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Qualitatively different cognitive processing during online reading primed by different study activities

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ABSTRACT

This article uses eye-tracking technology to examine how study activities such as taking notes or filling in a graphic organizer affect cognitive processing during learning. College students read a computer-presented passage that compared the characteristics of eastern steamboats (top section) and western steamboats (bottom section), either by reading it twice (read-only group), typing notes into a textbox on the right side of the screen (note-taking group), or typing characteristics of the two types of steamboats into a compare-and-contrast graphic organizer on the right side of the screen (graphic organizer group). Compared to the note-taking group, the graphic organizer group displayed more eye movements between the top and bottom of the passage (i.e., integrative saccades, $d = 1.03$), more eye movements between the text and the type-in window on the right side (i.e., constructive saccades, $d = 0.79$), fewer constructive saccades during initial reading ($d = -0.64$), and less time looking to the right side during initial reading ($d = -0.81$); and scored higher on a comprehension test given afterwards ($d = 1.17$), although both study groups outscored the read-only group. Results suggest that students in the note-taking group (and read-only group) tended to use a *linear learning strategy* in which their eyes followed the text in the order presented whereas students in the graphic organizer group tended to use a *generative learning strategy* in which their eyes searched for connections between specific information across the passage required to make comparisons.

1. Introduction

Being able to learn from expository text (i.e., text that describes or explains) is a central skill in the development of literacy, and has received increased scrutiny because of its prominence in new curriculum frameworks such as the Common Core Standards in the US (Porter, McMaken, Hwang, & Yang, 2011) and in international assessment programs such as the Programme for International Student Assessment (Organization for Economic Co-operation and Development, 2013). The goal of the present study is to compare the cognitive processes that are fostered by two different study strategies intended to improve learning from expository text—taking notes and filing in a graphic organizer—in order to better understand how study activities can improve learning. Consequently, the primary research question addressed in this study is whether these study activities—note taking and graphic organizers—prime qualitatively different cognitive processing during learning.

Consider a student who reads an expository passage presented on a computer screen, such as the steamboat passage—adapted from (Meyer & Poon, 2001)—shown in Fig. 1. For example, to enhance learning, some students could be asked to take notes by typing into a textbox on the right side of the screen during learning, such as shown in Fig. 2. In a different attempt to enhance learning, other students could be asked to complete a compare-and-contrast graphic organizer that enables them to compare the two types of steamboats along several key dimensions by typing in the name of each dimension as well as the corresponding attributes for each type of steamboat, as shown in the right side of Fig. 3.

Most previous research assesses the impact of different study strategies by examining learning outcomes, such as measured by comprehension tests or memory tests (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Mason, Pluchino, & Tornatora, 2013; Mayer, 2008). In the present study we sought a more direct measure of learners' cognitive processing during learning primed by different study strategies. Therefore, we used eye-tracking methodology to examine students' eye movements as they simply read a text (read group), took notes by typing into a textbox as they read a text (note-taking group), or filled in a graphic organizer as they read a text (graphic organizer group).

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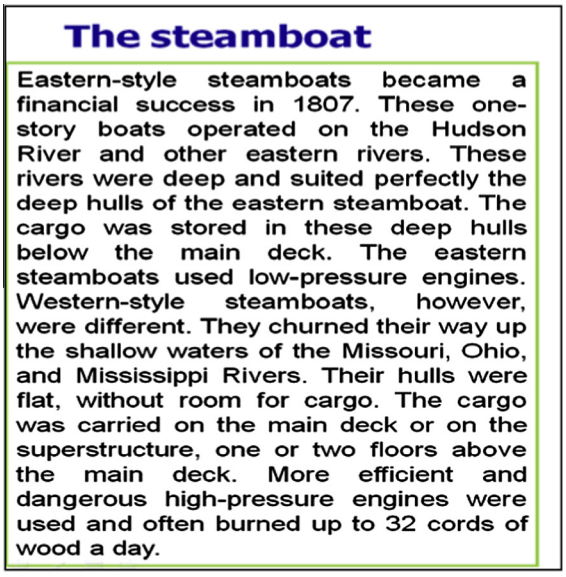

Fig. 1. The steamboat passage in the read-only condition.

2. Research on note-taking and graphic organizers

A study activity refers to actions performed by a learner during learning that are intended to improve learning, whereas a learning strategy refers to cognitive processing performed by a learner during learning which can be primed by a study activity (Mayer, 2008; Weinstein & Mayer, 1985). The conventional view is that study activities such as taking notes or filling in graphic organizers cause students to engage in more useful cognitive processing during learning and thereby result in better memory for the material than when students do not engage in study activities (Dunlosky et al., 2013; Mayer, 2011).

