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ABSTRACT

This study investigates the relationship between speed of recognition and accuracy of the responses when visual mental imagery is controlled through imagery instructions. The procedure was to compare the achievement of learners where the independent variable was imagery instructions. The subjects were two 20-person groups of undergraduates from a small liberal arts college. The experimental treatment consisted of the same materials for each group--a 5-page, 1200-word instructional booklet about a graphical user interface (GUI) computer operating system. The sessions were administered separately to keep knowledge of the independent variable from the control group. Subjects who were given imagery instructions prior to receiving the stimulus material required significantly more time to learn the material. The instructed subjects also had significantly faster retrieval time on a recognition posttest. Thus, the relationship between learning time and retrieval time for imaged information is inverse. The posttest scores of the imagery instructed subjects were not significantly higher than the uninstructed subjects. The two groups also had similar perceptions of their use of mental imagery. Visual mental imagery could be a technique which will reduce the speed-accuracy tradeoff when accurate responses must be made quickly. (Contains 23 references.) (Author/JLB)

The Role of Visual Mental Imagery in the Speed-Accuracy Tradeoff: A Preliminary Investigation

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Abstract

The study investigates the relationship between speed of recognition and accuracy of the responses when visual mental imagery is controlled through imagery instructions. Subjects who were given imagery instructions prior to receiving the stimulus material required significantly more time to learn the material. Additional time indicates imagery use. The instructed subjects also had significantly faster retrieval time on a recognition posttest. Thus, the relationship between learning time and retrieval time for imaged information is inverse. The posttest scores of the imagery instructed subjects were not significantly higher than the uninstructed subjects. The two groups also had similar perceptions of their use of mental imagery. Visual mental imagery could be a technique which will reduce the speed-accuracy tradeoff when accurate responses must be made quickly.

Introduction

In recent years there has been interest in a line of research that can inform training practices of those who must retain quantities of complex information. There is a need to train for real-world performance, not only for routine tasks but also for performance in emergencies when accurate split-second decisions must be made.

Acquisition conditions should require learners to use mental processes critical for actual performance [1]. Visual mental imagery is a prominent cognitive process and is essential for many tasks. While driving a car most of us turn on the headlights or heater without looking due to our image of the critical controls. The hypothesis for the present study, therefore, is that using mental imagery during training will improve posttest performance. Several researchers advocate a training technique that requires learners to be more involved with the content and achieve a high level of information processing [1,2,3,4]. To achieve a high level of information processing, research on cognitive strategies shows certain strategies to be superior in this respect. Elaboration strategies require learners to be actively adding their own information to the information they are learning [5]. These elaborations can be mental images or anything that learners can use to form connections between new and prior knowledge. To train for accurate real-world performance, we must understand more about mental processes themselves and their impact on learning.

Mental Imagery

Images are the result of highly processed information represented visually, but as a strategy for formal learning, mental imagery is thought to be under used. Images reduce the information processing burden by representing spatial information to allow learners to hold large amounts of information in working memory at one time [5]. Farah summarizes several studies that demonstrate an equivalence between imagery and perception, with the two sharing many similar features [6]. Mental imagery's use in learning new information must be investigated to understand how it functions in formal learning and performance. The benefits of mental imagery are that it is superior for spatial and temporal information [7,8] and produces a deeper level of information processing that results in richer memory structures [2]].

Imagery has been used to improve learning on both recognition tasks [9, 10, 11, 12] and recall tasks [13]. However, the best ways of inducing imagery to improve learning are not known [13]. To date, most imagery research focuses on understanding the properties and format of mental images, and the relationship of imagery to perception.

Task-specific training, as opposed to general techniques that promote rote memorization, has longer-lasting effects and uses different strategies [1,3]. The most common training variable is task practice, not those techniques that promote information processing. One task-specific strategy is mental imagery. Long accepted as a form of active processing that helps learners acquire a more meaningful representation, imagery instruction can help learners generate information-specific structures about the material or system to be learned. Unfortunately this strategy generally takes significantly more time [13].

