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Enhancing learning during lecture note-taking using outlines and illustrative diagrams

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ABSTRACT

The current study examined the effects of providing learning aids during a lecture on later test performance, and its relationship to structure-building ability. Before taking notes on an audio lecture, participants were either given a skeletal outline, an illustrative diagram, or no learning aid at all. After the lecture, participants were given a free recall test and a short-answer test that probed understanding of target concepts (requiring explanation). For low-ability structure builders, outlines improved free recall but not short-answer performance compared to the no-aid control condition. By contrast, providing high-ability structure builders with outlines improved free recall and short-answer performance (relative to the control). An illustrative diagram improved free recall and short-answer performance compared to the control condition, regardless of structure-building ability. Thus, these aids are generally useful for improving learning while listening to a lecture. Implications for the more specific enhancement patterns for low-ability structure builders are discussed.

1. Introduction

DiVesta and Gray (1972) have suggested that note-taking facilitates learning both at the time individuals take the notes (*encoding benefit*), as well when individuals review them (*external storage benefit*). A review by Kiewra (1985) identified 56 studies investigating the encoding function of lecture note-taking. Of those 56 studies, a slight majority 33 (59%) found a benefit of note-taking, whereas the remaining studies found no differences (21; 37%), or a detrimental effect of note-taking (2; 4%). Further, a recent meta-analysis by Kobayashi (2005) compared note-taking to no note-taking, and found only a small benefit of note-taking (Cohen's $d = .26$). The relative lack of consensus for an encoding benefit raises questions as to why students do not benefit from note-taking, with one popular idea being that the effect is limited by the quality of students' note-taking procedures.

Proponents of this encoding hypothesis (e.g., Bretzing & Kulhavy, 1979; Einstein, Morris, & Smith, 1985; Peper & Mayer, 1978) suggest that note-taking enhances learning by stimulating active processing and relating it to existing knowledge. However, studies examining students' note-taking behavior suggest that the encoding process is not overly effective because students' note-taking procedures are less generative than presumed, as students left to their own devices tend to take verbatim notes (e.g., Bretzing & Kulhavy, 1981; Kiewra, 1985) that are not overly elaborative of the material. One possible reason for this is that the cognitive demands typically associated with more generative note-taking strategies are too great for some students, leading them to resort to (less effective) strategies that are presumably less cognitively demanding, such as verbatim note-taking (e.g., Bui, Myerson, & Hale, 2013). In general then, note-taking does not always improve learning compared to not taking notes.

1.1. *Comprehension in note-taking*

To characterize shortcomings in student note-taking and to identify ways of improving note-taking, we appeal to a multi-level theory of comprehension (e.g., van Dijk & Kintsch, 1983; see also Schmalhofer, McDaniel, & Keefe, 2002), which suggests that listeners build complex mental representations of a discourse that includes a surface form representation (i.e., the words), a "text" base representation that captures propositional structure (i.e., the semantic relationship between the words), and a situation model to which the discourse refers (i.e., a mental model/representation of what the discourse is about). Constructing a coherent "text" base is a requisite component of comprehension that is important in its own right (Kintsch & van Dijk, 1978) and also provides a base

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for gaining deeper comprehension of a discourse. That is, comprehension at a higher level requires adequate understanding at the lower text-base level(s). Deeper comprehension requires the construction of a coherent situation model (e.g., Glenberg, Kruley, & Langston, 1994; van Dijk & Kintsch, 1983), which is akin to the notion of mental models described by Johnson-Laird (1983). More specifically, construction of good mental models requires integration of the text base, relevant aspects of the comprehender's knowledge, and relevant inferences (e.g., Kintsch, 1998; Kintsch & Rawson, 2005). Students' typical note-taking strategies may not always scaffold a complete representation of the lecture, and to the extent that students are taking verbatim notes, note-taking may serve to only emphasize surface level encoding (cf. Mueller & Oppenheimer, 2014). In turn, mental representations may be impoverished, and exam performance may suffer.

Thus, students may ordinarily engage in note-taking strategies that do not stimulate a relatively complete encoding of the lecture in terms of the multiple representational levels underlying deep comprehension and learning. Accordingly, the present study's objective was to explore whether aids given during a lecture could improve learning and retention of lecture material relative to having no aids. To provide a start toward informing this complex question (regarding the learning outcomes in terms of multiple representational levels), we administered a standard free recall test, as well as a short-answer test that required problem solving and drawing inferences from the material presented in the test. Following extant research and theoretical work, we assumed that free recall reveals, at least in part, the cohesiveness of the text-based representation acquired by the learner (Kintsch & van Dijk, 1978), and we assumed that the short-answer test, adopted from Mayer and Gallini (1990), gauges the quality of the mental model representation acquired by the learners (see Mayer & Gallini).

