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ABSTRACT

A critical process in developing lessons for computer-based instruction (CBI) is to determine the manner in which information will be displayed on the screen, taking care not to ignore the computer's special display capabilities. The underlying assumption of this study was that reducing the density of text presentation would be effective for improving readability and learning under CBI. Subjects were 221 preservice teachers, who were randomly assigned to seven treatment groups according to a 2 (presentation mode: CBI or print) x 3 (density condition: high, low, or learner control) factorial design with one outside condition, "full" learner control of density and media selection. A preattitude survey, pretest, and reading test were administered during a regular class session. Major dependent variables consisted of four achievement measures (knowledge, calculation, and transfer subtests and a delayed posttest), total attitude score, and lesson completion time. Results supported earlier findings with print material by showing low-density text to be as effective as high-density text on every achievement measure. In contrast, fairly effective meta-cognition strategies appear to have been used by both low-achievers and high-achievers in selecting text density. Finally, no meaningful differences between presentation media were found on task outcomes. It may be that comparing media is less important than the selective and systematic matching of instructional strategies to the specific media that must powerfully represent them. (12 references) (CGD)

Title:

Reducing the Density of Text Presentations using Alternative Control Strategies and Media

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Reducing the Density of Text Presentations

Using Alternative Control Strategies and Media

A critical process in developing lessons for computer-based instruction (CBI) is to determine the manner in which information will be displayed on the screen. Unfortunately, in many commercial CBI products, the computer's special display capabilities are ignored, much as if the monitor screen were simply an electronic representation of a print page (Burke, 1981; Bork, 1987). The present research addressed this issue in reference to the specific problem of displaying instructional text. The underlying assumption was that reducing the density of text presentations would be effective for improving readability and learning under CBI. In the present study, a "low -density" version of an instructional unit on central tendency was prepared from conventional, "high-density" text by reducing sentences to main ideas and deleting unnecessary modifiers, articles, and phrases.

A third experimental condition was "learner-control" in which individual students were allowed to choose the density level they preferred at the beginning of each of five lessons. Clearly, the issue of learner-control has attracted considerable interest and extensive inquiry among CBI researchers. Although some studies have shown positive results for learner control, recent findings have more often been negative (Carrier, Davidson, & Williams, 1985; Tennyson, 1980). An overall interpretation is that many sudents, especilly low-achievers, lack the expertise to make effective decisions regarding the quantity and type of instructional support to select. On the other hand, learners may be sufficiently perceptive about personal interests and learning styles to judge what <u>mode</u> or <u>form</u> of presentation best accommodates their needs. Given this rationale, we examined the questions of: (a) What learner characteristics relate to the selection of high- and low-densiy material? and (b) How does learner-control overtext density influence learning and motivation? Other features of the design permitted examination of an extended learner-control strategy that allowed selection of presentaton medium (print vs CBI) in addition to density level, and of aptitude-treatment interaction (ATI's) effects involving reading ability and prior achievement.

Method

<u>Subjects and Design</u>

Subjects were 221 preservice teachers. They were randomly assigned to seven treatment groups arranged according to a 2(presentation mode: CBI or print) x 3(density condition: high, low, or learner control) factorial design with one outside condition, "full" learner control (density and media selection).

<u>Preattitude survey and pretest.</u> This measure consisted of a brief questionnaire to determine subjects' attitudes towards the subject to be taught and CBI. Ratings were recorded on a five-point Likert-type scale, with "5" representing the most positive reaction. For full-LC subjects, an additional item indicated that during the instructional phase they might be asked to study a lesson from either printed materials or from a computer lesson, and to check which of the two modes they would prefer. The unit pretest, administered to all subjects, consisted of 10 items on the material covered in the instructional unit on central tendency.

Nelson-Denny Reading Test. Subjects were administered the "comprehension and rate" section of Form D of the Nelson-Denny Reading Test (Brown, 1976). Comprehension was measured by having examinees read eight paragraphs and answer multiple-choice questions on each. Reading rate was measured by asking them to record the number of the line they had reached following the initial 60 sec. of reading.

