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ABSTRACT

Two studies were conducted to clarify some problems in aptitude treatment interaction research, by concentrating on the macroprocesses in reading required by different instructional methods and the macroprocesses available to students. In the first experiment, three reading groups were used, the first receiving adjunct questions, the second also receiving feedback on the correctness of their answers to the adjunct questions, and the third reading the text without the adjunct questions. Results showed (1) that groups receiving questions scored higher on the posttest than the read-only group, (2) no differences between the adjunct question groups, (3) significant differences in the frequency of various macroprocessing option use, and (4) an "incredible" variability in students' choices of cognitive processing options. In the second study, two options--review of either an alternate or the main text--were prescribed when comprehension difficulty was evident. Four groups were involved: a read-only group, an adjunct question group, a group required to review the main text if question responses were incorrect, and a group required to review an alternate text in the same situation. Results showed that the significant differences among groups on the macroprocessing options used were attributable to the review option. (Tables of findings are included). (DF)

Review, Other Macroprocesses, and Individual Differences

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The work in which we are presently involved was originally stimulated by the difficulties in aptitude treatment interaction (ATI) research. This field intends to establish interactions between learner attributes and instructional methods so as to provide the knowledge base to assign students to the instructional methods ideally suited for them. As described elsewhere in some detail (Tobias, in press; Cronbach & Snow, 1977) the number of positive results in this field generally equal the negative findings, results frequently can not be replicated or extended, and variations in samples or procedures often lead to markedly different outcomes.

It has been suggested (Tobias, 1982) that the problems of replication and generalization of ATI research may be attributable to two sets of unverified assumptions. First, that varying instructional methods induced different cognitive processing of the instruction, called macroprocessing. Second, that the macroprocesses required by the methods were differentially available to students. Finding replicable ATIs requires that both assumptions are supported. Since most ATI studies have little independent verification of either assumption, the variable research results in this area are hardly surprising.

Our recent research was intended to clarify the ATI problem by concentrating on both the macroprocesses required by different instructional methods and available to students. There are

different ways of studying cognitive processing of instruction, such as by stimulating the recall of students after an instructional event (Peterson, Swing, Stark & Waas, 1984; Rohrkemper, McCauley & Slavin, 1983), by training students in the use of these processes (Palinscar & Brown, 1984; Paris, Cross & Lipson, 1984), and by the procedures described by the other papers presented at this symposium.

Macroprocesses in Reading

Our approach to the study of macroprocesses was to develop an unobtrusive paradigm to monitor the cognitive processes used by students while reading from text. A passage is displayed on microcomputers in a series of numbered sentences, one at a time. When the space-bar is touched the present sentence disappears, though it's number and the space it occupied remains while the succeeding sentence is displayed. This presentation mode enables students to invoke a variety of options quite rapidly and conveniently on the computer system, while we are able to determine with some precision the strategies used. The adjunct question paradigm was used in order to stimulate comprehension and divide the text into target sentences which were either relevant to the content of the adjunct questions, or incidental to them.

In our research we have used a passage describing some principles of data processing and computer programming, illustrated by commands in the BASIC language. The main passage contains 49 paragraphs, 172 sentences and is written in a vocabulary appropriate for the 14th grade (Fry, 1968). An alternate, easier passage was prepared which paralleled the

content of the main text. The alternate passage of 182 sentences was written in a vocabulary appropriate for the 10th grade, and its logical structure followed a superordinate-subordinate clause structure more rigorously than the main passage.

A pilot study was conducted asking students to list the reading strategies used while engaged in school-related studying. The most frequently occurring strategies were embedded in a computer program developed to conduct the experiments. The following options were available to students: 1) Review; any segment of the main text could be reviewed by either touching the backward arrow, which exposed the preceding sentence, or giving a range of sentences that the students wished to review. 2) The alternate text could be consulted, or 3) reviewed. 4) Students could take notes right on the computer system and 5), review the notes. 6) An options menu could be requested, describing how the options could be invoked. In cur first study (Everson & Tobias, 1984) students were also able to preview either main or alternate text, and consult a display listing all the headings of the passage, and the sentence numbers in each heading.

