



AD-A177 676

NOVICE RULES FOR ASSESSING IMPORTANCE
IN SCIENTIFIC TEXTS

Diana Dee-Lucas and Jill H. Larkin
Carnegie-Mellon University

for

Contracting Officer's Representative
Judith Orasanu

BASIC RESEARCH LABORATORY
Milton R. Katz, Director

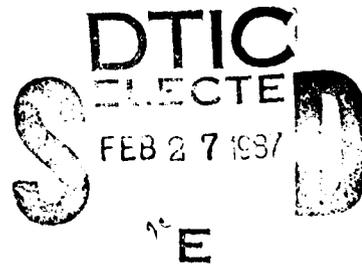


U. S. Army

Research Institute for the Behavioral and Social Sciences

December 1986

Approved for public release; distribution unlimited.



DTIC FILE COPY

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER Research Note 86-98		2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) NOVICE RULES FOR ASSESSING IMPORTANCE IN SCIENTIFIC TEXTS		5. TYPE OF REPORT & PERIOD COVERED Interim Report January 86 - July 86	
7. AUTHOR(s) Diana Dee-Lucas and Jill H. Larkin		6. PERFORMING ORG. REPORT NUMBER	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Psychology, Carnegie-Mellon University Pittsburgh, PA 15213		8. CONTRACT OR GRANT NUMBER(s) MDA 903-85K-0180	
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, VA 22333-5600		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q161102B74F	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) - -		12. REPORT DATE December 1986	
		13. NUMBER OF PAGES 36	
		15. SECURITY CLASS. (of this report) Unclassified	
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE - -	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)			
18. SUPPLEMENTARY NOTES Judith Orasanu, contracting officer's representative			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Text Learning Expert-Novice Differences			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) >This study complements research indicating that content-area novices judge the importance of what they read in texts on the basis of sentence type (e.g. whether sentences are definitions or statements). Subjects varying in expertise judged the importance of sentences in physics texts which were presented as definitions or as statements of fact. Definitions and statements were identical in substantive content. Those in the categories of expert and novice judged the variants as equal (over)			

ARI Research Note 86-9820. Abstract (continued)

in importance. Beginning physics students, however, judged the definitions as more important. These results suggest that sentence form is a salient text feature for beginning-level students. Beginners lack the knowledge necessary to judge the importance of content directly, but they have developed general rules about what types of information are often important in physics. By contrast, sentence form is not relevant for people with no training in physics -- they have no expectations at all regarding what types of information should be important; and experts pay little attention to sentence form because they have rich content schemas which enable them to judge importance directly. These results have theoretical implications for understanding content schema development and also have practical implications for the writing of textbooks.

Novice Rules for Assessing Importance in Scientific Texts: Executive Summary

In learning from text, finding the important information is crucial, particularly for a novice reader (i.e., one who is unfamiliar with the content domain). Such information serves as a focus around which to organize related details. This research examined novice strategies for determining what is important in texts containing unfamiliar content. The research reported here provides the theoretical background for related research which demonstrated that novices' inability to correctly identify important text information can influence their learning in adverse ways.

This study specifically examined how novices process definitions and facts, two types of information that are both common and important in formal domains. The results indicate that in judging importance, novice readers tend to focus on definitions to the exclusion of facts. This study had novices judge importance in passages which contained definitions and facts that were (through experimental manipulation) identical to each other in content. Even though the definitions and facts contained the same information, novices judged the definitions to be more important. This was not true of experts, who judged definitions and facts containing the same content to be equal in importance.

These findings suggest how novices begin to develop a "content schema" for expository knowledge domains. Novices learn that certain easily identifiable types of information (e.g., definitions) are more important--a reasonable general rule. However, they judge importance on the basis of information-type category without regard for content, considering the same information to be more important if it is expressed in the form of a definition. Thus novice readers can be very sensitive to the form in which information is presented, in that minor variations in wording (i.e., saying something "is defined as") can influence novices' perception of how important that information is. Accordingly, writers can unintentionally signal particular information as important through wording selections of this kind if they are unaware of novice preconceptions about the types of information that are important. On the other hand, knowledge of novice rules can be used in conjunction with rhetorical indicators of importance (i.e., underlining, signaling, structural changes, etc.) to emphasize important content and de-emphasize less critical information. Additionally, knowledge of novice content schemas and how they differ from those of experts gives us a basis for designing instruction in a way that helps novices develop better text-learning skills.

Abstract

This study complements research indicating that content area novices judge importance in texts on the basis of sentence type (e.g., whether sentences are definitions or facts). Subjects varying in expertise judged the importance of sentences in physics texts which were presented as definitions or facts. The definitions and facts were identical in substantive content. Experts and subjects without physics training judged these variants as equal in importance. However, beginning physics students judged definitions as more important. These results suggest that sentence form is a salient text feature for beginning-level students. They lack the knowledge necessary to judge the importance of content directly, but have developed general rules about what types of information are often important in physics. Sentence form is not relevant for people without physics training--they do not have expectations regarding what types of information are important. Sentence form also has little influence on experts, who have rich content schemas allowing them to judge importance directly. These results have theoretical implications for understanding content schema development, and practical implications for textbook writers.

Novice Rules for Assessing Importance in Scientific Texts

Diana Dee-Lucas & Jill H. Larkin
Carnegie-Mellon University

Scientific textbooks are typically densely packed with complex information, including equations, symbols, and specialized terms. Consequently, it can be very difficult for students who are unfamiliar with scientific subject matter to distinguish the important content from the elaborative information when reading this type of text. The purpose of the present research was to investigate rules used by novice readers (i.e., readers who are unfamiliar with the text content domain) in determining what is important in scientific texts.

