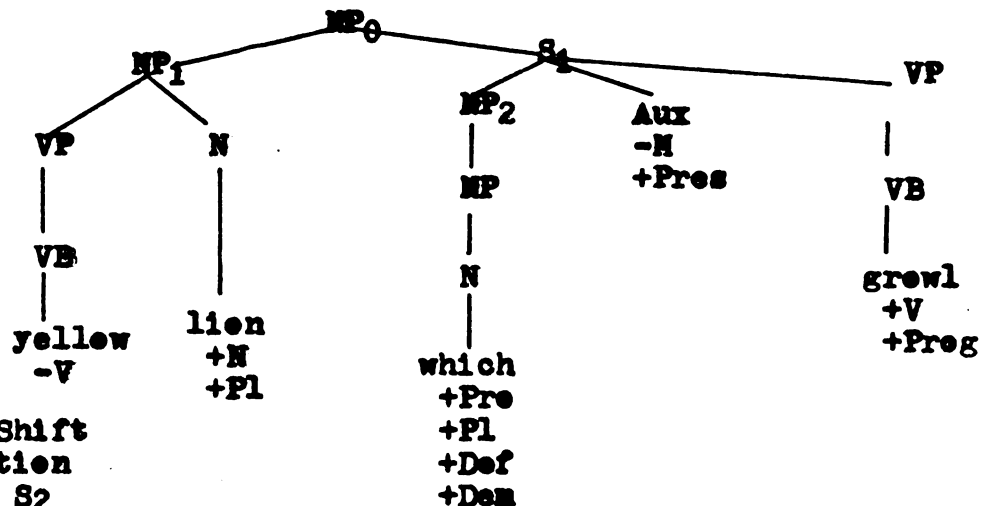
Relative
Transformation
applied to S₂

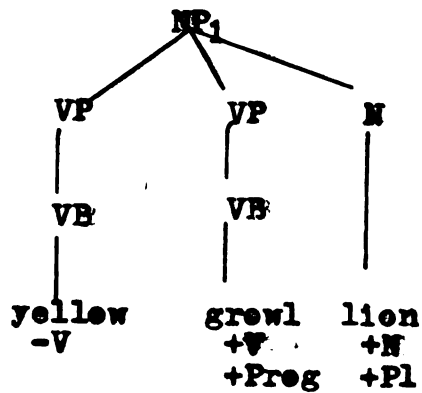


Relative
Transformation
applied to S₁

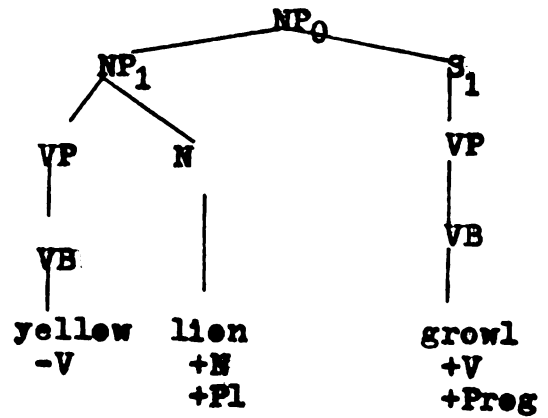


Adjective Shift
Transformation
applied to S₂

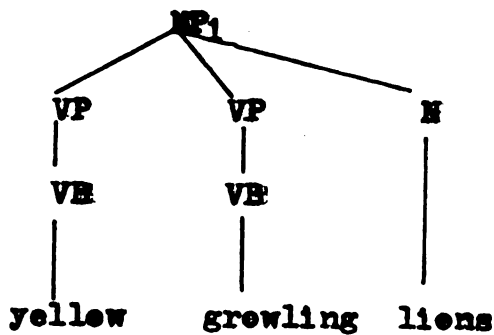




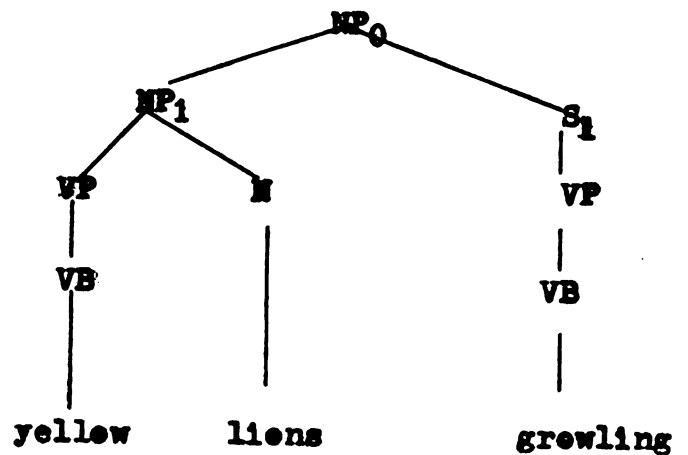
Adjective Shift
Transformation
applied to S_1



Relative Clause Reduction
Transformation applied
to S_1



Simple Phrase



Complex Phrase

Noun Affix and Progressive Affix Transformations
applied to both structures to generate the surface
structures.