Our interest in macroprocesses was stimulated by a variety of sources. First, as outlined above, it seemed vital to identify the mediating cognitive processes (Doyle, 1978) intervening between the presentation of instruction and student learning. Second, macroprocesses seemed to be relatively molar units easily subjected to analysis. Third, it seemed convenient to relate the type of macroprocesses used and their frequency to achievement outcomes as well as to other student characteristics. In general it was hypothesized (Tobias, 1982) that more intensive

macroprocessing would lead to greater learning. Finally, students seemed aware of these processes and, it therefore appeared likely that they might be able to control them.

Experiment I

In our first experiment (Everson and Tobias, 1984) we employed three groups: 1) A group receiving adjunct questions, 2) A second adjunct question group which also received feedback regarding the correctness of their answers to the adjunct questions. 3) A group reading the text without questions. As expected, the results indicated that groups receiving questions earned higher posttest scores than the read only group. There were no posttest differences between the adjunct question groups; the performance of the question plus feedback group was lower, though not significantly so than that of the group receiving only adjunct questions.

There were significant differences among the groups in the frequency with which different macroprocessing options were used, with the adjunct question group employing them most frequently, and the reading group least often. The major surprise in our first study was the incredible variability of the data involving students' choice of cognitive processing options. Frequently, the standard deviations of these data were two and three times the size of the mean, even though the variabilty of these results had been reduced somewhat by setting outlying scores to values of three standard deviations above the mean. Frequency of option use was also variable, ranging from a low of 12% for some of these strategies, to a high of 82% for others. Finally, there were few significant correlations between use of options and

various measures of reading ability, test anxiety or prior knowledge of the subject matter. Even more surprising was an absence of relationship with posttest scores suggesting that use of the options appeared not to be in the service of improving achievement.

There were a number of ways of interpreting these macroprocessing data. Perhaps students did not care about the outcomes of their efforts and were simply using the machines much the way one might employ a computer game, rather than attempting to learn from them. This interpretation was contradicted by the grand mean of 70% for all groups on a relatively difficult posttest requiring constructed responses. Clearly, such a score could not have not been obtained without effort. The second interpretation was that either students were unaware of what cognitive processes they used, or that they did not know which of the reading strategies led to higher achievement. These possibilities were examined in our next experiment.

Experiment II

Our succeeding study prescribed the use of two options, review of either alternate or main text, when there was evidence of comprehension difficulty. Review of preceding text had been found to lead to improved learning (Gustafson & Toole, 1970; Schumacher, Moses & Young, in press) in prior research. It was reasoned that if groups for whom option use was prescribed learned more than those who could pick options freely, then students used opitons ineffectively, probably due to limited knowledge regarding which macroprocessess improved learning. In order to determine awareness of their use of reading strategies

we asked students to report the strategies typically employed during reading, and related these to the macroprocessing options actually used on our experimental tasks .

The second study (Tobias, 1985) employed four groups: two were identical to those used in the preceding study, namely a read only-group and an adjunct question group. The third group was required to review the main text if their responses to adjunct questions were incorrect. The fourth group was identical to the third except that the alternate text had to be reviewed when an answer to an adjunct question was wrong. Options which were found to be completely unrelated, or negatively related to achievement in the first study were removed, such as the option to preview, and to request an organizational display of the text. The major results of that study are displayed in Table 1. Multivariate multiple regression

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Insert Table 1 here
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analysis indicated that groups required to review obtained significantly higher scores on the portion of the posttest relevant to the content of the adjunct questions, though not on the incidental posttest. Table 2 displays

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Insert Table 2 here
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the means and standard deviations of the macroprocessing data. Multivariate multiple regression analysis indicated that there were significant differences among the groups on the macroprocessing options invoked. These differences appeared to be wholly attributable to the review option. As indicated in

Table 2, the required review groups re-read between 12-20 times more sentences than the others.