There are various sources of information that novices readers could use in assessing importance. Most research has focused on how text-based indicators of importance such as text structure and signaling devices (e.g., underlining, adjunct questions, staging, typographical cuing, etc.) influence novice readers' attention. These textual manipulations are "content-free," in that their effects should not depend on the nature of the text content or the expertise of the reader. In contrast, a "content-specific" source of information for assessing importance in texts is the reader's "content schema" (Kieras, 1985). A content schema consists of domain-specific knowledge about how information in a content area is typically organized, including what is important.

Past research has largely ignored the role of content-based schemas in the comprehension of novice readers. This is because it has typically been assumed that novice readers who are unfamiliar with the content domain of a text would lack such a schema (see Kieras, 1985, for discussion). However, recent work by Dee-Lucas and Larkin (1986) suggests that novices do develop a rudimentary "content schema" for scientific content domains. This content schema consists of rules specifying the types of information (i.e., definitions, facts, etc.) that are important to that domain. In their research, Dee-Lucas and Larkin compared the importance judgements of expert and novice physicists for different

types of information in physics texts. They found that both groups judged definitions to be more important than facts. However, the novices were even more likely than the experts to judge definitions as important and facts as unimportant, suggesting that they had "overgeneralized" this rule. The experts discriminated between important and unimportant information within the type categories to a greater degree than the novices, indicating a more articulated content schema. Thus novices are inaccurately identifying the important text content on the basis of these overgeneralized rules.

This research comparing the judged importance of definitions and facts did not, however, control for content differences between the two sentence types. Thus novices in these studies may have been basing their importance judgements on some feature of the content that differed between definitions and facts, rather than on the definition/fact distinction per se. For example, novices may have considered definitions to be more important than facts because the definitions may have contained more new terms. If this were the case, then the rule used by the novices would be that statements with new terms are more important than statements involving known terms, rather than a rule that definitions are more important than facts.

The current study provides a strong test of the hypothesis that novices are using a rule involving a pure sentence type distinction; in other words, that novices consider definitions to be important simply because they are definitions, regardless of their content. This was tested by comparing novices' and experts' relative sensitivity to the form (i.e., definition or fact) in which information is presented in physics passages. Experts and novices judged the importance of target sentences in physics texts when they were presented as definitions or facts. These target sentences contained information which could be stated as facts or definitions through minor variations in wording which did not alter the primary sentence content. In this way, the content of the definitions and facts remained constant and only the form in which the information was presented varied. Thus unlike

earlier research, this study controlled for possible sentence-type effects due to content differences between definitions and facts. Two versions of two physics passages were used, each version being identical except for the form in which the target sentences were presented. The importance judgements of the novices and experts for the fact and definition versions of the target sentences were compared to see to what extent the sentence form influenced the perceived importance of the information.

Method

Stimulus Materials

One passage was about work and energy and one dealt with fluid statics. Each was about 50 sentences long. One contained 9 target sentences and one had 11 target sentences.

The definition and fact versions of the target sentences differed in that definitions always included "is defined as," and thus were signaled as being definitions. In the fact versions, "is defined as" was dropped or replaced with "is represented as," "is calculated as," or "is indicated by." Thus the facts were "non-definitions" in that in place of definition signaling they contained phrases indicating that the sentence was presenting attributive information about the sentence topic (as opposed to criterial attributes defining the sentence topic). Examples of the definition and fact versions of some of the target sentences are shown in Table 1. There were two versions of each passage. In one version, the odd-numbered target sentences were definitions and the even-numbered were facts; in the second version this was reversed.

Insert Table 1 about here

Each of the target sentences was classified according to its level in the hierarchical structure of the passage. The procedure used for the structural analysis is reported in Dee-

Lucas and Larkin (1986). This analysis produced a hierarchy with the main topics or concepts occurring at the highest levels and modifying information occurring at the lower levels. Modifying information consisted of examples, attributes and properties, derivations (i.e., information implied by or derived from higher level information), explanations, sub-topics, and preconditions (i.e., necessary conditions for a rule, principle, or fact to hold true). The hierarchical analysis was performed at the sentence level. There were 7 sentences at level 1 (the most superordinate level), 6 sentences at level 2, and 7 sentences at level 3. Hierarchical level was included as a variable in the data analyses to see whether perceived importance was influenced by level, and if this variable interacted with sentence form (i.e., definition or fact).

Subjects

The novices were 24 undergraduates with 2 or 3 semesters of college physics. Novices with this level of physics training were selected to insure that the novice group had had enough exposure to physics to have developed information-type rules, but had not approached the expert level in training. The 24 experts had completed at least one year of graduate study in physics.

Two control groups were also run in the experiment to see if expert-novice differences in the perceived importance of the target sentences were due to differences in educational level (i.e., undergraduate vs. graduate level training) as opposed to differences in physics knowledge. The two control groups were selected so as to differ in their educational level in the same manner as the two experimental groups. However, none of the control group subjects had taken any college-level physics, so they were similar to each other in terms of their physics knowledge. The undergraduate control group consisted of 24 undergraduates; the graduate student control group consisted of people who had completed at least 1 year of graduate training in the humanities or social sciences. Although this group will be referred to as the graduate student control, it included some post-doctoral researchers and

faculty. This was also true of the corresponding expert experimental group.

Although the control groups were specifically selected to control for educational differences, they would also indicate differences in perceived importance due to age, maturity, and verbal ability. In the case of verbal ability, it is reasonable to assume that graduate students in the social sciences/humanities would be as high in verbal ability as graduate students in physics. Similarly, it is likely that undergraduates attending the same university are roughly equivalent in verbal ability.

Procedure

The subjects were given one version of each passage. They were told to read each passage carefully, then rate the importance of each sentence on a scale from 1 (most important) to 5 (least important), and then indicate the 10 most important sentences in each passage. The instructions for the rating task indicated that each rating should be used at least once. All of the sentences were rated, but only the ratings for the target sentences were analyzed. The order in which the passages were read and the versions of the passages received were counterbalanced.