<u>Speed-Accuracy Trade off</u>

The traditional speed-accuracy trade off involves reduced accuracy with increased response time under performance conditions. Perkins mentions a quantity-quality trade off where greater fluency often means reduced quality in problem solving [14]. Mental rotation studies [15] produced reduced accuracy and increased response time as the degree of rotation increased. Conversely, increases in accuracy were accompanied by slower responses.

Paivio notes the picture superiority effect where size comparisons of objects were faster with pictures than with their word labels alone indicating the importance of the visual memory system for accurate physical comparisons [16]. Biederman and Cooper discuss a visual priming effect where prior viewing of objects are thought to activate a representation of its components in specific relationships making recognition faster [17]. Meyer et al. proposes investigating complex tasks with visual mental imagery as a variable noting that current speed-accuracy trade off studies do not investigate level of information processing [18]. However, they find that the response strength with the best speed and accuracy occurs when the fastest normal process is concurrent with the highest level of information. Further investigations require a levels of processing approach to speed-accuracy trade off studies.

Method

The procedure was to compare the achievement of learners where the independent variable was imagery instructions. The experiment used two groups and a single independent variable in a posttest-only control group design. The instructional materials consisted of 5-page, 1200-word instructional booklet about a graphic user interface (GUI) computer operating system designed to be similar to common GUI systems and yet unlike the existing systems (figure 1). The interface had both horizontal and vertical scrollbars and boxes, a document line and a menu bar.

The booklet described the function and position of each of the screen features, i.e. menus and buttons. A diagram appeared on each page with that page's features labeled.

Sample

The subjects were drawn from a population of undergraduates at a small liberal arts college. Subjects were a mix of juniors and sophomores; in compliance with informed consent, participation was voluntary and they were allowed to withdraw at any time. The imagery instructed group had received prior instruction in imagery as a mnemonic technique and elaboration strategy.

The experimental treatment consisted of the same materials for each group. The group's sessions were administered separately to keep knowledge of the independent variable from the control group. The subjects were not familiar with a GUI system prior to the experiment.

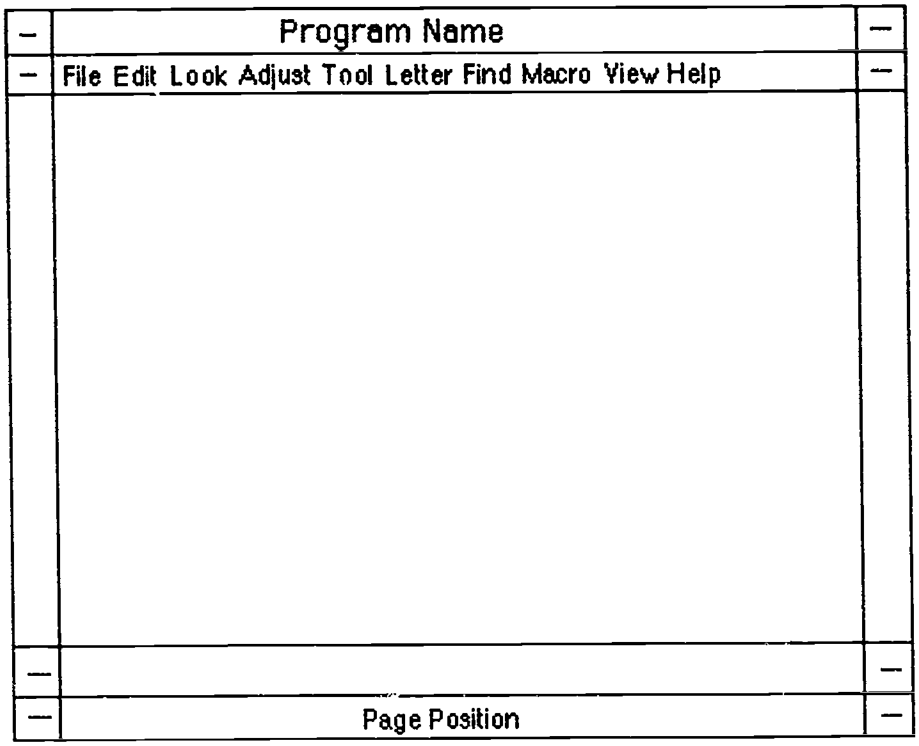
Program Name
File Edit Look Adjust Tool Letter Find Macro View Help
Page Position

