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Note-Taking Functions and Techniques

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This experiment investigated three newly classified note-taking functions: encoding (take notes/no review), encoding plus storage (take notes/review notes) and external storage (absent self from lecture/review borrowed notes), relative to three note-taking techniques (conventional, linear, matrix). Results pertaining to note-taking functions indicated that encoding plus storage was superior to encoding and to external storage for recall performance, and superior to encoding for synthesis performance. External storage was also superior to encoding for synthesis performance. Results pertaining to note-taking techniques indicated that matrix notes produced greater recall than conventional notes. Results were explained by variables relating to repetition, generative processing, the completeness of notes, and the potential of note-taking techniques to facilitate internal connections.

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Beginning with Di Vesta and Gray (1972), researchers have distinguished two functions of note-taking: encoding and external storage. The encoding function suggests that the process of recording notes facilitates learning. It is measured by comparing the performance of students who listen to a lecture but do not record notes with the performance of those who listen and record notes. Neither group is allowed to review following the lecture. Results of research on the encoding function have been mixed. In 61 studies reviewed by Hartley (1983), Kiewra (1985), or both, 35 found facilitative encoding effects, 23 indicated that notetakers and listeners did not differ significantly on performance tests, and 3 reported that listening without note-taking led to better performance than note-taking.

The external storage function suggests that the review of notes stored in a written form facilitates performance. It is measured by comparing the performance of students who record and review their notes with those who record notes but are forbidden to review their notes. The efficacy of reviewing an external record of the lecture has been well documented. In 32 studies reported by Hartley (1983), Kiewra (1985), or both, 24 found that students who reviewed their notes had higher achievement on performance tests than those not permitted to review. Eight other studies reported no differences between reviewers and nonreviewers; no study indicated that review was dysfunctional.

On the basis of the reviews by Hartley (1983) and Kiewra (1985), it is evident that considerable research has been conducted on the encoding and external storage functions of note-taking. The general consensus is that both functions contribute to learning but that the external storage function is the more important function.

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We think that there are two problems with this research: (a) The encoding and external storage functions have not been clearly and fairly differentiated, and (b) the possibility that different techniques for note-taking might produce differential encoding or external storage effects has not been adequately addressed. With respect to the problem of differentiation, what traditionally has been called external storage is really the combination of encoding and external storage. Students are both taking and reviewing notes. An independent comparison of encoding and external storage has not been made. In the present study we reclassify the traditional external storage function as an "encoding plus storage" function and propose a new, independent external storage function represented by those who review notes but who have not previously viewed (or encoded) the lecture. This is done by absenting students from the lecture and then providing them with "borrowed" notes from fellow students to review. This all-too-common practice of reviewing borrowed notes has never been investigated. These variations result in three note-taking functions: the original encoding function (take notes/no review), the newly classified encoding plus storage function (take notes/review), and the new, independent external storage function (borrow notes/review).

Our hypotheses regarding the three functions of note-taking were based on two theoretical notions: repetition and generative processing. Repeated exposures to text or lecture information results in greater learning (Bromage & Mayer, 1986; Kiewra, Mayer, Christensen, Kim, & Risch, 1991). This is an advantage for the encoding plus storage group because they have two opportunities to process information, whereas the other groups have one.

The notion of generative processing (Wittrock, Marks, & Doctorow, 1975) is that actively generating relations among the parts of the learning material or between the learning material and one's prior knowledge produces greater learning than less generative forms of processing. Examples of generative processing include the student's development of summaries, graphs, tables, analogies, examples, and conclusions. Examples of nongenerative processing include maintenance rehearsal, copying, or simply reading already-generated material.

There is some debate whether note-taking serves a generative function. Peper and Mayer (1978, 1986) found that notetakers outperformed nonnotetakers on a problem-solving test. However, there was no relationship between the content of students' notes and their performance on the problem-solving test. Other researchers who have examined lecture notes have also found little or no evidence for generative processing among notetakers. Bretzing and Kulhavy (1981) found that students tended to record verbatim notes. Kiewra and Fletcher (1984) actually directed students to record generative notes but found that students were largely unable to do so.

