THE EFFECTS OF WORD ORDER ON SENTENCE-PAIR COMPREHENSION

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ON
SENTENCE-PAIR COMPREHENSION

By

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A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfilment of the Requirements

for the Degree

Master of Arts

McMaster University

July 1974

MASTER OF ARTS (Psychology)

McMASTER UNIVERSITY Hamilton, Ontario

TITLE: The Effects of Word Order on Sentence-Pair Comprehension

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NUMBER OF PAGES: v, 80

ABSTRACT

This thesis describes four experiments which make an initial attempt to examine differences in difficulty of comprehension of pairs of sentences which all have the same first sentence. The basic paradigm was that of the three-term series, as used previously in numerous studies of deductive reasoning (e.g., Huttenlocher, 1968; Clark, 1969), but with no reasoning being required: only one sentence of a pair was tested and correct answers did not require the two sentences to be combined in any way.

Three dependent measures were used: (1) likelihood of error in answering the question; (2) time to answer the question; and (3) performance on a secondary, interpolated memory task, designed as a measure of processing capacity left over after sentence processing. The last two measures did not produce consistent results but differences between sentence-pairs in terms of likelihood of error were significant and reliable throughout all four experiments. The order of difficulty of sentence-pairs differed only slightly from that preferred by subjects in a creative discourse situation (Morley, 1971), but was substantially different from that found in deductive reasoning studies using the same material.

The presence of different kinds of interpolated material did not interfere with this main effect but the presence or absence of the interpolated memory task produced differences in the function relating the likelihood of error to time.

The results were interpreted as consistent with the supposition that the process of understanding as a prerequisite for deductive reasoning is not the same process that was investigated here and that deductive reasoning is probably not a two-stage process. In addition, some common features seem apparent between the writer and the reader in terms of surface structure word orders that are on the one hand most preferably produced, and on the other, most easily understood.

ACKNOWLEDGEMENTS

The author wishes to thank Dr. Jonathan Baron for his trenchant criticism and helpful guidance throughout the preparation of this thesis.

Thanks also to Drs. Ian Begg and Lee Brooks and to Richard Heath for their constructive comments at various stages of the development of the thesis.

Last but by no means least, a special thankyou to Ms. Kathy Taylor for so courageously giving of her talents in my hours of greatest need.

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INTRODUCTION

The present study is an initial attempt to examine the difficulty of comprehension of different kinds of pairs of sentences. These pairs are all related in that either the "topic" or the "comment" of the second sentence was the "topic" or "comment" of the first sentence. Each pair of sentences contains three names and there are thus four different kinds of sentence-pairs. Henceforth these are referred to as AB-AC, AB-BC, AB-CA and AB-CB, where A, B, and C refer to the three names in the order in which they occur in the two sentences, with either A or B repeated in the second sentence. For example:

Mary is older than Joe.	Mary is younger than Sam.	AB-AC
	Joe is older than Sam.	AB-BC
	Sam is older than Mary.	AB-CA
	Sam is younger than Joe.	AB-CB

In previous studies, using similar material, different orders of difficulty of different kinds of relations between sentences have been found for different tasks. These are summarized in Table 17.

Various authors (e.g., Huttenlocher, 1968; Clark, 1969a, b; De Soto _et al._, 1965) have investigated the process of deductive reasoning using three-term series problems in the above format, with proper names for A, B, and C and a comparative in each premise. There is no overall consistency in their results and it seems that the particular experimental procedure used in each study is important in determining the strategies Ss use to reason and the orders of difficulty that are found. For example, Huttenlocher (1968) presented the first premise and then tested for understanding of it before presenting the second premise and the final test question, whereas Clark (1969a, b) did not test for understanding of the first premise but presented the two premises and the question in quick succession. The explanations which the two investigators give for their respective results seem to depend on their respective procedures: Huttenlocher stresses the importance of the third term (C), whether it is subject or object of the second premise, and says that if it is not the subject then Ss have to carry out mental operations to achieve such correspondence in order to understand the statements. Huttenlocher's paradigm, in which the presentation of the two premises is disrupted and delayed by the test of the first premise, tends to place importance on the subject of the second premise (since it comes immediately after the break) and in particular on how it relates to the information that the first premise has already placed in the Ss consciousness. Her explanation thus seems well fitted to her paradigm.

Clark's explanation of what his subjects were doing in his task is a linguistic one. He mainly considers the way individual premises are understood in isolation and is not concerned with any interaction between the comprehension of the two premises in a three-term series. His paradigm was well fitted to this explanation since he presented the premises one at a time but with no break between them and hence no experimentally induced emphasis placed on any of the parts of the two premises.

Huttenlocher's and Clark's and all previous explanations of deductive reasoning make the (sometimes unstated) assumption that in order to solve a three-term series problem, it is necessary to first understand each of the separate premises. However, these studies have not concerned themselves with how the process of understanding the separate premises varies with the order of presentation of the items within them, even though this variable is critical in determining the ease of reasoning with a particular pair of premises. The present study begins this investigation.

In order to avoid confusion over the meaning of "understand," let us at this point distinguish between two relevant senses of the word. The process of combining the two premises of a three-term series is required for a S to be able to answer a question that requires information from both of them. However, before this can be done, the S must read the premises separately and "understand" them. There are thus two senses of "understand" in this context: (i) S must first understand the meanings of the two separate premises before he can (ii) understand the relationship between them. Huttenlocher's paradigm makes this clear since she checks for understanding of the first premise before presenting the second premise and the problem question, but she is concerned with the latter sense of "understand." We are now concerned with the former, with the process of understanding as opposed to reasoning, based on the relationship between adjacent sentences, for, if there are differences in the ease with which Ss simply read and comprehend different pairs of sentences this may affect the solution time and difficulty of three-term series problems independently of any differences in difficulty of combining the information from the same sentences. Any questions concerning the process of reasoning with three-term series problems do not therefore have any direct bearing on this issue although the converse is probably not true and is discussed later in the light of experimental results.

The experiments reported here are concerned with the understanding of successive sentences as a function of the relation between them (in terms of the relative positions of the repeated element in a three-term series). Whatever the ultimate explanation of three-term series reasoning, one factor on which it depends is the ability to understand the two premises independently, and for the second premise, this means understanding it immediately after the first premise. The investigation of this process is the focus of all the experiments that are reported here.

A different ordering of premise-pairs from those found by Huttenlocher and Clark was found in a different situation by Morley (1971) (see Table 17). In this experiment, 128 Ss were asked to create a discourse by making a choice at each sentence boundary from a group of 2 or 4 sentences according to which sentence they preferred to follow what they had already "written." Only one set of alternatives was available to Ss at each choice point, i.e., they could not see previous or future choices. By using active and passive, conjoined and embedded sentences, it was possible to write down the same semantic information in a large number of different ways. However, Ss showed significant preferences for certain sentence-sentence orderings of noun-phrases. The most preferred order was AB-BC. For example, given the sentence, "The car (A) hit the dog (B)" and a choice between "It (B) was killed instantly by the impact (C)" and "The impact (C) killed it (B) instantly" the first alternative was preferred. The same effect was found in examples of published discourse. In topic-comment notation the results was that (a) topics are preferred if they have already been used in the previous phrase, especially if they were the previous comment, and (b) new comments are preferred. The main phenomenon underlying discussions of "topic" and "comment" is the distinction between old and new information and the result of this experiment agrees with Chafe (1970, 1974), who says that in "the 'least marked' instances, a surface structure subject carries the old information of a sentence" (1970, p. 212) and goes on to say that new information is introduced at the end of a sentence and, in speech, given higher pitch and greater amplitude. Chafe concludes, however, that is is impossible to make general statements about word order and new and old information with much assurance since the matter has been so little studied.

The present series of experiments attempts to study the comprehension by the reader of different sentence-sentence relations. If we accept the possibility that the process of language creation and of the comprehension of language have certain common features then one approach to studying the latter is to look for phenomena that have already been found in the former (and vice-versa). If there are certain forms of written discourse that are more easily or preferably generated than others then this is an indication that certain forms of discourse input, quite likely the same or similar forms, are easier to decode and comprehend than others; and if these differences in output format are stated in terms of inter-sentential differences in the occurrence and re-occurrence of semantic elements, then this is one obvious independent variable with which to start looking for comprehension differences between the same kinds of sentence-sentence pairings.

The experiments reported here examine the effects of different noun orderings in pairs of sentences in yet another experimental situation. It seems unlikely that an experiment could be contrived which would directly test between the different results and explanations so far reported since they were obtained from different tasks. However, if the result of this experiment does not agree with those from studies of deductive reasoning, doubts will be raised about the assumptions made in such studies. For if the order of difficulty for understanding is different than that for reasoning it means either (i) the reasoning process produces its own order of difficulty, depending on the experimental paradigm, despite the order of difficulty produced after understanding. It is necessary to assume that understanding, in some sense, must precede reasoning and that the two processes each have their own order of difficulty which seem to produce the order observed in reasoning studies; or (ii) that the process of understanding is done differently in different tasks. Still assuming that understanding is a prerequisite for reasoning, this alternative would allow the two processes to occur simultaneously or for the understanding process to be changed by the presence and necessity of the combining operation in the deductive reasoning situation. In fact it seems likely that if a S is instructed to reason with the information in a string of sentences his reading strategy may be quite different than if he is only instructed to read and comprehend them.

In either case, the process of reasoning, assumed by Huttenlocher, De Soto, Hunter, and others, to be a necessary but inconsequential part of the deductive reasoning process, becomes a very important process in its own right. It follows that manipulation of the understanding process could affect any reasoning that is associated with it. This would suggest that the rules which govern the understanding of the information in a string of sentences are not the same rules that govern the combination of bits of information from the same sentences.

The design of the experiments described below utilizes a micro-approach to the problem. Although we are interested in paragraphs and the comprehension of continuous discourse, the analysis of performance on a large discourse would be cumbersome if we were looking for differences between different kinds of adjacent sentences or phrases. In any case, the use of reading time of a large discourse as a dependent measure, for example, would not be justified. We cannot assume that a pair of sentences will not be read as quickly just because there is something about them that makes them harder to understand: maybe they will not be understood as well or remembered for as long. Tests of comprehension of a paragraph would probably produce too much variability to make them sensitive to differences between adjacent sentences. The three-term series format, with two premises and a question, was used in all experiments because as well as providing a convenient paradigm with which to study the comprehension of adjacent sentences, the results can be compared with those of deductive reasoning studies which used the same format.

The micro-approach used in the experiments here allows the use of sentence pairs which have congruent syntactic structure but which differ in certain critical aspects. We should, therefore, be able to isolate any differences in comprehension that are due to intersentential differences or at least separate them from intrasentential differences.

