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ABSTRACT

Four text passages varying along the dimensions of the number of propositions unifying one or more text paragraphs and text length were constructed. The text content pertained to nine concepts in the area of operant conditioning psychology. Fifty-eight university students were pretested and then blocked on prior text-related knowledge, and read one of the four passages. Sorting, verification, and posttest tasks were performed. Data were analyzed with hierarchical cluster analysis and with analyses of variance. W. Kintsch's hypothesis that the organization of text information in memory is a function of the degree of prior knowledge, the number of unifying text propositions, and text length was given support. Reading times and the number of verification task errors significantly differed as a function of the number of unifying text propositions. Educational implications are discussed. (Author/RD)

The Effect of Prior Subject Matter Knowledge and Text Structure on the Organization of Text Information in Memory

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Paper presented at the Annual Meeting of the American Educational Research Association, Toronto, Canada, 1978.

Abstract

Four text passages varying along the dimensions of the number of propositions unifying one or more text paragraphs and text length were constructed. Subjects were blocked on prior text-related knowledge and read one of the four passages. Sorting, verification, and posttest tasks were performed. The hypothesis that the organization of text information in memory is a function of the degree of prior knowledge, the number of unifying text propositions, and text length was given support. Reading times and the number of verification task errors significantly differed as a function of the number of unifying text propositions.

The Effect of Prior Subject Matter Knowledge and Text Structure on the Organization of Text Information in Memory

One theoretical framework within which the organization of text information in memory has been studied is Kintsch's (1974, 1976a) theory of text meaning. According to this theory, each paragraph in a text passage can be represented as a list of interrelated propositions. In addition, these propositions are assumed to be organized into a text structure which is hierarchical in nature. Comprehension of the text passage, in turn, is hypothesized to lead to the acquisition of text information which also becomes hierarchically organized.

Research on the organization of text information in memory has been oriented towards either providing support for this hierarchical model (Kintsch & Keenan, 1974; Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975; McKoon, 1977) or exploring the effects of various text structure factors such as the number of text propositions (Kintsch & Keenan, 1974), the number of word concepts (Kintsch et al., 1975), text length (McKoon, 1977), and the height of specific text information in the text structure (McKoon, 1977; Meyer, 1975). Although it has been shown that a learner's prior text-related knowledge influences what is learned from textual materials (e.g., Lewis, Note 1; Mayer, Stiehl, & Greeno, 1975), the relationship between this learner variable and the memorial organization of text information has not been investigated.

Three questions are, therefore, addressed in this study in an attempt to explore that relationship. First, to what degree is the memorial organization of text information a function of a learner's prior text-related knowledge? Second, assuming that organization to be hierarchical, is the degree to which it is hierarchical a function of such prior knowledge? Third, do any characteristics of the text structure affect the degree of memorial organization?

These questions are considered within an extension of Kintsch's theory. While it is assumed that the text information in memory is hierarchically organized, it is also hypothesized that this organization occurs as a result of hierarchically ordering propositions which unify one or more of the different text paragraphs. These propositions are assumed to be either constructed by the reader or identified within the paragraphs themselves. Furthermore, the hierarchical ordering of the propositions is considered to be a function of the degree of paragraph commonality: the greater the number of paragraphs that a proposition links together (unifies), the more superordinate that proposition should be in the propositional hierarchy.

This theoretical hypothesis concerning the construction of a hierarchical organization of text memory, along with the reported findings that a learner's prior knowledge significantly influences the acquisition of information from text (Lewis, Note 1; Mayer, Stiehl, & Greeno, 1975), suggests that both the degree of memorial organization and the degree of hierarchical organization should be a function of the degree of prior text-related knowledge and the number of unifying text proporitions. If this is true, then, given a fixed number of unifying propositions in a text

passage, the greater the degree of prior knowledge, the more highly organized and structured the text information should be in memory (as indicated by a hierarchical clustering analysis). Also, given a fixed level of prior knowledge, the greater the number of unifying propositions in a passage, the higher the degree of text organization. In addition to this theoretical hypothesis, the role played by the unifying propositions in the acquisition and organization of the text information is explored in the context of the following experimental predictions:

(a) The greater the number of unifying text propositions, the longer the reading time (cf. Kintsch & Keenan, 1974) and the greater the number of errors when subjects are given a verification task consisting of sentences similar to the unifying propositions.