When considering the information-processing demands of lecture learning, it seems unlikely that much generative processing can occur during the lecture. During lecture learning, students must continuously and simultaneously listen, select important ideas, hold and manipulate lecture ideas, interpret the information, decide what to transcribe, and record notes. Some resources are additionally spent on the mechanical aspects of note-taking such as spelling, grammar, and notational style. It is unlikely that many resources are available for more generative processing of lecture information, particularly when lecture rates are rapid (Peters, 1972). During the review phase of learning, however, students do not have to divide their attention among so many tasks. Information-processing resources are free for generating relations among lecture ideas or between lecture ideas and prior knowledge.

In terms of generative processing, then, we expected an advantage for the encoding plus storage and the external storage groups over the encoding group, given that the former groups would probably engage in generative activity while reviewing notes, whereas the latter group would be less likely to do so while recording notes. When both repetition and generative processing were considered, we hypothesized that test performance would follow this pattern: encoding plus storage > external storage > encoding. On the basis of these same two theoretical ideas, we further expected that the encoding group would perform similarly to a control group that views the lecture without note-taking or review. Both the encoding group and the control group would have exposure to a single lecture presentation (the repetition hypothesis), and both would be unable to review (the generative hypothesis). Thus, there was no expected advantage for simple writing over listening.

The second problem with research on note-taking functions is that note-taking techniques have rarely been manipulated. As a result, little is known about how students should take notes and what type of notes is best for review. Students in most experiments are left to record notes in their conventional styles despite considerable evidence indicating that conventional note-taking practices generally produce notes that are incomplete and ineffectively organized (e.g., Bretzing & Kulhavy, 1981; Kiewra & Benton, 1988). In this study, conventional note-taking was compared to note-taking in linear and matrix frameworks. A linear framework lists the lecture's main topics and subtopics in an outline form and provides spaces between ideas for note-taking. A matrix framework presents the same information in a two-dimensional table; main topics are named across the top of the page and subtopics are listed down the left margin. The internal cells are used for note-taking.

Two different theoretical notions guided our hypotheses about note-taking techniques: completeness and internal connections. Note completeness is positively related to test performance (e.g., Kiewra & Benton, 1988). Limited research on linear frameworks indicates that they increase the number of ideas recorded in notes beyond students' conventional techniques (Kiewra, Benton, Christensen, Kim, & Risch, 1989). The provided topics and subtopics in linear frameworks increase selective attention; the provided spaces certainly invite a written record. In fact, Hartley (1976) demonstrated that students record greater amounts of information on linear outlines when spaces are made larger. We assumed that the matrix framework, which also presents topics, subtopics, and space for note-taking, would have the same completeness effect as the linear framework. On the basis of relative completeness, we predicted that both linear and matrix notes would be more effective than conventional notes.

When students form internal connections (i.e., relations) among lecture ideas, learning is facilitated (Mayer, 1984). Because conventional notes typically follow the organization of the lecture, students are not apt to perceive relations not made explicit in the lecture. In fact, our observations have been that conventional notetakers often miss relations made explicit in the lecture. For example, given the lecture statement, "The motivation for expressive creativity is to create a momentary flash of brilliance," the conventional notetaker will often write the statement "create momentary flash of brilliance" beneath the topic of expressive creativity. Associating this idea (along with several others) to the general topic of expressive creativity, but not to the specific subtopic of motivation, can be problematic. If later asked specifically about the motivation for expressive creativity, the conventional notetaker would have difficulty retrieving the idea from memory given that it was not encoded with the subtopic of motivation (Tulving, 1983).

Linear notes should foster internal connections beyond conventional notes in two ways. First, their organized structure should make superordinate–subordinate relations apparent. For example, in the linear notes used in this experiment subtopics appear below topics and are indented. Second, because topics and subtopics are provided, all recorded lecture points are connected to at least a topic and subtopic, thereby offering at least two retrieval pathways to any recorded idea.