The novice and the undergraduate control groups were told that in completing the tasks, they were to indicate which sentences they thought would be most important to learn if they were going to be tested on the passage content. The expert and the graduate student control groups were told to pretend that they were teaching a course and indicate which sentences they thought were most important for their students to learn. These instructions match those used by Dee-Lucas and Larkin (1986) in their initial research on expert-novice differences in perceived importance. The instructions were designed to compare what novices think they should learn with what experts (their instructors) think novices should learn.

Results

The data from the two dependent measures were analyzed in two ways. The ratings data were analyzed using a multiway frequency analysis. This analysis fits a loglinear model to categorical data. The number of responses in each rating category (1 through 5) for each sentence type (definition and fact) occurring at each level (1 through 3) was tabulated for each of the subject groups. The multiway frequency analysis was performed on the total number of responses occurring in each of these cells.

The data from the sentence selection task (i.e., select the 10 most important sentences) were analyzed with a logistic regression. The variables entered in the analysis for each target sentence for each subject were sentence type (definition or fact), level (1 through 3), and subject group (novice or expert). The dependent measure was whether or not the sentence had been selected as one of the most important.

The data from the two control groups were submitted to identical analyses. The results of these analyses were compared to the results of the corresponding analyses of the experimental group data to determine if expert-novice differences were also reflected in differences between graduate students and undergraduates who had had no advanced physics training.

Ratings Data

Experimental groups. The multiway frequency analysis of the ratings data indicated that the best-fitting model was a hierarchical model including the type x group interaction and the main effect of level ($\chi^2 = 23.80$, $df = 30$, $p < .78$). The mean ratings predicted by the model for the type x group interaction are shown in Figure 1a. The predicted means for the novices are 1.67 when the sentence was in the form of a definition and 1.89 when it was in the form of a fact. For experts, the predicted ratings are 1.79 for definitions and 1.82 for facts. This interaction indicates that novices were influenced in their importance

ratings by the form in which the information was presented. They considered the same content to be more important if it was stated as a definition as opposed to a fact. The experts, on the other hand, did not appear to base their ratings on sentence form; there is very little difference in their predicted mean ratings for definition and fact versions of the target sentences.

Insert Figure 1 about here

The parameter estimates for the main effects and interaction for the complete model are shown in Table 2. Because of the usual constraints placed on the model, all parameter estimates for each main effect and interaction are constrained to sum to zero. Therefore, for all effects the magnitude of the parameter estimates for each variable are the same but in the opposite direction. The ratios of the estimates to the standard errors indicate the degree to which the parameter estimates differ from zero.

Insert Table 2 about here

The parameter estimates for the main effect of group show little difference between the experts and novices in their use of the five rating categories. The largest differences occurred in the use of rating 5 (the lowest rating) and rating 3 (the middle rating). The novices tended to use the rating 3 category more often than the experts (as indicated by the positive parameter estimate), while the experts tended to use the lowest rating more often than the novices. This suggests that the experts rated the target sentences lower in importance than the novices.

The parameter estimates for the main effect of type indicate that the largest difference occurred in the rating 3 category (the middle rating). The negative parameter estimate indicates that this rating was used more often with facts than definitions. There were also

smaller differences in the use of the first two rating categories, with the definitions rated 1 or 2 more often relative to facts. This indicates that definitions were rated higher overall in importance than facts.

The type x group interaction estimates indicate that the greatest differences between experts and novices in rating definitions and facts occurred in the first two rating categories. The novices were more likely than experts to give a target sentence a rating of 1 if it was in the form of a definition, and somewhat more likely to rate it a 2 if it was in the form of a fact. The opposite was true for the experts, relative to the novices.

Level had a very strong influence on the target sentence ratings, as shown by the large parameter estimates for this effect. Level 1 target sentences tended to be rated as most important, indicated by the large positive estimate for the rating 1 category. The ratings for level 2 target sentences were spread over the categories without any strong clustering in any one category; none of the parameter estimates for level 2 sentences differed from zero by more than two standard errors. Level 3 target sentences tended to be rated as 3 or 4 in importance, indicated by the positive parameters for these ratings categories. Level did not interact with type or group in influencing the ratings (i.e., including these effects reduced the fit of the model).

Control groups. The multiway frequency analysis of the control group data indicated that the best-fitting model included only the main effects of group and level ($\chi^2=28.64$, $df=40$, $p<.91$). The inclusion of the type x group interaction or the main effect of type reduced the fit of the model to the data set. The mean ratings predicted by the model with the type x group interaction included are presented in Figure 1b for comparison with the corresponding experimental group means. As Figure 1b shows, there was no difference between the undergraduate and graduate controls in the influence of sentence type on the mean ratings of the target sentences. Additionally, the lack of a main effect of sentence type indicates that the form in which the target sentences were presented did not influence

the control group ratings (i.e., they did not consider definitions to be important than facts).

The parameter estimates for the loglinear model including the main effects of group and level are shown in Table 3. The estimates for the main effect of group indicate that the undergraduates and graduates differed primarily in their use of ratings 1 and 4. The positive estimate for the undergraduates for rating category 1 indicates that they gave the target sentences a rating of 1 more often than the graduate controls. The opposite was true for the rating 4 category, with the graduates using this rating more often relative to the undergraduates. This indicates that undergraduates rated the sentences as more important overall than the graduate controls. This effect is also apparent in Figure 1b.

Insert Table 3 about here

The pattern of parameter estimates for the main effect of level is similar to that obtained with the experimental groups. Level 1 target sentences were most likely to receive a rating of 1, indicated by the large positive parameter estimate for that rating. The ratings given to level 2 target sentences were spread over the categories, with the strongest clustering in the rating 1 category (though this parameter estimate was much smaller than the rating 1 estimate for level 1 sentences). Level 3 target sentences were most likely to receive a rating of 4, with 3 as the next most frequent rating category for this level.

