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The Effect of Interactive Overviews on the Development of Conceptual Structure in Novices Learning from Hypermedia

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Prior research has shown that advance organizers in the form of structured interactive overviews alter the learning experience when used as part of a hypertext program, especially when there is a well defined learning goal (Dee-Lucas & Larkin, 1995). The effect of the interaction between one's goals and the structure of an overview, as evidenced in the structure of the learner's acquired knowledge base, was explored in the present study. Novices in the domain of biology were assigned to identical hypermedia systems equipped with one of two interactive overviews and to one of two learning goals. Each subject's goal and overview were either consistent (e.g., learn about animal families and use an overview organized by animal families) or inconsistent (e.g., learn about animal families and use an overview organized by ecosystems). Cued-association and card sorting posttests were administered to provide measures of conceptual structure. Strong main effects of overview structure were found on both measures. The learners' goals had only a small effect on the shape of conceptual structure and there were no significant interactions between goal and overview structure on any measure. These results converge on the conclusion that, when the learner has no prior knowledge, the influence of an overview is powerful enough not only to guide the structure of a novice's internal representations, but to overshadow the effect of the learning goal during that process. When learners do have some background information, however, the effect of the overview is significantly reduced. The discussion centers on these theoretical points as well as practical implications of this research.

Advance organizers are devices used to indicate the organization of a body of information for the learner. For example, the table of contents provides information about the organization and order of topics in a book. Electronic media such as the World Wide Web (WWW) and hypermedia systems often use interactive overviews (IO's) as advance organizers. In this context, entries in the organizer can be clicked to access the documents they represent. Advance organizers have been shown to affect learning outcome (Glover & Krug, 1988; Snapp & Glover, 1990; Townsend & Clarihew, 1989) and conceptual structure, the organization of information in memory (Kraiger, Salas, & Cannon-Bowers, 1995). The present investigation was conducted to explore the effect of the interaction between novice learners' goals and the structure of IO's on conceptual structure. The following section reviews some of the literature on the effects of advance organizers that motivated the present study. Theories proposed to account for these effects are explained in the subsequent section.

Advance Organizers, Learning, and Conceptual Structure

A large number of studies have shown the facilitating effect of advance organizers on a large assortment of outcome measures. For example, Snapp and Glover (1990) studied both 8th-graders and college students and found that, for the younger subjects, careful examination of an advance organizer (controlled through a paraphrasing task) improved performance on both high order and low order study questions. The college students also showed improvement on high order study questions due to careful study of an advance organizer. Likewise, Glover and Krug (1988) gave 15-17-year-old students outlines as advance organizers before having them read a text. This group was compared to a control group which was not given the overview. They were able to show that those in the experimental group were able to identify significantly more false statements embedded in a text (56%) than those who were not shown the advance organizer (26%).

Townsend and Clarihew (1989) explored the effects of advance organizers on the comprehension of text. Specifically, they were interested in the interactions of prior knowledge and visual information with the effect of advance organizers. They found that the advance organizer alone had little effect on 7-10-year-olds' comprehension of text when they had little prior knowledge. However, when pictures were added to the verbal advance organizer, comprehension improved significantly over the control group with no advance organizers.

Retention of textual information has also been shown to be affected by the presentation of pictorial advance organizers by Tajika, Taniguchi, Tamamoto, and Mayer (1988). Eighth-graders were given either an integrated pictorial advance organizer, a fragmented advance organizer, a preview of the text, or no advance help. Those in the integrated overview condition were able to recall more information from the passage they studied than all other groups. This was true in tests of immediate and delayed recall. Kraiger et al., (1995) were also able to show that conceptual structure is affected by advance organizers. They presented undergraduates in a naval decision-making task with advance organizers that explicated the goals of the learning task. Those who were exposed to advance organizers developed more meaningful mental structures for the material included in the training session than control subjects.

Dee-Lucas and Larkin (1995) were able to show that hypertext users exposed to interactive overviews outperformed learners who studied the same materials using traditional text on tests of breadth of recall and memory for text topics. When given a specific learning goal, however, hypertext users working with a structured overview (a hierarchy) even outperformed other hypertext learners who were exposed to an unstructured overview (an alphabetical index). This study is particularly relevant to the present investigation not only because it was conducted using hypertext rather than traditional text, but also because it indicates that there is a relationship between the learner's goals and the structure of an advance organizer. Subjects in that study were told they would have to summarize the system's information. The hierarchical overview seems suited for that particular task. Since hierarchies are organized to clarify a domain's major information units and the relationships between them, the overview structure would have provided cues helping to identify main points and meet the learning goal. In short, the compatibility of the learners' goal and the overview structure may have been a determining factor in the results of that study.

The literature provides no evidence about the effects of an incompatibility between an advance organizer and learners' goals. A study by Mannes and Kintsch (1987), however, did explore the effects of compatibility between advance organizers and text structure. They gave students one of two outlines of a text before allowing them to read the text. The first was consistent with the structure of the text and the second was not. Both outlines contained the same information, some of which was in the text and some was not. They found that novice students who saw the consistent outline did better on recall tasks for information in the text, which confirmed that the advance organizer aided in recall. Mannes and Kintsch (1987) propose that the advance organizer provides a skeleton, what Kintsch (1988) has called a *text base*, upon which to build new information. When the essay is read, information from the essay can easily be added to that structure. On the other hand, if an advance organizer produces text base X and the essay produces text base Y, it is harder to add the new information.

This report concurs with that of Zeitz (1990) who had literature experts and novices read poetry (among other pieces of text) and then tested them on their memory for the structure and content of what they read. She also probed their internal representations of the standard verse structure. She found that an important part of learning is obtaining an organized structure in which to store information.