Instructional unit. The learning material was an introductory unit on central tendency prepared by Morrison, Ross, & O'Dell (1988). The content was adapted from self-instructional learning modules used in an undergraduate statistics course. For research purposes, the unit was organized into five sections ("lessons") covering the mean, the median, the mode, uses of central tendency measures in different distributions, and positions of central tendency measures in different distributions. Emphasis was on teaching facts and conceptual information that students would need to recall for solving and interpreting problems. A conventional (high-density) print version of the lesson, patterned after the original text (Ross, 1982), was initially prepared. Total length was 18 pages and 2,123 words. Within each lesson the basic instructional orientation involved defining the main concept or idea and then illustrating its application with several numerical examples. Following Reder and Anderson's (1980; 1982) procedure, the low-density version was developed by (a) defining a set of general rules for shortening the material, (b) having at least two judges discuss the rules and rewrite the materials accordingly, and (c) reviewing the material and making changes until consensus was achieved that all criteria were satisfied. The rules employed were:

1. Reduce sentences to their main ideas.

    a. Remove any unnecessary modifiers, articles, or phrases.
    b. Split complex sentences into single phrases.

2. Use outline form instead of paragraph form where appropriate.

3. Delete sentences that summarize or amplify without presenting new information.

4. Present information in "frames" containing limited amounts of new information.

The completed low-density lesson consisted of 1,189 words, a 56% savings relative to the high-density version, and 15 pages, a 17% savings. CBI versions of the high- and low-density lessons were prepared directly from the print materials. Word counts for corresponding low- and high-density versions were identical across print and computer modes. Due to the much smaller display area of the computer screen, it was not possible (or considered desirable) to duplicate the print page formats. Computer frames were thus designed independently, using what were subjectively decided to be the most appropriate and realistic screen layouts. This orientation emphasized organizational devices such as headings, liberal "white space," and standard uses and locations of verbal and symbolic prompts. Each screen provided both back- and forward-paging options. The final versions of the low- and high-density CBI lessons consisted of 49 and 66 frames, respectively. Figure 1 shows one of the high-density frames along with its parallel low-density version.

Insert Figure 1 about here

Attitude survey. A 6-item printed attitude survey was administered to all subjects at the completion of the lesson. Items consisted of statements about the learning experience to which subjects indicated levels of agreement or disagreement on a 5-point Likert-type scale (e.g., 1 = "strongly disagree," 5 = "strongly agree").

Achievement posttest. The achievement posttest (print format) consisted of three sections designed to assess different types of learning outcomes. The first section was labeled a knowledge subtest, since it assessed recognition or recall of information exactly as it appeared in the text. The first 17 knowledge items were multiple-choice questions, each consisting of a statement defining one, all, or none of the three central tendency measures (mean, mode, or median). Eight additional questions asked the student to determine relative placements of the mean and the median in distributions that were exact replications of examples that appeared in the lesson. On four of those items, subjects were asked to write a brief rationale for their answers.

The calculation subtest contained five problems requiring computation of different central tendency measures from new data not used in lesson examples. The transfer subtest consisted of 13 items that involved interpreting how central tendency would vary with changes in distributions or individual scores. Items of this type were not included in the lesson, nor were the underlying principles needed to answer them explicitly stated.

Scoring rules on objective items and calculation problems awarded one point for a correct answer. On interpretative items, one point was awarded for a correct answer and an additional point for a correct explanation. A summary of subtest and total test lengths, maximum points, and KR-20 internal consistency reliabilities is as follows: knowledge (25 items, 29 points, r = .81); calculation (5 items, 5 points, r =.68); transfer (13 items, 20 points, r = .82); and total test (43 items, 54 points, r = .90).

Delayed posttest. The delayed posttest (r =.84) consisted of 13 items patterned after pretest items. Ten of the items tested knowledge definitions and relative positions of central tendency measures; the other three tested computational skills.

Procedure

The preattitude survey, pretest, and reading test were administered during a regular class session. During the learning phase of the study, from 2-12 subjects representing a random mixture of treatments attended an individual session. The classroom used for the CBI condition contained 12 Apple IIe computers. Following introductory instructions and a review of prerequisite information, the learning materials were distributed according to treatment. Full-LC subjects received their preferred presentation mode, CBI or print, as selected on the preattitude survey.