Furthermore, we do not want Ss to do any understanding in the combining sense as used by Huttenlocher. We are not concerned with the actual content of the sentences being read but with the way such information is comprehended, the independent variable being the relationship between semantic elements of the perceived sentence and those of the previous sentence. By using the three-term series format, which retains syntactic and informational congruency over all sentence-pair examples, we can vary semantic relations independently and still retain semantic and logical validity.

Three dependent measures were used in the four experiments: (a) probability of error in answering a question which tested the comprehension of a sentence; (b) time to answer the question; (c) performance on a secondary, concurrent memory task which was assumed to overload Ss processing capacity and possibly be a measure of capacity left after the primary sentence-pair task, as used by Savin and Perchonock (1965).

The first experiment was a pilot study to see if any differences could be found in error rates in tests of comprehension of the separate sentences of different kinds of pairs of sentences in three-term series format. The interpolated memory task was also used.

The second experiment was designed to replicate the first and to rectify possible procedural flaws that may have allowed Ss to use undesirable strategies. In the second experiment, we also examined progressive memory differences for different sentence-pairs and the effects of different kinds of intervening material on the comprehension of and memory for different sentence pairs.

Experiment III used nonsense material in the format of three-term series statements in an attempt to find out whether the effects found for different sentence-pairs were dependent on the material having meaning or whether it could be explained solely in terms of memory for the same recurring literal unit. In this experiment a "same or different" testing method was used in a comparison between the presented non-sentence and a test non-sentence.

The fourth experiment measured time to answer a question about one of the sentences of a three-term series.

METHOD

Basic Experimental Paradigm

All experiments were carried out with a PDP-8/L computer and Tektronix 602 oscilloscope display. Responses were made on the computer teletype and with two response buttons also interfaced to the computer. Stated simply, the main objective of the whole series of experiments was to compare different sentence-pair types in terms of understanding the second sentence given the same first sentence. This was tested using a question which followed presentation of the sentences and was of the form "Is A older than B?" or "Is C better than A?" The question referred to either one of the two sentences presented on the trial but not to both and so _S_s were not required to combine the information presented in the two sentences. _S_s did not know, however, which sentence of a pair would be tested on any trial.

Although the important dependent variable was the understanding of the second sentence, it was necessary to test the understanding of the first sentence for two reasons--to ensure that _S_s did in fact read it and to check the expectation that performance on the first sentence would be the same for all sentence-pairs, since differential effects of second sentences on the understanding of the first sentence cannot otherwise be ruled out.

Half of the questions were answered correctly by "no" and of these, half were "no" because the comparative was changed and half were "no" because the order of the names was reversed. Thus half of the questions which were correctly answered by "yes" were "yes" because there was no change in names or comparative and half were "yes" because both had been changed.

If the question was given immediately after the sentences it is unlikely that Ss would make mistakes and it was thus necessary to "force" Ss into making mistakes so that differences in understanding of different sentence-pairs, if any, could be measured by differences in number of errors. This was achieved by introducing an irrelevant task, unrelated to sentence processing. It is assumed that this makes mistakes more probable. A list of eight digits in the range one through four was presented after the second sentence and Ss were required to remember them and recall them, in order, after answering the question. The use of the numbers and the fact that the sentences were presented briefly, for approximately long enough for one reading, was thought to make the question-probe technique more sensitive to processing differences between the sentence-pairs. Also, if different sentence-pairs have different processing capacity requirements this might also be expected to produce differences in the number of digits remembered.

Independent variables that were manipulable were: (a) type of sentence-pair; (2) type of question--(a) whether about the first or second sentence and (b) whether forwards or backwards, i.e., whether the order of the names was reversed or not. In Experiment I, the adjectival form used in the question was always the same as that presented in the sentence being tested. This meant that for questions about the first sentence, the unmarked adjective was used in all questions. In subsequent experiments both adjectival forms were used equally often in formulating the question from the premise. (3) The time lag between the second sentence and the question; (4) the nature of the material intervening between the second sentence and the question.

The position on the screen of the second sentence and the question relative to the position of the first sentence was also changed after the first experiment in an attempt to improve the experimental design by reducing the possibility of differential subjective strategies for different kinds of sentence-pairs. Each experimental session lasted between 30 and 50 minutes.

Experiment I

The first experiment was designed to see if there were any measurable differences in error rate in the comprehension of different pairs of sentences in three-term series format.

On each trial a sentence-pair was randomly selected and constructed, using 3 names from a pool of 128 in storage and either one or two comparatives (depending on which sentence-pair was under construction) chosen from the list in the Appendix. The comparative was used in the first sentence was always unmarked. The first sentence was displayed in upper case letters about 2.5 mm. high, for a period which varied across subjects between 900 and 1900 msec. Following the first sentence, the second was displayed, for the same amount of time and in the same place on the screen. This was immediately followed by the list of eight randomly selected digits (1 through 4), displayed simultaneously, which the subject was asked to remember as a second priority, the first being to understand the sentences. The digits were the same size as the letters and were separated by one letter-width. They were displayed for 2-3 sec. and appeared in the same place on the screen as the sentences. The computer then randomly selected, constructed and presented a question, which remained on the screen until the S answered either "yes" or "no." The question only required information from one sentence for a correct answer and the comparative used was always the same as that presented in the sentence. For example, for a pair of sentences "A > B; A < C" there were four possible questions that could be asked:

(a) Is A > B?
(b) Is B > A? } about sentence one.
(c) Is A < C?
(d) Is C < A? } about sentence two.

After the S answered the question, the computer then waited for the S to type in eight digits on the teletype. After the eighth digit, the S received feedback on the screen in the form of "OK" or "WRONG" (for the question) and the number of digits correctly recalled in position.

Six <u>S</u>s each did between 700 and 900 trials over 5 sessions, divided equally among the four sentence-pair types. <u>S</u>s were instructed to read the pair of sentences, read the digits and the question, answer the question either "yes" or "no" and then type in the digits on the teletype in the order in which they were presented and guess when they couldn't remember. The <u>S</u> sat about 60 cm. from the screen with his right hand on the teletype over the numbers 1, 2, 3, 4 and his left hand spanning a response box with "yes" and "no" buttons. Sentence-type, question-type, names and comparatives used in each trial were randomly selected on each trial. Sentence-type, question-type, correctness of answer and number of numbers correctly recalled were recorded on each trial. Before the first session for each <u>S</u>, the time to read a sentence was measured and the presentation time of the sentences in subsequent sessions was kept constant for each <u>S</u>.

Results

Individual data are presented and analysed in Tables I and II. With only one reversal (Subject TN: CA > CB) the results for all subjects are that

$$ABBC > ABAC > ABCB > ABCA$$

in terms of percent correct answers to questions about the second sentence. Chi-square tests for each <u>S</u> are all significant (smallest $p < .01$ for TN and EH) and an overall repeated measures analysis of variance is significant ($p < .001$, Table II). A test of the mean differences between sentence-pairs after the analysis of variance is summarized in Table IV(a): all differences between individual sentence-pairs are significant except between ABAC and ABCB.

Performance on first sentence questions was worse on -CA sentence-pairs than on the other three which did not differ from each other (see Tables III and IV(b). In view of the main result (that BC > AC > CB > CA on second sentences), this suggests that the difficulty involved in reading and understanding a CA second sentence after a regular AB- sentence is enough to interfere with the understanding or memory of the AB sentence that came before it, since the actual reading of an AB sentence is not affected by what is following it.

The number of digits remembered after each of the sentence-pairs did not vary significantly and neither did the number of numbers remembered after correct and wrong responses. These data are presented in Table V. This is a little surprising at first because it is tempting to think that for a difficult sentence-pair (i) the numbers will be processed less well, and also (ii) the Ss will take longer than average to answer the question, resulting in less numbers being recalled. A possible explanation of this is given in the general discussion after Experiment IV where further implications of the present results are discussed.

Experiment II

In the second experiment we were looking for differences in the change in the likelihood of error as a function of time, for different sentence-pairs. The same basic paradigm as Experiment I was used but the presentation time of the numbers was varied, thus effectively varying the time between presentation and questioning of the sentences.

Another variable that was also manipulated in Experiment II was the type of material intervening between the sentences and the question. One reason for the use of the digits in the first experiment was that it was felt that they would make mistakes more likely on the sentence-question task, thus increasing the sensitivity of the question-probe technique. However it is possible that the use of the numbers made the task unlike a normal reading situation since Ss were doing more than simply reading and understanding sentences. Although irrelevant to the sentence reading, the presence of the numbers may have meant that S's cognitive facilities were not distributed in the same way that they would have been in normal reading. The fact that Ss were required to use their short-term memory to the limit (in remembering the supra-span digits as well as the sentences) may have caused a change in reading strategy. The possibility of trade-offs between the two tasks is discussed later.

For these reasons the numbers were dispensed with in one condition and a visual mask consisting of a row of Xs was substituted. In this condition the S had only one task, that of reading the sentences and answering the question. In this case there are two possible predictions that might be made: (i) overall performance on the mask condition is better than the numbers conditions because the task involves less cognitive load; (ii) the main effect of differences between sentence-pairs is reduced because the question-probe is less sensitive since Ss will not make so many errors; Ss can take longer to answer the question without fear of decreasing overall performance by doing poorly on the numbers task.

The experimental procedure of Experiment II differed from the first experiment in that: (i) The intervening material was either a mask or the numbers. For any particular session, either one or the other was used throughout. (ii) Four different presentation times were used for the mask/numbers. The time used on a trial was selected randomly from the values .1, .75, 1.5, and 2.25 sec. and each was used equally often with all four sentence pairs. Six Ss all did both the mask and numbers condition, 1100 trials of each type over eight sessions. In the mask condition the teletype was turned off and each trial took correspondingly less time since there was only a single response per trial.

On each trial the following information was recorded: (a) Type of sentence-pair; (2) Type of question; (3) Length of presentation of numbers or mask (mask or numbers was constant within sessions);

(4) Correstness of response to question; (5) Number of digits correctly recalled in the numbers condition.

Short-cut strategy

In Experiment I there is at least one possible technique that Ss could have used as a crutch to help them answer the question. Consider each of the four sentence pairs:

AC	John is taller than Dick. John is shorter than Bill.
BC	John is taller than Dick. Dick is taller than Joe.
CA	John is taller than Dick. Bill is taller than John.
CB	John is taller than Dick. Bill is shorter than Dick.

The sentences start at the same place on the screen. This means that for AC the word John will not appear to change position when the second sentence appears. Since the word John will necessarily appear in the question (it is the name that appears in both sentences) and since the comparative used in the question is the same one that was used in the sentence being questioned, it follows that if the word John is at the beginning of the question the correct answer will be "yes" and if it is at the end of the question the correct answer will be "no," irrespective of whether the question is about the first or the second sentence. The same applies in reverse to CB sentence-pairs but not to BC or CA. If

Ss were to use this strategy then performance on AC and CB would be improved. None of the Ss in Experiment I said that they made conscious use of such a strategy when asked after the experiment. However in subsequent experiments this possibility was eliminated by (i) changing the position on the screen of the second sentence so that the names did not appear in the same place; (ii) asking questions in which the comparative was not the same as that in the sentence being questioned. This was not done in the first experiment because it was felt that this might make the subject reorder the sentences, which was not desired. This kind of question also ensured that the S was not answering the question by memory alone, i.e., he had to definitely understand the sentences before he could be sure of getting the question correct, whereas previously he may just have been recalling the sight or sound of the sentence being questioned in order to answer the question.

