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CODING SYSTEMS AND THE COMPREHENSION OF INSTRUCTIONAL MATERIALS

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The objective of the current study is to improve instruction, especially instruction of adults who come to the instructional situation with varying degrees of relevant background and information. The practical problem is how to interface the instructional materials and their presentation with the skills and knowledge that the learner brings with him to the task. The research program attempts to supply some of the basic research that will help to answer such practical questions. Reicher and Schaeffer are focusing on the skills necessary to take in new information. Reicher began by comparing how the novice does it. He has found that

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e expert decomposes the material into much larger units or "chunks" than does ne novice. The expert also is able to more quickly distinguish and ignore those portions of the information that are least important or irrelevant. Schaeffer is concerned with the initial acquisition of the skills necessary to encode the new material. He believes that the novice or the individual who lacks the skills to cope with instructional material may be in the same position as a child who is first learning to read or to acquire information. Wickelgren is working on the more theoretical aspects of these questions. He places the problem of instruction in the context of the psychology of memory. He has been working on a theory of the structure of semantic memory and the inference process. Hyman has been developing experimental paradigms to investigate questions about how the content and structure of what a learner already knows affects the way he interacts with new information about the relevant area. In some cases the knowledge that the learner brings with him to the instructional situation gets in the way or prevents efficient absorption of the instructional materials. In other cases, this prior knowledge greatly facilitates the assimilation of the new material.

0.0 Technical Report Summary

This report marks the half-way point in our three year contract. But it falls far short of the halfway point in our output. We planned to spend the first year "tooling up" and trying out a number of potential paradigms. This we did. We planned to emphasize, during the second year, the development of an integrated framework within which to organize our own work and that of our colleagues in other laboratories. This we are currently in the process of doing. We plan to describe the framework and illustrate its applications in the next semi-annual technical report. Our expectation, then, is that the first two years would be prepatory towards a full, and sustained program of empirical research during the final or third year of the project. This will be possible because our new Prime Computer system (expected in January) will greatly expand our experimental capabilities. In addition, the final completion of the rennovation of Straub Hall should be accomplished just prior to our third year. And, finally, our completed framework will serve as the source of many new experimental paradigms.

Hyman reported on the first two experiments using his new impression formation paradigm at the Tenth Annual Carnegie Mellon Conference on Cognition in June, 1974. At that time, he could report that the paradigm looked quite promising, but any immediate results were quite tentative. Since that time, Hyman, Polf and Neill have completed a total of four experiments employing the paradigm. The paradigm presents the subject with a brief personality sketch about a hypothetical individual along with the occupational category to

to which he belongs. The subject's immediate task is to form a coherent impression about this individual so that he can make various judgments about him. He describes this impression on a checklist of traits. This description provides us with information on how the subject has encoded the input and the sorts of inferences he has made about the hypothetical individual. At a later point in the session, we unexpectedly test the subject's memory for the original personality sketch. We are interested, at this point, in the mistakes and distortions that occur in the subject's memory. This will tell us something about how inferences and comprehension of the original material affect what is stored and available in memory.

In these experiments we vary the degree of compatibility between the occupational assignment and the personality sketch. We find that both recognition and recall memory are affected similarly by this manipulation. When the occupational category (say "Social Worker") and the personality sketch (say it is about an individual who is described as sympathetic, generous, tolerant, etc.) are compatible, the subject tends to remember both the actual descriptors we presentd him with as well as a number of other descriptors that are consistent with the stereotype of a social worker or a generous and friendly individual. When the occupational category and the personality sketch are incompatible (say that we assigned the previous sketch to "accountant"), the correct recall for the descriptors actually used in the sketch is the same as for the compatible case. But in the incompatible case the tendency to recall associated or related descriptors is much less.

This latter finding suggests that the subject has encoded the material in two different ways. In the compatible condition, he encodes the input description

in highly generic terms. When he receives input that is consistent with his expectation, he does not process it into those features that distinguish each descriptor from the others. Rather, he focusses only upon the common features. Thus, in later recall he cannot distinguish the input items from items that are consistent with their general import. In the incompatible case, however, the inconsistency with expectation forces the subject to attend to the distinctive features of each descriptor. He thereby is not tempted, in later recall, to confuse the input inormation with closely associated descriptors. Many ingriguing educational implications of this finding suggest themselves, but we are pursuing it into other contexts before we speculate further.

Wickelgren continued his theoretical work on the inference process in semantic memory. And Barbara Dosher and Al Corbett are now in the process of collecting data on their applications of the speed-accuracy tradeoff paradigm to problems of how information is represented in semantic memory and how categorization occurs. Both Reicher and Schaeffer continue the work reported on in the last report. All these projects are long-term in nature, involving many sessions over long periods of time, with the same subjects. We do not expect to have results to report, therefore, until later in the project.

