Perceptual Load in Multimedia Learning

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Abstract. To what extent does perceptual load play a role in learning from text and pictures? Theories of multimedia learning often discuss the effects of working memory load, but rarely address the earlier processing that must occur in the initial stages of viewing instructional material. In earlier studies, adding text to pictures instead of narration caused perceptual load for learners. This load may contribute to an overall experience of cognitive load and to decreased learning outcomes. The current study investigates the perceptual load involved in a split presentation of pictures and text, compared to a presentation in which text is placed next to the relevant part of the picture, by measuring eye fixations on task-irrelevant distractors. Data collection is currently in progress.

Keywords: multimedia learning; perceptual load; working memory load

Introduction

When people learn from an instructional lesson containing pictures and text, there are many demands on their limited cognitive resources. Together, these processing demands may overload the learner's cognitive resources. Theories of multimedia learning – such as the cognitive load theory (CLT; Sweller, 1994) and the cognitive theory of multimedia learning (CTML; Mayer, 2009) – have described effects of overloading processing capacity during learning and have prescribed design principles that are aimed at avoiding this overload. For example, studies have shown that people learn better from pictures and text when the text is integrated into the relevant part of the picture, rather than presented, for example, under the picture (e.g., Moreno & Mayer, 1999). What has not yet been empirically explained, however, is the underlying processing that leads to this type of effect.

In general, CLT and CTML tend to rely on theories of working memory (WM; Baddeley, 1990) to explain these effects. For meaningful learning to occur, pictures and words must be actively processed in WM. Additionally, processing that is required only by the instructional design (referred to as *extraneous load*) is also thought to occur in WM. The most common type of evidence for this argument comes from studies that show decreased scores of learning outcome when the instructional materials require extraneous processing above the capacity of one's WM (Mayer & Moreno, 2003).

However, visual differences between multimedia designs may yield not only WM load, but also impose higher demands on the perceptual system. The aim of the current study is to empirically test which type of processing is affected by the placement of text in relation to a picture. Lavie and colleagues (e.g., Lavie, Hirst, deFockert, & Viding, 2004) have established a methodology that allows for a distinction between perceptual load and WM load. In these studies, the typical task involves a visual search task containing task-irrelevant distractors. The distractors' interference in the search task decreases when the perceptual load of the task is high, but increases when the WM load of the task is high. In a high perceptual load situation, perceptual resources are unavailable to additionally process distractors. In a high WM load situation, WM resources are not available to inhibit responses to distractors.

The current study adapted this methodology by presenting visual task-irrelevant distractors during multimedia lessons containing pictures and text that was either presented under the pictures (split format), or placed next to the relevant part of the picture (integrated format). The primary dependent measure of this study was the number of times learners looked at these distractors during learning, with the assumption that learners look at distractors because they have noticed them, when they would instead benefit from ignoring them.

Given that the amount information presented in the two conditions is identical, the main difference between the two conditions lies in the amount of visual scanning and search that must take place, with the split format requiring more. Knowing where to look and when may guided by working memory, and this process is made more difficult when relevant information is not spatially close together. However, this process might also impose a significant amount of perceptual load by requiring learners to search a larger space and to make more (and/or larger) eye movements. This difficulty in visually processing the information on the screen may prevent some of the necessary information from being perceived early on, and thus from being further processed in WM, eventually resulting in lower learning outcomes. Therefore, increases in perceptual load, as well as in WM load, have the possibility of leading to less effective learning.

The Working Memory Hypothesis

According to the *working memory hypothesis*, when a lesson requires extraneous processing for scanning a display for relevant text or pictures, learners should have fewer free WM resources available to inhibit responses to distractors and should therefore make more eye fixations on the distractors. In this case, measures of cognitive load during the lesson should correlate positively with the number of fixations on the distractors. Scores on transfer tests should, in turn, be negatively correlated with the number of fixations on distractors and with measures of cognitive load.

