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Learning terms and definitions: Drawing and the role of elaborative encoding

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A R T I C L E I N F O

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A B S T R A C T

Traditionally, students adopt the strategy of taking written notes when attending a class or learning from a textbook in educational settings. Informed by previous work showing that learning by doing improves memory performance, we examined whether drawing to-be-remembered definitions from university textbooks would improve later memory, relative to a more typical strategy of rote transcription. Participants were asked to either write out the definition, or to draw a picture representative of the definition. Results indicated that drawing, relative to verbatim writing, conferred a reliable memorial benefit that was robust, even when participants' preexisting familiarity with the terms was included as a covariate (in Experiment 1) or when the to-be-remembered terms and definitions were fictitious, thus removing the influence of familiarity (in Experiment 2). We reasoned that drawing likely facilitates retention at least in part because at encoding, participants must retain and elaborate upon information regarding the meaning of the definition, to translate it into a new form (a picture). This is not the case when participants write out the definitions verbatim. In Experiment 3 we showed that paraphrasing during encoding, which, like drawing and in contrast with verbatim writing, requires self-generated elaboration, led to memory performance that was comparable to drawing. Taken together, results suggest that drawing is a powerful tool which improves memory, and that drawing produces a similar level of retention as does paraphrasing. This suggests that elaborative encoding plays a critical role in the memorial benefit that drawing confers to memory for definitions of academic terms.

1. Introduction

The colloquialism ‘a picture is worth a thousand words’ has reverberated through the decades, and its essence is apparent in the incorporation of pictures and diagrams into textbooks, slides, and posters as a means of presenting information more intuitively for consumption. There is a rich tradition of research which demonstrates that incorporating image creation into experimental encoding manipulations lead to better later retention (see Van Meter & Garner, 2005 for a review). Similarly, previous research has indicated that even doodling, which involves the creation of images completely *unrelated* to studied information, might facilitate later recall (Andrade, 2009, but see Meade et al., submitted). Our previous work demonstrated that at a basic level, drawing led to better later memory for single words than did a number of competing encoding strategies (Wammes, Meade, & Fernandes, 2016, in press). The benefit of drawing, relative to writing out the words was characterized as ‘the drawing effect’. The aim of the current set of experiments was to determine whether this effect could generalize to written passages that were more complex; that is, academic definitions from university textbooks (Experiment 1). We also negated the influence of pre-experiment familiarity by examining whether the drawing effect would apply to fictional terms and definitions of our own creation (Experiment 2). Lastly, we compared memory for academic terms that were drawn by participants during encoding, with memory for those that were encoded by paraphrasing (i.e. writing in one's own words), which is a frequently used elaborative note-taking approach (Experiment 3).

Picture superiority, the finding that pictures are more readily remembered than words, is not a new concept (e.g. McBride & Dosher, 2002; Paivio, 1971, 1991, 2014; Weldon & Coyote, 1996; Whitehouse, Mayberry, & Durkin, 2006). Paivio's (1971) dual code hypothesis suggests that pictures are easier to remember than words because they are mentally represented in two ways; as both a visual image and its verbal label. Interestingly, subsequent work from Paivio and Csapo (1973) suggested that dual-coded representations might also be formed as a result of drawing one's own images. Our previous work examined more directly whether drawing could benefit later memory performance. We found that drawing words during encoding was reliably associated with

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better later recall performance than was writing the words out at encoding (Wammes et al., 2016). From this point, one might reason that the benefit of drawing is driven by increased visual imagery (D'Argembeau & Van der Linden, 2006), which has been shown to improve memory, or by picture superiority (Paivio, 1971), which is the finding that pictures are better remembered than words. One might also argue that drawing simply promotes a deeper level of processing (LoP); a greater degree of semantic or cognitive analysis (Craik & Lockhart, 1972; Walsh & Jenkins, 1973), which drawing would certainly require. However, our subsequent experiments indicated that drawing was significantly more effective than these well-established mnemonic strategies in improving retention (Wammes et al., 2016). This finding alone signifies the potential utility of drawing as a mnemonic strategy; one which might apply to lengthier texts, as in scholastic material.

Interestingly, the principles underlying the picture superiority effect (Paivio, 1971) appear to 'scale up' and apply in other arenas as well. Most pertinent for the current work, the inclusion of conceptual diagrams in educational materials leads to reliably better retention of the associated material. In support of this statement, a great deal of work has demonstrated that graphic representation, especially in science texts, can benefit later learning (Ainsworth & Loizou, 2003; Arnold & Dwyer, 1975; Carney & Levin, 2002; Mayer & Moreno, 2003; Reid, 1984; Reid & Beveridge, 1986; Rigney & Lutz, 1976; Scaife & Rogers, 1996; Shah & Hoeffner, 2002). Such findings speak to the robustness and generality of the picture superiority effect. Accordingly, it was our aim to determine whether, like picture superiority, the drawing effect previously observed for memory of individual words (Wammes et al., 2016) would generalize, or 'scale up' when the to-be-remembered information consisted of longer texts; specifically, terms and definitions taken directly from university textbooks.