1.2. Learning aids

Given the above theoretical analysis, we believe that learning aids should be able to improve learning for students as they are listening to and taking notes on a lecture. Providing aids may reduce cognitive demands in comprehension, allowing students to focus on developing more complete mental model representations of the lecture (cf. Hidi, 1990). This is consistent with research indicating that on initial exposure to discourse, readers' resources are focused on extracting surface-level and propositional information; on a second exposure, resources are then available to construct a coherent mental model (Stine-Morrow, Gagne, Morrow, & DeWall, 2004). Similarly, work by Mayer (1983) demonstrated that providing participants with a learning aid (an advanced organizer that identified the main concepts of the to-be-learned topic) before the start of an audio presentation led to better test performance than providing participants with no such learning aids before listening to the lecture. Participants provided with learning aids also performed comparably to participants who had listened to the presentation several times without learning aids, suggesting that advanced organizers and repetition each confer similar benefits. Moreover, these benefits appeared to be more robust for conceptual information than factual information, leading Mayer to suggest that, similar to repetition, advanced organizers provide learners with a schema for the to-be-learned topic. These results, together with the Stine-Morrow et al. (2004) analysis, support the premise that learning aids could be beneficial in assisting learners with acquiring a more complete encoding (and learning) of the lecture. To that end, we identified two types of aids that might improve learning for students while listening to and taking notes on a lecture.

One method of improving learning while listening to a lecture is to provide skeletal outlines, which present the topic's main ideas with important subtopics subsumed beneath each main idea. Importantly, space is provided on the paper between these ideas for students to write in and expand on throughout the lecture. Skeletal outlines may help students identify key points of a lecture, and to identify superordinate–subordinate relations among those key points. Moreover, outlines can free up cognitive resources otherwise devoted to extracting the organization of the propositions (i.e., developing the text base) to construct a more complete mental model.

The existing literature is mixed, however, with regards to whether skeletal outlines improve learning while listening and taking notes on a lecture (see Armbruster, 2009; Kiewra, 1991, for reviews), with a range of patterns reported. Recent work by Peverly et al. (2013) found that providing outlines during a lecture led to improved recall compared to not providing outlines, and they suggested that outlines may help students create better representations of the lecture, which in turn may aid test performance (for a similar argument, see also Kiewra et al., 1991). By contrast, Frank, Garlinger, and Kiewra (1989) found that participants who took notes during a video lecture using an outline performed worse on a factual (multiple-choice and cued recall) test compared to those who did not use an outline. Finally, Kiewra, DuBois, Christensen, Kim, and Lindberg (1989) found no differences in synthesis performance (which is akin to deep levels of learning) for participants who were given outlines to take notes on compared to participants who were not given an outline to take notes on, mirroring results by Barnett, DiVesta, and Rogozinski (1981) using a cued recall test.

Another type of aid that might be given to assist learning while listening to a lecture that may facilitate performance on a later test is illustrative diagrams. Mayer and Gallini (1990) describe illustrative diagrams as drawings of each major component of a given topic, with accompanying text describing the relationship among these components. For example, in depicting how a car engine works, an illustrative diagram would contain a drawing/labeling of the key components of the engine, along with text describing how the crankshaft interacts with the connecting rod, how the connecting rod interacts with the piston, and so on. Mayer and Gallini found that providing these illustrative diagrams during reading facilitated recall of conceptual information and problem solving (inference) questions over non-diagram and partial diagram controls. The authors argued that the diagrams improve learners' mental models and interpretation processes by portraying the major components and operative relationships among the components. More specifically, doing so should improve understanding of how a system works and functions under various state changes. This presumably improves mental models, and thus understanding of the material. In support of this claim, three experiments showed that such illustrative diagrams facilitated recall of conceptual information and problem solving (inference) questions over non-diagram and partial diagram controls (Mayer & Gallini, 1990).

Though illustrative diagrams seem to promote construction of coherent mental models (e.g., Mayer & Gallini, 1990), their role in learning from a lecture while engaged in note-taking has not been investigated. Consequently, little is known about the potential benefits that illustrative diagrams may have in assisting mental model construction during a lecture and thereby improve later test performance. It is worth noting, however, that previous research has shown that participants who were given semantic maps (designed to also promote comprehension) with which to take notes performed better on a later test compared to participants who were given outlines (e.g., Robinson & Kiewra, 1995). For the target content used in the present study (how particular mechanical devices work), illustrative diagrams may better support construction of a mental model than semantic maps, as semantic maps do not have the benefit of conveying visual–spatial aspects. That is, illustrative diagrams directly convey to learners where a brake shoe is relative to the brake drum, and that there are pistons on the inside of the