APPENDIX B

Noun phrases and strings of words used in Experiment I.

Noun Phrases		Word Strings
Simple:	bright blinding lights	decline joy garden wage
Complex:	bright lights blinding	nail oak object pack
Simple:	strict demanding parents	feed vote office gas
Complex:	strict parents demanding	need add lay knief
Simple:	fierce barking dogs	hard safe up only
Complex:	fierce dogs barking	nest jump future put
Simple:	slim dancing girls	pause here band fate
Complex:	slime girls dancing	elect hat adopt castle
Simple:	fat preaching monks	open sold what yard
Complex:	fat monks preaching	rush duty kill earth
Simple:	yellow growling lions	feature ready virture wave
Complex:	yellow lions growling	tea said uncle able
Simple:	black running cats	nose hely each palace
Complex:	black cats running	vast dead bank teeth
Simple:	famous performing artists	guide utter visit tape
Complex:	famous artists performing	large bar keep sat
Simple:	happy playing children	test get wander handle
Complex:	happy children playing	danger ill wide knock
Simple:	peiseneus hissing snakes	half lack equal child
Complex:	poisonous snakes hissing	empire else saw tender
Simple:	strong invading armies	wait join yield afford
Complex:	strong armies invading	dash care final bee
Simple:	green wriggling tadpoles	yet wash you editor
Complex:	green tadpoles wriggling	health park knee name

APPENDIX C

Grammar pre-test for Experiment I

SNARLING TIGERS KILL	SENTENCE	PHRASE
HOUNDS ARE BAYING	SENTENCE	PHRASE
INVESTIGATIONS ARE REVEALING	SENTENCE	PHRASE
STRONG RECURRING ILLUSIONS	SENTENCE	PHRASE
LOUD ALARMS RINGING	SENTENCE	PHRASE
FLYING BIRDS SING	SENTENCE	PHRASE
ZEALOUS EXPLORERS COLONIZING	SENTENCE	PHRASE
MASSES WERE CLAMORING	SENTENCE	PHRASE
POWERFUL REIGNING KINGS	SENTENCE	PHRASE
SPOTLESS KITCHENS GLEAMING	SENTENCE	PHRASE
DECREPIT CREAKING CHAIRS	SENTENCE	PHRASE
WOODEN HOUSES BURN	SENTENCE	PHRASE
SMALL BOYS WHISTLING	SENTENCE	PHRASE
RULES ARE FRUSTRATING	SENTENCE	PHRASE
PASSIONATE CONSUMING LOVE	SENTENCE	PHRASE
DARING MEN FLY	SENTENCE	PHRASE

APPENDIX D

Raw data Experiment I

Grammar Pre-test

<u>S</u>	Number of correct identifications
1	15
2	14
3	16
4	16
5	16
6	16
7	16
8	16
9	15
10	15
11	14
12	16
13	16
14	15
15	14
16	12

Immediate Recall Test

<u>S</u>	Number of Phrases Correct		Number of Words Recalled after Correct Phrases	
	Simple	Complex	Simple	Complex
1	4	6	16	18
2	5	3	22	8
3	6	6	22	15
4	3	5	10	14
5	2	4	6	11
6	2	5	4	8
7	2	5	9	22
8	2	6	18	6
9	5	4	18	11
10	5	4	12	13
11	3	3	7	12
12	4	1	14	5
13	6	3	25	11
14	5	4	20	20
15	2	4	3	5
16	6	2	18	5