Figure 1.

There were 20 subjects in each group. The subjects were given a brief orientation to the procedures and allowed to ask questions before starting. The imagery instructed group also received instructions to form images prior to starting. The materials did not contain imagery instructions on each page as in a previous study [13] since learners in the present study were instructed prior to the experimental session.

Dependent Variables

After reading the instructional material, subjects completed a post-treatment survey about their use of imagery and cognitive strategies [13]. The survey used a five-point Likert scale and had only five items. The first item, for example, asked the subjects if they "formed pictures in their mind" during the task they had just completed. The remainder of the questions collected a profile of the subjects' imagery, or mental "picture," use during formal learning, other situations, and asked the subjects to rate the accuracy of their images. A fifth item was a multiple-choice item which inquired about the subjects' dominant learning strategy while reading the materials. A drawing test followed the survey. The drawing test (the recall task) comprised a page with list of twenty structures described in the booklet. Giving the recall test after the survey ensured that the recall test was a test of long-term memory. Each structure had to be included on the drawing. A point was given for each correctly placed structure on the drawing. A Kuder-Richardson reliability coefficient of 0.839 was calculated for this test.

Farah identified six tasks that are relevant to assessing imagery ability [19]. A drawing task was used since it requires the subjects to generate an image in the visual buffer of short term memory before they can correctly reproduce the system's components with respect to each other. This is the visual-to-motor translation process described by Farah in her extension of Kosslyn's imagery model [19, 7].

The last task was a recognition test of the twenty GUI components. The test questions measured basic facts and concepts presented in the materials. The Cronbach's alpha for the recognition test is .712. The following are sample questions:

15. To learn about features without looking in a manual, use the ___ ___.

19. To enlarge the active window to fill a larger part of the screen, use the __________.

Finally, measures of time were collected for each of the main tasks: reading, drawing (recall), and the recognition test. The subjects marked the time they began and ended each activity in a box on the page.

Results

Independent t-tests were used on all dependent measures. An alpha of 0.05 was used. The critical value of F for 38 degrees of freedom is 2.036.

Effects of Imagery Instructions

For the measure of reading time, the instructed subjects required significantly more time ($\underline{M}$ = 321.75 s) to read the instructional booklet then the uninstructed group ($\underline{M}$ = 237 s). The value of $\underline{t}(38)$ was 3.75, $\underline{p} < .001$.

Table 1. Mean recorded times in seconds for both groups (n=40)

Reading Time	
Instructed Group	321.75 s
Uninstructed Group	237.00 s
t (38)	3.75, $\underline{p} < .001$
Recognition Test Time	
Instructed Group	353.38 s
Uninstructed Group	456.85 s
t (38)	2.66, $\underline{p} < .01$

For the time to complete the recognition test, the instructed group required significantly less time to complete the test ($\underline{M}$ = 353.38 s) compared to the uninstructed group ($\underline{M}$ = 456.85 s), $\underline{t}$ (38) = 2.66, $\underline{p} < .01$. There was no significant difference between either the recognition or drawing test scores of the two groups.

