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The effects of time-compressed instruction and redundancy on learning and learners' perceptions of cognitive load

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A B S T R A C T

Can increasing the speed of audio narration in multimedia instruction decrease training time and still maintain learning? The purpose of this study was to examine the effects of time-compressed instruction and redundancy on learning and learners' perceptions of cognitive load. 154 university students were placed into conditions that consisted of time-compression (0%, 25%, or 50%) and redundancy (redundant text and narration or narration only). Participants were presented with multimedia instruction on the human heart and its parts then given factual and problem solving knowledge tests, a cognitive load measure, and a review behavior (back and replay buttons) measure. Results of the study indicated that participants who were presented 0% and 25% compression obtained similar scores on both the factual and problem solving measures. Additionally, they indicated similar levels of cognitive load. Participants who were presented redundant instruction were not able to perform as well as participants presented non-redundant instruction.

1. Introduction

The multimedia principle suggests that using multiple representations (verbal and non-verbal) that explain for one another is better for learning than using just one. Accordingly, multimedia learning is defined as a combination of verbal (text or narration) and non-verbal (images or icons) representations used for learning (Mayer, 2005). Over the last two decades, a myriad of studies have suggested support for the multimedia principle (Austin, 2009; Eilam & Poyas, 2008). For instance, Mayer and Sims (1994) conducted an experiment which found that learners who were presented with both verbal and non-verbal representations concurrently outperformed those that were presented with single representations on transfer knowledge assessments. Thus, presenting learners with verbal and non-verbal representations that explain for one another is better for learning than presenting only one.

However, some combinations of representations are better than others for learning in a multimedia environment. The modality principle suggests that when presenting multiple representations, verbal representations should be presented as spoken words rather than text (Low & Sweller, 2005). This reduces the cognitive load placed on the learner by allowing them to focus on the image and listen to the narration at the same time. Otherwise, learners would need to split their attention between the verbal (text) and non-verbal (image) representations, which would increase cognitive load. Thus, presenting audio and image representations together, rather than text and image representations, more effectively utilizes working memory and is more suitable for learning (Tindall-Ford, Chandler, & Sweller, 1997).

However, in today's fast paced world, audio narration is not always the preferred method of verbal delivery because learners can read much faster (270 wpm) than the average human speaks (120–180 wpm), making audio take significantly longer to listen to (Monroe & Ehninger, 1974). In addition, time is a critical issue for many in today's workforce. Employees and students in all fields have to take time out of their daily tasks to go through computer-based training courses often required by their employer or instructor. For instance, many companies have computer-based training modules that employees can complete for self-improvement, promotion, certification, learning a new system or job task, etc. This gives reading a time-savings advantage in a computer-based training (CBT) environment where these types of modules are being delivered.

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In light of that, recent research has revealed that audio can be compressed up to a certain point and still support learning. Time-compressed speech refers to audio that has been increased in speed yet has retained its audio output (Arons, 1992). Prior research has revealed that time-compressed instruction can be compressed up to 50% without sacrificing intelligibility and recall (Heiman, Leo, & Leighbody, 1986). However, a majority of this research does not address complex learning. More recently, Pastore (2009) revealed that spoken words could be digitally time-compressed up to 25% in a multimedia environment while preserving complex learning. Thus, a one-hour multimedia session could take 45 min if time-compressed 25% and still maintain the same level of learner comprehension. As a result, it appears that learners may be able to listen as fast as they can read, thus preserving the time-savings associated with text over spoken words. This implied that narration, which is usually spoken at 120–80 wpm, more closely matches to the 270 wpm reading speed of adults when time-compressed. Using time-compressed instruction rather than regular paced narration or text could result in better designed training (modality effect with time-compressed narration) that still keeps training time to a minimum (when going through CBT). However, with only a few studies examining this topic, more studies are needed to support these conclusions. Thus, this study will address time-compression on learning.

In addition, few studies have examined time-compressed narration that was presented with redundant text representations. The redundancy principle suggests that presenting redundant representations, such as text and spoken words, reduces comprehension (Sweller, 2005).