Summary. The results of the multiway frequency analyses indicate that novices base their judgements of the importance of text information on the form in which the information is presented. They specifically rate the same content as more important when it is presented as a definition as opposed to a fact, as is shown in Figure 1a. Expert physicists are not influenced by sentence form in rating importance, presumably basing their importance judgements on the nature of the sentence content. Similarly, subjects without advanced physics training are not influenced by sentence form, so that they appear to behave like experts in rating importance. This can be seen in Figure 1b. This is most

likely because these subjects have no strong expectations about the relative importance of definitions and facts in physics texts, and thus are not influenced by this text feature. The lack of a type x group interaction in the control group data indicate that expert-novice differences in the perceived importance of definitions and facts are not due to differences in educational level.

Sentence Selection Data

Experimental groups. The sentence selection data were analyzed using a logistic regression. The regression analysis indicated that a good fit to the experimental group data was provided by a hierarchical model including the group x type interaction and the main effect of level ($\chi^2 = 8.69$, $df = 7$, $p < .276$). This is the same model found to provide the best fit for the ratings data from the experimental groups. The predicted mean proportion of target sentences selected for the type x group interaction are shown in Figure 2a plotted on a logit scale. This interaction is very similar to the type x group interaction obtained with the ratings data. It shows that the novices were more likely to select a target sentence as important when it was presented in the form of a definition than a fact, while the experts were relatively unaffected by sentence form in their selection of the important sentences.

Insert Figure 2 about here

The parameter estimates for the complete logistic regression model are shown in Table 4. Unlike the estimates for the multiway frequency analysis, the logistic regression estimates show the size of the difference between the means for the two variables in an effect. Therefore only one parameter estimate is presented for each main effect (two for the interaction) and the ratios indicate the size of the difference between the two variables in each effect and interaction.

Insert Table 4 about here

The negative estimate for the main effect of type indicates that subjects tended to select more target sentences when they were presented in the form of a definition. This is consistent with the main effect of type found with the ratings data from the experimental groups. The estimate for the main effect of group indicates little difference between the experts and novices in the number of target sentences selected as important. The negative estimate indicates that the novices selected more target sentences than the experts. However, the parameter estimates for the two groups differed by less than two standard errors.

The type x group interaction estimates indicate that novices were more likely to select target sentences as important when they were in the form of a definition rather than a fact. Relative to novices, the experts were more likely to select the sentences when they were in the form of a fact. These findings are shown by the positive estimate for definitions and the negative estimate for facts.

The very large parameter estimates for the main effect of level indicates that this variable had a strong effect on which target sentences were selected as important. The negative estimate indicates that target sentences from the upper levels of the passage hierarchy (level 1) were selected more often than the target sentences from the lower levels (level 3). This finding is also consistent with the strong levels effect found in the ratings data. As with the ratings data, there was no indication that level interacted with sentence type or group in influencing sentence selection.

Control groups. The logistic regression for the control group data indicated that the best-fitting model was a hierarchical model including the main effect of group and the type x level interaction ($\chi^2 = 1.78$, $df = 5$, $p < .879$). The inclusion of the type x group interaction reduced the fit of the model to the data. Thus there was no evidence that the importance

judgements of the undergraduate and graduate control groups differed in the degree to which they were influenced by sentence type. This can be seen in Figure 2b, which shows the predicted mean proportion of definitions and facts selected by the two control groups plotted on a logit scale.

The parameter estimates for the regression model including the effects of group and the type x level interaction are presented in Table 5. Unlike the experimental groups, level did not have a linear effect on the number of target sentences selected by the control groups. It was therefore entered into the analysis as a categorical (as opposed to a linear) variable, and separate parameter estimates were obtained for each level. The parameter estimates presented for the main effect of level represent the size of the difference between levels 1 and 2, and levels 2 and 3. For the type x level interaction, the parameter estimates indicate the size of the difference between definitions and facts at each level.

Insert Table 5 about here

The negative parameter estimate for the main effect of type indicates that the control groups were more likely to select a target sentence when it was in the form of a definition than a fact. However, the type x level interaction indicates that the effect of type varied with level. The negative parameter estimate for level 1 indicates that facts were selected more often than definitions at the top level, while the positive parameters for levels 2 and 3 show that definitions were more likely to be selected than facts at the lower levels. The predicted cell means for this interaction are presented in Figure 3. Figure 3 shows that the main effect of sentence type is due primarily to a very large sentence form effect at level 3.

Insert Figure 3 about here

This finding suggests that subjects without physics training may tend to judge details (low-

level information) in physics texts as being more important when they are presented as *definitions* than facts. However, this sentence type difference is based on very few data points, as most level 3 sentences were not selected as important. The mean number of sentences from level 3 selected by the control groups were 2.3 for the undergraduates and 1.6 for the graduates. Additionally, this type x level interaction was not found in the ratings data for the control groups. Therefore, it is possible that this particular effect is not replicable.

The negative parameter estimate for the main effect of group indicates that undergraduates selected more target sentences as important than the graduate control group. This is consistent with the finding in the ratings data that undergraduates tended to rate the target sentences higher in importance relative to the graduate controls.

The positive parameter estimates for the main effect of level indicate that the number of sentences selected as important decreased with level. The size of the estimates show that the drop in the number of target sentences selected as important was much greater between levels 2 and 3 than between levels 1 and 2. This can also be seen in Figure 3.