Instructions for all treatments indicated that (a) five lessons would be presented on central tendency; (b) learning was to be self-paced; (c) turning back to reread preceding pages (or frames) was permitted if desired; d) it was permissible to ask the proctor any questions about the task procedure while learning; and e) a posttest would be given following the learning task. Subjects in the two LC treatments received additional instructions indicating that, depending on how much explanation they desired, they could choose between "long" and "short" presentations on each unit. Examples of matched high- and low-density displays were shown to help them make a selection for the initial lesson. In the CBI condition, subjects pressed a key to indicate their preferences; in the print condition they informed the proctor. Density-level selection was repeated at the beginning of each of the remaining four lessons. After subjects completed the last lesson, their finish times were recorded and the attitude survey and immediate posttest were administered. Approximately three weeks later, they were administered the delayed pottest at the beginning of a regular class meeting.

Results

Major dependent variables consisted of four achievement measures (knowledge, calculation, and transfer subtests; delayed posttest), total attitude score, and lesson completion time. In preliminary analyses, no differences were found between treatment groups in pretest performance, pretask attitudes, reading comprehension, or reading rate.

Learner Control Analyses

Full- vs. partial-LC. In an initial set of analyses, outcomes in the partial-LC and full-LC treatments were compared. Inspection of LC treatment means showed them to be quite similar to one another and directionally higher than those for the standard high- and low-density treatments. A 2(LC-strategy) x 2(presentation medium) MANOVA on achievement confirmed the former impression by failing to show any significant effects due to LC-strategies. Nor were significant LC-strategy effects obtained in a univariate ANOVA on attitude scores. The ANOVA on completion time, however, yielded a significant LC-strategy x presentation medium interaction, F (1,69) = 5.71, $p < .02$, and LC-strategy main effect, F (1,69) = 7.73, $p < .01$. Follow-up analyses indicated that in the print condition, no differences occurred between learner control variations, but under CBI, the full-LC group (M = 18.9 min.) took significantly less time than the partial-LC group (M = 29.0 min.). Thus, those who selected CBI completed the lesson more quickly than those who were prescribed CBI (partial-LC), perhaps as a result of having greater experience and confidence in using that medium. Another explanation, supported in the next analysis, is that faster readers were more apt to select CBI than print, thus giving the full-LC group a built-in advantage on the completion rate criterion.

Media preferences. Media selections by the full-LC group were almost equally distributed between print (n = 11) and CBI (n = 13). For exploratory purposes a discriminant analysis was performed using the subgroups as the criterion and the following as predictors: preattitudes, pretest, reading comprehension, and reading rate. Applying step-wise selection, only reading rate was found to be a significant discriminator ($p < .01$). Subjects who selected CBI had higher reading rate scores (M = 271.8) than those who selected print (M =189.3).

Density selections. A 2(LC-strategy) x 2(presentation mode) ANOVA was performed on the total number of low-density selections (out of a possible 5) made by LC subjects. No significant effects were found. Overall means were 3.5 for print and 3.0 for CBI. Thus, there was a general tendency by subjects to prefer low-density materials, regardless of presentation mode. To examine whether certain types of individuals were more likely than others to select low-density material, the number of low-density selectins was regressed, using a step-wise procedure, on the four pretask predictor variables. Again, only reading rate was identified as a significant predictor, ($p < .01$). As reading skills decreased the tendency to select low-density material also declined.

Density Condition X Presentation Mode Analyses

For analyses of achievement and attitudes, data from the full- and partial-LC treatments were pooled within presentation modes. Results for each variable are reported below.

Achievement. The 2 x 2 MANOVA on achievement data showed both main effects to be significant ($p < .05$). In follow-up univariate tests, the density condition effect was significant on all dependent measures except the knowledge subtest. Tukey HSD comparisons showed that on the calculation subtest, F (2,215) = 2.88, $p < .05$, the LC group (M = 3.71) was directionally, but not significantly, superior to botn the low-density (M = 3.19) and high-density (M = 3.27) groups. On the transfer subtest, F (2,215) = 5.53, $p < .01$, the LC group (M = 12.33) had a significant advantage ($p < .01$) over the low-density group (M = 9.58) and a near-significant advantage ($p < .10$) over the high-density group (M = 10.58). Similarly, on the delayed posttest, F (2,186) = 5.41, $p <$ .01, the LC group (M = 8.30) was significantly superior to the low-density group (M = 7.02), and directionally superior to the high-density (M = 7.34) group. None of the comparisons between high- and low-density means was significant. The only significant presentation mode effect occurred on the delayed posttest on which CBI subjects (M = 7.95) surpassed print subjects (M = 7.00), F (1,186) = 8.61, $p < .01$.