(b) If the number of unifying propositions influences the degree of text organization and the degree of organization is related to the degree of meaningful learning (Ausubel & Robinson, 1969), then the greater the number of unifying text propositions, the higher the score on a posttest consisting of questions based on the text information.

(c) Assuming that the number of unifying propositions is held constant, the longer the text passage, the higher the degree of text organization (cf. McKoon, 1977).

The present experiment was designed to test all of these predictions.

Method

Experimental Materials

Text bases consisting of lists of propositions comprising the meaning of the text (Kintsch, 1976b) were separately constructed for each of 9 concepts in the area of operant conditioning. The concepts were operant

response, operant level, response strength, learning, positive reinforcer, continuous reinforcement, shaping, extinction, and resistance to extinction. Concepts from the area of operant conditioning were chosen because there exists a substantial base of subject matter characterizations of these concepts (definitions, prose descriptions, examples) from which to construct the text bases.

The different subject matter characterizations were sampled from operant conditioning textbooks and publications (e.g., Deese & Hulse, 1967; Reese, 1964). The relationships underlying each of the concepts were then identified from the sampled materials and assembled into the text bases. The bases varied in length from 7 to 30 propositions. After the bases were constructed, prose descriptions of the concepts were generated by translating the propositions in the bases into sentences. In this way, the specific information contained within the text passages was controlled for.

Four different text passages were written from the text bases. One passage consisted of the prose descriptions of the concepts, together with introductory and summary paragraphs, and transition sentences connecting the paragraphs. The additional sentences embodied propositions that were intended to give the text a unifying hierarchical structure. These sentences contained, for example, information about the goals of psychology, the nature of behavioral psychology, the task of the behavioral psychologist, and the role of different conditions of practice. This passage will be called the (unified, long) passage. This passage was composed of 18 paragraphs and 2161 words. A second passage (non-unified, long) consisted of the first passage minus the additional sentences. It had 12 paragraphs and 1446 words. A third passage (unified, short) consisted of the first passage

minus propositions in the text dealing with the concepts of operant response, response strength, positive reinforcer, and shaping. It had 15 paragraphs and 1613 words. The same propositions were also deleted from the (non-unified, long) passage, thus giving rise to the fourth (non-unified, short) passage. That passage consisted of 9 paragraphs and 906 words.

A pretest and a posttest were also constructed in order to assess a subject's knowledge of the concepts prior to, and after, the presentation of the text passage. Both tests consisted of concept identification and multiple choice questions. The concept identification questions consisted of hypothetical behavioral situations. For each situation, subjects were asked to identify and analyze as many of the events and items as they could in terms of the 9 operant conditioning concepts. In the multiple choice questions, subjects had to state what would happen if a factor in a hypothetical behavioral situation changed, or draw a conclusion about a relationship that exists within such a situation. There were two multiple choice and three concept identification questions on the pretest. These same questions were on the posttest, along with two new multiple choice and three new concept identification questions.

Procedure

Each of the text passages was presented to a different treatment group. Prior to reading the passages, however, the subjects were given the pretest. Then, based upon the pretest score, each subject was assigned to either a low, medium, or high block within one of the treatment groups. The assignment to the treatment groups was random. The low, medium, and high blocks were determined by partitioning the computed difference between the lowest and

highest pretest scores of all the subjects into three divisions. Hence, a randomized block design was used, where the blocked factor was the pretest score group, and the other two factors were text structure (unified, non-unified) and text length (short, long).

Each subject read the treatment passages at his own rate of speed and recorded the times at which reading began and ended. After reading the passage, each subject was given several tasks to do. First, subjects in each treatment group performed a sorting task on the propositions in the passage they had read. That is, given sheets of paper with the passage paragraphs numbered on them and arranged in random order, they were asked to sort the paragraphs into groups such that all the paragraphs in one group "go best together" (Kintsch, 1976a). Second, the subjects were given a ten sentence verification task. They were asked to identify whether or not they had read each sentence before exactly as it was written. Some of the sentences in this task were modifications of sentences that embodied the unifying propositions, while the rest of the sentences were taken verbatim from the text passages. Third, the subjects completed the posttest. Lastly, the subjects were given ten sentences. These sentences were generated from propositions which were either the same or slightly different from those in the text bases. The differences were created by either negating a relationship in a proposition or by taking a relationship from one proposition and placing it in another one. The subjects had to identify each of the ten sentences as being true or false.

Scoring and Dependent Measures

All of the veridical tasks were blindly scored. The dependent measures for the verification and true-false tasks were the number of correct responses.