It is encouraging that this possible effect did not appear to account for all the results. Sentence-pair BC was not amenable to this strategy and yet it was the easiest to understand.

Results

Data were analyzed for each subject separately and over all subjects (Tables VI-XI, Figure 1). The main effect of Experiment I was replicated in both the mask and numbers conditions in that questions about the second sentence of a pair were more likely to be correctly answered for AB-BC pairs than for AB-CA, with AB-AC and AB-CB falling between them. There was no difference between the mask and numbers condition in the strength of this effect. This was determined by comparing the main effect of mask and numbers conditions, which proved insignificant ($F = 0.14$, N. S., Table VIII). The data for questions about the first sentence also replicate the findings of the first experiment--questions about the first sentence in an AB-CA sentence-pair are more likely to be answered incorrectly than questions about the first sentence in an AB-BC, AB-AC or AB-CB sentence pair.

Individual curves are plotted for both the mask and numbers conditions in Figure 1. The main effect of differences between sentence-pairs is significant at all presentation times in both conditions (smallest ($F = 5.67$, $p < .01$, for presentation time 0. 1 sec. in the mask condition). However, although the order of the sentence-pairs is the same in both the mask and the numbers conditions, the shape of the forgetting curves are different. For all Ss, in the mask condition performance improves with increasing delay between sentence and question and then falls off. The mask presentation-time at which performance stops improving is shorter for those sentence-pairs which are more likely to produce errors. In the numbers conditions the reverse effect is observed: performance falls off immediately when the numbers are presented but then improves later. The numbers presentation-time at which performance begins to improve again is longer for those sentence-pairs which are more likely to produce errors.

For the numbers condition, the mean number of digits correctly recalled after each sentence-pair and when correct and wrong are given in Tables X and XI. There are several interesting but few significant differences: (a) for correct and wrong answers taken together over sentence-pairs, the differences are not significant but the difference between BC and CA, the two furthest apart in terms of percent correct, is significant ($\bar{X}_{BC} = 3.82$, $\bar{X}_{CA} = 3.41$, $t = 2.75$, $p < .01$). (b) There are no differences between the number of digits correctly recalled after correct and wrong answers over all sentence-pairs, but for BC: $\bar{X}_C = 3.59$, $\bar{X}_W = 4.05$, $t = 2.71$, $p < .05$). Other differences show the same trend (Table X).

In Experiment II, unlike Experiment I, questions were asked in which the comparative was not the same as the comparative used in the sentence under test. The type of comparative used in the question might have made a difference in the likelihood of an error. The relevant data are presented in Table XII. There are no differences in likelihood of error within any sentence-pair type resulting from any combination of comparatives in sentence and question for either first or second sentences.

Experiment III

One way of summarizing the main effect found in Experiments I and II is that the likelihood of error on a pair of sentences depends on how far apart the repeated semantic element is. In sentence-pair AB-BC the repeated elements are adjacent and less mistakes are made than AB-AC and AB-CB in which there is another noun-phrase intervening between the two occurrences of the repeated element. For AB-CA there are two such intervening noun-phrases and it is the most difficult. This suggests a possible explanation of the findings. There could be a loss of information about the repeated element which impairs its perception or encoding the second time it occurs. If this were the case it is possible that the effect does not depend on the material having meaning, from which it would follow that the effect would still be found with non-meaningful material. In this case the mechanism that mediated the phenomenon would depend on memory for a repeated identical lexical unit and the distance apart of the two units would be the determinant of how difficult the pair of sentences was to perceive or non-semantically encode for later use.

Alternatively, if the effect of differences between sentence-pairs in terms of likelihood of error in tests of comprehension, depends on the meaning of the sentences, then the effect would not be found with non-meaningful material. Morley (1971) showed that in the creative discourse situation a non-semantic encoding explanation was not sufficient to explain why _S_s used and preferred the optional pronominalization transformation to the retention of the original animate noun-phrase.

Pronominalization retains the same meaning as the original noun but changes the lexical unit in the surface structure. Therefore in that situation, preferences for nouns and noun-phrases do not depend on the re-occurrence of identical lexical units but on the re-occurrence of semantic units, at least in part. If the effect found in Experiments I and II depends on meaning then an encoding interpretation would not be a sufficient explanation. We would need to look for linguistic differences between sentence-pairs to explain why some are easier to comprehend than others.

In order to distinguish between a memory-for-identical-lexical-units explanation (a non-semantic one) and a semantic explanation we need to observe what happens to the effect when the semantic aspects of the situation are removed. This is the rationale for Experiment III. Even without this question it would be interesting to know whether the effect holds for non-linguistic material.

In the third experiment, nonsense words were used in the format of three-term series. The names were retained but it was necessary to modify the original paradigm in order to be able to question the "understanding" of nonsense material. The S's task was to read the non-sentences and then say whether a third non-sentence was the same as one of them or different than both of them. Half of the test sentences were changed, by either (i) changing the nonsense comparative or (ii) changing the order of the names in one of the non-sentences of the non-sentence-pair. If the original phenomenon of differential understandability of different sentence-pairs is dependent on the material having meaning then it will disappear or be reduced under these conditions. If it is some kind of psychological phenomenon that can be generalized from the linguistic setting then it would still be present with nonsense material.

Thus the subject saw a pair of non-sentences, each presented for 1 sec. and then a mask which lasted approximately 2 sec., e.g.,

John ob mapper krin Dick.	John ob kuppel krin Paul.	AB-AC
	Dick ob mapper krin Paul.	AB-BC
	Paul ob mapper krin John.	AB-CA
	Paul ob kuppel krin Dick.	AB-CB

This was followed by the test sentence which remained on the screen until S pressed either the "yes" button indicating he thought that the test non-sentence was the same as one of the previous non-sentences, or "no" indicating that he thought it was different than both of them. Six Ss each did 300 trials of each non-sentence-pair, randomly distributed over three experimental sessions. The results are shown in Table XIII. An overall analysis of variance shows that the original effect is still present ($p < .05$, Table XV, analysis of variance). However, the range of best-worst in Experiment III is much smaller than that in Experiments I and II (AB-BC and AB-CA = 4.18 in Experiment III, 22.12 in Experiment II, 17.2 in Experiment I), which suggests that the effect is significantly reduced in Experiment III.

It is not possible to conclusively show this difference since the S's task in Experiment III was not the same as the S's task in Experiments I and II: in Experiment III the task was to detect a change in either name or comparative whereas in Experiments I and II the task was to answer a question which tested the comprehension of a sentence. It is probably impossible to completely rule out the possibility that the smaller effect found in Experiment III was due to the change in the nature of the task and not to the change from meaningful to non-meaningful material. However, even though the tasks were different, the format of the test questions are comparable across all three experiments. As Table XVIII shows, the test questions used in Experiments I and II include those used in Experiment III and since the range of scores in Experiments I and II are both much larger than the range in Experiment III, it would seem unlikely that the change in task between Experiments I and II and Experiment III would account for the difference in result.

Table XIV summarizes a series of Mann-Whitney U Tests comparing all combinations of pairs of sentence-pairs with respect to the differences between Experiment III and Experiment I in the likelihood of a correct response when there is a change in the names between sentence presentation and test. Except for ABCB-ABCA all the differences are significant (largest chance probability is .032 for AC-CB). Also, the number of individual departures from the main effect in Experiment III is considerably more than in Experiment I (11 to 1). Both these facts support the contention that the effect of differences between sentence-pairs is reduced by using non-meaningful material.

Experiment IV

Figure 1 suggests the presence of decay rate differences in sentence-pairs in the mask condition of Experiment II. The decrement in performance that occurs with time is greatest for those sentence-pairs which initially produce more errors. This suggests that sentence-pairs which are easier to understand are so because they are easier to remember. It might be expected that another index of difficulty of understanding would be the time taken to answer the question in the basic paradigm of Experiments I and II. This is what Experiment IV examined.

Several investigators have used reaction-time as a dependent measure in deductive reasoning studies (e.g., Huttenlocher, 1968, 1970, 1971; Clark, 1969a, b). The present experiment will therefore be more directly comparable to deductive reasoning studies.

Using the same paradigm as the mask condition of Experiment II, with a constant mask presentation time of 2.3 sec., *S*s were instructed to respond as quickly as possible without forsaking accuracy. Four *S*s each did 300 trials of each sentence pair.

The results are presented in Table XVI. There were no consistent differences in times to answer questions about the four sentence-pairs either for questions about the second (range = .06 sec.) or first (range = .05 sec.) sentences. There was also no difference in times between correct and wrong responses (range = .05 sec.). The within Ss variability was very high in all conditions. The effect of differences between sentence-pairs was replicated as measured by percent correct responses ($p < .01$, analysis of variance, range ABBC-ABCA = 19.48 percent).

It was concluded that the use of reaction time is not a sensitive measure of differences between different sentence-pairs or between correct and wrong responses, at least under conditions in which error rates are high.

DISCUSSION

The main result, found in all four experiments, is that the position of the three semantic items in a three-term series is crucial in determining the likelihood of an error in response to a question which tests the comprehension of the second sentence. The order of difficulty, beginning with the easiest is,

AB-BC
AB-AC
AB-CB
AB-CA

Assuming that likelihood of error is a measure of difficulty of comprehension, this means that:

(1) If the first item in the second sentence occurred in the first sentence then it is easier to understand than if the first item is new (BC and AC better than CB and CA).

(2) If the repeated item was the object of the first sentence it is easier to understand than if it was the subject (BC better than AC; CB better than CA).

Clark (1969a) used three linguistic principles to explain differences in difficulty of comprehension of isolated comparative sentences. Even if these principles are correct, and they have been heavily criticised (notably by Huttenlocher, 1968, 1971, 1972), they do not appear to be sufficient to explain differences between different comparative sentences that are preceded by another comparative sentence since they do not predict the results found in the present experiments.

The principle of lexical marking states that the contrastive sense of a comparative takes longer to store and retrieve than the nominal sense. Thus for the sentence pairs,

A is better than B.
a) B is better than C.
b) A is worse than C.
c) C is worse than B.
d) C is better than A.

the principle of lexical marking predicts that (a) and (d) would be of equal difficulty since the comparative "worse" is stored in a less accessible form than "better." This does not agree with the experimental results, (a) and (d) being the most widely separated of the four in terms of probability of error.