Summary. The results of the sentence selection task analyses are consistent with the findings from the ratings data. Sentence form influenced the importance judgements of novices, with novices selecting more target sentences when they were presented in the form of a definition (see Figure 2a). Sentence form had very little effect on the sentences selected by experts. There again was no type x group interaction in the control group data, as shown in Figure 2b, indicating that expert-novice differences are not due to differences in educational level. Sentence form did have some influence on the judged importance of sentences for the control groups. The regression analysis indicated that the control groups tended to select more sentences from level 3 when they were in the form of a definition than a fact. Thus it is possible that there is a bias towards considering low-level definitions as important in subjects who do not have scientific backgrounds.

Discussion

Although much research has examined the knowledge representations of experts, relatively little is known about the knowledge structures of novices. This is most likely because novice representations are assumed to be more variable than those of experts, and thus are studied less. However, how novices represent unfamiliar content domains and the nature of the changes occurring in these representations has important educational implications for facilitating learning from text. Characterizations of the knowledge structures used by novices to govern text processing indicate how text should be structured, both globally and locally, to maximize the probability that novices will learn the important text content.

This study examined one feature of novice knowledge representations--rules for assessing importance in unfamiliar scientific domains. It investigated the nature of novice scientists' content schema for physics subject matter, specifically testing the hypothesis that novices judge importance in physics texts on the basis of sentence form. This was done by using minor wording changes to transform sentences into definitions or facts, and looking at how this altered their perceived importance. Novices judged the same information as more important when it was presented as a definition, indicating that they based their judgements on sentence form. The form of the information did not affect the importance judgements of experts. The experts presumably judged the importance of the information according to its content, rather than its form. This type by group interaction was not found with undergraduate and graduate controls, so this interaction is not due to differences in the educational level of the physics experts and novices.

These findings indicate that novices who have had some college physics develop a rule that definitions are more important than facts. This rule is not inappropriate--experts also consider definitions to be more important than facts in physics passages in which content differences between the two sentence types have not been controlled (Dee-Lucas &

Larkin, 1986). These expert data suggest that definitions in physics textbooks may contain information that is particularly important for understanding these texts. However, the results of the current study indicate that novices judge importance on the basis of sentence type category without regard for sentence content. They judged the same information as more important when it was presented as a definition, indicating that they consider definitions to be important regardless of their content. This suggests that novices are applying this information-type rule too rigidly, in that they are not distinguishing between important and unimportant information within the definition and fact categories. In this sense, they have "overgeneralized" the rule. This overgeneralization results in novices systematically misidentifying the important text information by missing important facts and focusing on unimportant definitions.

These findings parallel those on expert-novice categorization of problem types in physics and math (Chi, Feltovich, & Glaser, 1981; Schoenfeld & Herrmann, 1982). This research on problem identification has found that novices are influenced by surface-level features in their early categorization schemes, but move to a more expert-like representation with instruction. In the current study, the novice rules are also based on superficial characteristics (e.g., category type membership). However, the resulting importance judgements based on these rules are not radically different from those of experts, indicating that this feature is related to some degree to the underlying content structure defining importance within the domain of physics.

Information-type rules of the kind demonstrated here can be thought of as the foundation for a content schema. A content schema includes knowledge about what information is important in a content area. The results of the current study suggest that an early stage in the development of a content schema for scientific subject matter may be the specification of rules indicating what types of information are important in that content domain. These information-type rules have important learning consequences. Previous

research has found that novices spend more time on definitions than facts when reading physics passages, recall more definitions than facts afterwards, and include more definitions than facts in their summaries of physics texts (Dee-Lucas & Larkin, 1985, 1986). Thus these information-type rules appear to influence novice readers' attentional processes during reading, as well as the macrostructure they develop for physics texts.

Unlike novices, the importance judgements of the control subjects with no college physics were largely unaffected by sentence form. These subjects therefore appear similar to experts. This is most likely because they have no strong expectations about what types of content should be important in physics texts. Thus the control subjects were not influenced by sentence form because they lack a physics-relevant content schema; the experts were not influenced by form because they have developed a much more refined schema which indicates the importance of specific information within the domain of physics. The experts' content schema includes a finer-grained analysis of the importance of the information than that captured by sentence-type classifications.

This suggests an inverted U-shaped relationship among naive, novice, and expert physicists in their sensitivity to sentence form. Both naive and expert subjects are not influenced by sentence form; they judge the same content equal in importance regardless of its form. Novices, on the other hand, are "distracted" by form in their importance judgements, in that they alter their judgements according to whether the information is presented as a definition or a fact. This is because their knowledge of physics has caused them to develop a general expectation that definitions are more important than facts (an expectation lacking in naive subjects), but they do not have sufficient knowledge to judge the importance of specific content within these categories (as experts can), and thus rely on this general rule based on sentence form.

A similar U-shaped relation has been found among beginning, intermediate, and expert radiologists in diagnosing x-ray pictures. Lesgold, Feltovich, Glaser, & Wang (1981) found

that beginning residents and experts were better than intermediate-level radiologists in the diagnostic reading of certain classes of x-ray films. This is because accurate diagnosis involves an interaction between the physical features found on the x-ray and the radiologist's knowledge of the relevant contextual features which constrain the possible alternative diagnoses. Beginning-level radiologists base their diagnoses on the physical features of the x-ray, and are accurate when there happens to be a match between their interpretation of those features and the actual pathology; experts use their schematic knowledge to interpret the physical features in the context of other relevant information (such as the patient's medical condition), and thus are systematically accurate in their diagnoses. Intermediate-level radiologists possess some schematic knowledge, but this knowledge is not refined or flexible enough to provide accurate diagnoses--it "distracts" them from the direct physical features used by beginners, and is not elaborate enough to allow them to pinpoint the appropriate alternative in the same manner as experts.