The dependent measure for both the pretest and the posttest was the total number of points awarded on the test. Either 0 or a full 10 points was awarded for the answer to a multiple choice question. The number of points awarded for an answer to a concept identification question varied from 15 to 30 points, depending upon the number of concepts that were present in that question. In order to judge these questions, sample answers were first written out. Points were then assigned based upon the degree to which the answers corresponded to the sample answers. Five points were given if a concept was correctly identified in a question, while two and one-half points were given if the concept name was identified, but not the event or item corresponding to it.

Subjects

There were 58 subjects. All were enrolled in an introductory educational psychology course at Michigan State University and were awarded points toward their grade for participating. Fifteen subjects received the (unified, short) and the (non-unified, short) passages, while there were 14 subjects in each of the other two treatment groups.

Results

Two different sets of analyses were performed on the experimental data. Hierarchical clustering analyses were carried out for the sorting task data. Analyses of variance were conducted for the dependent variables of reading time, the number of correct responses on the verification and true-false tasks, and the number of points on the posttest. The three independent variables that were considered in these statistical analyses were pretest score block (low, medium, high), text structure (unified, non-unified), and text length (short, long).

Hierarchical Clustering Analyses

Hierarchical clustering analyses were carried out in order to assess the degree of organization and structure of the text information (Fillenbaum & Rapaport, 1971; Kintsch, 1976a; Miller, 1969). First, frequency cooccurrence matrices were constructed from the sorting task data for each pretest score block within each treatment group. The rows and columns of these matrices are the numbers of the paragraphs in the text passage that were read. Each cell in a matrix indicates the number of times that two paragraphs were sorted together by the subjects in the block. The hierarchical clustering analyses were then carried out on these cooccurrence matrices using a hierarchical clustering program, LAWS (Michigan State University, Note). The degree of organization of the text information was inferred from the number of higher-order major cluster groupings and higher-order connections between the clusters. The greater the number of such groupings and connections, the more highly organized and structured the information was assumed to be.

For each of the two treatment groups receiving the unified text passages, the following trend was observed: as the degree of prior knowledge increased, so did the number of major clusters and inter-cluster connections, i.e., the more highly organized the text information appeared to be. For example, only two major cluster groupings were seen for the subjects who received the unified, long) passage and had low pretest scores (Figure 1), while three and four major cluster groupings were seen, respectively, for the subjects receiving the same passage who had middle and high pretest scores (Figures 2, 3). In addition, the greater the degree of prior knowledge, the more hierarchical the cluster analysis appeared to be.

Insert Figure 1 about here

Insert Figure 2 about here

Insert Figure 3 about here

A similar trend was not seen for the treatment groups receiving the non-unified passages. In that case, the degree of organization appeared to be about the same for each pretest score block receiving the same passage. An example of this trend can be seen by looking at Figures 4 and 5. Figure 4 depicts the organization of the (non-unified, long) text by the low pretest score group, while figure 5 shows the organization of the same text by the high group.

Insert Figure 4 about here

Insert Figure 5 about here

Both clustering analyses appear to have three major groupings. Also, there does not appear to be any marked difference in the degree to which these two clusterings are hierarchical or in the number of inter-cluster connections that are present in each analysis. The most noticeable change seems to be in the composition of the central cluster of these two figures. In the central cluster of the low group (Figure 4), the two paragraphs involving definitions of learning (paragraphs 5 and 6) are related, as are the paragraphs involving definitions of learning and the results of learning (7 and 8). Then a paragraph involving shaping (10) is hierarchically added to the 4 paragraphs involving learning and the paragraph involving a positive reinforcer (9) is then also added to this cluster. In the central cluster of the high group (Figure 5), however, all of the paragraphs involving learning (5,6,7) are initially clustered together. Then paragraphs relating to the results of learning (8) and shaping (10) are added to the cluster. In this analysis, the paragraph relating to a positive reinforcer (9) was part of a cluster relating to extinction (paragraphs 11 and 12), rather than to learning.

A comparison between the clustering analyses of the four treatment groups also revealed mixed findings concerning the degree of organization when both the degree of prior knowledge and text length were fixed. The clustering analyses for subjects with high pretest scores who received the unified passages appeared to have a greater number of major clusters and inter-cluster connections than the clusterings of high pretest scoring subjects receiving the non-unified passages. On the contrary, however, the clusterings of low and middle pretest scoring subjects receiving the non-unified passages appeared to have a greater degree of organization,

respectively, than the clusterings of the low and middle pretest scoring subjects who received the unified passages. Examples of these results can be seen by comparing figures 3 and 5, and figures 1 and 4, respectively.