The principle of congruence states that information cannot be retrieved from a sentence unless it is congruent in its functional relations with the information being sought. This would predict differences in difficulty of answering different question-types: that for (a) and (d) the question will be easier to answer if it contains the comparative "better" and for (b) and (c) it will be easier if it contains the comparative "worse." This prediction is not borne out by the results, there being no differences between different question-types (see Table XII).

The principle of the primacy of functional relations stresses the importance of the deep structure of a sentence and states that the information most readily available from an interpretation of a sentence is its underlying functional relations. This principle is irrelevant to the present study, however, since deep structure and surface structure are completely confounded.

Regardless of whether any or all of these principles contribute to the present results, a stronger mechanism than any of them is obviously also at work. The presence of the previous sentence is obviously critical and the simplest and most likely explanation of the results is one that depends on the items in this first sentence and how they are related to the items in the second sentence. We must assume that the information that has been placed in the S's consciousness by the first sentence, as he starts to read the second sentence, determines the ease with which the second sentence is comprehended. If the subject of the second sentence was also in the first sentence then there is a longer total reading time for the three items than if the object of the second sentence was also in the first sentence, i.e., for AB-BC and AB-AC the three items are input faster than for AB-CB and AB-CA. Thus for AB-BC and AB-AC, the S has more time to organize and encode the second sentence in his memory since he does not have to place the third item there so soon. In this case AB-BC and AB-AC would be better understood and remembered than AB-CB and AB-CA.

Ss reported that they did not try to combine the two sentences in order to remember them, in which case the task effectively contains four items, the two occurrences of the repeated item being treated by the S as separate items. Since the results show that AB-BC produces less errors than AB-AC, it seems that if the first item in the second sentence is already in the S's consciousness, as is the case with AB-BC, it is easier to relate it to the third item which follows next.

This agrees with Chafe (1970, 1974) who postulates that speakers tend to introduce new semantic information in relation to the semantic information that is already assumed to be in the listener's consciousness and that word order reflects this process, with the new information coming at the end of a phrase, at which point it is taken as being in the listener's consciousness in preparation for the introduction of still newer information.

For AB-AC, the "A" item is less close to the surface of the reader's consciousness than the "B" item and so the link to the "C" item is slightly more difficult. For AB-CB and AB-CA, the preferred old-new order does not apply. The new information is presented first and related to the old information. The C-B link produces less errors than the C-A link, presumably because the "B" item is closer to the surface of the reader's consciousness than the "A" item, the "B" item having been presented more recently than the "A" item.

The sentence-pairs effect was considerably reduced in Experiment III, in which nonsense-material was used, which suggests that it depends, at least in part, on meaning. It seems likely that the positive results of Experiment III occurred because Ss treated the nonsense words as meaningful words, for example by making up meanings for them. Some Ss did verbalize their strategies in this form. It is hard to conceive of any kind of relations between non-meaningful things and to this extent, any explanation of the phenomenon found in these experiments must depend on meaning. It is likely that material in linguistic format is particularly susceptible to such an effect but on the other hand the effect would not necessarily generalize to other media.

Relation to Other Paradigms Using Similar Material

Creative discourse

The order of difficulty found in the present experiments differs only slightly from that found for preferred order of repeated semantic items in adjacent phrases (Morley, 1971) which was

AB-BC
AB-AC
AB-CA] switch
AB-CB]

In the creative discourse experiment the difference between AB-CA and AB-CB was not significant and it seemed likely that the introduction of two new semantic elements in the second sentence (AB-CD) was preferred to either AB-CA or AB-CB. Whether or not this also applies to the comprehension of similar sentence-pairs is an empirical question but the correspondence in the results suggests a common mechanism at work in the writer and the reader, such that those inter-clause semantic relations that are most easily produced are also most easily comprehended. Perhaps this is because the writer writes with the purpose of making things easy to read, which, as a reader himself, he can judge.

Deductive reasoning

The order of difficulty of the sentence-pairs in the present understanding task is not the same as that found by Huttenlocher (1968) or Clark (1969a, b) in deductive reasoning tasks (see Table XVII). They invoke different theories to account for their results, as noted in the introduction: Huttenlocher attributes to her Ss a strategy of constructing spatial images and Clark uses the three principles described above to explain the two orders of difficulty he found. He found different results depending on the adjectival form used in the question. In comprehending pairs of sentences this is not the case, there being no differences between types of question in Experiment II (Table XII). Also, with regard to the first sentence of the pair, the same results were found in Experiments I and II even though in Experiment I the questions only used the unmarked comparative whereas in Experiment II both the marked and unmarked. AB-CA produced more errors than AB-BC, AB-AC or AB-CB for questions about the first sentence.

Obviously neither Huttenlocher's or Clark's explanation is sufficient to explain the data in the present experiment, but there is a logical connection between the present task and the task of deductive reasoning. In order to do either Huttenlocher's or Clark's deductive reasoning tasks, the Ss must comprehend the material to some extent, i.e., understanding in some sense must precede reasoning. The possibility that understanding is done differently in the two situations was considered earlier and in view of the very different orders of difficulty in the current situation and in deductive reasoning situations this seems a more reasonable alternative than to postulate that the process of understanding which precedes reasoning is the same process investigated here and that the process of combining the premises produces different differences in difficulty which overwhelm the differences produced by understanding; e.g., AB-CB is the easiest with which to reason (according to Huttenlocher) and the second most difficult to understand here. If one postulates a rigid two-process model of reasoning in which at some stage AB-CB is the second most likely to produce errors then one would have to go on to say that even though the two sentences are relatively poorly understood it is very easy to combine them, after which AB-CB produces least errors in deductive reasoning. This seems less plausible than to postulate that the processes of understanding and combining take place simultaneously and that the sentences are combined as they are understood and vice-versa. There are no grounds for assuming that Ss would separate the two components of the reasoning task and it is probably less efficient. A process of different but additive difficulties for different sentence-pairs at different stages is much more complicated than a single stage with only one order of difficulty produced from it.

One aspect of this explanation is that it presupposes the necessity of understanding the premises as a prerequisite for reasoning. Most investigators of deductive reasoning make this assumption but it is in fact possible to solve a three-term series problem without understanding both premises and such a method would predict, coincidentally, the same order of difficulty for reasoning as was found in the experiments reported here.

Henle (1962) was not the first to point out that the process of thinking and reasoning does not necessarily have to follow a logical form or the syllogistic form. Various authors have attempted to show the logical sequence involved in solving linear syllogistic reasoning problems and they have usually attributed it to combining information from the separate premises so that any question about the order can be answered; e.g., De Soto, Hunter, Huttenlocher. Only Clark (1969) has implied that the process may be anything else. He contends that the difficulty of solving a reasoning problem is directly related to the difficulty of understanding the separate premises. However, even this approach may be too complicated. It is in fact possible to solve a three-term series problem by understanding only one of the premises. The simplest way to solve such a problem is:

1) look at the first premise and take note of the names, placing them in some kind of temporary storage buffer.
2) Look at the second premise and note which name is repeated. This name is necessarily the middle term in the ordering.
3) Understand one of the premises and place the end-item it contains in its absolute position in the array, either above or below the middle term. The third term must then be placed in the only remaining space in the array.

It is therefore only necessary to understand one of the premises and to note which of the terms is repeated. This is an easier task than setting up a partial array for the two terms in the first premises, understanding the second premise and fitting the third item into the array based on the relationship described in it (as Huttenlocher suggests) or looking at each item separately in a search for the attributes of the item in the question (as Clark suggests).

Since the repeated item cannot be determined until both premises have been scanned the optimum strategy is to first note the two names in the first premise and then begin reading the second premise for comprehension. If the repeated item is the subject of the second premise (i. e., AC or BC) then the ordering can be done as the second premise is read. If the repeated item is the second item in the second premise (CA or CB) then the order cannot be set up until after the second premise has been read, thus the time taken to set up the array will be longer for CA and CB than for AC and BC.

Given that AC and BC sentence-pairs are easier to solve than CA and CB, it follows that any difference between them will depend on the difficulty of understanding AC and BC sentences following the scanning of an AB sentence and we have seen that it is easier to understand BC than AC sentences. The same applies to CB and CA, CB being easier.

If this strategy is accepted as a way of solving three-term series problems (i. e., all you need to know is the repeated (middle) item and one of the relationships described by the premises) then it becomes an important empirical question as to whether it is easier (1) to fix the ordering by first determining the middle item and then understanding one of the premises or (2) to fix the ordering by first understanding one of the premises and then determining the middle item.

(1) corresponds to the process described above in which the names only are extracted from the first premise and the second premise is read for the repeated item and for meaning.

(2) corresponds to reading the first premise for meaning and then scanning the second premise for the repeated item.

The question is important, and worthy of investigation, because if (1) is easier then it means that Huttenlocher's (1968) subjects were prevented from using this optimum strategy by the nature of the experimental design. They had to show that they understood the first premise (by answering a question about it) before they were given the second premise and were therefore forced to use (2) or the method Huttenlocher attributed to them, namely that they tried to understand both premises before attempting to combine them. It is unlikely that her Ss used the method described by (2) and is more likely that they did in fact try to understand both premises because of the set induced by being required to understand the first premise.

It becomes important to carefully define what one means by deductive reasoning. Does it mean the ability to draw a conclusion from two premises or does it refer to a specific way of doing this, as Huttenlocher seems to assume? The argument above would suggest that if Ss were not constrained in the way in which they could take in and process the premises of a three-term series problem then the order of difficulty of solving different kinds of problems would not necessarily be the same as Huttenlocher (1968) reported. It is unlikely that many Ss in any deductive reasoning studies have used the above strategy because the necessity of understanding both premises is immediately assumed by most Ss, thus creating a set in which alternative strategies to understanding both premises are not even considered. One experimental approach that could be used to distinguish between processes (1) and (2) above would be to remove the comparative from one of the premises of a three-term series problem. At the same time it would be necessary to compare this kind of task with performance when subjects are tested for understanding of both premises separately before being allowed to combine them. Another way would be to give "insoluble" problems and question one end only or to allow "can't say" as an answer.

Memory Effects

For all subjects in the mask condition the percent correctly answered questions for sentence-pairs -BC, -AC and -CB increases with increasing mask presentation time and then falls off. The maxima in the curves are not the same for the different sentence-pairs: BC continues increasing longer than AC which continues slightly longer than CB. In the numbers condition both these effects are completely reversed. The percent correct for BC, AC and CB decreases with increasing numbers presentation time and then increases again. For BC the decline does not last as long as for AC for which it does not last as long as CB. For the CA sentence-pair there is a progressive decline in percent correct as the time between the presentation of the sentences and the question increases. This occurs in both the numbers and the mask condition (see Figure 1).