Matrix notes particularly help students to build internal connections. Similar to linear notes, they accent superordinate–subordinate relations and tie recorded information to topic and subtopic. In addition, matrix notes emphasize cross-topical relations. With a matrix, a student can readily examine all information about a subtopic (e.g., motivation) by following that subtopic across the major topics (e.g., different types of creativity). This permits a student to synthesize ideas across topics. Linear and conventional notes, because they appear over several pages, may actually obscure such relations. In a

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study comparing the external storage function of provided notes, Kiewra and his colleagues (Kiewra, DuBois, Christian, & McShane, 1988) found that subjects who reviewed complete matrix notes or complete linear notes recalled more than those who reviewed a complete text of the lecture. On a synthesis test—requiring cross-topical connections—the matrix group alone outperformed the text group.

With respect to internal connections, then, we predicted that matrix notes would be superior to linear notes, which in turn would be superior to conventional notes. In fact, on the basis of the combined notions of completeness and internal connections, the predicted ordering for note-taking techniques was the same as that based on internal connections alone.

Method

Subjects and Design

Ninety-six undergraduate volunteers were randomly assigned in proportional numbers to one cell of a 3 × 3 design. The first variable was note-taking function: encoding (take notes/no review), encoding plus storage (take notes/review), and external storage (borrow notes/review). The second variable was note-taking technique (conventional notes, linear notes, and matrix notes). Twenty-four subjects were assigned to the encoding group, 24 were assigned to the encoding plus storage group, and 48 were assigned to the external storage group. This last group contained twice as many subjects so that the notes recorded by all 48 note-taking subjects (rather than a sample of them) could be reviewed by a borrower in the external storage group. Originally, 76 subjects participated in the experiment. Twenty subjects were added later to make the group sizes proportional. Twenty-four subjects were also added as a control group. Although the 44 additional subjects participated at a later time, they were members of the same subject pool. Differences between the original subjects and those participating later (with respect to important factors such as prior knowledge and motivation) were, therefore, considered minimal.

Materials and Apparatus

Materials included a videotaped lecture, television monitors, materials for note-taking, and performance tests. The 19-min videotaped lecture about five types of creativity contained 1,881 words and was delivered at a rate of approximately 100 words per minute on two 19-in. color television monitors. The lecture contained 121 idea units, based on a procedure developed by Kintsch and van Dijk (1978).

Materials for each conventional notetaker included four sheets of lined paper. Participants in the linear notes group each received four mimeographed pages that contained a linear outline of the lecture, with spaces between ideas for note-taking. The linear notes listed each of the five types of creativity (e.g., expressive and adaptive) with the nine common dimensions (e.g., definition, distinguishing characteristics, examples, and myths) subsumed beneath each of the types. Subjects in the matrix note-taking group were given a single 38 × 20 cm sheet of paper for note-taking. Along the horizontal axis, the five types of creativity were named; along the vertical axis, the nine dimensions describing the types of creativity were listed. The empty cells of the matrix differed somewhat in size on the basis of the relative amount of information pertinent to each cell.

Two different performance tests were administered. The cued recall test asked students to recall whatever information they could about specific dimensions of the five types of creativity. The nine specified dimensions were identical to those named throughout the lecture and contained in the linear and matrix notes. The maximum number of recallable ideas was 121. The five-item synthesis test required 10 responses. Each item asked subjects to name the two types of creativity that shared a common characteristic (e.g., "Which two types of creativity take a lifetime to develop?"). The lecture did not specify the shared characteristics. A student had to synthesize this knowledge.