Other studies have led to the same conclusion. Chi and Koeske (1983) studied a four-year-old's knowledge of dinosaurs. They engaged him in a series of spontaneous and cued recall tasks, and used that information to map his internal representation for that domain. They found that his cognitive structure was roughly hierarchical. Chi, Hutchinson, and Robin (1989) further explored the impact of internal structure on knowledge use. They studied a group of children who were dinosaur experts and a group who were novices. They found that the experts and novices differed in the organizations of their internal representations for the domain. They also found that the experts were better able to use their knowledge to generate causal explanations, use categorical reasoning, and induce attributes about novel dinosaurs. Whether the relationship observed in that study is causal is unknown, but such results do indicate that the organization of an individual's conceptual structure is related to learning and memory. Indeed, it has been argued that the information processing approach to cognition assumes that the primary result of instruction is the "...acquisition of particular kinds of memory structures. The latter structures, in turn, are the antecedents that enable the human learner to display retention and transfer in terms of new performances." (Gagne & White, 1978, p. 187)

In summary, a large number of studies have indicated that advance organizers augment the learning outcome on a variety of measures. Dee-Lucas and Larkin (1995) have also shown that there is a relationship between the structure of an advance organizer and learners' goals when learning from hypertext. While Mannes and Kintsch (1987) have shown the importance of consistency between an advance organizer and the text it represents for novices, the effect of an inconsistency between the overview and learning goal is unknown. The present study investigates this effect by examining learners' mental representations for newly acquired material after exposure to IO's which are either consistent or inconsistent with their goals.

Explanations of the Effects of Advance Organizers

The most widely accepted explanation of the effect of advance organizers is that they allow the learner to connect incoming information to prestored knowledge so that deeper learning may take place. The advance organizer allows the learner to access the appropriate information for integration. This idea is central to Kintsch's (1988) construction integration model which distinguishes between knowledge which is stored without becoming integrated into prior knowledge and that which is integrated into prior knowledge. When prior knowledge is not integrated, the stored information from the text is called a *text base* and learning is thought to be more "shallow." When the text base is incorporated with prior knowledge, a *situation model* is formed and "deeper" learning takes place. Likewise, Mayer (1975; 1979) has proposed assimilation theory, which proposes several conditions of meaningful learning. One of these is "availability" which refers to the need for the learner to have a store of knowledge related to the new information. Activation of that knowledge is then necessary for integrating the new and old information.

In a meta analysis of 44 studies on advance organizers, Mayer (1979) was able to show that the assimilation of new information with previously stored information can account for a great deal of the published results on advance organizers. He was able to show that the locus of the effect is in the encoding stage of memory, as the learner activates prior memory and incorporates the new information. Mayer was also able to show that advance organizers are of particular benefit when a text is poorly organized. He explains that the overview offers a context which may be used as a cue to access the relevant prior knowledge. Without it, the learner is presumably unable to make enough sense of the confusing text to access the appropriate knowledge for assimilation.

Indeed, in all four of the studies that allowed the comparison, Mayer was able to show that there is an interaction between the use of an advance organizer and the organization of a text. When a text was poorly organized or in an unfamiliar format to the learner, the advance organizer augmented the learning outcome. When the text was well integrated and in a familiar format, the advance organizer had no effect. The explanation offered by assimilation theory is that the familiar or well organized text offers enough information to activate an appropriate context for the learner. Because the poorly structured text does not allow the learner to activate the appropriate prior knowledge, the advance organizer is useful.

In short, multiple models of text-based learning have proposed similar explanations of the phenomenon, each based on the assumption that this tool allows prior memory to be accessed and integrated with new information. The present study was designed to address two questions. First, what if the learner is a novice and there is little prior knowledge within which to assimilate new information? Townsend and Clarihew (1989) found that subjects with high and low prior knowledge showed differences in text comprehension when pictures were added to textual advance organizers. What is the relationship between IO's and prior knowledge with regard to the creation of mental representations in novices? Second, what is the effect of an overview when its structure is incompatible with the user's goals? Dee-Lucas and Larkin (1995) were able to show that there is a relationship between the structure of the IO and learners' goals with reference to the learning outcome, but the nature of that relationship us unknown.

It is important to learn more about the relationship between IO's and learner goals because an incompatibility between these factors is increasingly common as educational hypermedia and web-based instruction become more common. For example, the Computer Information Sciences Department at the University of Massachusetts has created a "people" page that lists its members under the headings of faculty, graduate students, undergraduate students, or staff. Each name is an interactive button leading to a profile of the individual. This kind of an overview is very common within the WWW and is extremely helpful if one is interested in learning about faculty, students, and so forth. However, what if one is interested in learning about department members involved in object-oriented programming research? The information is embedded in the system, but the user must use the IO to work through the names, creating one's own view of the information from that perspective. Under such circumstances, what is the relationship between an IO and the user's goals? Which is the dominant factor of conceptual structure development in such a case, the overview or the goal? This study explores the level of influence overviews have in concept formation by addressing these questions.

METHODS

Subjects. Forty-four undergraduates at University of Massachusetts participated in the study. Participation partially fulfilled a requirement for their general psychology course.

Design and Procedure. The equipment consisted of a Macintosh Power PC computer for each participant. The computer stimuli were presented with HyperCard 2.3.5, and consisted of biological and ecological information pertaining to fictitious animals. Illustrations and some of the information was taken from Dougal Dixon's *After Man: A Zoology of the Future* (1981). Fictitious stimuli were used in order to control for participants' prior knowledge.