Suppose that immediately after the second sentence has been presented Ss do not fully understand the meaning of it. They have read it once but the meaning takes some time to be internalized. In the mask condition processing continues after the presentation of the mask, but stops with the question, hence the rise in the curves. After a certain point, at which understanding is maximal, forgetting begins to occur and the percent correct declines. Thus the mask does not disrupt processing. On the other hand, the presentation of the digits or the question does disrupt the consolidation process. In the numbers condition, the process of internalizing the meaning of the second sentence is abruptly stopped as soon as the digits appear and forgetting begins immediately. It is suggested that the reason for the subsequent rise in the curves in the numbers condition is that Ss switch back to processing the sentences after they have read the digits and try to continue where they left off in internalizing the meaning, but they do not do this if the question comes too soon.

The different temporal positions of maxima for different sentence-pairs in the mask condition and the different temporal positions of minima in the numbers condition, if reliable, are explicable by reference to the main effect of differences between sentence-pairs. BC sentences are better understood and less likely to produce errors. Internalization of the meaning of sentences after the mask is presented is also easier for BC sentences, making them less subject to decay and interference (from the first sentence, AB). Internalization will therefore continue longer into the mask before forgetting does cause an increase in likelihood of error, resulting in a maximum for the BC curve that is at longer mask presentation times than AC, CB and CA.

The numbers condition is more interesting in this respect. First, why should Ss switch back to processing the sentences on long numbers presentation times? The presentation time is variable and Ss do not know, on any trial, how long it will be. Since they wish to perform as well as possible on both the numbers and the sentences and since the numbers do not take as long to read as the maximum presentation time of 2.3 seconds, the optimum strategy is to switch back to the sentences as soon as the numbers are read. Given that the curve for BC sentences in the numbers condition starts to rise before the other sentence types it does not seem unreasonable to suggest any or all of the following:
(a) that Ss can switch from processing a BC sentence to the numbers faster than they can for AC, CB and CA sentences; (b) they can switch back to a BC sentence faster than to the others after reading the numbers; (c) there is less interference during the number processing from an inadequately understood BC sentence than there is from an inadequately understood or confusing AC, CB or CA sentence-pair, i.e., the numbers can be processed faster after a BC sentence-pair than after an AC sentence-pair and so on, and therefore S can switch back to the sentences sooner in the BC condition. This explanation is supported by the fact that there was a significant difference between the number of digits recalled after BC and CA sentence-pairs (3.82 vs. 3.41) which suggests that in the CA condition Ss did not have time enough to fully process

the numbers, even at long presentation times. It is therefore not surprising that there was no rise in the CA percent correct curve in the numbers condition at long presentation times since Ss did not have time to switch back to the sentences. The CA curve in the mask condition does not show the characteristic rise and this suggests that the CA sentences were never internalized any better than they were after the presentation of the sentences.

Whatever the nature of these kinds of memory differences the most important point about them is that under no conditions of presentation time or sentence-pair or intervening material did they interfere with the main effect of differences between sentence-pairs.

Regarding the number of numbers recalled after each presentation time (Table XI) there are obvious increases as presentation time increases. The difference between the number recalled at 1.5 and 2.25 seconds (4.41 and 4.51) is not significant and suggests that the switching point after the numbers have been processed is in this range.

For all sentence-pairs and all numbers presentation times more numbers were recalled when the question was answered incorrectly than when it was answered correctly. The only point at which this trend was significant was for BC sentence-pairs ($\overline{X}_{corr.} = 3.59$, $\overline{X}_{wrong} = 4.05$, $t = -2.71$, $p < .01$) but the trend suggests that when subjects do not know the answer to a question, they quess quickly and do not spend as much time on the question and are thus able to remember more numbers.

The Numbers Technique

The main effect of differences between sentence-pairs was observed in both the mask and numbers conditions of Experiment II and the differences remained in memory for at least a few seconds. It thus seems that the numbers were not necessary to force Ss to make mistakes on sentences, as was first thought. Therefore, in future, it may not be necessary to use the numbers technique, unless the sentences themselves are too short to produce errors under conditions in which all words are read. The use of the numbers as a measure of left-over processing capacity differences between sentence-pairs does not seem very sensitive either.

In the reading process fluctuations of attention are presumably occurring all the while as the difficulty of the perceptual and memory operations that are being simultaneously performed change relative to each other in response to the material that is being continuously processed. The numbers technique is a method of overloading the total processing capacity and thus could be used to investigate other instances of the division of attention in the reading of different kinds of linguistic material, especially by considering the points at which processing breaks down when the system becomes overloaded. The division of attention could probably be manipulated independently by varying payoffs for performance on different tasks that are being carried out simultaneously, as another method of studying the interaction between perception and memory processes.

Table I

Experiment I

Number of correct and wrong answers to questions about the second sentence for sentence-pair conditions AC, BC, CA and CB.

subject		AC	BC	CA	CB	χ^2	p
DM	#correct #wrong %correct	235 10 95.92	175 18 90.90	165 38 81.28	155 25 86.11	26.24	< .001
RV	#correct #wrong %correct	153 37 80.52	180 70 72.00	121 87 57.17	150 75 66.67	24.89	< .001
TN	#correct #wrong %correct	196 20 97.02	196 6 90.74	220 30 88.00	202 30 87.06	14.94	< .01
EH	#correct #wrong %correct	196 44 81.66	188 66 74.02	156 79 66.38	190 72 72.52	14.04	< .01
BB	#correct #wrong %correct	146 62 70.19	122 68 64.21	98 126 43.75	120 92 56.60	34.58	< .001
HP	#correct #wrong %correct	204 4 98.08	212 14 93.80	154 34 82.91	188 28 87.03	35.73	< .001
	$\bar{X}$%	87.13	80.95	70.01	76.02		

Table II

Analysis of variance (repeated measures) for data in Table I

Source	SS	DF	MS	F	
Total	4678.47	23			
Subjects	3580.97	5			
Sentpairs	954.187	3	318.06	33.29	$p < .001$
Error	143.313	15	9.554		

Table III

Experiment I:

Analysis of variance (repeated measure) for % correct on questions about first sentence

Source	SS	DF	MS	F	
Total	1169.53	23			
Subjects	752.53	5			
Sentpairs	307.94	3	102.65	14.11	$p < .001$
Error	109.06	15	7.27		

Table IV

Experiment I; Comparisons between individual sentence-pair means for percent correctly recalled (by Tukey's method)

(a) To questions about the second sentence

	BC	AC	CB	CA
$\bar{X}$	87.2	80.9	76.1	70.0
AC	$p<.05$	-		
CB	$p<.01$	N. S.	-	
CA	$p<.001$	$p<.01$	$p<.05$	-

(b) To questions about the first sentence

	BC	AC	CB	CA
$\bar{X}$	86.3	86.7	87.3	78.5
AC	N. S.	-		
CB	N. S.	N. S.	-	
CA	$p<.01$	$p<.01$	$p<.01$	-

Table V

Experiment I; Mean number of numbers correctly recalled after correct and wrong responses to questions

	BC	AC	CB	CA	
correct	4.65	4.53	4.54	4.52	4.56
wrong	4.67	4.64	4.57	4.41	4.57
	4.66	4.58	4.55	4.46	

None of the differences are significant.

Table VI

Experiment 2: Individual data and analysis are presented in the next 12 pages. On each page the sentpairs are in the order BC, AC, CB, CA and the mask/numbers presentation times are in the order .1, .75, 1.5, 2.25 secs. The scores at each sent-pair-presentation time combination represent percent correct answers to questions about the second sentence of the pair.

SUBJECT =NH CONDITION =NUMBERS

JO. OF SENTPAIRS?:4
JO. OF PRESENTATION TIMES?:4

SENTPAIR= 1
TIME = 1:82.75
TIME = 2:75.86
TIME = 3:83.33
TIME = 4:84.61

SENTPAIR= 2
TIME = 1:74.31
TIME = 2:77.27
TIME = 3:72
TIME = 4:74.Ø7

SENTPAIR= 3
TIME = 1:72.72
TIME = 2:7Ø.83
TIME = 3:67.74
TIME = 4:68

SENTPAIR= 4
TIME = 1:66.7
TIME = 2:62.16
TIME = 3:59.37
TIME = 4:55.55

SOURCE	SS	DF	MS	F	
TOTAL	= Ø.1Ø4494E+Ø4=	15			
TIMES	= Ø.335781E+Ø2=	3=	Ø.111927E+Ø2=	Ø.915117E+ØØ	N.S
ENTPAIRS=	Ø.9Ø1281E+Ø3=	3=	Ø.3ØØ427E+Ø3=	Ø.24563ØE+Ø2	p < .001
RROR	= Ø.11ØØ78E+Ø3=	9=	Ø.1223Ø9E+Ø2		

SENTPAIR MEANS FOR BC,AC,CB,CA
1 = 81.64
2 = 74.41
3 = 69.82
4 = 6Ø.95

PRESENTATION TIME MEANS FOR .1,.75,1.5,2.25 SECS
1 = 74.12
2 = 71.53
3 = 7Ø.61
4 = 7Ø.56

```
:CT =WC                              CONDITION =NUMBERS

)F SENTPAIRS?:4
)F PRESENTATION TIMES?:4


PAIR=  1
 =   1:96.43
 =   2:81.48
 =   3:84.2
 =   4:88

PAIR=  2
 =   1:90.47
 =   2:77.77
 =   3:82.35
 =   4:77.27

PAIR=  3
 =   1:90.32
 =   2:78.57
 =   3:75
 =   4:76.23

PAIR=  4
 =   1:86.36
 =   2:76.47
 =   3:65.21
 =   4:60.87


CE          SS           DF        MS            F

L     = 0.126372E+04=   15
S     = 0.601500E+03=    3= 0.200500E+03= 0.994557E+01     p<.01
PAIRS= 0.480781E+03=    3= 0.160260E+03= 0.794953E+01      p<.01
R     = 0.181438E+03=    9= 0.201597E+02


PAIR MEANS FOR BC,AC,CB,CA
   = 87.53
   = 81.97
:  = 80.03
:  = 72.23

ENTATION TIME MEANS FOR .1,.75,1.5,2.25 SECS
   = 90.90
:  = 78.57
)  = 76.69
:  = 75.59
```

```
G
SUBJECT =EH                    CONDITION =NUMBERS
NO. OF SENTPAIRS?:4
NO. OF PRESENTATION TIMES?:4


SENTPAIR=  1
TIME =  1:95.24
TIME =  2:88.46
TIME =  3:89.47
TIME =  4:91.52

SENTPAIR=  2
TIME =  1:88.23
TIME =  2:82.6
TIME =  3:78.57
TIME =  4:86.27

SENTPAIR=  3
TIME =  1:85.51
TIME =  2:81.08
TIME =  3:78.46
TIME =  4:80.28

SENTPAIR=  4
TIME =  1:78.57
TIME =  2:72.22
TIME =  3:69.56
TIME =  4:64


SOURCE          SS           DF         MS              F

TOTAL     = 0.104730E+04=  15
TIMES     = 0.143172E+03=   3= 0.477240E+02= 0.573524E+01     p<.05
SENTPAIRS= 0.829234E+03=   3= 0.276412E+03= 0.332178E+02     p<.001
ERROR     = 0.748906E+02=   9= 0.832118E+01


SENTPAIR MEANS FOR BC,AC,CB,CA
=  1  = 91.17
=  2  = 83.92
=  3  = 81.33
=  4  = 71.09

PRESENTATION TIME MEANS FOR .1,.75,1.5,2.25 SECS
=  1  = 86.89
=  2  = 81.09
=  3  = 79.02
=  4  = 80.52
*
```

