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The effects of verbally redundant information on student learning: An instance of reverse redundancy

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A B S T R A C T

This study aimed to examine the effects of redundant on-screen text on student learning outcomes (i.e. comprehension, matching, spatial labeling, and diagram reconstruction) when learning from multimedia instruction. An interactive, learner-controlled multimedia material was developed to teach the points of articulation used to describe human speech sounds. Participants included 137 undergraduate students from a large southwestern university in the U.S. who were randomly assigned to one of two treatment conditions: (1) an audio only treatment where audio descriptions of each point of articulation were provided, (2) an audio with text label treatment where audio descriptions of each point of articulation plus redundant text labels were provided. The results showed that having redundant on-screen text with spoken information was helpful for student learning. Overall, results confirm an instance of the reverse redundancy effect when instructional material is complex; redundant on-screen text is short; and learners have control over the pace of instruction.

1. Introduction

Multimedia instruction can contain information in visual (i.e. graphics, animation) and verbal (i.e. narration, text) forms (Mayer & Moreno, 2002). With innovations in computer and internet technologies, multimedia materials have been used widely when delivering instruction through computers (Adesope & Nesbit,2012; Mayer, 2009). Further, it has been found by many researchers that multimedia instruction, if designed effectively, can enhance learning (Mayer, 2009; Sweller, 1999; Van Merriënboer, 1997). With his multimedia principles, Mayer (1999) defines the boundaries of learning from multimedia when the instructional materials incorporate different forms of information (i.e. verbal, non-verbal). Mayer further provides practitioners with theoretical explanations and specific recommendations for how multimedia instruction should be designed. Cognitive theory of multimedia learning (CTML) is built on three assumptions: dual channels, which postulates that working memory has two channels (i.e. visual and verbal channels), limited capacity, which claims that each channel in working memory has limited capacity for processing incoming information, and active processing, which requires learners to actively participate in the learning process, summarize and synthesize just learned information and connect it with prior knowledge (Mayer, 2009).

CTML postulates the flow of newly received information as follows: (1) information is first received by the eyes and ears, and goes to sensory memory which has unlimited capacity but keeps information for a very brief period of time; (2) selecting by attention, information is transferred to working memory where it is processed and integrated with existing knowledge from long term memory; and (3) information is stored in long-term memory (Mayer, 2009). Built on Paivio's dual coding theory which proposes that human cognitive system is composed of two distinct subsystems to process verbal (e.g., spoken words) and nonverbal (e.g., images) information (Paivio, 1986), the dual

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channels assumption states that incoming multimodal information is processed separately in working memory. For instance, the visual channel of working memory deals with visual information received from the eyes and the auditory channel processes verbal information received from the ears. Therefore, all graphics and written text delivered in an instance of multimedia instruction will be processed via the visual channel whereas all sounds including spoken text will be processed via the auditory channel.

The limited capacity assumption of CTML considers the limited processing capacities of the visual and verbal channels of working memory (Baddeley, 1992; Chandler & Sweller, 1991). According to this assumption, presenting too much information to be processed by only one channel of working memory may lead to cognitive load in that channel (Mayer & Moreno, 2002). For example, if both on-screen text and graphics are processed through the visual channel of working memory, the visual channel may be overloaded resulting in decreased learning performance. To reduce the cognitive load in the visual channel, it is recommended that on-screen text be replaced with spoken text in a multimedia instruction that contains visual elements such as graphics and animations (Mayer, 2009).

Cognitive Load Theory (CLT), which shares similar assumptions with CTML, explains this phenomenon in the context of extraneous cognitive load. Sweller, Van Merriënboer, and Paas (1998) defined three types of cognitive load: (1) intrinsic cognitive load imposed by the element interactivity inherent to the learning task, (2) germane cognitive load which enhances learning by devoting cognitive resources for schema construction and automation, and (3) extraneous cognitive load imposed by ineffective instructional design which does not consider human cognitive architecture (Paas, Renkl, & Sweller, 2003; Sweller, 1994). Because working memory has limited capacity, the presentation of redundant on-screen text together with spoken text and graphics simultaneously creates unnecessary extraneous load in working memory that may possibly hinder learning (Plass, Moreno, & Brünken, 2010; Sweller, Ayres, & Kalyuga, 2011). Additionally, the simultaneous presentation of graphics, on-screen and spoken texts requires learners to compare the incoming streams of verbal information (i.e. written and spoken text), resulting in high cognitive load and thus harm the learning process (Kalyuga, Chandler, & Sweller, 1999; Mayer, 2009; Sweller et al., 1998). Both CTML and CLT suggest that instruction should be designed in a manner that reduces extraneous cognitive load. One technique, for example, may be by using spoken text when the instructional material contains visual elements associated with the text.