The study employed a 2 (overview structure) X 2 (learning goal) between subjects factorial design. Information about each animal family or ecosystem was presented on its own "card" (screen), as was each individual animal. With the exception of cards which presented introductions to each animal family (in the animal family condition) or ecosystem (in the ecosystem condition), all of the content cards were identical between the two systems. In the animal families system, there were a total of 17 cards (1 interactive overview card, 12 content cards, and 4 animal family cards). In the ecosystems system, there were 16 cards (1 interactive overview card, 12 content cards, and 3 ecosystem cards). Figure 1 provides examples of animal family, ecosystem, and content cards.

(a)

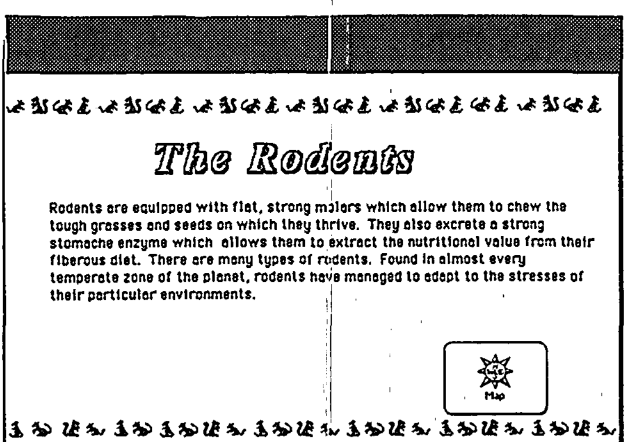
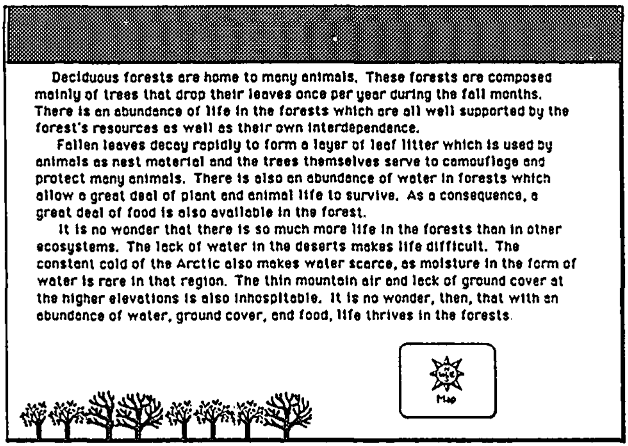


Figure 1. Grayscale reproductions of (a) an animal family overview card, (b) an ecosystem overview card, and (c) a content card viewed by subjects in both overview conditions (continued)

(b)



(c)

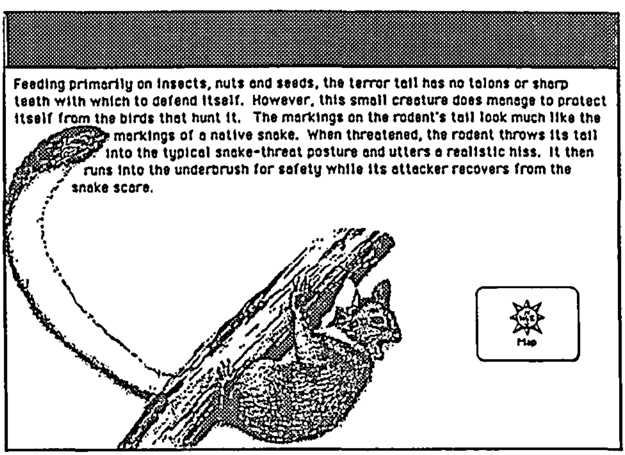
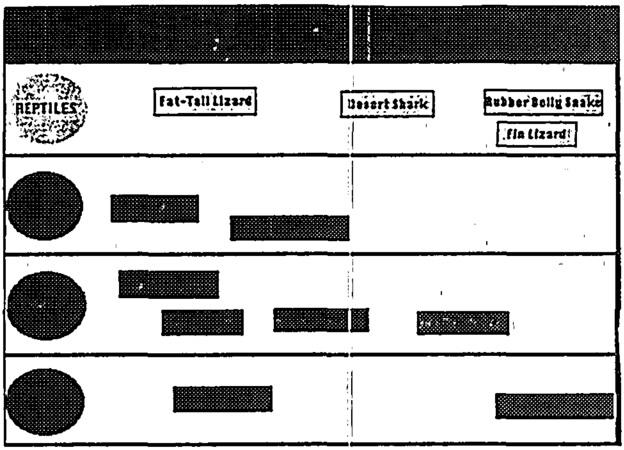


Figure 1. Grayscale reproductions of (a) an animal family overview card, (b) an ecosystem overview card, and (c) a content card viewed by subjects in both overview conditions

The IO's were arranged either by animal family or ecosystem. Both of the overviews contained "buttons" that represented cards in the system. The topic of the card was indicated in the button itself. Participants could move through the system by "clicking" on the button for the corresponding card they wished to view. Figure 2 shows reproductions of the IO's.

(a)



(b)

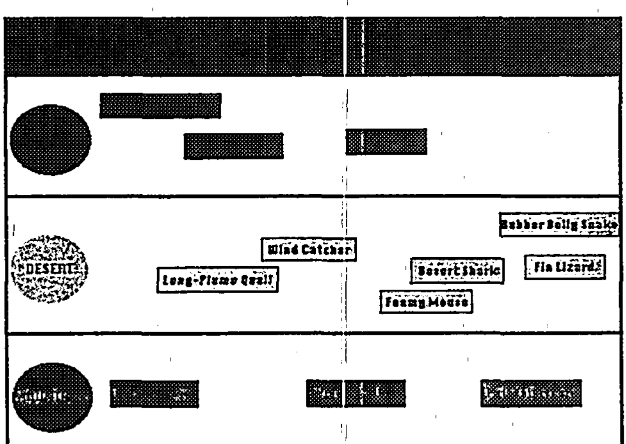


Figure 2. Grayscale reproduction of the (a) animal family and (b) ecosystem interactive overview maps

The animal family overview presented the fictitious animals according to their respective animal families (i.e., birds, herders, rodents, and reptiles). To help the participants identify each animal family, the map was color-coded so that each animal button was identical in color to its corresponding animal family button. The ecosystem overview was organized by the three ecosystems presented: forest, desert, and mountains. In this case, the individual animal family buttons were color-coded to correspond to the particular ecosystem with which they were associated.