Procedure

The experiment was conducted in two stages. During Stage 1, subjects from the encoding and encoding plus storage groups assembled in a large classroom. Written general instructions informed all participants that they would take notes while viewing a 19-min videotaped lecture about creativity and would be tested. The instructions did not describe the nature of the tests and did not specify whether or not notes would be reviewed. Specific instructions did, however, inform each participant about his or her particular note-taking technique (conventional, linear, or matrix notes). After instructions were read, subjects removed from their packets the corresponding materials for note-taking. After the lecture was played, subjects in the encoding group were allowed 22 min to complete the recall test without an opportunity for review. Subjects in the encoding plus storage group reviewed their notes for 22 min while the encoding group took the recall test. The 22-min time limit for recall and for review was used because it was the maximum time limit possible within the experimental period, and yet was comparable to the length of the lecture (i.e., 19 min). Subjects in the encoding group next took the 5-min synthesis test and were then dismissed simultaneously. Following review, subjects in the encoding plus storage group were administered the two tests in the same manner used for subjects in the encoding group.

For Stage 2 of the experiment, conducted following the completion of Stage 1, subjects assigned to the external storage condition were assembled and asked to play the role of students who had missed a lecture. They were to study a set of borrowed notes in preparation for performance tests. Each new subject was randomly given a unique set of notes to review that had been recorded by one of the notetakers in Stage 1. The notes were unaltered and appeared in the original notetaker's hand. All of the notes were examined previously, and all were legible. Subjects had 22 min to study the borrowed notes before taking the same tests.

These procedures were followed for the 76 subjects initially participating in the study, and later for the 20 additional subjects. At that later time, the control subjects also participated. Written instructions informed control subjects that they would view a 19-min videotaped lecture about creativity and would be tested. Subjects were told that they would not be permitted to take notes during the lecture. Immediately following the lecture, subjects were administered the recall and synthesis tests.

Results

To determine the effects of the note-taking functions (encoding–take notes/no review, encoding plus storage–take notes/review, and external storage–borrow notes/review) relative to the three note-taking techniques (conventional, linear, and matrix), separate 3 × 3 proportional-N analyses of variance (ANOVAs) were conducted on cued recall and synthesis scores. Cochran's test for homogeneity of variance revealed no significant differences for recall or synthesis scores. Significant main effects were further analyzed using the Fisher LSD procedures ($\alpha = 0.05$). The cell means appear in Table 1.

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Table 1
Weighted Mean Scores for the Groups on Performance Tests

Group	Performance test: Cued recall	Synthesis
Encoding (n = 24)	13.54	5.88
Conventional notes (n = 8)	10.75	5.50
Linear notes (n = 8)	15.88	5.63
Matrix notes (n = 8)	14.00	6.50
Encoding plus storage (n = 24)	24.21	7.71
Conventional notes (n = 8)	20.00	7.38
Linear notes (n = 8)	24.88	7.38
Matrix notes (n = 8)	27.75	8.38
External storage (n = 48)	17.54	6.90
Conventional notes (n = 16)	14.06	7.19
Linear notes (n = 16)	15.44	6.25
Matrix notes (n = 16)	23.13	7.25
All groups (n = 96)		
Conventional notes (n = 32)	14.72	6.81
Linear notes (n = 32)	17.91	6.38
Matrix notes (n = 32)	22.00	7.34
Control group (n = 24)	13.33	6.08

The ANOVA for cued recall indicated a main effect for note-taking function, $F(2, 87) = 8.12, p < .002, MS_e = 86.66$. Fisher LSD tests indicated that subjects who took and reviewed notes (encoding plus storage) recalled more than either subjects who took but did not review notes (encoding) or subjects who only reviewed notes (external storage). There was also a main effect for technique, $F(2, 87) = 4.92, p < .01$. Fisher LSD tests indicated that the taking or review (or both) of matrix notes led to significantly greater recall than the taking or review (or both) of conventional notes. The note-taking function by technique interaction was not significant, $F < 1$.

The ANOVA for synthesis also revealed a main effect for note-taking function, $F(2, 87) = 5.70, p < .006, MS_e = 3.56$. Fisher LSD tests indicated that subjects who took and reviewed their notes (encoding plus storage) and subjects who borrowed notes (external storage) both scored significantly higher than those who simply took but did not review notes (encoding). The main effect for note-taking technique was not statistically significant, $F(2, 87) = 2.11, p > .10$, nor was the function by technique interaction, $F < 1$.