Lastly, when text structure was held constant, the groups receiving the longer passages had more clusters and inter-cluster connections than the groups receiving the shorter passages.

Analyses of Variance

Reading times

The reading times for the groups receiving the unified text passages were significantly higher than the times for the groups receiving the non-unified passages, F (1, 57) = 9.949, $p < .003$. There were no significant reading time differences between the groups with respect to text length, F (1, 57) < 1.

Verification task scores

Subjects receiving the non-unified passages had a significantly higher number of correct responses on this task than subjects reading the unified passages, F (1, 56) = 18.220, $p < .001$.

Posttest scores

The posttest scores differed significantly with respect to the blocked factor, pretest score, F (2, 56) = 6.341, $p < .004$. Collapsing over the treatment groups, subjects in both the high and medium groups performed significantly better on the posttest than subjects in the low group, t (46) = 3.385, $p < .001$ and t (46) = 2.780, $p < .008$, respectively. The scores of subjects in the medium group did not differ significantly from those in the high group. Neither text structure nor text length was a significant variable with respect to posttest score.

True-false task scores

No significant differences were found with respect to text structure or text length on this task. There was, however, a significant interaction between text structure and text length, $F(1, 57) = 5.970$, $p < .018$. Subjects receiving the short non-unified passage scored higher than those receiving the short unified passage, while those receiving the long unified passage scored higher than subjects receiving the long non-unified passage.

Discussion

This study examined the effects of the variables of prior text-related knowledge and text structure on the organization of text information in memory. Assuming a hierarchical clustering analysis to be an accurate reflection of that organization, support was found for the hypothesis that the degree of memorial organization was a function of both variables. The relationship, however, between these variables and the degree of organization was complex.

Two different kinds of interaction effects were seen between these variables and the degree of organization. First, as predicted, the degree of (hierarchical) organization was found to be directly related to the degree of prior text-related knowledge when the text structure contained a fixed number of unifying propositions. This finding did not hold, however, when those propositions were absent from the passage. In that case, only slight differences in the organization of text information were seen as a function of the degree of prior knowledge.

The second interaction effect appeared when the degree of prior knowledge was fixed. Unequivocal support was not found for the hypothesis that the degree of text organization was directly related to the number of unifying

text propositions. While this was seen for subjects with a high level of prior knowledge, it was not seen for subjects with lower levels of initial knowledge. In that case, the degree of organization for subjects who read passages without the unifying propositions was greater than for those who read passages which contained those propositions.

A possible explanation for both of these interaction effects could be that the unifying propositions, rather than facilitating the organization of text information for students with a relatively low degree of prior knowledge, actually interfered with the organization process. Because these propositions introduced additional knowledge to the text, subjects would have had to make sense out of that knowledge by relating it to all of the other propositions that were being processed in reading the passage. Subjects who had relatively little knowledge to begin with could have been hampered by the presence of these additional propositions. Subjects who already had a high level of initial knowledge, however, could have ignored that information or used it as cueing information while processing the other knowledge being presented.

The study also supported two of the three experimental predictions concerning the influence of the unifying propositions on the acquisition and organization of text information. Reading times were directly proportional to the number of unifying propositions in the text. Subjects receiving passages with unifying propositions did make more errors than subjects receiving passages without such sentences. Also, the degree of text organization was higher for subjects receiving a long text than for those receiving a short text, regardless of the text structure. The predictions regarding the posttest and true-false tasks were not supported. Neither

of these scores differed significantly between the text structure treatment groups.

The finding about reading time replicates Kintsch and Keenan's (1974) result. As the number of propositions increases, so does the amount of information to be processed and the time needed for processing. The results of the verification task seem to indicate that, when unifying propositions were present, they were processed and organized in memory. They were not remembered verbatim, but could have been used as anchors around which to organize the other knowledge that was presented. The fact that text length affected the degree of organization appears to be due primarily to the inclusion in the clustering analyses of the introductory and summary paragraphs. These two paragraphs themselves were part of a cluster. Lastly, the lack of significance with respect to the posttest and true-false scores may have been due to the nature of the test questions. These questions may only have tapped knowledge based on information present within both kinds of text passages. If this was the case, then it is not surprising that no performance differences were found. It is unclear why the interaction effect was found in the true-false task. It is difficult to explain why groups receiving texts differing in both text structure and text length should have performed equally well on the task.