Participants were allowed to navigate through the system in any manner they chose. They were allowed to review specific cards as many times as they felt necessary. As shown in Figure 1, each card presented a button that allowed the participants to click back to the IO when they were ready to go on to a new next card.

The participants were assigned one of two learning goals, either an ecosystem goal or an animal family goal. Subjects in the ecosystem condition were given the following instructions: "Your task is to learn as much as you can about the relationship between animals in each ecosystem. In other words, become an expert on how the animals in each region compete for food, hunt one another, defend against predators, and so forth". The animal family group was read the following instructions:

> Your task is to learn as much as you can about the similarities and differences between animals within a family. In other words, become an expert on how the animals in each family are similar and how they differ from one another in terms of behavior and physical features.

The participants were randomly placed in one of four overview/learning goal conditions that were either compatible (e.g., animal family overview/animal family learning goal) or incompatible (e.g., animal family overview/ecosystem learning goal).

Pretesting. Participants were each given a variety of pretests including a sorting task to determine how they were inclined to organize biological information. For this task, 16 index cards were given to each participant in one randomly shuffled pile. Each card had the name of one common animal printed on one side (such as cheetah, gazelle, mountain goat, and cougar). The items chosen for the task could be sorted according to family resemblances (cheetah and cougar; gazelle and mountain goat) or ecosystems (cheetah and gazelle; cougar and mountain goat). The participants were instructed on paper as well as verbally to sort the animals in a manner that seemed appropriate to them, and also that they were allowed to create as many or as few groups as they felt necessary. Subjects' sorting strategies were categorized in order to assess their understanding about ecology. Sorting strategies which relied on surface features such as feathers, fur, or four legs, for example, were categorized as "animal family" strategies. Those that relied on predator/prey relationships were categorized as "ecosystem" strategies. Those who's logic could not be inferred were categorized as "other." The majority, 61%, sorted the cards by family. Only 15% sorted the cards thematically, into groups that share an ecosystem. Twenty-four percent used other criteria. This bias toward the feature characteristics of biological organisms is common in the literature on categories and categorical reasoning. For example, Tanaka and Taylor (1991) were able to show that novices tend to use salient surface features of animals when reasoning inductively about them. Such results concur with the general conclusions drawn by Rosch and colleagues (Rosch, 1973; Rosch, 1975; Rosch and Mervis, 1975) and Wittgenstein (1953) who have written extensively on the prevalent use of family resemblances as a basis for classification.

When they were finished with the sorting task, participants were given a seven item questionnaire to test their general knowledge of plant/animal biology and ecosystems. The items on the test were written in collaboration with a professor of biology at the University of Massachusetts who specializes in ecology. Those who scored greater than 57% correct on the questionnaire were excluded from the study. The purpose was to control for expertise within the domain.

Learning Phase. The participants were told that they could work as long as they needed in order to feel comfortable with the information presented. They were also informed that they would be required to answer some questions about what they had learned from the computer presentation. Participants were given a brief lesson on how to use the mouse to move through the system. All participants were urged to make an honest effort at paying attention and learning as much as possible from the presentation. As part of their instructions they were read their learning goal and an index card with their goal printed on it was placed in front of them as they worked to remind them of their task.

Posttesting. When the participants notified the experimenter that they were done with the learning phase, they were given a cued-association task. This task was also presented on the computer. The participants were asked to write down the first three system topics that immediately came to mind when the name of an animal presented in the system was displayed on the screen. After writing these down, the participants could advance to the next animal name by clicking a button with the mouse. The participants did this for all 12 animals that appeared in the computer presentation. There were two lists used for the cued-association task. The animals in each list were in a different, random order. The presentation of the two lists was counterbalanced between the participants in each of the four conditions.

The participants were then given a sorting posttest. The instructions for this task were identical to those of the sorting pretest. In the posttest, 12 index cards each listed the name of a different animal presented by the computer during the learning phase. The cards were given to the participants in one randomly shuffled pile and they were asked to sort them into groups. Individual subjects' sorting strategies were categorized by the same criteria used to score the sorting pretest.[1]

RESULTS AND DISCUSSION

Cued-Association Posttest

The cued-association test was scored by categorizing the responses to the cued items according to the relationships between each cue and response pair: animal family associates, ecosystem associates, or neither. For example, the fact that the fin lizard and the long-plume quail share an ecosystem was available in the system. These animals, then, were considered "ecosystem associates." If a subject wrote the name "fin lizard" when prompted with the cue "long-plume quail," that response was counted as an ecosystem associate. Each response indicated by subjects during the cued-association task was tallied in this way. The total number of associates as well as the number of animal family and ecosystem associates given as responses to each cue was calculated for each subject.

