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Thematic Review

An integrative review of the cognitive costs and benefits of note-taking

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ABSTRACT

Students frequently engage in note-taking to improve the amount of information they remember from lectures. One beneficial effect of note-taking is known as the encoding effect, which refers to deeper processing of information as a consequence of taking notes. This review consists of two parts. In the first part, four lines of research on the encoding effect are summarized: 1) manipulation of the lecture material, 2) manipulation of the method of note-taking, 3) the importance of individual differences, and 4) the testing procedure used in the empirical studies. This review highlights the fragmented nature of the current literature. In the second part of this review five forms of cognitive load that are induced by note-taking are distinguished. Cognitive load theory is used to integrate the divergent results in the literature. Based on the review, it is concluded that cognitive load theory provides a useful framework for future theory development and experimental work.

1. Introduction

The density of information presented to students increases as they proceed from primary school to secondary school to university. Students are required to comprehend and acquire more information in the same amount of time. To cope with this increasing demand on their information-processing capabilities, students frequently engage in note-taking to improve how much information they remember (Christopoulos, Rohwer, & Thomas, 1987). For decades, note-taking has been an analogue activity, with students taking notes using pen and paper (i.e. longhand note-taking). The increasing availability of portable electronic devices has changed the way in which students take their notes. Longhand note-taking is now considered 'traditional' note-taking (Lin & Bigenho, 2011; Reimer, Brimhall, Cao, & O'Reilly, 2009), while typing is a more modern form of note-taking.

Memory benefits of note-taking have been classified into two groups (Di Vesta & Gray, 1972). On the one hand, note-taking offers long term benefits by having notes available for review and rehearsal. This is known as the *external storage effect* of note-taking. On the other hand, note-taking offers immediate benefits as students taking notes engage in a deeper level of processing. This is known as the *encoding effect* of note-taking. The beneficial effects of note-taking have been well-established (e.g. Barnett, Di Vesta, & Rogozinski, 1981; Carter & Van Matre, 1975; Weiland & Kingsbury, 1979). Kiewra (1987, 1989) integrated these studies and distilled several factors influencing these effects. In recent years, laptop note-taking and video lectures have become increasingly popular. New studies have been performed, but study results are still frequently in disagreement; some showing positive effects of note-taking (e.g., Peper & Mayer, 1978), some showing negative effects of note-taking (e.g., Peters, 1972), and some showing differing effects dependent on note-taking conditions (e.g., Mueller & Oppenheimer, 2014) and between participants (e.g., Peverly et al.,

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2007). As note-taking is however common among students (Carrier, Williams, & Dalgaard, 1988), and its importance is often stressed for cognitive strategy instruction (e.g., Daher & Kiewra, 2016; Trevors, Duffy, & Azevedo, 2014), we need to better understand when and how note-taking is beneficial for students' learning.

The aim of the current paper is therefore to review the literature on the encoding effect of note-taking. This integrative review is both timely, due to the diverging results found in past and more recent literature, and necessary in order to point scholars to this field in need of further research and to help guide future studies aiming to address current discrepancies in the literature (Svinicki, 2017). To reach this aim, the paper is split into two parts. In the first part, the factors possibly affecting the effectiveness of note-taking for memory performance are explored, giving possible answers to the research question 'What causes the differing effectiveness of note-taking on memory performance?' Four lines of research are summarized. First, we review studies that have manipulated aspects of the lecture material presented, such as its format (e.g. audio or video lectures). Second, we review studies that manipulated the way in which participants took notes (e.g., by hand or typing). Third, we review studies that measured individual differences, such as cognitive ability, and related those to the effects of note-taking on post-test performance. Finally, we review studies that examined the influence of the testing procedure used. In the second part of the review, we focus on answering the research question 'Can the diverging research results be consolidated in a single framework?' We highlight how many of the variables that are shown to influence the encoding effect in note-taking influence the cognitive load experienced by the note-taker. This suggests there is an important role for cognitive load when modelling the effect of note-taking on memory performance. We distinguish five forms of cognitive load that are induced when taking notes while comprehending a lecture, and link the four lines of research reviewed in the first part of this article to one or more types of cognitive load that are induced. By reviewing and integrating literature in this way, we arrive at an explanatory framework that allows us to better understand the current discrepancies in empirical evidence on the encoding effect, and provides useful pointers towards future research.

2. Lines of research

A literature search was conducted for studies exploring the effect of note-taking on memory for lecture content. The search query consisted of two components, one focussing on note-taking and the other on memory. The exact search term used was *(note-taking OR (taking note*) OR (note* taking) OR notetaking) AND (memory OR performance OR achievement OR knowledge OR remembrance OR remember*)*. This search was conducted on October 4th, 2016 in the Scopus database resulting in 467 hits and in the PsycInfo database resulting in 454 hits. Titles and abstracts of the results were scanned for suitability for the current study. The focus of this paper is on empirical studies of the encoding effect. Therefore, papers had to include at least two experimental conditions without note review, and a memory measure for the lecture content. The study had to be conducted in an educational setting (e.g., note-taking during law trials was excluded) and the literature search was restricted to articles in English. Articles that focused on collaborative note-taking or on a special population of students (e.g., students with disabilities, mental disorders) were excluded. After filtering the results from the database, we used snowballing to identify relevant studies that were not part of the corpus resulting from our search query. See Appendix A for an overview of the studies included in this review.

As the literature to date is highly dispersed, and often includes rather complex study designs, we will discuss characteristics of the studies that have repeatedly been investigated separately. Four lines of research have been distilled based on a commentary (Svinicki, 2017) and a previous meta-analysis (Reed, Rimel, & Hallett, 2016): 1) lecture characteristics, 2) note-taking method, 3) individual differences, and 4) testing procedure.

2.1. Lecture characteristics

When examining effects of lecture characteristics on the relationship between note-taking and memory performance, three important lecture characteristics can be identified: the modality in which information is presented, lecture speed and lecture structure.

2.1.1. Modality of lecture material

Lecture modality concerns the way in which a lecture is presented, this can be either written or spoken. Spoken lectures can furthermore be presented with audio only, with a video lecture or with a live lecture. Modality may influence memory as one can take notes parallel with note-taking for text, but not for spoken lectures. In a study conducted by Peters (1972), participants were presented with a 1613 word lecture. The lecture was presented either in written form, spoken at 146 wpm, or spoken at 202 wpm. Participants were randomly distributed over these three conditions. Furthermore, for each modality half of participants was allowed to take notes while the other half of participants was not allowed to take notes. After the lecture, memory for the lecture content was measured with a 25-item 5-alternative multiple choice test. There was a main negative effect of note-taking, as those who took notes performed worse on the multiple choice test than those who did not take notes. There was no main effect of modality, nor did modality interact with note-taking. Given the small sample size, this suggests that the modality of the lecture does not have a large effect on the effect of note-taking for memory of the lecture content. Follow-up research by Peper and Mayer (1978, study 2) also looked at the potential influence of lecture modality on the effect of note-taking on memory for lecture content. Forty-eight participants either watched a 22 min video or read a transcript of this video (i.e. modality manipulation). During this lecture, half of participants were allowed to take notes, while the other half was not. Afterwards, participants' memory for the lecture content was measured with 12 open-ended questions. In line with Peters (1972), no main effect of lecture modality was observed. They did however find a main effect of note-taking, which surprisingly was in the opposite direction as observed by Peters (1972). Note-taking led to better performance in the memory task, regardless of the modality in which the information was presented. A study by Schoen