SUBJECT =HP CONDITION =NUMBERS

```
NO. OF SENTPAIRS?:4
NO. OF PRESENTATION TIMES?:4


SENTPAIR=  1
TIME =  1:96.87
TIME =  2:90.91
TIME =  3:93.33
TIME =  4:95.83

SENTPAIR=  2
TIME =  1:88.23
TIME =  2:85.18
TIME =  3:80
TIME =  4:90.91

SENTPAIR=  3
TIME = 1:84.91
TIME =  2:83.33
TIME =  3:79.59
TIME =  4:86.36

SENTPAIR=  4
TIME =  1:62.5
TIME =  2:61.54
TIME =  3:60.38
TIME = 4:60.34


SOURCE          SS          DF        MS           F

TOTAL     = 0.251436E+04=  15
TIMES      = 0.703594E+02=    3= 0.234531E+02= 0.46518E+1       p<.05
SENTPAIRS= 0.239863E+04=    3= 0.799542E+03= 0.158587E+03     p<.001
ERROR     = 0.53750E+02=    9= 0.504167E+01

SENTPAIR MEANS FOR BC,AC,CB,CA
= 1   =94.24
=  2   = 86.08
=< 3  = 83.55
=  4   = 61.19

PRESENTATION TIME MEANS FR .1,.75,1.5,2.5 SCS
= 1   = 83.13
=  2   = 80.24
=  3   = 78.33
=  4   = 83.36
*
```

```
SUBJECT =NW                    CONDITION =NUMBERS

NO. OF SENTPAIRS?:4
NO. OF PRESENTATION TIMES?:4


SENTPAIR=  1
TIME =  1:94.73
TIME =  2:84.21
TIME =  3:88.88
TIME =  4:92.31

SENTPAIR=  2
TIME =  1:92.85
TIME =  2:8Ø.77
TIME =  3:78.26
TIME =  4:81.25

SENTPAIR=  3
TIME =  1:86.67
TIME =  2:76.19
TIME =  3:72.73
TIME =  4:72.97

SENTPAIR=  4
TIME =  1:76.19
TIME =  2:67.85
TIME =  3:6Ø
TIME =  4:58.Ø6


SOURCE          SS            DF        MS            F

TOTAL     = Ø.1824Ø6E+Ø4=   15
TIMES     = Ø.4Ø64Ø6E+Ø3=    3= Ø.135469E+Ø3= Ø.1Ø4Ø4ØE+Ø2   p<.01
SENTPAIRS= Ø.13ØØ47E+Ø4=    3= Ø.43349ØE+Ø3= Ø.33292ØE+Ø2   p<.001
ERROR     = Ø.117188E+Ø3=    9= Ø.13Ø2Ø8E+Ø2


SENTPAIR MEANS FOR BC,AC,CB,CA
=  1  = 9Ø.Ø3
=  2  = 83.28
=  3  = 77.14
=  4  = 65.53

PRESENTATION TIME MEANS FOR .1,.75,1.5,2.25 SECS
=  1  = 87.61
=  2  = 77.26
=  3  = 74.97
=  4  = 76.15
*
```

SUBJECT =MD CONDITION =NUMBERS

NO. OF SENTPAIRS?:4
NO. OF PRESENTATION TIMES?:4

SENTPAIR= 1
TIME = 1:88.57
TIME = 2:90.56
TIME = 3:93.33
TIME = 4:85.71

SENTPAIR= 2
TIME = 1:83.33
TIME = 2:86.66
TIME = 3:89.28
TIME = 4:82.35

SENTPAIR= 3
TIME = 1:76.92
TIME = 2:85.71
TIME = 3:86.21
TIME = 4:80.85

SENTPAIR= 4
TIME = 1:77.32
TIME = 2:83.78
TIME = 3:83.63
TIME = 4:77.41

SOURCE	SS	DF	MS	F	
TOTAL	= 0.344578E+03=	15			
TIMES	= 0.140578E+03=	3=	0.468594E+02=	0.224925E+02	$p < .001$
SENTPAIRS=	0.185250E+03=	3=	0.617500E+02=	0.296400E+02	$p < .001$
ERROR	= 0.187500E+02=	9=	0.208333E+01		

SENTPAIR MEANS FOR BC,AC,CB,CA
= 1 = 89.54
= 2 = 85.41
= 3 = 82.42
= 4 = 80.54

PRESENTATION TIME MEANS FOR .1,.75,1.5,2.25 SECS
= 1 = 81.54
= 2 = 86.68
= 3 = 88.11
= 4 = 81.58
*

Subject NH Condition = Ø MASK

```
NO. OF SENTPAIRS?:4
NO. OF PRESENTATION TIMES?:4

SENTPAIR=  1
S=  1:81.08
S=  2:82.05
S=  3:82.75
S=  4:77.27

SENTPAIR=  2
S=  1:74.07
S=  2:75
S=  3:75.67
S=  4:72

SENTPAIR=  3
S=  1:74.47
S=  2:71.82
S=  3:71.42
S=  4:65.38

SENTPAIR=  4
S=  1:73.53
S=  2:68.88
S=  3:62.79
S=  4:50

SOURCE          SS            DF        MS              F

TOTAL     = 0.982391E+03=  15
TIMES     = 0.220469E+03=   3= 0.734896E+02= 0.410055E+01      p<.05
SENTPAIRS= 0.600625E+03=   3= 0.200208E+03= 0.111712E+02      p<.01
ERROR     = 0.161297E+03=   9= 0.179219E+02

SENTPAIR (TREATMENT) MEANS - BC,AC,CB,CA
=  1  = 0.807875E+02
=  2  = 0.741850E+02
=  3  = 0.707725E+02
=  4  = 0.638000E+02

PRESENTATION TIME MEANS
=  1  = 0.757875E+02
=  2  = 0.744375E+02
=  3  = 0.731575E+02
=  4  = 0.661625E+02
```

```
SUBJECT =WC                              CONDITION =MASK

NO. OF SENTPAIRS?:4
NO. OF PRESENTATION TIMES?:4


SENTPAIR=  1
S=  1:94.28
S=  2:94.59
S=  3:95.55
S=  4:94.28

SENTPAIR=  2
S=  1:93.1
S=  2:94.12
S=  3:90.91
S=  4:89.74

SENTPAIR=  3
S=  1:91.07
S=  2:91.17
S=  3:88.23
S=  4:86.05

SENTPAIR=  4
S=  1:90.47
S=  2:86.21
S=  3:83.33
S=  4:81.25


SOURCE          SS            DF        MS            F

TOTAL      = 0.271734E+03=   15
TIMES      = 0.478594E+02=    3= 0.159531E+02= 0.459450E+01      p<.05
SENTPAIRS= 0.192625E+03=    3= 0.642083E+02= 0.184920E+02      p<.001
ERROR      = 0.312500E+02=    9= 0.347222E+01


SENTPAIR MEANS - BC,AC,CB,CA
=  1   = 94.68
=  2   = 91.97
=  3   = 89.13
=  4   = 85.32

PRESENTATION TIME MEANS
=  1   = 92.23
=  2   = 91.52
=  3   = 89.51
=  4   = 87.83
*
```

```
SUBJECT =EH                                CONDITION =MASK

NO. OF SENTPAIRS?:4
NO. OF PRESENTATION TIMES?:4

SENTPAIR=  1
TIME =   1:92.85
TIME =   2:93.94
TIME =   3:94.44
TIME =   4:85.71

SENTPAIR=  2
TIME =   1:88
TIME =   2:89.28
TIME =   3:92.31
TIME =   4:80.55

SENTPAIR=  3
TIME =   1:85.33
TIME =   2:86.84
TIME =   3:86.95
TIME =   4:82.35

SENTPAIR=  4
TIME =   1:79.31
TIME =   2:78.87
TIME =   3:70.73
TIME =   4:65.82

SOURCE          SS           DF        MS           F

TOTAL     = 0.984766E+03=  15
TIMES     = 0.193125E+03=   3= 0.643750E+02= 0.779647E+01     p <.01
SENTPAIRS= 0.717328E+03=   3= 0.239109E+03= 0.289586E+02     p <.001
ERROR     = 0.743125E+02=   9= 0.825694E+01

SENTPAIR MEANS - BC,AC,CB,CA
=  1   = 91.74
=  2   = 87.54
=  3   = 85.37
=  4   = 73.68

PRESENTATION TIME MEANS
=  1   = 86.37
=  2   = 87.23
=  3   = 86.11
=  4   = 78.61
*
```

```
SUBJECT =HP                        CONDITION =MASK

NO. OF SENTPAIRS?:4
NO. OF PRESENTATION TIMES?:4


SENTPAIR=  1
TIME =   1:86.84
TIME =   2:92
TIME =   3:96.2
TIME =   4:93.33

SENTPAIR=  2
TIME =   1:84
TIME =   2:87.03
TIME =   3:81.82
TIME =   4:79

SENTPAIR=  3
TIME =   1:81.97
TIME =   2:82.09
TIME =   3:80.3
TIME =   4:78.57

SENTPAIR=  4
TIME =   1:52
TIME =   2:45.45
TIME =   3:44
TIME =   4:40.65


SOURCE          SS           DF        MS           F

TOTAL     = 0.518395E+04=  15
TIMES     = 0.340781E+02=   3= 0.113594E+02= 0.832549E+00      N.S
SENTPAIRS= 0.502708E+04=   3= 0.167569E+04= 0.122815E+03      p<.001
ERROR     = 0.122797E+03=   9= 0.136441E+02


SENTPAIR MEANS FOR BC,AC,CB,CA
=  1   = 92.09
=  2   = 82.96
=  3   = 80.73
=  4   = 45.53

PRESENTATION TIME MEANS FOR .1,.75,1.5,2.25 SECS
=  1   = 76.20
=  2   = 76.64
=  3   = 75.58
=  4   = 72.89
*
```

```
SUBJECT =NW                          CONDITION =MASK

NO. OF SENTPAIRS?:4
NO. OF PRESENTATION TIMES?:4


SENTPAIR=  1
TIME =  1:86.11
TIME =  2:9Ø.91
TIME =  3:94.71
TIME =  4:88.23

SENTPAIR=  2
TIME =  1:83.33
TIME =  2:87.5
TIME =  3:86.96
TIME =  4:82.96

SENTPAIR=  3
TIME =  1:82.Ø5
TIME =  2:84.Ø9
TIME =  3:83.Ø5
TIME =  4:82.Ø1

SENTPAIR=  4
TIME =  1:76.92
TIME =  2:75.67
TIME =  3:69.7
TIME =  4:67.57


SOURCE          SS           DF        MS            F

TOTAL     = Ø.779156E+Ø3=  15
TIMES     = Ø.434219E+Ø2=   3= Ø.14474ØE+Ø2= Ø.164147E+Ø1     N.S
SENTPAIRS= Ø.656375E+Ø3=   3= Ø.218792E+Ø3= Ø.248128E+Ø2     p <.001
ERROR     = Ø.793594E+Ø2=   9= Ø.881771E+Ø1


SENTPAIR MEANS FOR BC,AC,CB,CA
=  1   = 89.99
=  2   = 85.19
=  3   = 82.8Ø
=  4   = 72.47

PRESENTATION TIME MEANS FOR .1,.75,1.5,2.25 SECS
=  1   = 82.1Ø
=  2   = 84.54
=  3   = 83.61
=  4   = 8Ø.19
*
```

```
SUBJECT =MD                        CONDITION =MASK

NO. OF SENTPAIRS?:4
NO. OF PRESENTATION TIMES?:4

SENTPAIR=  1
TIME =   1:89.47
TIME =   2:91.3
TIME =   3:91.57
TIME =   4:85.19

SENTPAIR=  2
TIME =   1:86.95
TIME =   2:88.23
TIME =   3:79.16
TIME =   4:76

SENTPAIR=  3
TIME =   1:85.18
TIME =   2:78.26
TIME =   3:70.37
TIME =   4:69.23

SENTPAIR=  4
TIME =   1:80.32
TIME =   2:73.07
TIME =   3:58.06
TIME =   4:49.32

SOURCE          SS             DF        MS             F

TOTAL     = 0.217024E+04=  15
TIMES     = 0.613406E+03=   3= 0.204469E+03= 0.659577E+01    p<.05
SENTPAIRS= 0.127783E+04=   3= 0.425943E+03= 0.137401E+02    p<.01
ERROR     = 0.279000E+03=   9= 0.310000E+02

SENTPAIR MEANS FOR BC,AC,CB,CA
=  1  = 89.38
=  2  = 82.59
=  3  = 75.76
=  4  = 65.19

PRESENTATION TIME MEANS FOR .1,.75,1.5,2.25 SECS
=  1  = 85.48
=  2  = 82.72
=  3  = 74.79
=  4  = 69.94
*
```