An analysis of variance revealed no significant effect of the IO's or goal conditions on the total number of responses provided during the cued-association task, $F < 1$ in both cases. Nor was there any significant interaction between these factors, $F < 1$. This result indicates that the number of associations subjects stored in memory between newly learned topics was equivalent between subject groups. However, there was a difference in the nature of the associations they stored. There was a significant effect of IO on the number of animal family associates, $F(1, 40) = 16.26$, $p < .05$, and ecosystem associates, $F(1, 40) = 15.05$, $p < .05$, provided by subjects. As indicated in Table 1, subjects who viewed the animal family overview responded with a higher number of animal family associates and those who saw the ecosystem overview responded with a greater number of ecosystem associates. In fact, when association type is used as an independent variable and crossed with overview structure, there is a significant interaction, $F(1, 84) = 32.99$, $p < .001$. (This analysis illuminates the relationship between the four numbers in the "totals" row of Table 1.) The structure of the IO had a strong effect on the type of associations subjects acquired.

Table 1

The mean number of (a) Animal Family and (b) Ecosystem Associates (and standard deviations) given by subjects on the cued-association task, by overview structure and goal conditions.

	Overview Condition		
Goal Condition	Animal Families	Ecosystems	TOTALS
Animal Families	(a) 5.3 (2.25) (b) 3.2 (4.47)	(a) 1.36 (1.87) (b) 6.36 (2.79)	(a) 3.00 (3.71) (b) 5.04 (2.99)
Ecosystems	(a) 4.5 (3.34) (b) 1.6 (2.12)	(a) 1.3 (1.16) (b) 5.2 (3.94)	(a) 2.9 (2.94) (b) 3.4 (3.59)
TOTALS	(a) 4.9 (3.87) (b) 2.4 (2.28)	(a) 1.33 (1.58) (b) 5.88 (3.29)	

There was no main effect of goal condition on the number of animal family associates, $F < 1$, or ecosystem associates, $F(1, 40) = 2.51$, $p > .05$. There were no significant interactions between system and goal on the number of animal family associates, $F < 1$, or ecosystem associates, $F < 1$. The fact that subjects' responses reflect the IO's they saw and not their intended learning goals is striking. These results suggest that the effect of the overview structure was powerful enough to override the intentions of these novices as they processed the information at hand. The implications of this point will be discussed in the conclusions.

Sorting Posttest

As with the pretest sorting task, subjects' sorting strategies were classified as either "animal families," "ecosystems," or "other." The category of "other" was designated when the cards were not clearly sorted into animal or ecosystem groups. A chi-square revealed a significant difference between IO condition groups on sorting strategy, $chi^2 = 9.72, p < .01$. As Figure 3b shows, a majority of subjects assigned to the animal family overview condition (80%) sorted the animals by family with fewer (only 10%) sorting by ecosystem. A majority of those in the ecosystem condition (39%) sorted by ecosystems while slightly fewer (34%) sorted by animal families.

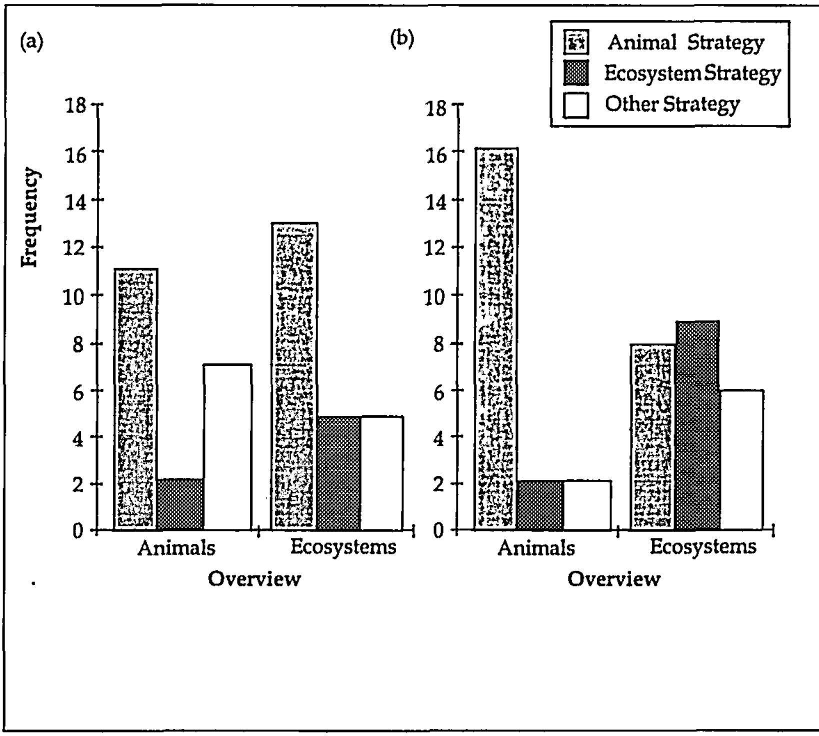


Figure 3. The number of subjects sorting by animal families, ecosystems, or other criteria on the (a) sorting pretest and (b) sorting posttest, broken down by overview condition groups.

These data represent a change from the sorting strategy observed on the pretest, where all subjects generally revealed a bias toward sorting by family resemblances. To facilitate the pre/posttest comparison, Figure 3a shows the sorting pretest results, broken down by the conditions to which subjects were eventually assigned. Using the pretest sorting strategy data as expected values, chi-square analyses revealed a significant change from pretest to posttest strategies for both the animal family IO group, $chi^2 = 6.29, p < .05$; and the ecosystems IO group, $chi^2 = 7.12, p < .05$. Of those eventually assigned to the animal family overview condition, 55% sorted by animal families and 10% sorted by ecosystems on the pretest. On the posttest, that group became even further polarized with 80% sorting with a family resemblance strategy and 10% sorting by ecosystems. Of those eventually assigned to the ecosystem overview condition, 56% initially sorted by animal families while only 22% sorted by ecosystems on the pretest. On the posttest, however, the bias toward a family resemblance strategy disappeared and the majority, 39%, sorted with an ecosystem strategy while only 35% continued to sort according to family resemblances. In short, subjects in the animal family condition became even more biased toward a family resemblance view of the material after working with the animal overview while many of those in the ecosystem condition overcame their initial bias and sorted according to new criteria.