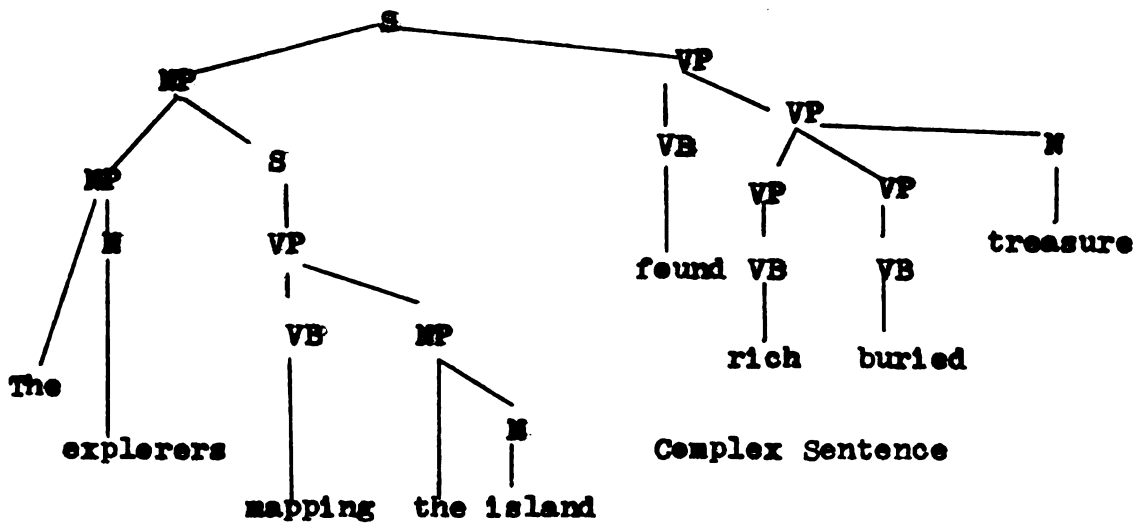
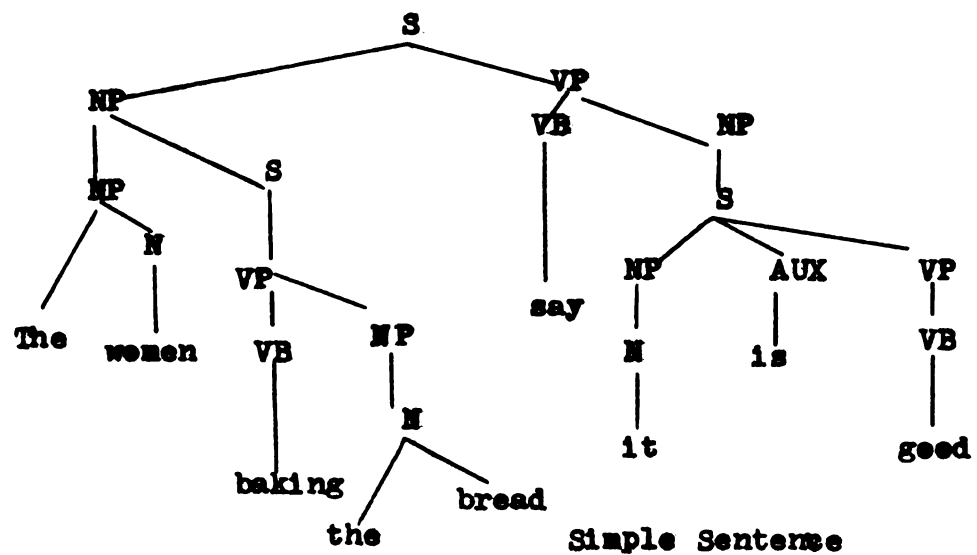
Final Recall Test

<u>S</u>	Number of Phrases Recalled	
	Simple	Complex
1	1	1
2	3	1
3	0	1
4	1	2
5	1	1
6	2	2
7	0	2
8	0	1
9	0	3
10	0	3
11	0	2
12	3	0
13	1	2
14	2	2
15	0	2
16	1	1