Table VII

Experiment II: Analysis of variance over all subjects for the data in Table VI; also testing the interaction between presentation times and sentpairs

a) mask condition

Source	SS	df	MS	F	
Total	13799	95			
Times	756.5	3	252.2	3.2579	$p < .05$
Sentpairs	6327.8	3	2109.3	27.25	$p < .001$
Times x S.P.	522.6	9	58.07	.75	N.S.
Error	6192.1	80	77.40		

b) numbers condition

Source	SS	df	MS	F	
Total	9542.6	95			
Times	598.1	3	199.4	4.68	$p < .01$
Sentpairs	5241.6	3	1747.2	41.04	$p < .001$
Times x S.P.	296.9	9	32.98	.775	N.S.
Error	3406.0	80	42.6		

Table VIII

Experiment II: Test of the relative strength of the sentence-pairs effect in the mask and numbers condition

Source	SS	df	MS	F	
Total	4887.1	47			
Mask/#s	7.1	1	7.1	.14	N. S.
Sentpairs	2881.8	3	960.6	19.35	
Mask/#s x SP	12.8	3	4.3	.09	
Error	1985.4	40	49.6		

Table IX

Experiment II

Comparison of individual sentence-pair (% correct) means by Tukey's method, performed after the analyses in Table VII

(a) mask condition

	BC	AC	CB	CA
$\overline{X}$	89.78	84.19	80.76	67.66
AC	$p < .05$	-		
CB	$p < .05$	N. S.	-	
CA	$p < .01$	$p < .05$	N. S.	-

(b) numbers condition

	BC	AC	CB	CA
$\overline{X}$	89.02	82.51	79.05	68.59
AC	$p < .05$	-		
CB	$p < .05$	N. S.	-	
CA	$p < .01$	$p < .05$	N. S.	-

Table X

Experiment II

Mean number of numbers recalled for correct and wrongly answered questions about second sentence of four sentence-pairs.

	Correct	Wrong	
BC	3.59	4.05	3.82
AC	3.57	3.75	3.66
CB	3.47	3.62	3.54
CA	3.39	3.42	3.41
$\bar{X}$	3.51	3.71	

Table XI

Experiment II

Mean number of numbers recalled for correct and wrongly answered questions about the second sentence for four numbers presentation times

secs.	Correct	Wrong	
.1	1.87	1.97	1.92
.75	3.57	3.59	3.58
1.5	4.35	4.47	4.41
2.25	4.47	4.56	4.51

Table XII

Experiment II:

Mask condition: differences between questions containing marked and unmarked comparatives to second sentences in which marked or unmarked comparatives were presented. Comparable data for questions about the first sentence are given in parentheses.

		BC	AC	CB	CA	$\bar{X}$
Present Unmarked Comparative	test unmarked	88.44 (82.78)	(83.35)	(85.91)	69.76 (73.59)	79.6 (81.41)
	test marked	91.12 (86.08)	(83.07)	(83.61)	65.56 (77.69)	78.34 (82.61)
Present Marked Comparative	test unmarked		83.01	82.48		82.74
	marked		85.37	79.04		82.20
$\bar{X}$		89.78 (84.43)	84.19 (83.21)	80.76 (84.76)	67.66 (75.64)	

Table XIII

Results of Experiment III, showing percent correct responses to a recognition test of -AC, -BC, -CA, and -CB non-sentence-pairs. Lines between data points represent a departure from the main effect.

S	-BC	-AC	-CB	-CA
1	71.65	70.17	62.40 —	— 66.60
2	84.81	79.20 —	— 79.83 —	— 79.95
3	87.37	84.51 —	— 87.17	80.25
4	77.85	75.55 —	— 77.70	77.10
5	58.05 —	— 58.53 —	— 58.54	53.08
6	94.38	91.47	90.71 —	— 92.07
$\bar{X}$	79.02	76.57	76.05	74.84

Table XIV

Mann-Whitney U-tests to compare differences between sentpairs in Experiments I and III

difference	U	p
BC-AC	2	.004
BC-CB	0	.001
BC-CA	1	.002
AC-CB	6	.032
AC-CA	3	.008
CB-CA	9	.090

Table XV

Analysis of variance for the data in Table XII, for Experiment III, to test for differences between performance on different non-sentpairs

Source	SS	df	MS	F	
Subjects	3159.47	5			
Sentpairs	55.469	3	18.49	3.4346	$p < .05$
Error	80.750	15	5.3833		
Total	3295.69	23			

Table XVI

Mean time in seconds to answer questions about second sentence by four subjects in Experiment IV. Times to answer questions about first sentence are given in parentheses.

	MASK					
	correct		wrong			
BC	1.04	(1.08)	1.11	(1.09)	1.07	(1.08)
AC	1.02	(1.10)	1.05	(1.06)	1.03	(1.08)
CB	1.05	(1.06)	.98	(1.04)	1.01	(1.05)
CA	1.08	(1.07)	1.06	(1.05)	1.07	(1.06)
	——	——	——	——		
	1.04	(1.07)	1.05	(1.06)		

Table XVII

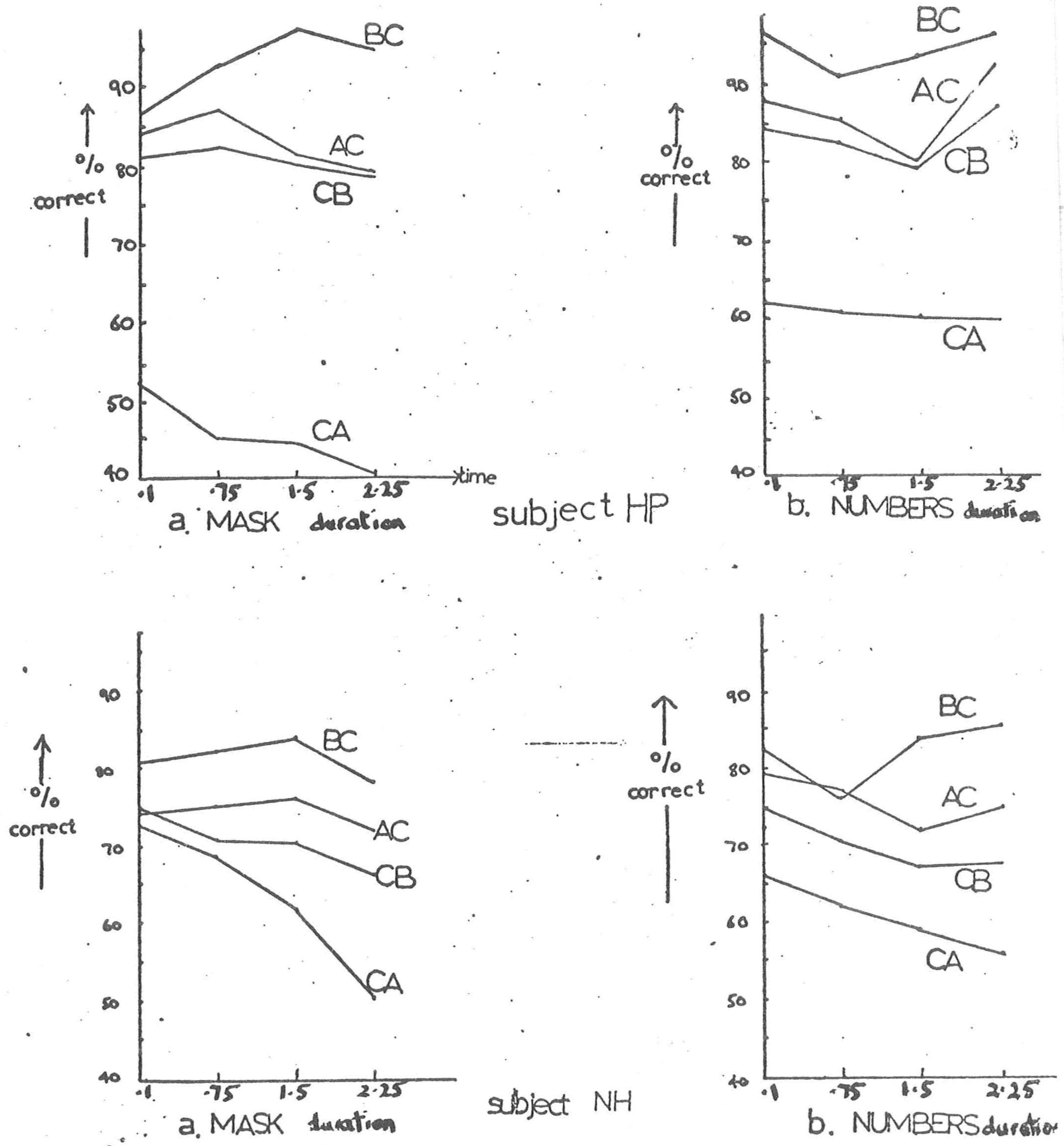
Different experimental situations and different orders of difficulty of nouns in adjacent sentences