As seen in Figure 4b, however, assigned goal condition did not have the same effect. Subjects' observed sorting strategies on the posttest revealed no effect of goal condition, $chi^2 = 4.34, p > .05$. The majority of subjects assigned to both the animal families and ecosystem goal conditions sorted according to family resemblance between animals. There was some shift from the pretest strategy in the ecosystems goal condition, however. Chi-square analyses of the posttest strategy using the pretest strategy data as expected values (illustrated in Figure 4a) revealed an effect of the ecosystem goal on sorting strategy, $chi^2 = 9.53, p < .05$. Sixty-three percent of the ecosystem goal group began with an animal family strategy and 11% with an ecosystem strategy. On the posttest, this group shifted to a more mild animal family bias with only 42% sorting by animal families and 32% sorting by ecosystems. It should be noted, though, that the majority of subjects still sorted with an animal family strategy. No significant change was observed for the animal families goal at all, $chi^2 = 5.83, p > .05$. While 50% of subjects in the animal family goal group sorted predominately according to animal families on the pretest and 67% did so on the posttest, this change was not statistically significant. In sum, an ecosystem goal did pull a minority of subjects away from an animal family conceptualization of the material toward an ecosystem sorting strategy. The animal family goal was not effective in further polarizing the subjects toward an animal family structure for the material.

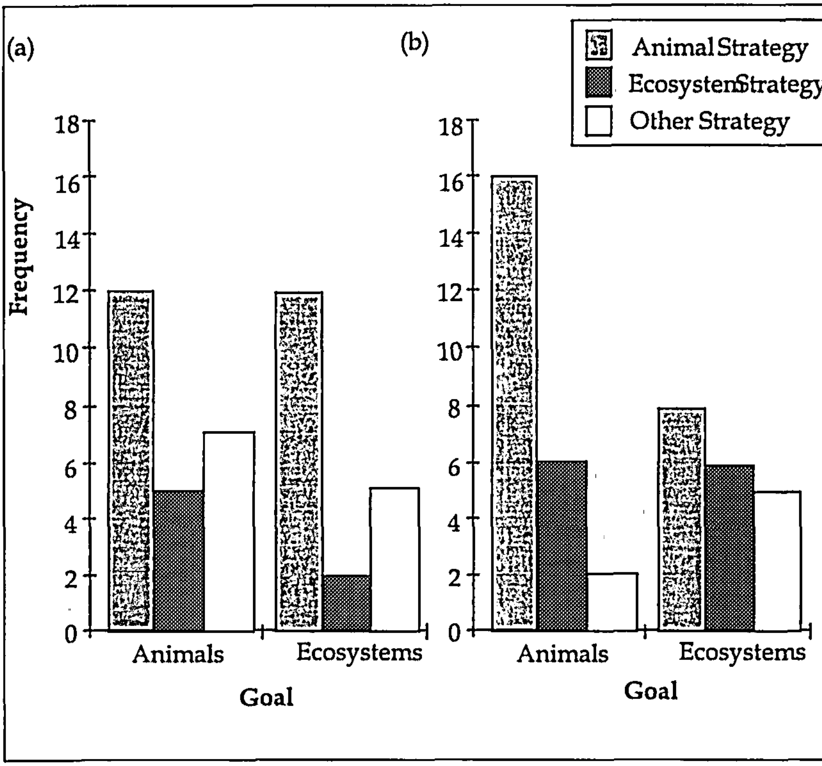


Figure 4. The number of subjects sorting by animal families, ecosystems, or other criteria on the (a) sorting pretest and (b) sorting posttest, broken down by goal condition groups

It appears, then, that all subject groups began the study with a bias toward organizing the information according to family resemblances based on physical features. When exposed to an IO which presented the information according to such criteria, subjects became even more polarized. When presented with an IO which offered an alternative way of viewing the material, many subjects' organization of the material reflected the new perspective. This change occurred regardless of learners' goals, which had only mixed and mild effects on conceptual structure.

CONCLUSIONS

The present study was designed to determine (a) the effect of IO's when they are at odds with the learning goal, and (b) the relationship between IO's and prior knowledge. Results presented here suggest that IO's can overshadow the learning goals of novices as they go about exploring material and structuring their internal representations. There was only a mild effect of one goal condition on learners' sorting strategies and none at all on their cued-associations. Further, there was no interaction between goal and overview structure on any measure of conceptual structure. Instead, only the structure of the IO was clearly and consistently effective in altering the nature of subjects' mental representations. Given the demonstrated relevance of a learner's goals to study strategies and subsequent learning outcome (d'Ydewalle & Roselle, 1978; Perfetto, Bransford, & Franks, 1983), this is a remarkable result. It means that an IO used by novices may become the central factor in determining the learning outcome. The practical implications of this finding could have wide impact on the use of hypermedia in educational settings. This point will be discussed in more detail below.

The results addressing the second issue, the relationship between IO's and prior knowledge for novices, were less straightforward. While the results of the cued-association posttest and the results of the sorting task for the animal families IO group suggest a simple interpretation of the overviews' role, the results of the ecosystem overview group's sorting task add some complexity to the issue. The cued-association posttest results suggest the IO's with which subjects worked were the determining factor in the creation of mental representations for the material; the nature of subjects' cued associates was consistent with their overviews. The results of the sorting task for the animal families IO group would lead to the same conclusion because that group became even more polarized toward an animal family sorting strategy from the pretest sorting task. However, the ecosystem overview group's sorting results do not fit this model. If it were simply the case that the IO dominates the creation of conceptual structure, this group should have been strongly biased toward an ecosystem sorting strategy. Instead they were fairly evenly divided between ecosystem and animal family strategies.