Miriam Rogers completed her dissertation under our sponsorship. She tried to demonstrate a symmetry between generating and using visual codes to the generation and use of name codes. Her data indicate, contrary to earlier models in information processing, that subjects tend to generate both visual and verbal codes to handle identification and sentence comprehension tasks.

During this period we were fortunate to have visits from Ulric Neisser, Rochelle Gelman, David La Berge and Elizabeth Loftus.

This report will be realtively brief because we are planning to make the next semi-annual technical report a full summary of the first two years of the project.

1.1 Introduction

To help put the work in context I think it might be helpful to first restate the objectives of the current contract. We are concerned with instruction, especially with instruction of adults who come to the instructional situation with varying degrees of relevant background and information. The practical problem is how to interface the instructional materials and their presentation with the skills and knowledge that the learner brings with him to the task. Should the instructional manuals and the manner of presentation of information be adapted to the current level of the learner? Or should the learner be taught the remedial skills and information necessary to enable him to handle the current instructional materials and programs?

Our research program attempts to supply some of the basic research that will help to answer such practical questions. Both Reicher and Schaeffer focus on the skills necessary to take in new information. Reicher begins by comparing how the novice does it. He finds, for example, that the expert decomposes the material into much larger units or "chunks" than does the novice. The expert also is able to more quickly distinguish and ignore those portions of the information that are least important or irrelevant.

The problem is to find ways for the novice to develop the codes or coding systems that enable the expert to take in relevant information in larger chunks and to more quickly recognize those parts of the input that can be ignored.

Schaeffer is more concerned with the initial acquisition of the skills necessary to encode the new material. He believes that the novice or the individual who lacks the skills to cope with instructional material may be in the same position as a child who is first learning to read or to acquire information. So Schaeffer attempts to set up laboratory situations in which subjects have to acquire a new code in order to take in the information being given.

Wickelgren and his students work on the more theoretical aspects of these questions. They place the problem of instruction in the context of the psychology of memory. Most of the empirical and theoretical work on the acquisition and retention of information has dealt with relatively meaningless or arbitrary items. The question naturally arises as to how much of this theory and research can be applied to the more realistic situation in which the information to be acquired is meaningful and related to material already stored in memory. To this end, Wickelgren has been working on a theory of the structure of semantic memory and the inference process. He hopes to come up with a paper on this soon.

Hyman and his students have been developing experimental paradigms to investigate a number of questions about how the content and structure of what a learner already knows affects the way he interacts with new information about the relevant area. In some cases, for example, the knowledge that the learner brings with him to the instructional situation gets in the way or prevents efficient absorption of the instructional materials. In other cases, this prior knowledge greatly facilitates the assimilation of the new material. At one extreme, the new information is so completely assimilated to the existing memory structure that no change is produced by the instructional material. The student treats the new input as familiar and fails to notice or distorts the new or novel aspects to fit his preconceived notions. In such cases, the instruction produces no change in the existing memory structure. At the other extreme, the new information is so discrepant from what the learner already knows that he has no basis for effectively encoding it or incorporating it into his memory. In this latter case, as well, the learner does not gain from his exposure to the material. The ideal situation, at least in terms of the model from which Hyman works, is one in which there is sufficient relationship between the new input and what the learner already knows so that he has a basis for "comprehending" or relating to the new input. At the same time, there must be sufficient discrepancy from what he knows so as to force some change in his existing memory structure to accomodate the new information.

Within this context, I will briefly describe what is new in our activities under the present contract.

2.0 Wickelgren and his Students

As I already mentioned, Wickelgren is working on a theory of how semantic memory is structured and how we retrieve information or make inferences about new inputs based upon this structure. Two of Wickelgren's students are carrying out Master's Theses under the present contract. In both cases, the students are employing Wickelgren's notions about how the speed-accuracy tradeoff function can be applied to teasing out the component processes involved in the retrieval of information from semantic memory. Barbara Dosher is using the speed-accuracy tradeoff method to test three different models about how information contained in sentences is represented in memory. Just about all the current models of how meaningful information is stored in memory assume that there are items of information which can be represented as nodes of a network and that the connections or relations between these items can be represented as labeled links. Dosher deals with the basic sentence form that involves a subject, an object, a verb, a location, and a time. An example that Anderson and Bower employ in their book on Human Associative Memory is: "The hippie kissed the debutante in the park yesterday." All these theories assume that any prose material can be decomposed into a series of propositions of this form. But Dosher claims that she can find differences in the structural details of some of these models; and these differences lead to predictable consequences. Her thesis attempts to see which of three models of how meaningful information is represented--that of Anderson and Bower, that of Norman and Rumelhart, and that of Wickelgren--best fits with the empirical data. If we can decide at this early stage what is the best way to represent the manner in which individuals organize basic propositional information, then we would have a powerful tool to construct instructional materials in various ways and to diagnose the ways an individual is lacking when he is having trouble in mastering new material.