Task	reasoning with three-term series First premise tested before presentation of second premise	reasoning with three-term series: No break between premises. Questions used unmarked adjectives.	reasoning with three-term series: No break between premises. Questions used marked adjectives	discourse creation: preferred order of nouns in adjacent phrases	comprehension of three-term series: likelihood of error in test question about second sentence of adjacent pair
	Huttenlocher (1968)	Clark (1969)	Clark (1969)	Morley (1971)	Morley (1974)
order of difficulty (easy ↓ hard)	AB-CB AB-BC AB-CA AB-AC	AB-CA AB-CB AB-BC AB-AC	AB-CB AB-AC AB-CA AB-BC	AB-BC AB-AC AB-CA AB-CB	AB-BC AB-AC AB-CB AB-CA

Table XVIII

Possible forms of test questions about the presented sentence XcY, for Experiments I, II and III and correct answers for each one in each experiment.

	XcY	Experiment I	Experiment II	Experiment III
1	XcY	yes (50%)	yes (25%)	yes (50%)
2	YcX	no (50%)	no (25%)	no (25%)
3	$X\bar{c}Y$	-	no (25%)	no (25%)
4	$Y\bar{c}X$	-	yes (25%)	-



<u>Experiment II</u>

<u>Figure 1</u>: Percent correct responses to questions about the second sentence for 4 mask/numbers presentation times.

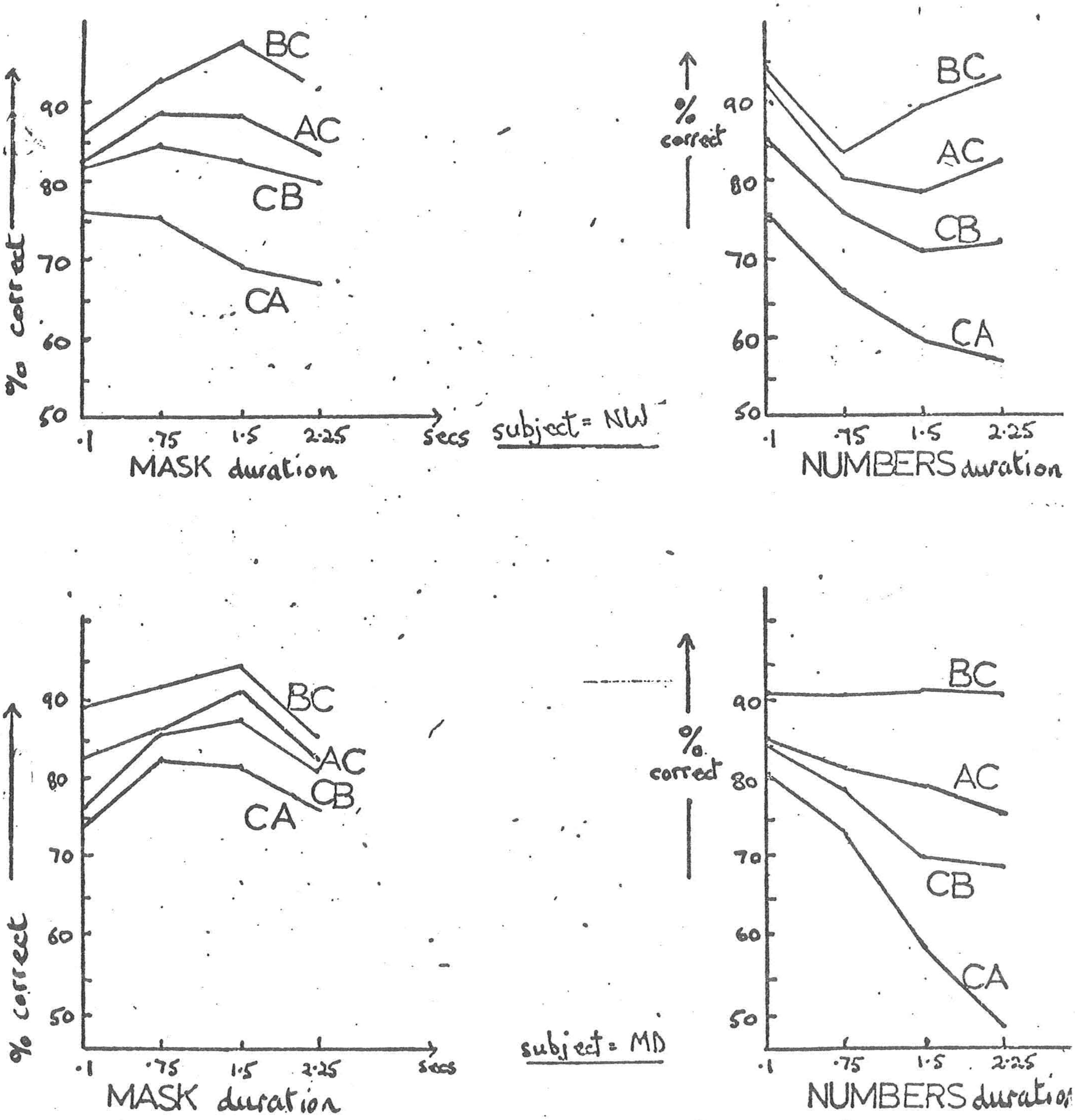

% correct
90
80
70
60
50
BC
AC
CB
CA
·1
·75
1·5
2·25
secs
MASK duration
subject = NW
% correct
90
80
70
60
50
BC
AC
CB
CA
·1
·75
1·5
2·25
NUMBERS duration
% correct
90
80
70
60
50
BC
AC
CB
CA
·1
·75
1·5
2·25
secs
MASK duration
subject = MD
% correct
90
80
70
60
50
BC
AC
CB
CA
·1
·75
1·5
2·25
NUMBERS duration

Fig. 1(cont)

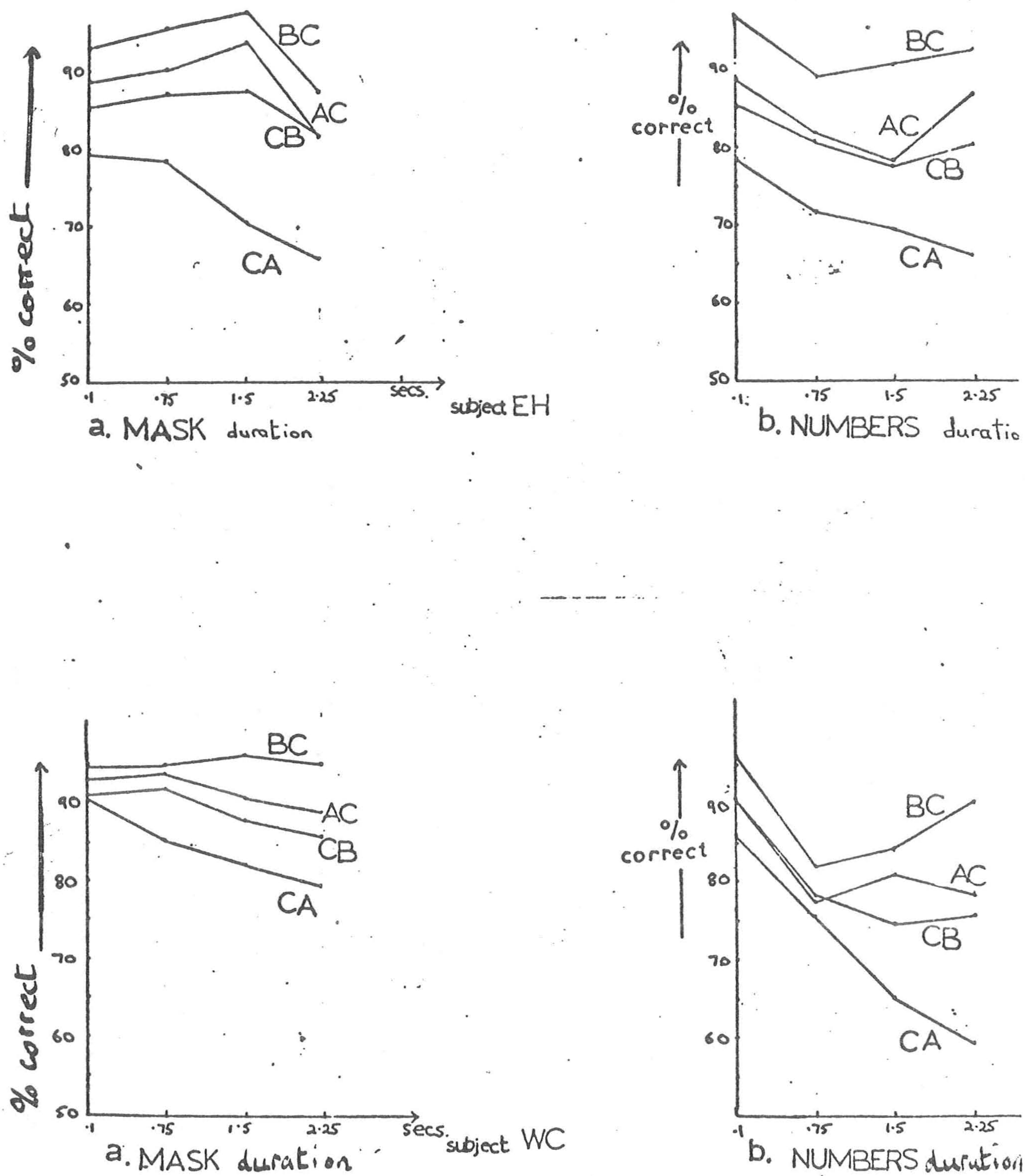


Fig.1 (continued)

APPENDIX

Comparatives used in the experiments

Better.............. worse
Bigger............. smaller
Darker.............fairer
Faster............. slower
Fatter.............thinner
Happier............ sadder
Heavier .... lighter
Higher .... lower
Earlier............later
Louder ....quieter
Older..............younger
Richer .... poorer
Rougher........... gentler
Smarter........... duller
Taller..............shorter
Warmer...........cooler

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