How can this result be explained? Prior knowledge and overview structure each provide a possible framework for the construction of mental representations. The construction integration model (Kintsch, 1988) and assimilation theory (Mayer, 1979) each accommodate both possibilities depending upon the type of learning in which the student is engaged. For example, the construction integration model would predict construction of a simple text base, guided by the IO structure, if learning is shallow. It would also predict the integration of new information with the prior knowledge of animal families in the case of more meaningful learning. Evidence of subjects' prior knowledge and IO are seen in their sorting behavior. Neither clearly dominated the creation of mental representations, as there was no apparent preference among subjects with regard to sorting strategy. In contrast to the sorting results, subjects in each IO group listed more associates consistent with their respective IO's during the cued-association task. This outcome supports the notion that the overviews were more influential in the creation of mental associations. The results of the cued-association and sorting tasks, then, are not parallel for the ecosystem subjects.

One reason for these incongruent results may be the fact that the cued-association and sorting tasks were designed to measure different aspects of subjects' mental representations. While the cued-association task was not designed to amass an exhaustive inventory of subjects' stored associations, it was designed to reflect the strongest associations. The sorting task, on the other hand, was designed to provide some measure of the "shape" or organization of those associations. Obviously, neither of these dependent measures is capable of providing a precise or comprehensive record of an individual's mental representations. While the measures employed here have been used by others with some success (Champagne, Hoz, & Klopfer, 1984; Champagne, Gunstone, & Klopfer, 1985) researchers interested in exploring the nature of mental representations have always been faced with the difficult question of *how* to measure them. Nonetheless, given that these measures are sensitive to different aspects of mental representations, the question at hand is how to explain the different outcomes for the ecosystem IO group.

One explanation of this discord is that the ecosystem IO subjects who sorted by animal family are members of a subgroup which was more influenced by its prior knowledge of animal family resemblances than the IO. This hypothesis is reasonable in light of prior research, which has shown that, under the right circumstances, prior knowledge can indeed offset an organizer (Mannes & Kintsch, 1987). If this explanation were accurate, the subjects who sorted by animal families would have responded to the cued-association results with more animal family associates and fewer ecosystem associates than the groups that sorted by other criteria. Additional analyses show, however, that this was not the case. In fact, analyses of variance comparing the "ecosystem sorters" with the "animal family sorters" and "other sorters" revealed no differences with regard to either the number of animal family or ecosystem associates, $F < 1$ in both cases.[2] In fact, a paired t-test comparing the number of animal family and ecosystem associates named by those who sorted by animal families indicates that, in spite of their sorting strategy, this group did respond with more ecosystem associates, $t(7) = 4.12, p < .01$ (as did the group sorting by ecosystems, $t(8) = 4.44, p < .01$).[3]

In light of these additional analyses, the statistically even distribution of ecosystem IO subjects sorting by animal families and ecosystems suggests a different explanation of the results than previously discussed. Specifically, the subjects attained multiple representations for the material and the pattern of sorting results is a by-product of task demands, which forced subjects to choose a single sorting strategy. This interpretation is bolstered by the cued-association results, which indicate that subjects attained more ecosystem associates than animal family associates, regardless of their varied sorting behavior. This is an indication that, while subjects acquired the IO's associations, many were also able to incorporate the new information with their prior animal family knowledge. This explanation is consistent with the construction-integration model (Kintsch, 1988). As discussed earlier, this model proposes that advance organizers provide a framework upon which incoming information may be structured to form a text base. It also proposes that more meaningful learning happens when the text base is integrated with prior knowledge, creating a situation model. The ecosystem IO subjects' overall results support this model, as they show indications of such layers of understanding.

If it is the case that subjects were able to acquire the IO's associations and integrate the new information with prior knowledge, it would mean that adding a new perspective to prior knowledge can be advantageous for the novice who comes equipped with a small amount of prior knowledge. Specifically, the new analyses presented above indicate that a notable percentage of those in the ecosystem IO condition were able to form multiple functional representations for the material, which means that they attained a more flexible understanding than the animal family IO group.

This idea has been written about extensively by Spiro and colleagues (Spiro, Vispoel, Schmitz, Samarapungavan, & Boerger, 1987) who have proposed the idea of *cognitive flexibility*. That is, material viewed from multiple perspectives will result in a more flexible understanding. The approach taken by that laboratory has been to use hypermedia systems to offer learners multiple perspectives on the same material in order to enrich their understanding of it. For example, one of their programs was designed to teach about the classic movie "Citizen Kane." Learners using that system are challenged to view particular scenes from the film from a variety of perspectives: foreshadowing, camera direction, common themes with other scenes, and so forth. By considering each scene from multiple perspectives, learners are able to create multiple representations and enjoy enhanced learning outcomes.

The present study has produced a similar effect in some of its participants. Many of them arrived in the lab with some prior knowledge of animal family relationships. Unlike those who used the animal families IO, those who viewed the novel biological information from the perspective of ecosystems were given the opportunity to gain a new perspective and add that to their mental representations. The present results suggest that giving students a new perspective on information with which they have at least some familiarity may stimulate greater depth and flexibility in their knowledge base. Because structure of stored knowledge has been found to be related to expert standing within a domain as well as problem solving ability (Chase & Simon, 1973; Chi, Hutchinson, & Robin, 1989; Chi & Koeske, 1983), the present results indicate that IO's may be used to augment learning along the lines which Spiro and colleagues have described. The present methodology is advantageous because it requires only simple programming skills to add IO's to hypermedia systems while the systems described by Spiro and colleagues are much more sophisticated. The data presented here, however, warrant caution in the use of IO's to offer perspective. Specifically, subjects in the present study were much more influenced by the IO's than their own goals. These results warn, then, that it may be unwise to set novice learners loose on the WWW or prepackaged hypermedia systems if their goals are not clearly supported by the IO's which may be incorporated into web pages or other hypertext resources.