There are three methodological issues that occur in connection with this study that deserve further examination. First, it is assumed that the degree of memorial organization can be inferred from the number of major clusters and inter-cluster connections in a hierarchical clustering analysis. While this assumption seems reasonable, its validity still needs to be supported by empirical data. One experiment that could be performed would be to show

subjects who have mastered the concepts presented in this study (e.g., subjects with a high degree of knowledge as evidenced on a test like the pretest) pairs of different hierarchical clusterings of the concepts. The subjects would be asked to rate the degree of similarity of organization of each pair or to indicate the member of each pair that has a greater degree of organization. In this way, the dimensions which are used in determining the degree of organization could be empirically evaluated.

A related methodological question has to do with the degree of generality of the experimental results. Are they domain-specific? That is, can similar conclusions about the relationships between prior knowledge, text structure, and memorial organization be reached when the concepts are, say, in the area of poetry? Repeating this study using a different set of concepts would help address this question.

The third issue concerns the relationship between memorial organization and text structure. To what degree are the organizations depicted in the hierarchical clusterings a function of the text structure and to what degree are they a function of an existing organization of conceptual knowledge in memory? An answer to this question would help to separate out the contributions of the text structure and prior knowledge to the memorial organization seen after reading. While it is likely that the text structure plays a greater role for learners with a low degree of prior knowledge and the memorial organization of prior knowledge plays a greater role for learners with a higher degree of prior knowledge, an analysis of these factors still needs to be made and empirically supported. One way that this could be done would be to gather data on the memorial organization of the experimental concepts both before and after reading the text. A sorting task could be used both times. Instead of

sorting paragraphs, however, subjects might be asked to group the concept words on the basis of their similarity of meaning.

Educational Implications

Perhaps the major implication of the interaction effects reported in the study is that the degree to which organizers such as the unifying propositions which were present in the text passages can aid the process of text organization may be a function of a learner's degree of prior text-related knowledge. Prior knowledge appears to help the organizational process along, but it may not be necessary if all the information that is needed for text comprehension and organization is present in the text in a highly organized and structured form.

Constructing and comparing analyses of a learner's knowledge (using a sorting task similar to the one used in the study) with that of the text information (as represented in the text structure) may be a useful way of diagnosing the specific concept groupings and links between the groupings that are missing in the learner's cognitive structure. With this information, the teacher could be directed to the specific knowledge that the student must learn.

Reference Notes

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2. Hierarchical Clustering Based on a Criterion of Largest Average Within-Cluster Similarity (LAWS). Technical Report No. 70-1, Michigan State University, June, 1977.

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Figure Captions

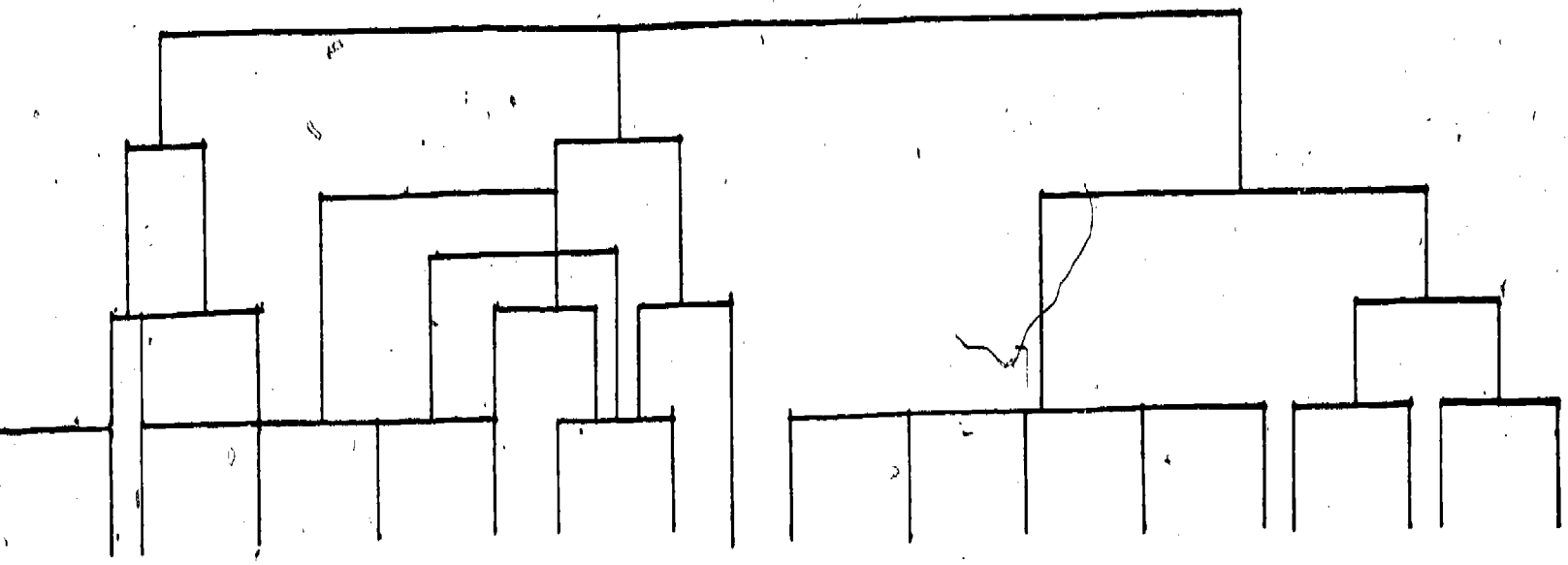
Figure 1. The hierarchical clustering analysis for subjects with low pretest scores receiving the (unified, long) passage.