However, current research has revealed a possible reversal effect associated with time-compressed instruction on factual knowledge (Ritzhaupt, Gomes, & Barron, 2008). The reversal effect suggests that groups who received redundant representations outperformed groups who received non-redundant representations. At this time however, no research has examined time-compressed instruction and redundancy on high-level learning objectives. As a result, this study will examine the impacts of time-compression and redundancy on learning.

2. Literature review

2.1. Cognitive load

Cognitive load refers to the informational load that is being processed in working memory (Van, Paas, & Sweller, 2010). Cognitive load theory explains that there is a certain amount of information that can be processed in working memory at one time without overloading processing capacity. Thus, when cognitive load is increased beyond our working memory capacity, learning is depressed. Initial research on cognitive load stems from the information processing theory, which explains that we have a limited short term or working memory and an unlimited long-term memory (Brünken, Plass, & Leutner, 2003). Miller (1956) explains that the mind can store seven units of information, plus or minus two units depending on how meaningful they are to the learner, at one time in our working memory without exceeding processing capacity.

Cognitive load is comprised of three types of load that are referred to as extraneous, intrinsic, and germane (Sweller, 2010; see also Künsting, Wirth, & Paas, 2011). Each of these types affects learning separately. Extraneous cognitive load is affected by the design of the instruction. This type of load suggests that irrelevant information results in high cognitive processing. So reducing irrelevant activities will reduce cognitive load and increase comprehension. Intrinsic cognitive load is affected by high element interactivity, such that information that is hard for the learners to interpret increases cognitive load. Germane cognitive load refers to load that is generated by instructional activities that lead to schema development and automation (Mayer, 2005).

In the experiment described in this paper, extraneous load is being manipulated. Typically designers aim to reduce extraneous load by following Mayer and colleagues' multimedia principles (Mayer, 2005; Sweller, 2010). Further explanation of the principles being utilized in this experiment will be explained in the sections that follow.

2.2. Multiple external representations (MERs)

The multimedia principle states that learning from a combination of verbal and non-verbal representations is better than learning from just a single representation (Mayer, 2005). For instance, Tindall-Ford et al. (1997) examined the multimedia principle in a series of experiments which compared a verbal (narration) and non-verbal (image) condition to a non-verbal (image only) condition and found the groups comprised of multiple representations to be vastly superior in each experiment on problem solving measures. Problem solving, for purposes of this paper, refers to a cognitive process where the learner combines levels of knowledge (facts, concepts, rules/procedures) to reach a solution to problem that they have never encountered (Gagné & Briggs, 1974; Mayer, 1992). Similar studies, supporting the multimedia principle, have been demonstrated throughout the literature (Austin, 2009; Eilam & Poyas, 2008).

The multimedia principle stems from a dual coding theory (Paivio, 1991). The dual coding theory suggests that our working memory is comprised of separate memory channels, which process information, known as verbal (logogens) and non-verbal (imagens) channels and that each have a certain processing capacity. In this setting, each channel can process information separately yet is interconnected through associative and referential connectors. More recently, Mayer (2001) has modified the dual coding theory in the cognitive theory of multimedia learning (CTML). The CTML has three assumptions (1) working memory is made up of a dual modality input channel system, (2) there is a limited capacity in working memory, and (3) that learners engage in active processing.

However, some combinations of MERs are better for learning than others. The modality effect hypothesizes that when representations explain for one another, verbal representations that are presented as spoken words are better for learning than representations that are presented as text (Low & Sweller, 2005). When learners are presented with spoken words and an image, they can listen to and look at both representations at the same time without the need to split their attention between representations in their short-term memory. Ginns (2005) confirms the modality effect in a meta-analysis that included 43 studies which found that presenting audio representations in a multimedia environment was better for learning than the presentation of text representations.

In light of the multimedia principle and modality effect, Mayer and colleagues have recommended many other principles for multimedia development including coherence, redundancy, signaling, spatial contiguity, and temporal contiguity. The experiment being described in this paper will examine the redundancy principle, which is explained in the following section.