Thus both with physicists and radiologists, there is a stage in the development of expertise in which novices possess a primitive schema incorporating very general information about the domain (i.e., what types of information are typically important for understanding physics; what contextual features are relevant for interpreting an x-ray). These schemata are not sufficiently refined to reliably allow accurate performance, and actually impair novice performance (relative to that of naive subjects) on certain tasks. Similar developmental trends have been found in the performance of children on a variety of cognitive tasks (see Richards & Siegler, 1982). These findings suggest that a short-term decrement in certain aspects of task performance may be a necessary consequence of the early forms of schematic knowledge that develop in the course of acquiring expertise in a variety of content domains.

This study was a strong test of the hypothesis that novices are influenced by sentence form in judging importance, in that all variables other than sentence form were held constant

in the target sentences. The differences in the perceived importance of definitions and facts obtained for novices were small in absolute terms. This is to be expected given the nature of the manipulation. The only difference between the definition and fact versions of the target sentences was in the use of the words "is defined as"--the substantive content of the sentences and their location in the texts remained the same for both sentence versions. Thus the contextual and content matter constraints on importance were identical for both versions. These constraints reduce the potential difference in the importance of the two versions by limiting the range of importance to that which is plausible given the relationship of the sentence content to the passage as a whole. The results of this study show that in addition to the usual contextual and subject matter constraints which influence all skilled readers, novice scientists are influenced in a systematic and reliable manner by the form in which the content is presented when judging importance in scientific texts.

These findings suggest that certain variations in wording which do not affect the reading of experts or domain-naive readers will have essentially a "signaling" effect on novice attention and recall. Signaling involves the use of non-content words, such as "more importantly," "note that," etc., to emphasize particular text information. Signaling has been found to alter readers' attention, as indicated by differences in recall patterns for signaled and unsigned texts (Loman & Mayer, 1983; Meyer, 1983). The results of the current study show that there are particular alternative wordings (e.g., "is defined as" vs. "is represented as") which do not function as signaling phrases for most readers but have a signaling effect for novice readers because they reflect the categorization scheme used by novices to assess importance. Therefore authors can unintentionally signal particular information as important through wording selections of this type if they are unaware of novice preconceptions regarding the text content domain.

On the other hand, an author can use knowledge of novice importance rules in conjunction with signaling techniques to guide readers' attention to the appropriate text

content. Writers can use signaling devices to emphasize important content within the sentence-type categories that novices consider unimportant, and de-emphasize less critical information in the categories that novices judge as important. Meyer (1975) describes four types of signaling techniques: (1) providing cues as to the text structure, as in "the problem is...the solution is," or "first...second...third;" (2) paraphrasing important text content before it is presented, such as "the important points in the following discussion are...;" (3) summary statements of key ideas presented after the relevant text; and (4) pointer words emphasizing specific statements in the texts, as in "more importantly," "it is notable that," "unfortunately," etc. These devices can be used independently of the overall hierarchical structure of the passage to emphasize specific content within each level, a technique that Meyer (1983) terms a "differential emphasis plan." These techniques have been found to be effective in altering recall patterns of readers of varying backgrounds and abilities (Loman & Mayer, 1983; Meyer, 1983).

Signaling devices can be used by writers of physics texts to help guide novices' attention to the important content. For example, the current study indicates that definitions are a type of content that is particularly salient to novices. Therefore, it would be helpful to novices if writers would differentiate the less important definitions from those that are central to the text. This could be done by including structural cues or preliminary summaries that emphasize the main topics or content that the author wants the reader to abstract from the text, and thus in effect "de-emphasize" unimportant definitions. This would help novices distinguish between the definitions that are to be learned (i.e., the main points) and those that are there to simply aid in comprehension or elaborate on the important points. Facts, on the other hand, are not particularly salient for novices, and earlier research indicates that novices may be missing important content of this type (Dee-Lucas & Larkin, 1986). In this case, the use of underlining and pointer words (e.g., note that, it is important to understand, this leads to the important conclusion that, etc.) could be

used to draw attention to important facts.

Another technique that could be used to help novices distinguish between important and unimportant information is to teach novices a general learning schema that can be applied to texts to assess importance. This approach to manipulating attention and learning is "strategy-based" rather than "text-based." The ability of students to acquire general skills for learning from scientific texts has been demonstrated by Larkin and Reif (1976). They taught students a skill for understanding quantitative relations in physics texts by having students work through a series of training materials that required them to read physics texts and answer a prespecified set of questions. The subjects were able to learn to use this question set as a strategy for acquiring an understanding of new relations, and performed appreciably better on tests of understanding than subjects who had not acquired this learning strategy. In the case of the current study, the goal of the learning schema would be to help readers distinguish between important and unimportant definitions and facts. This would involve teaching students what types of definitions and facts should be learned. For example, Larkin and Reif were able to specify a subset of facts (i.e., those dealing with units and typical magnitudes) that are particularly important for understanding quantitative relations. This type of schema could be used by novices in reading scientific texts to aid in identification of the important content within categories of information (like facts) that they generally assume are unimportant. This schema would hold true for a broad content area within the domain of physics, but would most likely vary to some extent with subfields of study in physics.

The present study indicates that novice readers can be sensitive to very minor changes in wording at the sentence level in a text, in that these changes can be relevant to distinctions made in their content schema for the text domain. This suggests that writers need to be aware of the manner of presentation of information at a fairly local level in a text. In particular, experts writing for a novice audience will be most effective in enhancing

learning of the important text content if they use text-based indicators of importance in conjunction with knowledge of their audiences' content schema. In this way, writers can use techniques such as signaling to provide novices with clear signals of importance which will help them distinguish between important and less critical content.