The encoding group was compared with the control group on recall and synthesis performance to determine whether it was more effective to listen and take notes during a lecture or to listen without note-taking. The groups did not differ on either the recall test or the synthesis test, $t(46) < 1$ in both cases. The control group was then compared with each encoding subgroup individually to determine how each particular note-taking technique (i.e., conventional, linear, or matrix) compared with listening without note-taking. In each case, the encoding subgroup did not differ from the control group on either the recall or synthesis test, $ts(30) < 1$. Means appear in Table 1.

The 48 sets of notes were scored for the total number of idea units (from a possible 121). A one-way ANOVA indicated that the three note-taking techniques were not homogeneous with respect to the number of lecture ideas in notes, $F(2, 45) = 6.78, p < .003, MS_e = 67.52$. Fisher LSD tests indicated that the matrix (M = 57.1) and linear (M = 56.4) notes contained significantly more ideas than conventional notes (M = 38.3).

Discussion

Results generally confirmed our hypotheses about note-taking functions and techniques. In terms of the functions, the encoding plus storage group outperformed the encoding group on both tests. These results were consistent with findings from the 24 studies reported by Hartley (1983) and Kiewra (1985) indicating that notetakers who review outperform notetakers who do not review. Theoretically, these findings can be explained by the repetition effect. The encoding group had access to the information one time; the encoding plus storage group had access two times. Results could also be explained by the generative effect: Generative activities were more likely to occur during review (when attentional resources were not divided) than during lecture learning. Of course, both the generative and repetition effects might have contributed to these findings.

The encoding plus storage group also recalled more than the external storage group. This new finding was expected, largely on the basis of the repetition effect. Both groups had an opportunity to review and perform generative activities, but the encoding plus storage group had two exposures to the material, whereas the external storage group had one. Repetition might not tell the whole story, however, given that the external storage group was not exposed to all of the lecture information. Rickards and Friedman (1978) have shown that reviewers tend to recall a large percentage of what they recorded in notes and a small percentage of information not recorded in notes. This latter information is said to be reconstructed from noted ideas during review. Obviously, the external storage group would be unable to reconstruct lecture points absent from notes. From a practical standpoint, the advantage for encoding plus storage over external storage suggests that missing a lecture and reviewing borrowed notes that are incomplete is not as effective as attending the lecture, taking notes, and reviewing them.

In addition, the external storage group outperformed the encoding group on the synthesis test. The synthesis test required generative processing in order to form relations that had not been stated explicitly in the lecture. Evidently, it is the review of notes—when time permits—that facilitates generative processing.

In terms of note-taking functions, results also indicated that taking lecture notes but not reviewing them (the encoding function) is no more effective than listening to a lecture without note-taking and without reviewing. This general finding is consistent with at least 23 other studies reporting that note-taking alone does not serve an encoding function (Hartley, 1983; Kiewra, 1985). More specifically, results from this study indicated that the encoding process is not aided by recording notes on linear or matrix frameworks. These devices failed to boost the performance of subjects who recorded notes on them but did not review notes, relative to the listen-only control group. Given the relatively low performance of the encoding group and the control group, we, in fact, contend

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Table 2
Point Totals Assigned for the Nine Groups

Group	Repetition	Generative processing	Completeness	Internal connections	Total
Encoding					
Conventional	1	0	1	0	2
Linear	1	0	2	1	4
Matrix	1	0	2	2	5
Encoding plus storage					
Conventional	2	1	1	0	4
Linear	2	1	2	1	6
Matrix	2	1	2	2	7
External storage					
Conventional	1	1	1	0	3
Linear	1	1	2	1	5
Matrix	1	1	2	2	6

Note. Column headings Repetition through Total fall under the spanning head "Variable".

that lecture learning, whether notes are recorded or not, is a very demanding process during which relatively little meaningful encoding actually occurs.