Figure 2. The hierarchical clustering analysis for subjects with middle range pretest scores receiving the (unified, long) passage.

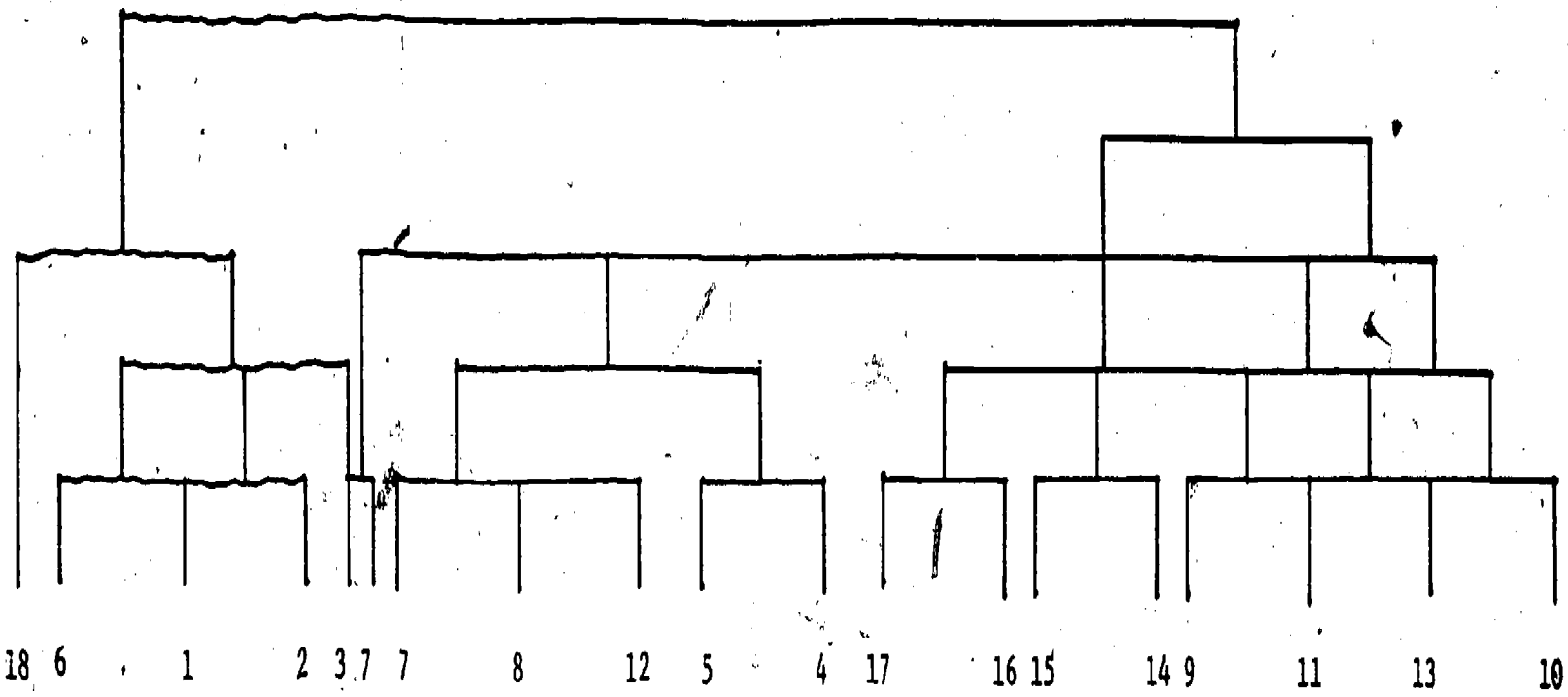
Figure 3. The hierarchical clustering analysis for subjects with high pretest scores receiving the (unified, long) passage.