References

- Chi, M., Feltovich, P., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science*, 5, 121-152.
- Dee-Lucas, D., & Larkin, J.H. (1985). *Attentional strategies for studying scientific texts* (Tech. Rep.). Paper presented at the annual meeting of the American Educational Research Association, Chicago.
- Dee-Lucas, D., & Larkin, J.H. (1986). Novice strategies for comprehending scientific texts. *Discourse Processes*, 9, 329-354.
- Kieras, D.E. (1985). Thematic processes in the comprehension of technical prose. In B.K. Britton and J.B. Black (Ed.), *Understanding expository text*. Hillsdale, N.J.: Lawrence Erlbaum.
- Larkin, J.H., & Reif, F. (1976). Analysis and teaching of a general skill for studying scientific text. *Journal of Educational Psychology*, 68, 431-440.
- Lesgold, A.M., Feltovich, P.J., Glaser, R., & Wang, Y. (September, 1981). *The acquisition of perceptual diagnostic skill in radiology* (Tech. Rep. PDS-1). Learning Research & Development Center, Univ. of Pittsburgh.
- Loman, N.L., Mayer, R.E. (1983). Signaling techniques that increase the understanding of expository prose. *Journal of Educational Psychology*, 75, 402-412.
- Meyer, B.J.F. (1975). *The organization of prose and the effect on recall*. Amsterdam: North-Holland.
- Meyer, B.J.F. (1983). Text dimensions and cognitive processing. In H. Mandl, N. Stein, & T. Trabasso (Ed.), *Learning and understanding from text*. Hillsdale, N.J.: Lawrence Erlbaum.
- Richards, D.D., & Siegler, R.S. (1982). U-shaped behavioral curves: It's not whether you're right or wrong, it's why. In S. Strauss (Ed.), *U-Shaped Behavioral Growth*. New York, NY: Academic Press.

Schoenfeld, A.H., & Herrmann D.J. (1982). Problem perception and knowledge structure in expert and novice mathematical problem solvers. *Journal of Experimental Psychology*, 8, 484-494.

Table 1: Examples of definition and fact versions of target sentences.

1. Absolute pressure is defined as simply the actual pressure at a point.

Absolute pressure is simply the actual pressure at a point.

2. Specific gravity is defined as the ratio of the density of a substance to the density of water.

Specific gravity is indicated by the ratio of the density of a substance to the density of water.

3. In terms of this notation, the work ΔW done by a force F in moving an object through a displacement Δr is defined as

$$\Delta W = F \cdot \Delta r = F (\Delta r \cos \theta)$$

In terms of this notation, the work ΔW done by a force F in moving an object through a displacement Δr is represented as

$$\Delta W = F \cdot \Delta r = F (\Delta r \cos \theta)$$

4. Specifically, the total amount of work done in changing the motion of a particle is defined as the sum of the works done by each of the individual forces acting on the particle.

Specifically, the total amount of work done in changing the motion of a particle is equal to the sum of the works done by each of the individual forces acting on the particle.

5. Intrinsic quantities are defined as quantities which are independent of volume.

Intrinsic quantities are independent of volume.

6. The unit typically used for measuring work, the joule, is defined as the work done by a unit force (one newton) acting on a unit distance (one meter).

The unit typically used for measuring work, the joule, indicates the amount of work done by a unit force (one newton) acting on a unit distance (one meter).

7. Pressure is defined as the magnitude of a fluid force divided by the area of the surface on which it acts.

Pressure can be calculated by dividing the magnitude of a fluid force by the area of the surface on which it acts.

Table 2: Parameter estimates, standard errors, and ratio of estimates to standard errors for a loglinear model of the ratings data from the experimental groups. Asterisks indicate coefficients that differ from zero by more than 2 standard errors

Effect	Coeff.	St. Error	Ratio: Coeff./St. Error
(a)Group: novice estimates (expert estimates are opposite)			
Rate 1:	.045	.066	.69
Rate 2:	.074	.075	.98
Rate 3:	.094	.090	1.04
Rate 4:	.019	.118	.16
Rate 5:	-.232	.182	-1.27
(b)Type: definition estimates (fact estimates are opposite)			
Rate 1:	.073	.067	1.10
Rate 2:	.082	.075	1.10
Rate 3:	-.224*	.090	-2.48
Rate 4:	.064	.115	.56
Rate 5:	.005	.192	.03
(c)Type x Group: definition estimates (fact estimates are opposite)¹			
Rate 1:			
Novice (+)	.133*	.066	2.01
Expert (-)			
Rate 2:			
Novice (-)	.098	.075	1.30
Expert (+)			
Rate 3:			
Novice (+)	.003	.081	.04
Expert (-)			
Rate 4:			
Novice (+)	.014	.117	.12
Expert (-)			
Rate 5:			
Novice (-)	.052	.180	.29
Expert (+)			

¹Parameter estimates indicate the size of the effect; positive and negative symbols indicate the direction of the effect for each group.

(d)Level**Level 1:**

Rate 1	.917*	.121	7.57
Rate 2	.214	.135	1.59
Rate 3	-.454*	.185	-2.46
Rate 4	-.504*	.250	-2.01
Rate 5	-.173	.351	-.49

Level 2:

Rate 1	-.042	.110	-.38
Rate 2	.052	.120	.44
Rate 3	.140	.148	.95
Rate 4	.165	.193	.86
Rate 5	-.315	.320	-.98

Level 3:

Rate 1	-.875*	.098	-8.97
Rate 2	-.265*	.104	-2.56
Rate 3	.314*	.128	2.46
Rate 4	.339*	.169	2.00
Rate 5	.488	.251	1.94

Table 3: Parameter estimates, standard errors, and ratios of estimates to standard errors for a loglinear model of the ratings data from the control groups. Asterisks indicate coefficients that differ from zero by more than 2 standard errors.