With respect to note-taking techniques, matrix notes were superior to conventional notes for recall. This could be the result of matrix notes' relative completeness (they contained 47% of the lecture ideas, whereas conventional notes contained 32%), their advantage for forming internal connections, or both. Although this was the only significant finding, the pattern of results favoring matrix notes over other types for recall and synthesis performance is consistent with those of Kiewra et al. (1988).

In order to determine further how well all of our data fit with our hypotheses regarding the variables of repetition, generative processing, completeness, and internal connections, we first assigned relative point values to each of the nine experimental groups on the basis of earlier predictions regarding these variables. For *repetition*, the encoding and external storage groups had one opportunity to process information and therefore received 1 point each; encoding plus storage groups had two opportunities and received 2 points each. For *generative processing*, encoding groups received 0 points because attention was divided among several tasks (i.e., listening, selecting ideas, holding and manipulating information, and recording notes), thereby leaving few resources available for generative processing. The encoding plus storage and external storage groups each received 1 point because during review information processing resources are free for generating relations among lecture ideas or between lecture ideas and prior knowledge. For *completeness*, conventional groups received 1 point; linear and matrix groups received 2 points. Results from this experiment, in fact, confirmed that linear and matrix notes were more complete. For *internal connections*, conventional, linear, and matrix groups received 0, 1, and 2 points, respectively. Conventional notes fail to highlight relations not explicit in the lecture; linear notes emphasize superordinate–subordinate relations within topics; and matrix notes emphasize both within- and across-topic relations. Points for each group were totaled (Table 2), rank ordered (using midranks for ties), and correlated with group means based on a sample size of 9. The rank-order correlations were .81 for recall scores, $p < .01$, and .70 for synthesis scores, $p < .025$. This rough analysis suggests that some combination of these factors relates to recall and synthesis performance.

In conclusion, we believe that this study makes three contributions. First, the external storage function was reclassified and a new means was introduced for assessing the external storage function independent of the encoding function. Our preliminary results indicated that the external storage function is superior to the encoding function with respect to synthesis performance. Second, the matrix framework was introduced to lecture note-taking. Previously, its use had been restricted to learning from text. It showed promise for directly increasing the amount of information in notes and for indirectly boosting recall performance and synthesis performance to some degree. Third, this study explained its findings by joining the theoretical ideas of repetition, generative processing, note completeness, and internal connections. Such explanations should replace oversimplified explanations suggesting that performance is merely the result of taking or reviewing notes.

Researchers can next investigate which of these explanations are most useful or how the factors of repetition, generative processing, note completeness, and internal connections interrelate. For example, Kiewra and colleagues (Kiewra et al., 1991) found that when a lecture is repeated, students add previously unnoted information (particularly details) to make their existing notes more complete. Presently, Kiewra and DuBois are training subjects to construct representations (including matrices) that foster internal connections. Some of these subjects are also trained in how to review representations using generative strategies. These types of investigations can both sharpen psychologists' understanding of the processes involved in note-taking and review and provide relevant implications for learning and instruction.

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Butcher, Geen, Hulse, and Salthouse Appointed New Editors, 1992–1997

The Publications and Communications Board of the American Psychological Association announces the appointments of James N. Butcher, University of Minnesota; Russell G. Geen, University of Missouri; Stewart H. Hulse, John Hopkins University; and Timothy Salthouse, Georgia Institute of Technology as editors of *Psychological Assessment: A Journal of Consulting and Clinical Psychology*, the Personality Processes and Individual Differences section of the *Journal of Personality and Social Psychology*, the *Journal of Experimental Psychology: Animal Behavior Processes*, and *Psychology and Aging*, respectively. As of January 1, 1991, manuscripts should be directed as follows:

- For *Psychological Assessment* send manuscripts to James N. Butcher, Department of Psychology, Elliott Hall, University of Minnesota, 75 East River Road, Minneapolis, Minnesota 55455.
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