Figure 4. The hierarchical clustering analysis for subjects with low pretest scores receiving the (non-unified, long) passage.

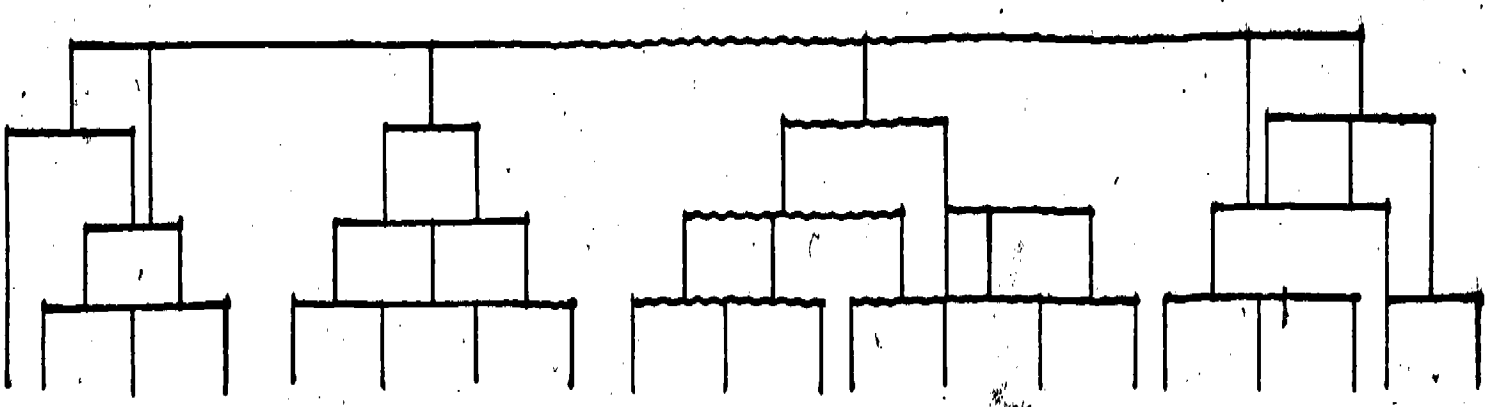
Figure 5. The hierarchical clustering analysis for subjects with high pretest scores receiving the (non-unified, long) passage.



Paragraph 16 describes extinction.
Paragraph 17 describes resistance to extinction
Paragraph 15 describes shaping
Paragraph 14 describes a positive reinforcer and continuous reinforcement
Paragraphs 11,9,10 characterize learning
Paragraph 12 describes the result of learning
Paragraph 13 characterizes conditions of practice
Paragraphs 7,8,5 characterize response strength
Paragraph 4 describes an operant response
Paragraphs 18,3,2,1,6 characterize behavioral psychology



Paragraphs 18,6,1,2,3 characterize behavioral psychology
Paragraphs 7,8,5 characterize response strength
Paragraph 12 describes the result of learning
Paragraph 4 describes an operant response
Paragraph 17 describes resistance to extinction
Paragraph 16 describes extinction
Paragraph 15 describes shaping
Paragraph 14 describes a positive reinforcer and continuous reinforcement
Paragraphs 9,11,10 characterize learning
Paragraph 13 characterizes conditions of practice