Two questionnaires had been administered to determine students' use of strategies in their reading. One of these required constructed responses regarding students' use of strategies in various types of reading. A second consisted of a Likert-type scale in which students were required to rate use of reading strategies in a variety of areas such as computer science, English and social studies. Surprisingly, neither of these scales were found to be significantly related to the actual strategies employed by students in this study.

The results of the second experiment suggested that students could be induced to use strategies such as review in order to improve their achievement compared to others for whom review was optional. It also seemed clear that there was a lot of noise in this system since the required review groups re-read between 10 and 20 times more sentences than comparison groups in order to increment posttest by a few points. So much extra work for such a small gain in learning can hardly be described as an efficient process.

The data also suggested that the ineffective use of strategies may be attributable to students lack of awareness of strategy use, as indicated by the absence of relationship between student's self-reports and option use in this experiment. Alexander, Hare, and Garner (1984), on the other hand, found that student reports of strategies matched those actually used. The differences between our findings and those of Alexander et al. might be attributable to the unique manner in which text was

read in our experiments, i.e., the computer display. The differences may also be due to the fact that we had fine grained information available regarding strat gy use, such as data on the number of sentences involved in option use whereas the observational data available to Alexander et al. may have been less precise. Obviously, these issues will have to be clarified in succeeding research. Whatever the reasons, it seemed clear that students were not aware of how intensively they used such strategies in our setting.

Another interpretation for the absence of relationships between self-reports and option use may be that students just do not have very clear impressions regarding the effectiveness of strategies used. Despite the superior achievement of the required review groups, the magnitude of the re-reading by these subjects clearly indicated that students were not using review very efficiently. Such ineffective use is not suprising when one considers that little instruction is typically offered at any level regarding effective study strategies. Students, then, probably infer which strategies are successful for them based on test results. Such data are rarely specific enough to indicate areas of strength or weakness, nor are they delivered promptly enough so that students can use such feedback to select the most effective strategies. In the absence of such data students' impressions about effective strategy use may be a case of "superstitious" behavior, in which chance reinforcement increases the frequency of behaviors unrelated to the occurrence of the reinforcement.

Strategic Reading and Comprehension

The descriptions of the results of both experiments have been summarized substantially so as to meet the time constraints of this presentation. We have described the enormous amounts of data gathered in this research elsewhere (Tobias,1984). There are a number of interesting double and triple interactions which would be difficult to detail in the time available, and we shall refer only to the most important of these here.

In general the findings answer some of our initial questions. In both experiments the various instructional methods led to differences in student utilization of options, indicating that the method variations used in these experiments did lead to differences in macroprocessisng. Furthermore, in both experiments groups which used the options most frequently had higher posttest scores than conditions with lower utilization. These findings confirmed our expectations (Tobias, 1982) that more intensive macroprocessing would lead to improved learning.

The data present an interesting paradox. On the one hand, both experiments provide substantial evidence of reading which is ineffective, and anything but strategic. On the other hand, evidence of strategic behavior is also available. For example, the finding in our second experiment (Tobias, 1985) that required review improved comprehension of only the relevant content suggested that the groups required to re-read skimmed the text for answers to the adjunct questions, rather than reading all parts of the passage carefully.

A second example of strategic behavior was seen in one of the interactions from the second experiment. The interaction,

shown in Figure 1,

Insert Figure 1

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indicates that students in the required review groups who had high pretest scores read more alternate text than those with less prior experience with the subject. Apparently, these knowledgeable students developed a preventative strategy of reading the alternate, easier text prior to presentation of the adjunct question so that they would be more likely to get the question right, and not be required to review. There is evidence, then, in the data of effective and strategic reading on the one hand, and ineffective, apparently random behavior on the other.

We have hypothesized that random and ineffective reading may be caused by students' unclear perception regarding when something is actually comprehended. That is, the internal representation of the subject matter, especially if it is fairly novel to students, is probably relatively undifferentiated giving them few clues regarding when they have adequate mastery of the material. In such instances ineffective use of reading strategies is expected. On the other hand, when clearcut criteria, against which students may assess their comprehension, are provided their reading is expected to become much more strategic. This can be seen in the data displayed in Figure 1, and in students' skimming for the correct answer.