With this in mind, it may be profitable to consider tailoring resources such as IO's for particular learning goals. One way of doing this may be the use of adaptive hypertext, a method of altering the identity of active buttons in a hypertext system. In the absence of this level of sophistication, a simple menu could be available which would allow learners to choose the perspective from which they would like to view a topic covered within a system. Clicking a "topic button" would lead the user to an IO of appropriate structure. Only basic HTML or *HyperTalk* programming abilities are required in this case. Making use of adaptive hypertext or multiple IO's would allow teachers to design overviews capable of offering new perspectives on material already covered. It could also ensure that the shape of the IO's used by students is compatible with their learning goals. Given the present results, a fruitful area for future investigations would be the use of the such tools for tailoring the structure of an IO to learners' goals.

References

Champagne, A.B., Hoz, R., & Klopfer, L.E. (1984). *Construct validation of the cognitive structure of physics concepts.* Paper presented at the meeting of the American Educational Research Association, New Orleans.

Champagne, A.B., Gunstone, R.F., & Klopfer, L.E. (1985). Effecting changes in cognitive structures among physics students. In L.H.T. West & A.L. Pines (Eds.) *Cognitive structure and conceptual change*, Orlando, FL: Academic, pp 163-187.

Chase, W.G., & Simon, H.A. (1973). Perception in chess. *Cognitive Psychology, 4*, 55-81.

Chi, M.T.H., Hutchinson, J.E., & Robin, A.F. (1989). How inferences about novel domain-related concepts can be constrained by structured knowledge. *Merrill-Palmer Quarterly, 35*, 27-62.

Chi, M.T.H., & Koeske, R.D. (1983). Network representation of a child's dinosaur knowledge, *Developmental Psychology, 19*, 29-39.

Dee-Lucas, D., & Larkin, J.H. (1995). Learning from electronic texts: Effects of interactive overviews for information access. *Cognition and Instruction, 13*(3) 431-468.

d'Ydewalle, G., & Roselle, H. (1978). Text expectations in text learning. In M.M. Gruneberg, P.E. Morris, & R.N. Sykes (Eds.), *Practical aspects of memory.* Orlando, FL: Academic.

Gagne, R.M., & White, R.T. (1978). Memory structures and learning outcomes. *Review of Educational Research, 48*, 187-222.

Glover, J., & Krug, D. (1988). Detecting false statements in text: The role of outlines and inserted headings. *British Journal of Educational Psychology, 58*(3), 310-306.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review, 95*, 163-182.

Kraiger, K. Salas, E., & Cannon-Bowers, J. (1995). Measuring knowledge organization as a method for assessing learning during training. *Human Factors, 37*(4), 804-816.

Mannes, B., & Kintsch, W. (1987). Knowledge organization and text organization, *Cognition and Instruction, 4*, 91-115.

Mayer, R.E. (1979). Twenty years of research on advance organizers: Assimilation theory is still the best predictor of results. *Instructional Science, 8*, 133-167.

Perfetto, G.A., Bransford, J.D., & Franks, J.J. (1983). Constraints on access in a problem solving context. *Memory & Cognition, 11*, 24-31.

Rosch, E.H. (1973). On the internal structure of perceptual and semantic categories. In T.E. Moore (Ed.), *Cognitive development and the acquisition of knowledge*. New York: Academic.

Rosch, E.H. (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology: General, 104*, 192-233.

Rosch, E.H., & Mervis, C.B. (1975). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology, 7*, 573-605.

Shavelson (1972). Some aspects of correspondence between content structure and cognitive structure in physics instruction. *Journal of Educational Psychology, 63*, 225-234.

Snapp, J., & Glover, J. (1990). Advance organizers and study questions. *Journal of Educational Research, 83*(5), 266-271.

Spiro, R.J., Vispoel, W.P., Schmitz, J.G., Samarapungavan, A., & Boerger, A.E. (1987). Knowledge acquisition for application: Cognitive flexibility and transfer in complex content domains. In B.K. Britton & S.M. Glynn (Eds.), *Executive control processes in reading* (pp. 177-199). Hillsdale, NJ: Lawrence Erlbaum.

Tanaka, J.W., & Taylor, M. (1991). Object categories and expertise: Is the basic level in the eye of the beholder? *Cognitive Psychology, 23*(3), 457-482.

Tajika, H., Taniguchi, A., Yamamoto, K., & Mayer, R. (1988). Effects of pictoral advance organizers on passage retention. *Contemporary Educational Psychology, 13*(2), 133-139.

Townsend, M., & Clarihew , A. (1989). Facilitating children's comprehension through the use of advance organizers. *Journal or Reading Behavior, 21*(1) 15-35.

Wittgenstein, L. (1953). *Philosophical Investigations*, translated by G.E.M. Anscombe. New York: Macmillan.

Notes

1. Timing data are not available for this study. However, several other studies run with very similar methodologies in our lab (and some with very similar stimuli), no differences in time on task have been found between conditions (Shapiro, 1998a; Shapiro, 1998b).
2. The mean number of animal associates for the "animal family sorters," "ecosystem sorters," and "other sorters" was 1.5, 1.1, and 1.5, respectively. The mean number of ecosystem associates for these groups was 6.6, 5.5, and 5.5.

3. The mean number of animal family and ecosystem associates for the "animal family sorting" group was 1.5 and 6.6, respectively. The means for the "ecosystem sorting" group were 1.1 and 5.5.

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