16 17 14 15 7 5 4 8 10 11 12 15 9 13 10 1 18. 2 6 3

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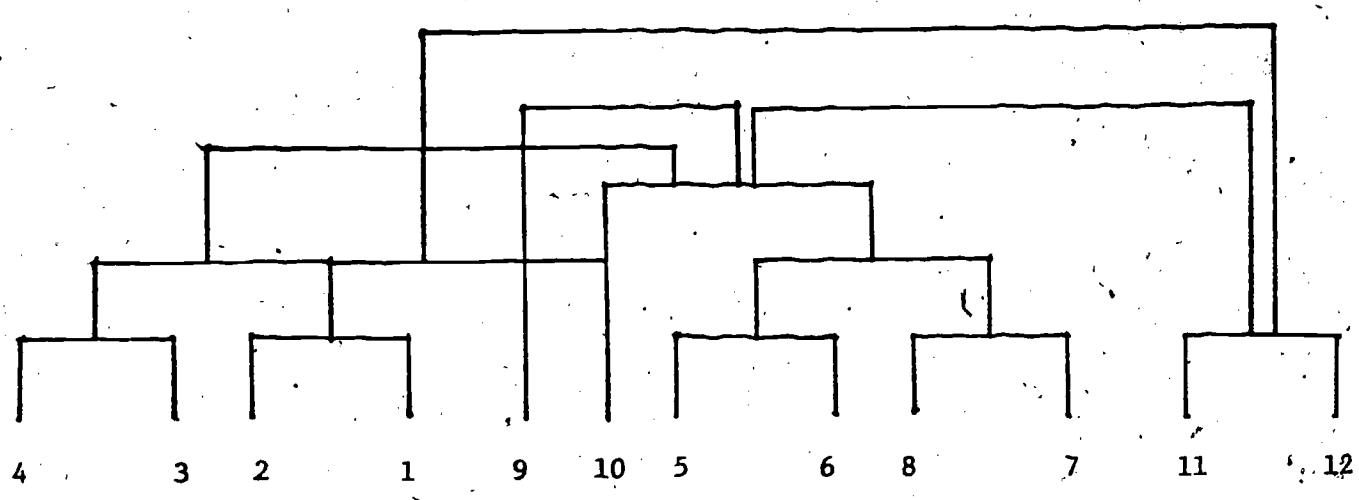
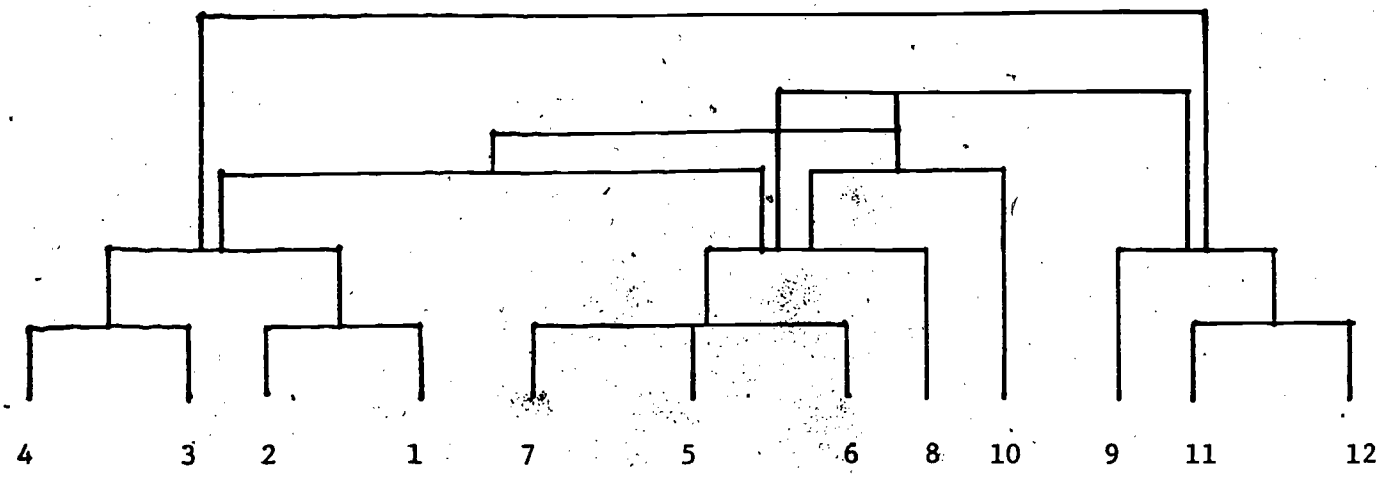
Paragraph 12 describes the result of learning
Paragraph 13 characterizes conditions of practice
Paragraphs 1,18,2,6,3 characterize behavioral psychology



Paragraphs 2,1 describe an operant response
Paragraphs 4,3 describe response strength
Paragraphs 5,6,7 characterize learning
Paragraph 8 describes the result of learning
Paragraph 9 describes a positive reinforcer and continuous reinforcement
Paragraph 10 describes shaping
Paragraph 11 describes extinction
Paragraph 12 describes resistance to extinction



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