We further hypothesize, that explicit criteria will be more beneficial for students with limited prior knowledge of the subject matter than for those with extensive familiarity with it.

The interaction described above suggests that students with substantial prior knowledge probably have a clearer internal representation of the content than those who know less about the subject. Therefore, we expect that knowledgeable students need less explicit criteria to assess their comprehension of incoming information than those with less familiarity with the subject. To relate this work to prior research (Tobias, 1976, 1982), instructional support in the form of external criteria of adequate comprehension should be more beneficial to those with limited experience with the content, than for more knowledgeable students

We are testing this hypothesis in our next investigation, currently in the data gathering phase, in which some students are being provided with quite explicit criteria to evaluate their comprehension, whereas the criteria remain vague for other groups. Specifically, when students do not answer adjunct questions correctly, one group merely reviews the preceding text, another is informed to think of the adjunct question as they review, and the question is actually displayed while a third group is conducting its review. Another classification in this experiment compares being required to review the text, to optional review in each of these three conditions. We hope that by next year's AERA convention we shall be able to be a little more knowledgeable about student use of reading strategies as a function of their prior knowledge, reading ability, and criteria against which to assess their developing comprehension.

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Table 1. Means and Standard Deviations of Selected Dependent and Independent Variables

		Main Review (M=25, F=10)	Alternate Review (M=29, F=6)	Optional Review (M=25, F=12)	Read Only (M=21, F=12)
Achievement Variables					
Posttest Relevant Score	Mean	14.2	13.12	11.6	10.35
	SD	4.78	5.97	5.43	5.3
Posttest Incidental Score	Mean	8.1	7.7	9.0	9.0
	SD	3.9	4.39	4.1	3.7
Posttest Total Score	Mean	22.3	20.8	20.6	19.3
	SD	8.26	9.94	9.10	8.7
Reading and Pretest Scores *					
Pretest Total Score	Mean	19.51	17.82	19.1	19.8
	SD	4.85	5.23	4.9	5.5
Nelson Denny Reading	Mean	34.03	34.45	35.83	35.1
	SD	11.03	14.85	11.95	11.7
Nelson Denny Comprehension	Mean	33.25	30.97	34.97	33.8
	SD	11.3	18.51	10.10	10.3
Nelson Denny Total	Mean	67.28	65.42	70.8	68.9
	SD	20.37	25.36	20.72	19.7
Anxiety Measures					
Test Anxiety Scale	Mean	19.45	18.08	17.81	17.6
	SD	5.30	7.57	5.55	5.4
Worry scale before reading	Mean	8.9	8.17	8.1	7.39
	SD	3.8	3.92	3.4	3.5
Worry scale during reading	Mean	8.6	9.37	9.7	7.96
	SD	3.2	4.6	4.8	3.2
Worry scale after reading	Mean	9.6	9.25	10.0	9.7
	SD	3.9	4.8	4.9	4.4

* Raw Score

Table 2. Means, Standard Deviations and Correlations with Posttest for Option Use Data.

		Main Review	Alternate Review	Optional Review	Read Only
Option Use Data					
Main Text Reviews[1]					
	M	100.51	3.05	12.32	17.57
	SD	39.76	3.80	15.46	16.39
	r	-.55**	.26	.18	.22
Alternate Text Reviews[1]					
	M	3.12	122.61	5.47	4.98
	SD	8.78	51.54	10.54	7.85
	r	.08	-.62**	.22	-.18
Inspection of Alternate Text[1]					
	M	28.51	27.21	19.48	22.68
	SD	48.80	44.13	35.88	36.35
	r	.32	.26	.14	-.27
Notes					
	M	5.68	7.02	7.35	8.48
	SD	10.72	8.45	11.27	9.32
	r	.10	.04	.11	.02
Review of Notes					
	M	.39	.76	.73	1.35
	SD	1.41	1.74	1.72	1.87
	r	.05	0.00	-.08	-.06
Options Menu					
	M	1.55	.97	1.10	1.84
	SD	2.08	1.93	2.01	2.73
	r	-.04	-.05	.28	-.06

[1] Number of sentences.