Al Corbett is applying the speed-accuracy method to the problem of finding out what makes some items or objects "better" examples of a semantic category than others. Both the literature on pattern-recognition and that on semantic memory has generated a variety of models to explain how some objects become more "typical" or representative of an entire category than others. Corbett is attempting to straddle the two previously separate areas of research on this problem. He is using some of the models tested and generated by Hyman, Posner and Keele, and Attneave in the pattern recognition domain. He is also looking at the models in the semantic memory area such as that of Collins and Quillian and Rosch, among others. For teaching concepts and learning to discriminate members of different categories from one another, the development of a theoretical basis for what makes some exemplars better than others could be quite useful.

3.0 Schaeffer

Schaeffer, as part of his program to investigate the acquisition of skills for encoding information, is currently teaching subjects a new alphabet. At one stage in learning to decode from the new alphabet to the familiar one, the subject will, it is theorized, make mistakes in terms of visual or formal confusions among the physical components of the code. At another stage in mastery, the confusions will be at the phonemic level, because part of the translation of the code into language involves articulatory processes. And, finally, there will be a stage at which the confusions will be at the semantic level. Some earlier work has indicated that retarded children and children who are having learning difficulties are more apt to make confusions between words that sound alike during learning tasks; but normal children and ones who are fairly proficient make mistakes at the semantic level.

4.0 Reicher

Reicher, who was the first to demonstrate the superiority of processing whole words over the processing of individual letters, has returned to the problem of word recognition. He sees this as another approach to investige how individuals handle meaningful groupings in reading and other skills. Previous studies of chess masters, sight readers, quality control inspectors, speed readers and others indicate that the ability to take in new information is what differentiates the expert from the nonexpert. The expert has developed a coding system that enables him to take in material in relatively large chunks that form meaningful units or patterns in terms of the material being processed. The challenge for an instructional technology is to find out what the basis is for this ability to segment the input into the appropriate meaningful units. Then it becomes a matter to find ways to teach novices how to discover and encode the material into the same sort of units. With the collaboration of Harold Hawkins, a visiting Professor, he has undertaken a series of experiments to see if the superiority of recognizing words over strings of letters is due to factors located in the articulatory or auditory system (pronounceability) or to factors specific to the visual system (spelling patterns or familiar groupings of letters). The experimental paradigm involves the interference paradigm which has been developed in our laboratories. Briefly, this involves tying up the auditory system with another task or tying up the visual system by masking to see how this affects the word superiority effect. Among some of the instructional implications would be possible information about what sorts of feedback to give or which modalities would be optimal to display auxiliary information during an instructional situation.

5.0 Hyman and his Students

Instruction deals with the acquisition of knowledge. A minimal requirement for instruction to be effective is that the learner add to what he already knows and/or restructure or otherwise alter what he already knows. Ever since his earlier studies on creative problem solving among engineers, Hyman has been concerned with questions about the "prepared mind." Any learner brings with him to the instructional task an already existing storehouse of knowledge, preconceptions, attitudes, beliefs and feelings about the material to be mastered. We can easily find examples, both in real life and the laboratory, to demonstrate how this organized memory based upon prior experience can hinder the acquisition of new information or can result in distorting the way the new information is assimilated. We can also find examples that seem to demonstrate that new material cannot be mastered or properly comprehended without previous relevant knowledge and experience. The question, of course, is not whether prior experience or the "prepared mind" is helpful or harmful when acquiring new information. Rather, the question is,under what conditions does prior experience help and under what conditions does it hinder the acquisition of knowledge?

Ever since he wrote his book on "The Nature of Psychological Inquiry" (1964), Hyman has been interested in applying the model that he adopted to describe the growth of knowledge. This model of how knowledge is acquired is applied to both the cognitive development within a single individual as well as the accumulation and revision of knowledge within a field of inquiry such as a scientific issue. The model can be labelled a schema-with-correction model or a discrepancy-from-prototype model. Such a model is implicit or explicit in positions put forth by Brunswik, Gombrich, Piaget, Kuhn. Briefly, the model says that we take in new information by an active, constructive encoding. This encoding involves a "match" process much like that proposed by Anderson and Bower in their model of HAM. The individual attempts to match as many elements or units in the new input as possible to nodes already existing in his semantic memory. These matched portions of the input need not be processed further. Those portions of the new input that cannot be successfully matched have to either be discarded, reinterpreted, or actively incorporated into the existing memory structure by the construction of new nodes and links from these already existing nodes.

At one extreme, if the individual cannot match any part of the new input to existing nodes in memory, there is no way for him to comprehend the new input or to incorporate it into his memory. It can have no effect. At the other extreme, the match can be so complete that no change is required in the existing memory structure to completely assimilate the information. Again, no active processing is required and no change occurs