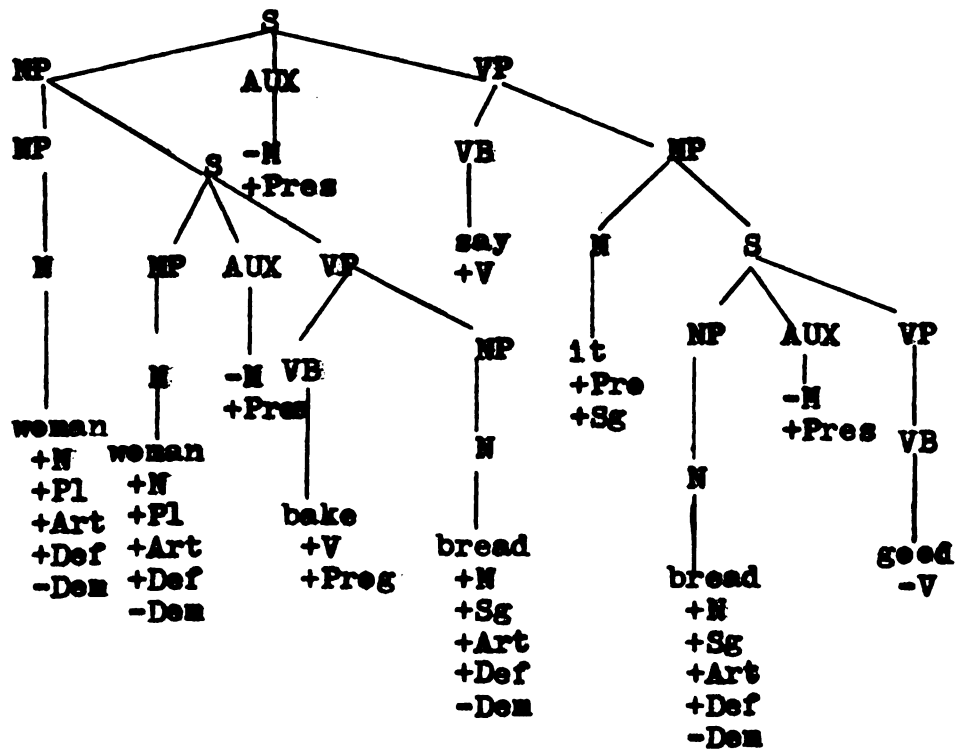
APPENDIX E

Surface and deep structures of Experiment II sentences.