The application of drawing-related techniques to learning, within scholastic settings, has been previously examined in a variety of ways in the educational literature (for a review see Van Meter & Garner, 2005). While this rich body of work describes the manner in which drawing might be incorporated into education, from first grade through to university, the results are quite mixed. As outlined below, studies vary greatly in their methodologies, and often include complex manipulations which make it more difficult to ascribe performance benefits solely to drawing in its basic form (i.e. drawing without additional manipulations or instructions). For example, while not a pure drawing manipulation, some researchers have asked participants to generate visual representations of to-be-remembered materials. Two such studies incorporated an 'illustration' condition, wherein first grade participants were provided with background scenes and cutouts, and instructed to assemble these in order to create a graphical depiction of the to-be-learned information (30–100 word narratives; Lesgold, De Good, & Levin, 1977; Lesgold, Levin, Shimron, & Guttman, 1975). Retention improved only if participants had the illustration assembled *for them*, or were *only* given the necessary cutouts for that particular narrative. These findings indicated that while pictorial content could improve retention of an associated narrative, free-form creation of graphical representations was actually a maladaptive strategy. Other work has indicated that drawing a map-like figure based on a narrative either improves (Dean & Kulhavy, 1981) or does not improve (Kulhavy, Lee, & Caterino, 1985; Snowman & Cunningham, 1975) retention in college students. However, it is important to note that Dean and Kulhavy (1981) compared drawing based on reading the narrative, to simply reading the narrative alone (i.e. no additional task).

Several other studies have since shown that drawing is particularly beneficial to later memory, though not without their own caveats (see Alesandrini, 1981; Greene, 1989 and Van Meter, 2001). As well, others have shown a lack of any effect (Hall, Bailey, & Tillman, 1997; Kulhavy et al., 1985; Rasco, Tennyson, & Boutwell, 1975), in some cases even reporting reductions in comprehension as a result of drawing (Leutner, Leopold, & Sumfleth, 2009). In a recent study, Schwamborn, Mayer, Thillmann, Leopold, and Leutner (2010), showed a substantial memory benefit stemming from drawing diagrams based on a studied science text. Their 9th grade participants though, not unlike in the foregoing studies by Lesgold et al. (1975; 1977), were provided with all of the individual components they should incorporate in their drawing, as well as a background that had been pre-drawn for them. While this strategy indeed acted as a scaffold for later understanding, the benefit to memory could not be ascribed to drawing alone.

On the surface, it seems clear that the literature on the effectiveness of drawing as an encoding strategy is divided. Upon closer inspection though, there are a few relevant factors in these studies that seem to obfuscate the question we are most interested in, which is whether, as in memory for individual words and pictures (Wammes et al., 2016, in press), freeform drawing of pictorial representations of textbook definitions might be a superior, or at least comparable strategy to prevailing methods of learning. These confounding factors include providing the basic elements of a potential drawing, leaving students to assemble them rather than free-form draw in a manner of their choosing (Lesgold et al., 1975, 1977; Schwamborn et al., 2010; Van Meter, 2001), comparing drawing to a control condition of silent reading alone (Dean & Kulhavy, 1981), or asking participants to generate only one image for a lengthy passage (Alesandrini, 1981; Dean & Kulhavy, 1981; Hall et al., 1997; Rasco et al., 1975).

Moreover, few studies have incorporated a pure free-form drawing instruction. The closest example was work by Alesandrini (1981), in which participants were given 60 min to learn 14 related terms, and then instructed to review the studied concepts by drawing pictures to illustrate them. However, in some cases participants were given specific instructions to make their drawings either 'analytic' or 'holistic' in nature, and it was only the latter condition that significantly improved memory relative to verbal strategies. Drawing however, led to only a 4% memory boost, leading the author to note that "the educational significance of strategies that raise test performance only a few points is questionable" (Alesandrini, 1981, p. 365). Similarly, Van Meter (2001) included a condition in which participants were told only to draw. However, this experimental manipulation was preempted by the inclusion of diagrams within the studied text, as well as extensive training on how one should draw diagrams, including rehearsal of rules and conventions for creating good diagrams, drawing practice, and experimenter feedback. While memory in their 'draw' condition was superior to their 'read' control, it is critical to note that this was only true in free recall, and not recognition, and that in free recall, participants spent only roughly half as much time on task in the 'read' control as they did in the basic 'draw' condition. Furthermore, it is unclear whether their extensive training protocol would be required to elicit a benefit of drawing.

The design nuances above are not highlighted here as flaws or shortcomings of the foregoing work. It is important to note that the aims of these research programs were vastly different than ours, and the researchers were largely successful in achieving a better understanding of whether image creation might be incorporated into pedagogy as a didactic tool, albeit with inconsistent results. It is not our intent to attempt to resolve this debate, but rather to determine whether when broken down closer to its most basic form (i.e. no extra instructions or implements), drawing to-be-remembered information leads to a memory trace that is more readily retrieved at a later time than does writing, and whether this benefit applies more broadly to terms and their definitions taken from a cross section of academic disciplines.

1.1. The present study

As in our previous work (Wammes et al., 2016), we began this line of experiments by comparing a trial type requiring one to draw pictures based on definitions, to a trial type requiring repeatedly writing out the definitions verbatim, which is also a prominent method used by students to retain information in a lecture setting or learning environment (e.g. Bonner & Holliday, 2006; Mežek, 2013; Pecorari, 2008; Van Meter,