** p. <.01

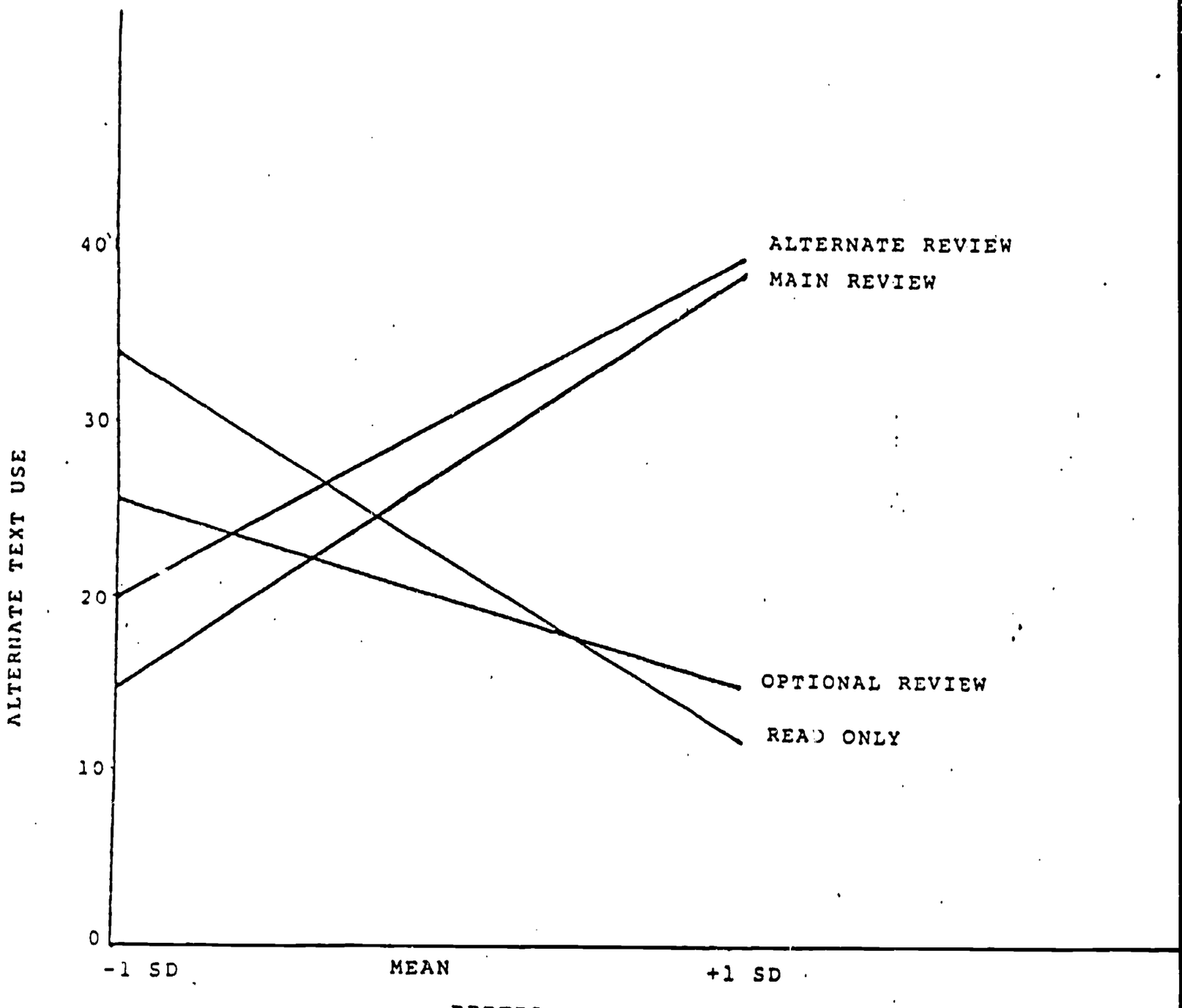

FIGURE 1. Interaction among treatment and pretest score on number of alternate text sentences reviewed.