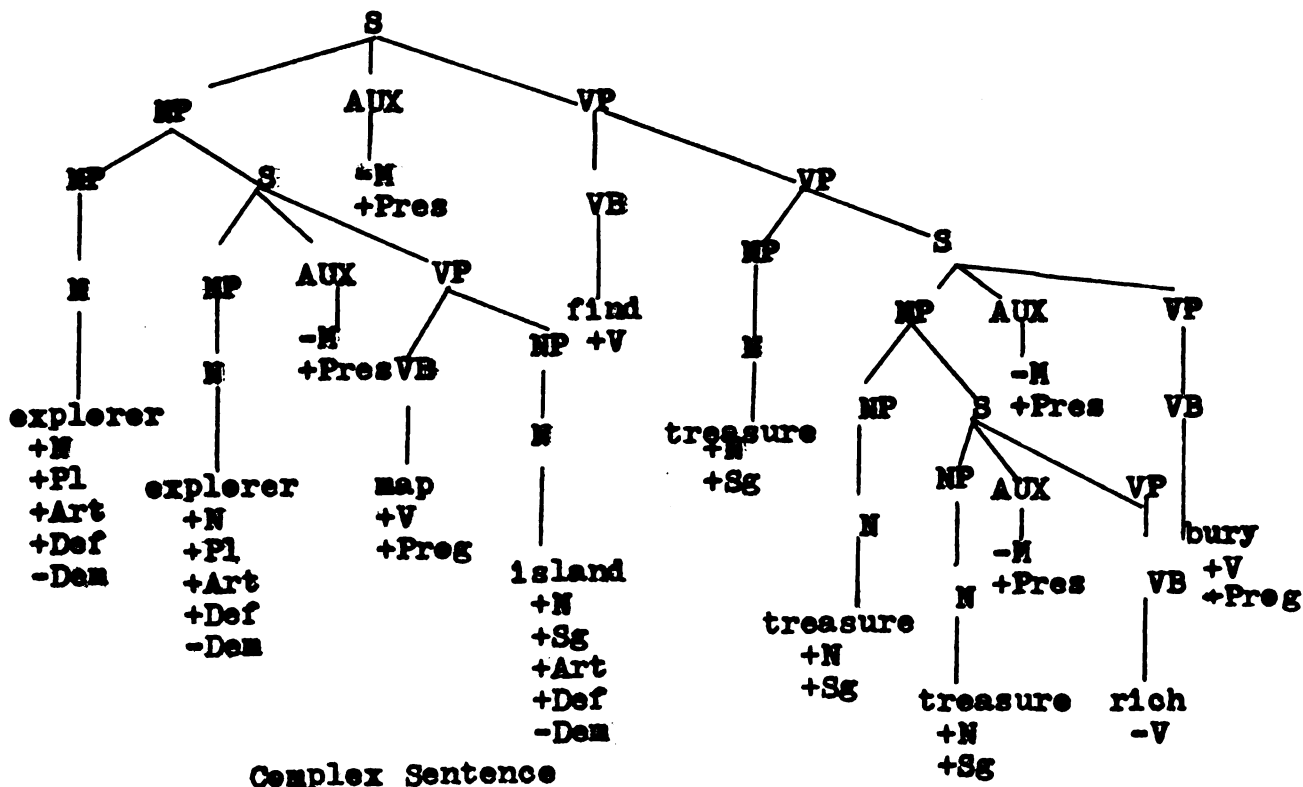
Surface Structures



Deep Structures



Simple Sentence



Complex Sentence

APPENDIX F

Sentences used in Experiment II

Simple

The monks chanting the prayers believe they are pious.
The doctors performing the operation report it was successful.
The pianist playing the sonata thinks he is talented.
The detective studying the trial reports it is fresh.
The women baking the bread say it is good.
The author writing the book says it will sell.
The artist painting the portrait feels it is excellent.
The police investigating the death believed it was suicide.

Complex

The lawyer defending the suspect uses long wordy arguments.
The friar preaching the sermon says long pious prayers.
The guide carrying the camera photographs rare black swans.
The people contributing the painting are famous wealthy writers.
The men examining the plans build large cargo ships.
The artist studying the scene paints gay colorful pictures.
The lady reading the book writes charming short poems.
The explorer mapping the island found rich buried treasure.

APPENDIX G

Mean number of errors per sentence in Experiment II.

Conditions		Number of errors/sentence				
		1	2	3	4	5
S-2	Trial 1	1.84	1.28	0.72	0.17	0.00
	Trial 2	1.28	0.57	0.00	0.00	0.14
S-4	Trial 1	1.43	1.43	0.86	0.17	0.00
	Trial 2	0.17	0.72	0.14	0.00	0.00
C-2	Trial 1	4.00	2.71	0.17	0.14	0.00
	Trial 2	1.28	1.14	0.86	0.17	0.00
C-4	Trial 1	3.00	2.39	0.44	0.14	0.00
	Trial 2	1.00	0.86	0.14	0.00	0.00

APPENDIX H

Raw Data Experiment II

Number of Sentences Correct								
Condition	S-2		S-4		C-2		C-4	
Trial	1	2	1	2	1	2	1	2
8								
1	2	3	3	7	0	7	2	6
2	7	7	3	7	0	0	1	4
3	2	6	1	5	1	4	4	8
4	3	6	5	7	1	2	4	7
5	7	7	6	8	3	8	0	2
6	1	6	2	6	1	5	2	7
7	5	7	5	8	0	6	2	6

Number of Words Correct								
Condition	S-2		S-4		C-2		C-4	
Trial	1	2	1	2	1	2	1	2
8								
1	53	64	60	70	58	71	64	69
2	69	71	60	70	29	40	47	65
3	58	70	61	69	52	64	62	72
4	52	66	63	69	48	53	67	72
5	69	71	70	72	59	72	41	60
6	53	68	56	69	40	68	59	71
7	63	71	61	72	50	68	54	70

Number of Errors								
Condition	S-2		S-4		C-2		C-4	
Trial	1	2	1	2	1	2	1	2
8								
1	11	7	12	2	11	1	8	4
2	4	1	9	2	12	20	12	5
3	8	2	11	5	10	7	7	0
4	8	6	5	3	14	15	5	1
5	3	1	2	0	8	0	14	10
6	14	4	12	3	10	4	9	1
7	6	1	5	0	11	4	11	2

Various Types of Errors Made

Type of error		Conditions			
		S-2	S-4	C-2	C-4
Deletions	Trial 1	12	12	37	27
	Trial 2	4	1	12	8
Extraneous intrusions	Trial 1	21	19	22	19
	Trial 2	8	5	19	5
Experimental intrusions	Trial 1	10	9	5	11
	Trial 2	4	2	9	2
Tense	Trial 1	6	6	1	2
	Trial 2	3	3	3	2
Additions	Trial 1	4	2	0	0
	Trial 2	2	0	1	0
Structural changes	Trial 1	1	7	10	5
	Trial 2	1	4	7	5
Number	Trial 1	0	1	0	2
	Trial 2	0	0	0	0

Total Errors

Conditions	S-2	S-4	C-2	C-4
Trial 1	54	56	76	66
Trial 2	22	15	51	22

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