Attitudes and Completion Time

The two-way ANOVA on attitude total scores failed to yield any significant effects. Completion times were longer for CBI (M = 25.8 min.) than for print (M =21.5), F (1,144) = 4.45, $p < .05$; and for high-density (M = 26.5) than for low-density text (M =21.0), F (1,144) = 8.60, $p < .01$.

Learning from High-Density Microtext

A collateral research interest was the relationship between student characteristics and learning from high-density microtext. Separate stepwise multiple regressions were performed on criteria consisting of immediate and delayed posttest scores, attitude total score, and completion time. Predictor measures consisted of the pretest, pretask attitudes, reading scores, and, where appropriate, other "criterion" variables.

When immediate posttest scores were treated as the criterion, reading comprehension (simple r = .51) was the first predictor entered in the equation (R^2 = .26, $p < .001$). Pretest score (simple r = .26), which had been expected to be the strongest predictor, was entered on the second step, but made a relatively weak contribution to the equation. No other predictors were entered. Other findings were: (a) no predictor variables were significant in accounting for variance in completion time, (b) pre-attitude score was the only significant predictor of attitude total score, (c) and pretest score was selected on the first step and reading comprehension on the second step with the delayed posttest as the criterion.

Discussion

The results support earlier findings with print material (Reder & Anderson, 1980; 1982), by showing low-density text to be as effective as high-density text on every achievement measure. Importantly, low-density narrative offered the advantage of reducing reading time by 13% in the print condition and by 28% in the CBI condition. Results were supportive of learner-control by showing it to yield significant achievement advantages over standard density treatments. To often, findings from learner-control studies are summarized by some global statement concerning "learner control's" ineffectiveness (or effectiveness) as an adaptive strategy. Such interpretations can be misleading since they fail to distinguish between the many different types of learner-control that can be employed. Specifically, resuslts concerning learner control of instructional support have shown a tendency by low-achievers to make inappropriate decisions (Ross & Rakow, 1982; Seidel, 1975).

In contrast to that pattern, fairly effective meta-cognitive strategies appear to have been used here by both low-achievers and high-achievers in selecting text density. Preferences for high-density materials were unrelated to prior achievement, which is typically a strong correlate of learner-control decisions (Tobias, 1987), but were negatively correlated with reading ability. Poor readers elected to receive greater narrative support whereas good readers opted for the more streamlined, low-density lesson which could reduce reading time, yet adequately (for them) support comprehension. These appear to be pedagogically sound decisions for the stdent groups concerned.

As might be expected (see Clark, 1985), no meaningful differences between presentation media were found on task outcomes. From a practical standpoint, comparing media seems much less important than the selective and systematic matching of instructional strategies to the specific media that must powerfully represent them. The present results suggest that traditional text narrative formats do not serve such purposes for CBI. The availability of low-density text as a standard component or learner-control option in narrative lessons deserve further attention as possibly beneficial alternative.

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Figure 1. Parallel high and low density frames from the instructional unit.

The median corresponds to the middle frequency score in a ranked set of data

Half the scores will be higher
Half will be lower

	X	f
	Hi	50%
Median	------------------	------------------
	Lo	50%

If N=40 (40 scores), median = 20th score
If N=17, median = 8.5 highest score

Median corresponds to the 50th percentile

Higher than half the scores
Lower than half

The median, another measure of central tendency, is the number that corresponds to the middle frequency (that is, the middle score) in a ranked set of data. The median is the value that divides your distribution in half; half of the scores will be higher than the median, and half will be lower than the median.

	X	f
	Hi	50%
Median	------------------	------------------
	Lo	50%

It is important to remember that the median is the halfway point in the distribution--in terms of frequencies. For example, if N=40 (meaning that you have 40 scores), the median will be your 20th score (in terms of rank); if N=17, the median will be your 8.5 highest score, etc.

Another way of defining the median is to say that it corresponds to the 50th percentile.

In any distribution, the median will always be the score that corresponds to a percentile rank of 50; it is higher than half the scores, and lower than half the scores.