Note-taking and graphic organizers are two well-known examples of study activities that are intended to support reading comprehension (National Institute of Child Health and Human Development, 2000). Research on note-taking has concentrated on its process and product functions: the process function (or encoding function) refers to the impact of taking notes on learning outcomes, while the product function (or external storage function) refers to studying the impact of reviewing notes on learning outcomes (Kiewra, 1985). Although most research has focused on note-taking during lectures, some general findings are relevant for this study. The process of note-taking promotes encoding and storage of information in long-term memory (Barnett, di Vesta, & Rogozinski, 1981). The process of reviewing notes supports retrieving information from long-term memory, and it facilitates remembering and provides opportunities for deeper elaboration of the presented material (Bohay, Blakely, Tamplin, & Radvansky, 2011). The act of note-taking has been demonstrated to improve students' performance on comprehension tests under appropriate circumstances (Kiewra, 1985; Peper & Mayer, 1978). However, research shows that in general students take incomplete notes and do not address critical points (Kiewra et al., 1991; Peverly, Brobst, Graham, & Shaw, 2003).

A graphic organizer, on the other hand, is a spatial structure for representing material (such as a matrix). Similar to note-taking, research on graphic organizers has concentrated on its process and product functions. The process function refers to researching the impact of using graphic organizers as thinking procedures to assist learners on the steps to carry out a cognitive operation (Beyer, 1997). A Venn diagram, for example, can support the development of the compare-and-contrast cognitive strategy by guiding students to establish the elements to be compared, to indicate their common characteristics, and to figure out their differences. Asking students to fill in graphic organizers during reading can improve students' learning outcomes (Ponce, Lopez, & Mayer, 2012; Robinson, 1998). On the other hand, the product function of graphic organizers refers to researching the impact of studying filled-in or teacher-made graphic organizers on learning outcomes (Stull & Mayer, 2007). Numerous studies have shown that using graphic organizers and note-taking appropriately employed in learning contexts are effective text comprehension activities, and that structured note-taking strategies such as with outline or matrix format are more beneficial than linear recording of information (Jairam & Kiewra, 2009; Kiewra et al., 1991; Piolat, Olive, & Kellogg, 2005).

Graphic organizers are tied to basic rhetorical structures (i.e., common ways of structuring text), such as compare-and-contrast (e.g., matrix), sequence (e.g., flow chart), or hierarchy (e.g., tree

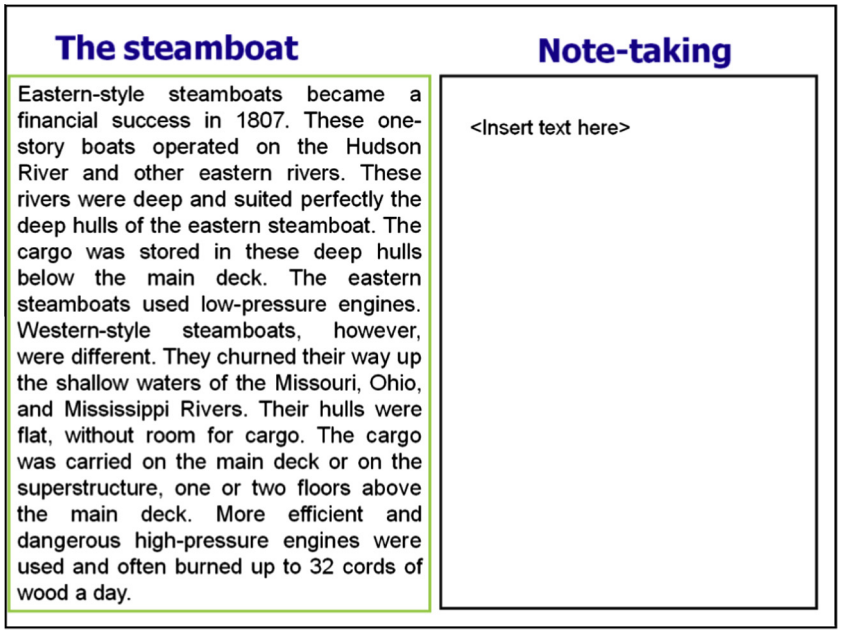

Fig. 2. The steamboat passage and the note editor.