The Perceptual Hypothesis

According to the *perceptual hypothesis*, when the lesson requires extraneous processing for scanning a display for relevant text or pictures, learners will have fewer perceptual (visual) resources available to process the distractors, leading learners to make fewer eye fixations on the distractors. In this case, measures of cognitive load during the lesson should correlate negatively with the number of fixations on the distractors. Scores on transfer tests should again be negatively correlated with measures of cognitive load, but should be positively correlated with fixations on distractors, since here more fixations on distractors indicate a lower amount of extraneous load.

Method

Participants learn about how toilet tanks work (Hegarty, Kriz, & Cate, 2003) and how lighting is formed (Mayer, Steinhoff, Bower, & Mars, 1995) in a within-subjects design, consisting of two levels of extraneous load: low extraneous load (integrated format) and high extraneous load (separated format). The lessons contain a series of static pictures depicting functional steps in each of the processes described in the accompanying text. Load is counterbalanced across lesson topics, and the order is counterbalanced across participants.

During each lesson, distractors appear on the screen for 400 msec each and randomly at one of four locations – to the left and right of the picture and to the left and right of the separated text. For 90% of the trials, there is an inter-stimulus interval (ISI) of 500ms, for the other 10% of the trials the ISI is longer (900ms) in order to prevent participants from expecting a distractor to appear at a particular time. Each lesson is between 1.5 minutes and 3 minutes long, allowing for between 96 and 146 presentations of the distractor stimuli.

After the Tobii 1750 eye tracker is calibrated, participants are reminded that their main task is to learn the information since there will be a test on it later. No instructions are given regarding the distractors that would appear. Participants watch the lessons on the eye tracker monitor. After each lesson, participants answer cognitive load questions and transfer test questions.

Analyses

Areas of interest (AOIs) are defined for the picture area, the text areas, and each of the distractor locations. Eye fixations (100ms or longer) on the four distractor locations will be summed for an overall count of fixations on distractors.

To determine whether WM or perceptual processing is affected by the types of multimedia designs used in this study, the proportion of eye fixations on the distractors out of the total number of fixations elsewhere during a lesson is compared across the lessons. The WM hypothesis predicts that there should be more fixations on distractors when extraneous load is high (split format). The perceptual hypothesis conversely predicts that if the experience of cognitive load is created by perceptual load, then there should be more fixations on distractors when extraneous load is low (integrated format). Data analysis is currently in progress and will be presented at the conference.

Discussion

The influence of WM load and perceptual load is important not only for theories of multimedia learning, but also for explaining the possible difficulties in learning from different types of multimedia design. A finding supporting the WM hypothesis would support the current state of reasoning in the field about how extraneous load influences learning outcomes. A finding supporting the perceptual hypothesis need not refute the WM point of view. Rather, it would better define the processes that are involved in learning from a multimedia lesson with a split presentation. Specifically, extraneous perceptual processing may be required for this type of presentation and may result in information that is necessary for learning to be “filtered out” before it can enter WM to be learned.

References

Baddeley, A.D. (1990). *Human memory: Theory and practice.* Needham Heights, MA, US: Allyn & Bacon.

Hegarty, M., Kriz, S., Cate, C. (2003). The roles of mental animations and external animations in understanding mechanical systems. *Cognition and Instruction, 21*, 325—360.

Lavie, N., Hirst, A., deFockert, J.W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology, 133*, 229—354.

Mayer, R.E. (2009). *Multimedia learning (2nd ed).* Cambridge University Press, New York.

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*(1), 43-52.

Mayer, R.E., Steinhoff, K., Bower, G., & Mars, R. (1995). A generative theory of textbook design: Using annotated illustrations to foster meaningful learning of science text. *Educational Technology Research and Development, 43,* 31—43.

Moreno, R., & Mayer, R. E. (1999). Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of Educational Psychology, 91*(2), 358-368.

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instructional Design, 4,* 295—312.