Perceptions of Imagery Use

The two groups did not differ in their perceptions of imagery use. Although the instructed group showed the expected increase in reading time denoting heavier use of imagery [7], possibly as task-specific processing [13], the two groups had similar perceptions of their imagery use. Theoretically, the instructed group's imagery should be more task-specific and purposeful as a cognitive strategy due to their prior instruction. Therefore the instructions did not effect the perceptions of imagery use, but the quality and task appropriateness of the imagery as evidenced by the recall task scores.

Discussion

The instructed group performed just as well on the recognition test as their uninstructed counterparts; however, the instructed group required less time. The instructed group did not perform better or faster on the drawing test which is the opposite of previous research findings [20].

The imagery instructions appear to be effective for information which is spatially represented during instruction. Poor retention is often thought to be due to poor internal organization of the information itself which occurs during learning [4]. Learners may benefit from specific instructions which not only increase elaborative activity, but also help them deal with the large amount of information presented in multimedia instruction [21]. Visual mental imagery can serve as a strategy to represent information concisely and facilitate information organization and retention through greater learner involvement. Perhaps the speed of processing is not only related the fact that this type of learner-generated elaboration results in a higher degree of internal organization in terms of the image, but that information is more available and accessible.

Additionally, the effect of the diagrams in the instructional booklet serve as a visual priming. Visual priming has been shown to increase the speed and accuracy of picture recognition [17]. Paivio also notes that the most imagery-evoking visuals are familiar, unambiguous visuals [22]. In combination with the task-specific use of imagery by the instructed group, the visuals helped to promote the processing that facilitates learning for faster retention. In prior research, the combination of imagery instructions and visuals has been shown to have a moderate interaction for similar learning tasks [13, 20]. However, the present study did not use visuals as an independent variable to investigate this interaction further.

Previous research [13, 20] found increased accuracy on the drawing test for instructed subjects. Unfortunately, the present study did not replicate that finding. The similar scores reveal a possible similarity of the visual representations between the two groups, and may indicate that effective representations result when imagery instructions are not given. This would support research that finds imagery to be an ongoing process [23]; however, in these instances imagery is not controlled as a variable.

Conclusions

It is difficult to explain the effects of the imagery instructions since visual mental imagery as a cognitive strategy can be highly task specific and individual.

However, there are several summaries of imagery research that show visual mental imagery to be a viable technique to facilitate learning and retention [5, 13]. Christina and Bjork note the need for training techniques that facilitate deeper processing and a higher degree of learner involvement to produce better long-term retention and performance [4]. Additionally, we need new approaches in training that use task-specific processing for memory improvement [3], as well as a technique that allows the additional time required to perform the deeper elaborative processing [21]. Visual mental imagery should be investigated as an integral part of any such line of research since it is known to be an activity high on the information processing continuum that improves retention.

At present, there are no specific examples of applications of imagery in techology-based learning systems. Further research will reveal the optimal time and place for imagery cues within instructional systems. Computer-based systems can display imagery cues during tutorials at a frequency that will maintain the strategy. Trainees destined to work on a simulator may need additional preparation time prior to entering the simulator. The additional time would be used to have the trainees image a part of the system, for example, the control panel, to ensure knowledge of the location of critical controls. A drawing test can verify the learning before simulator experience. Using imagery prior to simulator experience may increase the speed of responses without sacrificing accuracy.

Mental imagery as an instructional technique has great potential as a method to optimize retention and performance. Based on the present and previous studies there is evidence of an increase in retrieval speed [20]. Thus, imagery may be especially useful when information may be needed to make split-second decisions to reduce the speed-accuracy tradeoff. The result of highly processed information, image generation promotes learner involvement in an elaborative strategy. Questions we must ask are: Does image generation improve some aspect of the quality of information? Does imagery improve information's availability or accessibility--or both? How do operators of complex equipment and systems, such as pilots, use imagery?

Important cognitively and perceptually, imagery interacts with many important activities and often is not a conscious process. To determine the actual effects of imagery, investigate it on an individual level with talk-aloud strategies during learning and testing situations. Acceptance of a strategy that requires significantly more training time may require studies of its own.

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