

## Chapter II

# Multimedia Learning and Working Memory Capacity

**Peter E. Doolittle**

*Virginia Tech, USA*

**Krista P. Terry**

*Radford University, USA*

**Gina J. Mariano**

*Virginia Tech, USA*

### ABSTRACT

*This chapter addresses the role that working memory capacity (WMC) plays in learning in multimedia environments. WMC represents the ability to control attention, that is, to be able to remain focused on the task at hand while simultaneously retrieving relevant information from long-term memory, all in the presence of distraction. The chapter focuses on how individual differences in attentional control affect cognitive performance, in general, and cognitive performance in multimedia environments, in particular. A review of the relevant literature demonstrates that, in general, students with high WMC outperform students with low WMC on measures of cognitive performance. However, there has been very little research addressing the role of WMC in learning in multimedia environments. To address this need, the authors conducted a study that examined the effects of WMC on learning in a multimedia environment. Results of this study indicated students with high WMC recalled and transferred significantly more information than students with low WMC. Ultimately, this chapter provides evidence that individual differences in working memory capacity should be taken into account when creating and implementing multimedia instructional environments.*

## INTRODUCTION

Attention has been demonstrated to be an essential component of learning in multimedia instructional environments. Specifically, when a student's attention is split between multiple sources of information, such as when a student's visual attention is split between an animation-based tutorial depicting the cause of lightning and a simultaneously presented text-based description of the lightning tutorial (Mayer & Moreno, 1998), learning and performance suffer. In addition, when a student's attention is seduced away from important content toward interesting, but irrelevant information, such as when a student views an animation-based tutorial with concurrent narration describing the cause of lightning that includes interesting, but irrelevant background sounds and music (Moreno & Mayer, 2000), learning and performance suffer. In contrast to these negative effects of attentional interference, as a student's attention is guided toward relevant ideas or concepts through the inclusion of signals or cues, such as when a student views an animation-based tutorial describing airplane flight with concurrent narration that emphasizes important ideas by using a slower and deeper intonation of voice (Mautone & Mayer, 2001), learning and performance improve. Also, when a student's attention is guided toward a specific goal for reading and viewing an illustrated, text-based tutorial of the cause of lightning, such as when students are told to focus on learning the steps involved in creating a stroke of lightning prior to engaging the tutorial (Harp & Mayer, 1998), learning and performance improve.

These differential effects on learning and performance in multimedia instructional environments, based on treatment variations in attention, raise the question as to whether individual differences in attention may influence individuals' learning and performance in multimedia instructional environments. There is an extensive body of literature indicating that an individual's ability

to control attention affects performance on complex mental tasks (Daneman & Carpenter, 1980; Oberauer, Süß, Schulze, Wilhelm, & Wittmann, 2000; Unsworth & Engle, 2007). In this literature, attentional control is a component of working memory capacity (WMC; Kane, Bleckley, Conway, & Engle, 2001; Kane & Engle, 2003), that is, the ability to maintain information in working memory and to effectively retrieve task relevant information from long-term memory (Feldman Barrett, Tugade, & Engle, 2004). The purpose of this chapter is to explore the relationship between attentional control and learning in a multimedia environment.

## BACKGROUND

The successful completion of complex cognitive tasks requires that individuals are able to dynamically retrieve, maintain, manipulate, and update information in memory during task performance (Baddeley & Hitch, 1974). This dynamic memory model was investigated by Daneman and Carpenter (1980) who established a positive correlation between complex cognitive task completion and a measure of working memory capacity (WMC); specifically, through the positive correlation of global and local measures of reading comprehension with a working-memory span task involving both the storage and processing of information. Daneman and Carpenter's working-memory span task (i.e., reading span) required participants to read a series of sentences (processing), while maintaining a list of the last word from each sentence in memory (storage). This storage + processing working-memory span task differed from previous storage-only working-memory span tasks (e.g., digit span, word span) in that a secondary processing task, reading, provided additional working-memory load complexity. It is believed that this storage + processing working-memory span task provides a more complex memory task, and a better estimate of the cognition necessary to

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