Effect	Coeff.	St. Error	Ratio: Coeff./St. Error
Group: undergrad estimates (grad estimates are opposite)			
Rate 1:	.323*	.065	4.98
Rate 2:	.083	.074	1.12
Rate 3:	-.070	.089	-.79
Rate 4:	-.323*	.117	-2.76
Rate 5:	-.010	.172	-.06
Level			
Level 1:			
Rate 1	.695*	.105	6.62
Rate 2	.141	.119	1.18
Rate 3	-.302	.156	-1.94
Rate 4	-.492*	.220	-2.24
Rate 5	-.042	.282	-.15
Level 2:			
Rate 1	.128	.102	1.25
Rate 2	.013	.118	.11
Rate 3	.133	.137	.97
Rate 4	-.047	.188	-.25
Rate 5	-.226	.281	-.80
Level 3:			
Rate 1	-.822*	.092	-8.92
Rate 2	-.154	.099	-1.56
Rate 3	.169	.119	1.42
Rate 4	.539*	.155	3.48
Rate 5	.268	.226	1.19

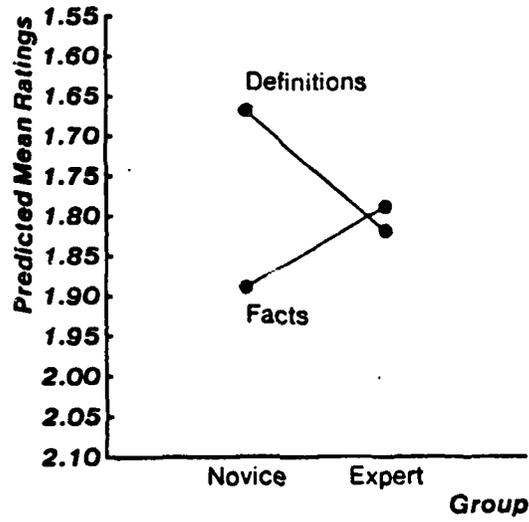
Table 4: Parameter estimates, standard errors, and ratios of estimates to standard errors for a logistic regression model of the sentence selection data from the experimental groups.

Effect	Coeff.	St. Error	Ratio
			Coeff./St. Error
Type:	-.414	.099	-4.18
Group:	-.186	.099	-1.88
Type x Group:	.236	.099	2.38
Definition (+)			
Fact (-)			
Level:	-1.016	.088	-11.49

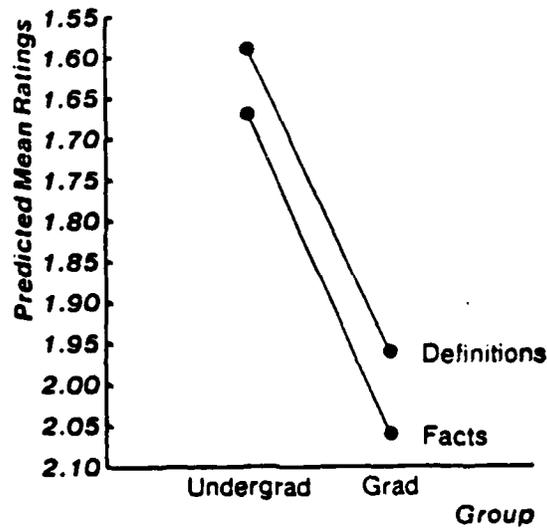
Table 5: Parameter estimates, standard errors, and ratios of estimates to standard errors for a logistic regression model of the sentence selection data from the control groups.

Effect	Coeff.	St. Error	Ratio: Coeff./St. Error
Type:	-.220	.098	-2.24
Type x Level:			
Level 1:	-.448	.139	-3.22
Level 2:	.014	.139	.10
Level 3:	.462	.140	3.30
Group:	-.590	.098	-6.02
Level:			
Level 1-2 diff:	.476	.139	3.42
Level 2-3 diff:	1.316	.140	9.40

Figure 1: Predicted mean ratings for the type x group interactions in the ratings data.

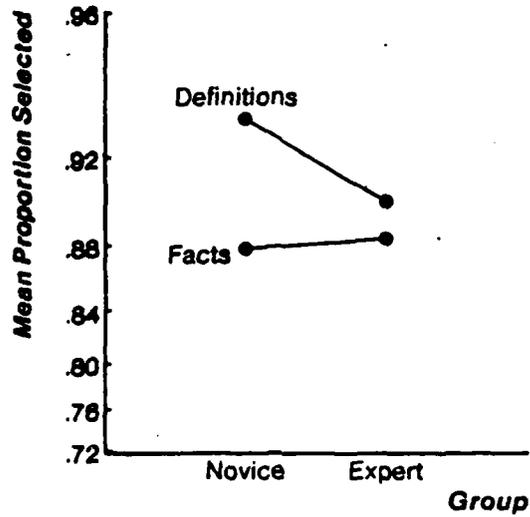


(a) Experimental Groups

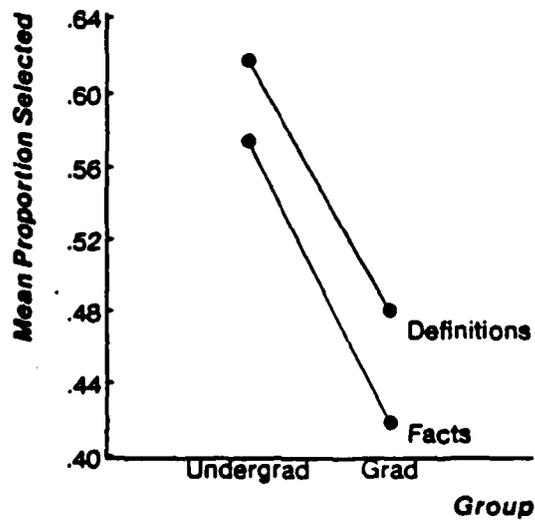


(b) Control Groups

Figure 2: Predicted proportion of target sentences selected as important for the type x group interactions in the sentence selection data.



(a) Experimental Groups



(b) Control Groups

Figure 3: Predicted proportion of target sentences selected as important for the type x level interaction in the sentence selection data for the control groups.