1.1. Redundancy/reverse-redundancy effect

The redundancy principle suggests that people learn better from graphics and spoken text than from graphics, spoken and on-screen text presented simultaneously (Mayer, 2001). In addition to theoretical support, the redundancy effect has been supported empirically (Kalyuga et al., 1999; Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2002a; Pastore, 2012). More specifically, the redundancy effect has been observed in situations when multimedia instruction contains self-explanatory diagrams and additional text that re-describes the diagram (Chandler & Sweller, 1991); when learners complete physical and mental activity concurrently (e.g., using a specific software while simultaneously reading the manual for the software) (Cerpa, Chandler, & Sweller, 1996; Sweller & Chandler, 1994); and when a comprehensive summary of a text is presented along with the full text (Reder & Anderson, 1980).

Despite empirical support, several boundary conditions for the redundancy effect have been identified. These include situations where spoken text is presented (and presumably processed) before on-screen text (Kalyuga, Chandler, & Sweller, 2004); when on-screen text is short and contains information about the major event described in spoken text (Mayer & Johnson, 2008); and when there is no graphic, and spoken and on-screen texts are short (Moreno & Mayer, 2002b). For instance, Leahy, Chandler, and Sweller (2003) reported that providing redundant information in a multimedia presentation about line graphs did not help students improve their learning performance. In two experiments, Mayer and Johnson (2008) re-examined the boundary conditions for the redundancy effect. Although non-significant, Mayer and Johnson (2008) reported that students working with multimedia materials that contained audio and visuals slightly improved their learning performance on transfer tests whereas students working with multimedia materials that contained redundant on-screen text, audio and visuals did not.

Contrary to the results of these studies, the reverse redundancy effect has been observed in instances of multimedia instruction where presenting redundant, explanatory on-screen text along with spoken text facilitated learning (Leslie, Low, Jin, & Sweller, 2012; Mayer & Johnson, 2008; Samur, 2012). Samur (2012) provides some support that students, who are learning a foreign language, can remember more vocabulary when they are provided with instructional materials that contain animation, narration, and text simultaneously. In another study, Leslie et al. (2012) pointed out that for less knowledgeable learners, the addition of redundant visual information to an audio presentation might improve the learning process. Similarly, Mayer and Johnson (2008) found that providing students with redundant on-screen text along with associated visuals and audio narration helped them improve their performance on retention tests when the on-screen text is short and explanatory.

Though many studies have examined the redundancy effect in multimedia instruction, the results from these studies are inconsistent. Additionally, very little is known on whether the redundancy or reverse redundancy effects hold for complex, interactive multimedia instruction where learners control the pace of the instruction (Mayer, 2009). Eliminating verbally redundant information in multimedia instruction might facilitate learning in certain conditions, however; there may be certain conditions where learners might benefit from verbally redundant information, as well (Adesope & Nesbit, 2012). Thus, with the current study we first aim to contribute to the literature on the redundancy effect and learning from multimedia instruction by investigating the reverse redundancy effect in a complex, interactive multimedia material. The findings from this study will provide educational researchers with valuable information to further clarify the boundaries of the redundancy effect in multimedia learning. Lastly, in regard to practical implications, this study will demonstrate an instance of a multimedia presentation for instructional designers and educators who incorporate multimedia materials into their educational practices.

1.2. Purpose of study

The purpose of the present study was to examine the effects of redundant on-screen text on college student's comprehension, spatial retention, mental effort, and study patterns when they were exposed to a complex, interactive and learner-controlled multimedia learning material. The research questions for this study were: