An Investigation of the Effect of Segmentation on Immediate and Delayed Knowledge Transfer in a Multimedia Learning Environment

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Abstract

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The purpose of this study was to determine the effects of segmentation on immediate and delayed recall and transfer in a multimedia learning environment. The independent variables of segmentation and non-segmentation, and immediate and delayed assessments were manipulated to assess the effects of segmentation on the participants' ability to recall and transfer information from the multimedia tutorial. Data was analyzed using a 2X2 factorial design. The results of this study found that segmentation of multimedia tutorials did not result in significant differences in recall or transfer. The results also revealed that the time period between when a tutorial was viewed and when the recall and transfer assessments were taken did significantly affect participants ability to recall and transfer information.

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Introduction

The use of multimedia environments as learning tools is on the rise, especially in educational settings. Yet, understanding how individuals learn through the use of multimedia technology, the attributes of the multimedia environment itself, and how these attributes affect learning are not well understood. In the past, multimedia research had been primarily focused on the technologies used to deliver instruction. More recently, however, the focus has shifted to a more learner-centered approach that is grounded in theories of how people learn (Mayer & Moreno, 2002).

Richard Mayer (see Mayer, 2005) has laid the foundation for current multimedia research in educational settings. His research focuses primarily on the effects of multimedia tutorials on recall and transfer among students. He studies the multimedia attributes signaling, segmentation, personalization, redundancy, contiguity and modality in order to understand the impact these variables have on learning. Mayer's research is predominately outcome focused, meaning, he examines the effect multimedia attributes have on learning outcomes such as recall and knowledge transfer. Mayer defines a transfer test as one in which "learners must solve problems that were not explicitly given in the presented material – that is, they must apply what they learned to a new situation" (Mayer, 2001 p. 16). He measures transfer by whether or not students are able to answer questions related to specific instruction on a transfer test. In his studies, however, Mayer does not specify the nature or type of transfer that has occurred, merely that transfer has or has not taken place.

The purpose of this study was to examine the role of transfer in multimedia instructional environments in light of current multimedia and transfer theory; specifically, how past and current understandings of knowledge transfer impact current learning and instructional design of multimedia environments.

Cognitive Theory of Multimedia Learning

The Cognitive Theory of Multimedia Learning seeks to explain how humans learn in a multimedia environment. The theory focuses on how humans process information in working and long-term memory so that delivery of information in a multimedia environment can result in a meaningful learning experience (Mayer, 2001). Specifically, the theory focuses on how words and pictures are selected, organized and integrated to form meaningful learning. This theory is based on a combination of three different theories – Baddeley's working memory model (Baddeley, 1986; Baddeley & Hitch, 1974), Paivio's dual-coding theory (Paivio, 1990; Sadoski & Paivio, 2001), and Sweller's cognitive load theory (Chandler & Sweller, 1991; Sweller, 1994) – and three related assumptions: dual-channel processing, limited capacity, and active learning. This theory has also resulted in several principles demonstrated to affect the cognitive processing of information: the modality principle, redundancy principle, contiguity principle, coherence principle, signaling principle, segmenting principle, personalization principle, voice principle, and individual differences principle (Mayer, 2005).

Dual-Channel Processing Assumption

The dual-channel processing assumption states that humans have two separate channels that process auditory and visual information. This dual-channel assumption aligns with and merges both Baddeley's working memory model and Paivio's dual-coding theory. Baddeley's (1986, 2007) working memory model describes how information is processed after it is perceived by sensory organs and proposes separate channels for processing visual and auditory information. Through his studies, Baddeley developed the working memory model, which encompasses three components: a supervisory central executive and two slave systems (see Baddeley, 1986, 2007; Baddeley & Hitch, 1974). The central executive system controls what enters working memory, selects strategies to process information, and coordinates information from the two slave systems – the phonological loop and the visuo-spatial sketchpad. The phonological loop serves to maintain auditory information in working memory through sub-vocal repetition but also has the capability of taking visually presented information, such as words or nameable pictures, and converting them into an auditory form (Baddeley, 1986). The visuo-spatial sketchpad is specialized for "the processing and storage of visual and spatial information, and of verbal material that is subsequently encoded in the form of imagery" (Gatherole & Baddeley, 1993, p.17).

While Baddeley's working memory model focuses on dual channels of visual and auditory information, Paivio's dual-coding theory emphasizes dual channels for verbal and non-verbal information (Paivio, 1971, 1990). These two processing channels, verbal and non-verbal, are functionally independent, yet interconnected. The verbal system processes verbal information, such as spoken or written words, regardless of the modality of origin. The nonverbal system processes nonverbal information, such as pictures, gestures, and music, again, regardless of origin.

It is apparent that Baddeley's and Paivio's interpretation of "dual-channels" is different, visual/auditory versus verbal/non-verbal. Mayer (2005) sought a compromise between both Baddeley's and Paivio's understandings of the separate channels. Mayer explains, "For purposes of the cognitive theory of multimedia learning, I have opted for a compromise in which I use the sensory modality approach to distinguish between visually presented material (e.g., pictures, animations, video, and on-screen text) and auditorily presented material (e.g., narration and background sounds) as well as a presentation-mode approach to distinguish between the construction of pictorially based and verbally based models in working memory." (Mayer, 2005, p. 34).

Limited Capacity Assumption

The limited capacity assumption holds that individuals are limited in the amount of information, or load, that can be processed in either of the dual channels at one time. The limited capacity assumption aligns with Baddeley's working memory model (Baddeley, 1986) and Sweller's cognitive load theory (1994). From Baddeley's working memory model the limited capacity assumption takes the idea of a dual-channel working memory with a limited capacity. From Sweller's cognitive load theory the limited capacity assumption takes the idea that each of the dual channels can be overloaded by the demands of a particular learning task. The cognitive load theory is based on the limitations of working memory, with separate, partially independent channels for visual/spatial and auditory/verbal information, which work together with long-term memory (Paas, Tuovinen, Tabbers, & Van Gerven, 2003). It takes into account the amount of information being processed, in this way no one channel is over burdened (Sweller, van Merrienboer, & Pass, 1998).

The limited capacity assumption follows the view of the working memory capacity literature. Working memory capacity has been seen as a limit in the ability to store information in working memory (Miller, 1956). This view was expanded upon to include the idea that working memory has two functions that must be considered: a limited storage capacity and a limited processing capacity (Engle, Tuholski, Laughlin, & Conway, 1999). Working memory storage capacity is the ability to maintain information in working memory. Working memory processing capacity is the ability to retrieve information relevant to a current problem from long-term memory. Both of these components of working memory are limited in amount (Kane & Engle, 2003). Studies have shown that individuals with high working memory capacity perform better than those with lower working memory capacity on tasks such as reading comprehension (Daneman & Carpenter, 1980), vocabulary learning (Daneman & Green, 1986), and reasoning (Kyllonen & Christal, 1990).

Active Processing Assumption

The active processing assumption holds that individuals actively engage in cognitive processing to construct mental representations of their experiences. This occurs through attending to, organizing and integrating incoming information (Mayer, 1997, 2005). The active processing assumption views individuals as actively processing and interacting with incoming information. Similarly, active learning is said to occur when individuals apply three cognitive processes to incoming information in order to promote learning: selecting relevant pieces of information to be processed, organizing this information, and integrating this incoming information with prior knowledge by building connections (Mayer, 2005).

These three assumptions – dual-channel processing, limited capacity processing, and active processing – form the foundation of the Cognitive Theory of Multimedia Learning. They affect each other and should be viewed as a collective unit of variables that affect learning in multimedia environments. Together, these assumptions form the cognitive basis for multimedia learning that takes into account the amount of information, type of information, and active cognitive processing simultaneously at work within working memory. This foundation is important because it provides a starting point for decisions regarding how to design multimedia instruction.

The Cognitive Theory of Multimedia Learning incorporates several principles based on these three assumptions. These principles focus on how to design instruction in multimedia environments that take into account what is known about the cognitive processes and limitations of working memory, in order to promote meaningful learning.

Nine Principles of Multimedia Learning

The principles of multimedia learning are meant to guide instructional design within multimedia environments by creating a sound framework for instruction. They are grounded in empirical research and theoretical rationales based on working memory, cognitive load theory, and dual-coding theory. The nine principles include the modality principle, redundancy principle, contiguity principle, coherence principle, signaling principle, segmenting principle, personalization principle, voice principle, and individual differences principle. They are each grounded in research relating to learning and seek to improve recall and transfer in multimedia environments.

Modality Principle

The modality principle is based on the limited capacity assumption of the Cognitive Theory of Multimedia Learning and holds that presenting information in both visual and auditory modes can reduce cognitive load (Ginns, 2005; Mayer & Anderson, 1991). Specifically, the modality principle suggests that working memory capacity limitations may be better taken into account by dividing the cognitive load necessary to present material into both the visual and auditory channels. For example, it was found that providing visual diagrams with auditory narration in multimedia presentations lead to an increase in recall and transfer as compared to when a visual diagram was paired with on-screen text (Kalyuga, Chandler, & Sweller, 1999) In this case, the on-screen visual and text created significant cognitive load in the visual channel that was then alleviated when the on-screen text was translated into auditory narration. By creating a balance of incoming information between both channels the cognitive load of any one channel is reduced, thereby leading to better retention and transfer.

Redundancy Principle

The redundancy principle explains that redundant information interferes with learning. This occurs when multimedia presentations include visual information (e.g., pictures) with simultaneous and redundant on-screen text and narration (Moreno & Mayer, 2002). That is, if the on-screen text and auditory narration are the same, then they are redundant, and this redundancy will only add cognitive load to the instructional situation (Jamet & Le Bohec, 2007; Moreno & Mayer, 1999). Decreasing irrelevant redundant information reduces cognitive load, thereby increasing working memory's ability to process incoming information, which can lead to increased recall and transfer.

Contiguity Principle

The contiguity principle explains that individuals learn more deeply when animation and narration are presented simultaneously, rather than successively, and when on-screen text is placed close to their referents, rather than far away (e.g., at the bottom of the screen). The effectiveness of multimedia instruction increases when narration, on-screen text, and pictures are presented contiguously, in time and space, instead of isolated from one another (Mayer & Anderson, 1992). Meaningful learning occurs when connections are made between verbal and visual information, and these connections are more likely to occur if the information is in working memory at the same time.

Coherence Principle

The coherence principle explains that individuals learn more deeply from a multimedia message when extraneous material is excluded instead of included (Mayer, Heiser, & Lonns, 2001; Moreno & Mayer, 2000). Gemino, Parker, and Kutzschan (2006) found that when students studied a diagram with simultaneous narration the inclusion of an additional graphic that contained irrelevant information *decreased* recall and transfer while the inclusion of an additional graphic that contained relevant information *increased* recall and transfer. This finding supports the idea that instruction should avoid the inclusion of irrelevant information. The addition of irrelevant information can have a negative impact on learning because fewer cognitive resources are available for building connections between the relevant verbal and visual information.

Signaling Principle

The signaling principle explains that individuals learn more deeply from a multimedia message when cues are added that highlight key concepts and the organization of essential material (Mautone & Mayer, 2001; Loman & Mayer, 1983). Lorch and Lorch (1996) found that larger and more complex information benefited from organizational signaling in that recall and transfer was increased compared to nonsignaled information. Organizational signals included headings, topical overview, and topical summary. When signals or cues are presented that serve to focus attention on relevant information, an individual’s cognitive resources are able to function more efficiently, reducing cognitive load.

Segmenting Principle

The segmenting principle explains that individuals learn better when a multimedia message is presented in learner-paced segments instead of a continuous flow of information (Mayer & Chandler, 2001). Learner-paced segments refers to segments of multimedia instruction that stop and provide a "Continue" button that allows the student to decide when to resume the instruction. Studies have found that when individuals have control over the pace of presented information, connections between verbal and visual stimuli have an increased chance of being made (Aly, Elen, & Willems, 2005; Dalton, 1990).

Personalization Principle

The personalization principle explains that when individuals listen or read verbal information that is spoken or written in a conversational tone instead of a formal tone, the information is processed more deeply (Moreno & Mayer, 2000). Mayer, Fennel, Farmer, & Campbell (2004) found that simply by changing the word "the" to the word "your" in 12 locations within a 2-minute multimedia tutorial lead to an increase in problem solving transfer. This is thought to occur because personalized verbal representations can activate a social response in an individual, thus allowing the individual to view the multimedia technology as a social partner.

Voice Principle

The voice principle explains that individuals learn better when words are spoken in a standard-accent human voice instead of a machine voice or foreign-accent human voice (Atkinson, Mayer, & Merill, 2005). Mayer, Sobko, & Mautone (2003) found that transfer increased when a human voice was used instead of a computer generated voice or a voice with a foreign accent (i.e., a Russian accent for native English speakers). Both the personalization and voice principles focus on auditory information in multimedia environments, which differentiates them from the other seven principles, which can focus on both visual and auditory information.

Individual Differences Principle

The individual differences principle takes into account the individual differences among learners, specifically certain characteristics, such as special ability (Moreno & Mayer, 1999), prior knowledge (Ollerenshaw, Aidman, & Kidd, 1997) and working memory capacity (Doolittle, McCloud, Byrd, & Mariano, 2008). For example, individuals with more background knowledge and pre-existing schemas are better able to generate their own mental images as they interact with visual and/or verbal stimuli than individuals with minimal background knowledge, thus leading to an increase in recall and transfer (Cooper, Tindall-Ford, Chandler, & Sweller, 2001). Similar results were found by Mayer and Gallini (1990) who assessed students after engaging in a tutorial addressing how tire pumps work. Mayer and Gallini found that students with high prior knowledge of general mechanics performed better on transfer tests than students with low prior knowledge due to an increased ability to make connections to information.

The cognitive theory of multimedia learning seeks to explain how individuals can learn in a multimedia environment. The three assumptions and nine principles of multimedia learning provide guidelines regarding the development and design of multimedia instruction. The theory seeks to develop approaches to instructional design, which take into account information processing, in order to better understand human learning. This effectiveness of multimedia instruction has been measured by recall and transfer tests (Moreno & Mayer, 1999; Mautone & Mayer, 2001). Transfer is an important concept in the areas of learning and education because the goal of learning is to apply information to different situations and problems (Anderson, Reder, & Simon, 1996). The importance of knowledge transfer and the existing literature on transfer will be discussed in the next section.

Knowledge Transfer

Researchers in the area of learning have studied and supported the concept of transfer and its importance in academic settings for decades. Transfer can be described as the ability to apply or use knowledge from one problem, situation or context to another (Anderson, 2005). Edward Thorndike, a learning theorist in the early 1900s, developed the seminal "identical elements" theory of transfer. The identical elements theory of transfer states that the amount of transfer between familiar and unfamiliar situations is determined by the number of elements the situations have in common. Charles Osgood (1949) developed a theory of transfer based on behaviorist stimulus-response pairs. Osgood's theory states that when stimulus-response pairs are similar in two situations, positive transfer occurs; when stimuli are different but responses are the same in two situations, some degree of positive transfer will occur; and when stimuli are the same but responses are different in two situations, no transfer will occur. Anderson (Singley & Anderson, 1989), a cognitive psychologist, stated that transfer was the product of overlapping or shared elements or abstract knowledge structures between a learned task and a new task. Each of these three theories of transfer is based to some extent on Thorndike's original idea that transfer is based on some type of similarity between the original learning situation and the subsequent transfer situation. However, what constitutes "similarity" is still at issue. These theories, however, have helped bring the concept of transfer to light within both research and education. Within the field of education, a central goal is that information learned in the classroom will be applied to problems and situations outside of the classroom. Unfortunately, this goal is not always achieved and students are often unable to transfer information outside of the context in which it was originally learned (Detterman & Sternberg, 1993).

Types of Transfer

While the concept of transfer has evolved, researchers have constructed several types of transfer. These types of transfer can be divided along three dimensions; positive, negative and zero transfer; near and far transfer; and lateral and vertical transfer (Glick & Holyoak, 1987). Positive transfer occurs when knowledge learned in one situation benefits learning in a new situation. For example, when key words and phrases were signaled, using a slower, deeper tone in the narration of a multimedia tutorial, there was an increase in problem solving transfer (Mautone & Mayer, 2001). Negative transfer occurs when knowledge learned in one situation interferes or hinders learning in another situation. An example of this occurred when Mayer, Sobko, & Mautone (2003) found that problem solving transfer decreased when native-English speaking individuals listened and viewed a multimedia tutorial with a foreign accent narration. And finally, zero transfer occurs when learning in one situation has no effect on learning in another situation.

Near transfer, or specific transfer, refers to the transfer that occurs between two situations or tasks that are similar in both their superficial and underlying characteristics and principles. Far transfer, or general transfer, refers to transfer between two situations or tasks that are dissimilar in both their superficial and underlying characteristics. In a different vein, lateral transfer is said to occur when the transfer of knowledge or skills occurs between two tasks or skills that are of similar complexity. This was found when Lee, Plass, and Homer (2006) observed that individuals showed transfer between low complexity multimedia tutorials and low complexity problem solving transfer tasks requiring them to answer questions of similar concepts to the tutorial. And finally, vertical transfer refers to the transfer of knowledge or skills between a less complex task or skill, usually a pre-requisite skill, and a more complex task or skill. An example of this can be seen when a segmented and non-segmented multimedia tutorial found that individuals engaging in the segmented version of the tutorial prior to the non-segmented version were able to make connections between the segments at their own pace (Mayer & Chandler, 2001).

In light of this, it should be noted that positive/negative, near/far and lateral/vertical transfers can occur simultaneously as they all incorporate the transfer of knowledge among similar pieces on knowledge. Thus, if a student learns the cause of lightning and then successfully transfers this to a problem addressing how to reduce the likelihood of lightning, positive-near-lateral transfer will have occurred.

Fostering Transfer

The past century and a half of experimental research into knowledge transfer has yielded both the presence and absence of transfer across a variety of transfer tasks and approaches (see Detterman & Sternberg, 1993; Singley & Anderson, 1989). This presence and absence of transfer, however, has yielded some consistent findings that have produced several guidelines for the fostering of transfer. These guidelines indicate that transfer is fostered when (a) knowledge is learned to a deep and meaningful level; (b) metacognitive awareness and control are developed; (c) comprehension of underlying principles is cultivated, not simply the acquisition of facts; and (d) multiple examples are used during the learning process.

One way to foster knowledge transfer is to learn information deeply and meaningfully. Deep learning or conceptual learning can result in more significant transfer than rote learning (Brown & Kane, 1988). Students who thoroughly learn information will be better able to apply this knowledge to other tasks (Prawat, 1989). The idea of conceptual learning is that individuals develop solutions to problems within the context of relevant knowledge (Ohlsson & Rees, 1991). By actively engaging in the elaboration of the material, to build connections between ideas, deep processing of the information occurs, which can lead to an increase in transfer (Moreno & Mayer, 2001). If students are instructed that the notion of transfer exists, they can use deep processing techniques and metacognitive processes, such as creating broader schemas and broader contexts to solve problems (Fuchs et al., 2003).

A second way to foster transfer is by developing metacognitive awareness and control. Metacognition occurs when a person purposefully evaluates what one understands and does not understand about a presented fact, concept, or idea and intentionally manipulates learning strategies to correct errors and misunderstandings (Conner, 2007; Houtveen & van de Grift, 2007). By gaining a deeper understanding of information, through the use of metacognition as a tool to promote transfer, there will be a durability of the information, thereby increasing the likelihood of transfer (Georghiades, 2000). Wang (2001) suggests that the use of metacognitive strategies such as summarizing and structured questions can have a positive effect on knowledge transfer. Lin, Newby and Foster (1994) found that when students were asked to engage in metacognitve processing such as using self-reflection when responding to questions from a computer program, transfer increased. This aligns with Mayer’s (1993) findings that students engaging in metacognitive strategies learn information faster, understand it better, and retain the information longer.

A third way to foster transfer is by learning abstract principles, not only discrete facts. It has been found that transfer increases when students learn abstract and underlying principles, rather than discrete facts (Barnett & Ceci, 2002; Singley & Anderson, 1989). Novick (1988) studied the ability of experts and novices to transfer an underlying mathematical principle to novel problems. It was found that more negative transfer occurred for novices when problems shared surface features, but not structural features. This finding suggests that discrete facts did not lead to an increase in transfer. Similarly, Brown (1990) argued that in order for transfer to be flexible, a deeper understanding of the material must occur, and merely attending to surface features of information will not provide this deep level of understanding. Deeper structural meanings must be sought.

And a fourth way to foster transfer is by providing the learner with multiple examples. Development of deep learning is facilitated by engaging in multiple and varied examples, which increases the use of concepts and procedures in varied situations, thereby facilitating transfer (Engle, 2006; Schmidt & Bjork, 1992). Traditional problem solving strategies place a heavy cognitive load on working memory, however studying worked examples can lessen the cognitive load because it allows learners to focus attention on relevant information (Sweller, 1988). It was also found that novice learners or learners with less experience can benefit from studying worked examples compared with novice learners traditional problem solving strategies (Kalyuga, Chandler, Tuovinen, & Sweller, 2001).

All of these strategies encourage students to take a more active role in the learning process. Therefore, it becomes important to shift from the traditional view, that students are passive recipients of knowledge, empty vessels to be packed full of facts, to a view of students as active participants who are able to take responsibility for their own learning (Driver, 1989). More recently, the study of knowledge transfer has been given attention in light of an increase in multimedia learning research. Multimedia learning often uses transfer tests as a measure of whether or not learning has occurred.

Transfer within the Cognitive Theory of Multimedia Learning

Transfer is found throughout the multimedia learning literature as a dependent measure of whether or not learning has taken place. Specifically, current research on transfer in multimedia environments focuses on near, positive and lateral transfer that has taken place immediately after instruction. For example, Eilam & Poyas (2007) found that using multiple representations in the form of printed text and graphics led to an increase in transfer. Transfer, in this case was determined by asking a series of questions requiring learners to apply the presented information to a new, similar situation immediately after instruction. Multimedia learning research does not focus on knowledge transfer as an independent variable. Consequently, the fostering of transfer and the exploration of types of transfer has not been the focus of multimedia learning research.

Knowledge transfer in multimedia learning literature is often represented by how basic cause and effect knowledge can be transferred to similar situations and problems (Hummel, Paas & Koper, 2004; Mayer & Moreno, 1998). These cause and effect situations involve the use of animation and narration (i.e., concurrent visual animation and audio narration) in scenarios such as how a tire pump works, compared with animation or narration alone (Mayer & Anderson, 1991). It has consistently been found that individuals construct a more integrated mental model when animation and narration are provided concurrently, rather than animation or narration only (Fletcher & Tobias, 2005).

Knowledge transfer in multimedia learning research tends to be measured through a series of problem-solving transfer questions (Mayer, 1999; Mayer & Chandler, 2001). These questions are designed to measure near, lateral and positive transfer. The determining factor is whether or not learners are able to answer these questions. For example, Mayer, Moreno, Boire, and Vagge (1999, p. 639) had students watch a multimedia tutorial addressing the cause of lightning, followed by a recall question (i.e., write down an explanation of how lightning works) and four transfer questions: "What could you do to decrease the intensity of lightning?"; "Suppose you see clouds in the sky but not lightning. Why not?"; "What does air temperature have to do with lightening?"; and "What do electrical charges have to do with lightning?"

Multimedia learning research has focused not only on near, lateral, and positive transfer, but also immediate transfer; transfer that is measured immediately after the learning episode. This type of measurement, however, does not provide evidence of sustained and durable transfer. Would the learning tasks typically provided in the current multimedia learning literature (e.g., how lightning forms, how a car brake works, how human respiration works) result in far transfer; that is, transfer to a transfer task that is less similar to the learning task than the typical problem-solving transfer questions and/or a delayed transfer task? For example, the multimedia learning principle of segmentation has been studied and has been demonstrated to foster near and lateral transfer when assessed immediately. Would this principle also demonstrate deep, sustained, and durable learning as evidenced by delayed transfer?

The Segmenting Principle: In Depth

The segmenting principle explains that individuals learn more from multimedia tutorials when they are allowed to control the pace of the tutorial, instead of playing the tutorial from beginning to end in a continuous flow (Mayer & Chandler, 2001). The design of segmentation involves dividing a multimedia tutorial into segments or pieces. Each short 30-60 second segment ends with the presence of a "Continue" button that allows the learner to stop and consider the previous segment's content and to begin the next segment when ready. If the tutorial were to be played without stopping, from beginning to end, the learner may experience cognitive overload, which could impair learning. This overload occurs due to the limited capacity and processing limitations of working memory. If too much information is presented, exceeding the capacity of a learners working memory, then this information cannot be processed or learned (Mousavi, Low, & Sweller, 1995)

The use of segmentation, however, allows the individual to stop during the tutorial and process information before proceeding to the next segment. The strain on working memory can be reduced if information is broken into smaller chunks, or segments, making it easier to understand, organize and integrate into long-term memory (Mayer & Moreno, 2003). Segmentation allows learners to take a more active role in the learning process. Milheim (1990) studied the effect of learner control of pacing and sequencing and found learner control had a significant impact on recall. The traditional approach to multimedia presentations has been for individuals to view a tutorial in its entirety. When this approach was compared to learner controlled segments, it was found that individuals viewing learner controlled segments performed better on transfer tests (Mayer & Chandler, 2001). Lusk et al (2008) examined the effects of working memory capacity on learning from segmented and nonsegmented multimedia instruction. Segmentation was found to have a significant effect on recall and knowledge application.

Although segmentation has been studied and found to affect recall and transfer positively in multimedia learning environments, the question that remains, is whether the learning that occurs as a result of segmented instruction is sufficient to foster near transfer when it is measured both immediately and delayed.

Delayed Transfer

Current transfer tests within multimedia learning environments are typically given immediately after learning occurs. Historically, delayed periods have not been a primary focus. Glick and Holyoak (1987, p. 10) state that "studies of delayed transfer have been infrequent in contemporary work". However, when delayed transfer is studied, differences vary between immediate and delayed transfer groups, regardless of the length of the delay period. According to Salden, Paas and van Merrienboer (2006) "Another, more indirect, way to create better understanding of the underlying cognitive processes would be to administer a delayed transfer test sometime after the training is given". Moreno and Valez (2007) studied differences between participants who watched a video and students who read a narrative about the same topic. Participants were given a transfer test immediately after learning and four weeks later. It was found that although the mean score differences in the delay test were lower, there was not a significant difference. Fong and Nisbett (1991) studied statistical reasoning through the use of the law of large numbers. Participants were given transfer tests immediately after learning or a two-week delay period. They found that although transfer did decrease over the delayed period compared to the immediate transfer tests results, delayed transfer was still significant. They attributed this to participants' memory for a rule or law instead of memorizing the details of a problem. Foster and Macan (2002) studied the differences between immediate and delayed performance by instructing participants to replicate models built with Lego pieces. After watching a demonstration, participants were immediately instructed to replicate the model. One week later, they were again instructed to replicate the model, as well as count the pieces used and decide on the cost it would take to manufacture many of these products, known as giving attentional advice. Results found that attentional advice affected both groups, however, the difference between the groups was not reported. This occurs frequently throughout the literature. Phye (1989) studied immediate and delayed transfer using advice and feedback given during analogical reasoning problem solving. It was found that the combination of advice and feedback had a positive effect on transfer, however a comparison between the immediate and delayed groups was not discussed in depth and the length of the delay period was not reported. Schroth (2000) studied pretraining and its effect on immediate and delayed transfer, the delayed period being 7 days. It was found that pretraining did facilitate transfer for both groups, however no differences were reported for the delayed group. Delayed transfer has been used as a dependent variable, although differences between immediate and delayed groups, specific details regarding length of delay period, as well as differences among multiple delayed groups is often limited, or not compared. There is a paucity in the literature comparing results of immediate and delayed transfer groups, as well as studies using immediate and delayed transfer as independent variables. Therefore, differences between immediate and delayed transfer in multimedia environments has yet to be determined.

Research Questions

1) What are the effects of segmentation on recall and transfer in a multimedia instructional environment?

2) What are the effects of immediate and delayed assessment on recall and transfer in a multimedia instructional environment?

3) Are there interaction effects between segmentation and non-segmentation, and immediate and delayed assessment on recall and transfer in a multimedia instructional environment?

Method

Participants and Design

The participants in this study were 214 undergraduate students at a large research university in the Mid-Atlantic region of the U.S enrolled in a 1000-level non-majors personal health class who were provided course credit for participating. Participants were randomly assigned to one of the following groups: Segmentation or No Segmentation condition and an Immediate Transfer or Delayed Transfer condition (see Table 1). The experimental design of the proposed experiment was a 2 (immediate transfer, delayed transfer) X 2 (no segmentation, segmentation) factorial design.

Table 1

Experimental Design

		Transfer	
		Immediate	Delayed
Segmentation	No Segmentation		
	Segmentation		

Materials

The materials used in this study included a pre-experiment questionnaire, a recall test, a transfer test, and two versions of a multimedia tutorial addressing how a car's breaking system works. The pre-experiment questionnaire assessed the participants' general mechanical experience. The recall test assessed the participant's knowledge of how brakes work. The transfer test assessed the participant's level of knowledge transfer of how brakes work to questions relating to this content. The multimedia tutorial explained how car brakes work. The content for each study session was exactly the same, but delivered via a segmented or non-segmented multimedia tutorial. The study and the test sessions were administered on Apple laptop computers using Adobe Flash with the aid of standard over-the-head audio headphones. The instruction is based upon a unit of instruction originally developed by Moreno and Mayer (2000) addressing the function of car brakes. The assessment questions for the recall test and transfer test are verbatim from the Moreno and Mayer study.

Pre-experiment questionnaire

Prior to beginning the actual experiment participants were given a questionnaire to assess their knowledge of automobile mechanics and repair, as well as demographic information. The participants were given a six-item activity checklist and a five-item self-rating. The instructions for the six-item knowledge checklist explained that participants should "Place a check mark next to the things you have done" (Moreno & Mayer, 2000, p. 121). The six items are as follows:

- I have a driver's license
- I have put air into a tire on a car
- I have changed a tire on a car
- I have changed oil on a car
- I have changed spark plugs on a car
- I have replaced brake shoes on a car

In addition, a five item self-rating scale required the participants to rate their knowledge of car mechanics and repair on a five point scale from 1 = *very little* to 5 = *very much*. The instructions for the self-rating ask the participants to "Please put a check mark indicating your knowledge of car mechanics and repair" (Mayer & Moreno, 1998). The pre-assessment questionnaire score was calculated by giving a point for each domain-related activity the participant checked from the checklist and adding that number to the number indicated by the participant in the self-rating scale. The maximum score a participant could receive on the pre-assessment questionnaire was 11. Only participants with low experience in car mechanics and repair indicated by a score of 5 or less were included in this study.

Recall Assessment

The recall assessment consisted of the question, "Please write an explanation of how a car's breaking system works." Participants were given 10 minutes to complete this assessment. This was the same question used in the Moreno and Mayer (2000) study.

Transfer Assessment

The transfer assessment consisted of the same four questions used in the Moreno and Mayer (2000) study and are as follows:

1. What could be done to make them more reliable, that is, to make sure they would not fail?
2. What could be done to make brakes more effective, that is, to reduce the distance needed to bring a car to a stop?
3. Suppose that you press on the brake pedal in your car but the brakes don't work? What could have gone wrong?
4. What happens when you pump the brakes (i.e., press the pedal and release the pedal repeatedly and rapidly)?

The transfer test was given to participant's either immediately after viewing the tutorial or after a delayed period of one week. Participants were given 20 minutes to complete all four transfer questions.

Multimedia tutorial

The computer based materials consisted of two versions of a multimedia tutorial on how car brakes function created using Adobe Flash animation. Both versions of the tutorial consist of a 60 second tutorial in which the animation demonstrates how car breaks function. The animation consisted of drawings of a foot pressing a brake pedal, a piston moving inside a master cylinder, brake fluid being pushed out of the master cylinder and expanding smaller pistons in the wheel cylinder, and the smaller pistons pushing the brake shoes against the brake drum. The segmented version was broken into three 20 second segments, whereas the non-segmented version will run continuously for 60 seconds. (see Appendix A) The segmented version has a "Continue" button on the screen, which the participant selects at the end of each segment of the tutorial, in order to move onto the next segment.

Procedure

Undergraduates taking an introductory personal health course were solicited to take part in the study. Participants who were interested were required to go to a website and register for the study. The compensation for participating in the study was 15% of the participants' final course grade for the personal health course. Participants who chose not to participate in the study were given the option of a weight change project worth 15% of the their final course grade. As part of the registration for the study, participants provided demographic information, take a pre-experiment questionnaire, and schedule a time to participate in the study. Prior to the registration process and the actual study, the protocol was approved by the university in accordance with the institution's Institutional Review Board (IRB) that governs all research conducted using human subjects.

As part of the online registration all participants were asked to read an electronic informed consent form which provided general information about the study- purpose of the study, procedures, risks, contact information, confidentiality statement, and disclaimer that participation in the study is voluntary. The participants selected if they agreed or disagreed to take part in the study. Participants that agree to take part in the study were automatically sent a copy of the Informed Consent form by e-mail and proceeded to the participant questionnaire section.

The first section, the participant questionnaire, consisted of general demographic information (i.e., e-mail, age, gender, academic classification, ethnicity and major). After participants completed the demographic information, they were given basic instructions for the second section, the pre-experiment questionnaire. Participants were asked to place a check mark next to the items that applyed to their knowledge of car mechanics (i.e., the six-item checklist) and place a check mark indicating their knowledge of car mechanics (i.e., five-item self-assessment). Once the online pre-experiment questionnaire was completed, the six-item knowledge checklist and five-item self-assessment scores were calculated and stored in a database along with the demographic information. The third section, the scheduling page, was designed for the participants to schedule a time to come into the computer lab to participate in the study. Once the participants submitted their schedule, the registration process was complete. The participants received an email confirmation that includes the date and time that they had selected and further details regarding the study.

Upon arrival at the computer lab, each participant was asked by the experimenter to sit at an available computer workstation. Participants were tested individually in groups of one to ten per session. Once all of the participants had arrived the session began. First, the experimenter presented oral instructions regarding the procedures for the study. The experimenter then explained that the study will take approximately 30 to 45 minutes to complete. After the oral presentation of instructions, the participants were provided with an opportunity to ask questions.

Second, the participants were asked to login using the user information that they used during the registration process. Once the participants had logged in successfully, they were given on-screen instructions to wait for the experimenter before proceeding. After the experimenter confirmed that all participants have successfully logged in, the experimenter informed the participants that they should click the “Continue” button to begin the first part of the study.

Third, the participants were directed to the on-screen instructions for the unit on “how a car’s breaking system works” and were prompted to put on headphones. The participants then clicked “Continue” when they were ready to proceed. The participants in the non-segmented instructional group were presented with a 60 second tutorial with no opportunity to stop, pause, advance, or rewind. Participants in the segmented instructional group were presented with a 60 second tutorial broken into three 20 second segments. At the end of each segment a “Continue” button appeared at the bottom of the screen. Once all participants complete the tutorial, they were instructed to click “Continue” to proceed to the assessment starting with the recall question followed by the four transfer questions.

Following the tutorial, the recall question appeared “Please write down an explanation of how a car’s braking system works”. A text box appeared and the participants were asked to type their response. Participants were given 10 minutes to complete the recall test.

Once the experimenter acknowledges that all participants had completed the recall questions, they were verbally instructed to click the “Continue” button to proceed to the next section. This section consisted of the four transfer questions. Following each of the four questions a text box appeared and the participant were asked to type in the appropriate response. Once the participant completed the fourth question, they were instructed to click a “Continue” button to proceed. The transfer test that each participant completed depended on whether they were in the immediate transfer group or delayed transfer group. The immediate transfer group answered four transfer questions related to how brakes work immediately following the brakes tutorial. The delayed transfer group answered four questions related to the cause of lightening. In a second session, one week later, the delayed transfer group took a transfer test consisting of the four transfer questions relating to how car brakes work, while the immediate transfer group answered the four questions related to the cause of lightening (see Table 2). The final screen of each session thanked participants for participating in the study. The experimenter also verbally thanked the participants for participating in the study and dismissed the participants.

Table 2

Assessment Schedule

	Week 1	Week 2
Immediate	Recall and Transfer Test – Brakes	Recall and Transfer Test – Lightning
Delayed	Recall and Transfer Test – Lightning	Recall and Transfer Test – Brakes

Scoring

Recall test. Two trained scorers were used to score the recall test. The recall test was scored by adding the number of idea units from the narration, out of a possible eight, although the wording did not have to be specific, just the main idea. One point was given for each of the following idea units: “(a) driver steps on brake pedal, (b) piston moves forward inside master cylinder, (c) piston forces brake fluid out to the wheel cylinders, (d) fluid pressure increase in wheel cylinders, (e), small pistons move, (f) small pistons activate brake shoes, (g) brake shoes press against drum, and (h) drum and wheel stop or slow down” (Moreno & Mayer, 2000, p. 122).

Transfer test. Two trained scorers were also used for the transfer test. The transfer test was scored by adding the number of acceptable answers for the four questions. Acceptable answers were determined by those established by Moreno and Mayer (2000). Acceptable answers for the first transfer question, “What could be done to make them more reliable, that is, to make sure they would not fail?” included adding a backup system or adding a cooling system; acceptable answers for the second transfer question, “What could be done to make brakes more effective, that is, reduce the distance needed to bring a car to a stop?” included using more friction sensitive break shoes friction or reducing the distance between brake shoe and brake pad; acceptable answers to the third transfer question, “Suppose you press on the brake pedal in your car but the brakes do not work. What could have gone wrong?” included that there may be a leak in the brake fluid line or a piston stuck in one position; and finally, acceptable answers to the fourth question “What happens when you pump the breaks?” included reducing heat or preventing the pad from becoming worn in one spot. The two scorers determined whether the response to the questions were within the acceptable answer range or unacceptable. Inter-rater reliability was determined using a Pearson's *r* correlation.

Results

This experiment was designed to (a) validate the effects of segmentation on recall and transfer in a multimedia learning environment (Moreno & Mayer, 2000; Mayer, Moreno, Boire, & Vagge, 1999; Mayer & Moreno, 1998); (b) evaluate the effects of segmentation on immediate and delayed recall and transfer; and (c) evaluate whether interactions effects occur between segmentation and transfer. These questions were analyzed using two 2 (non-segmentation, segmentation) X 2 (immediate recall & transfer, delayed recall & transfer) ANOVAs using the recall and transfer data. All pairwise comparisons used an alpha criterion of 0.05 and all effect size calculations involved Cohen's *d* (Cohen, 1998). Cohen's *d* effect sizes are interpreted as small, $d = 0.2$, medium, $d = 0.5$, and large, $d = 0.8$.

Analysis of the Segmentation Effect on Recall and Transfer

The first research question was what are the effects of segmentation on recall and transfer in a multimedia environment. According to the segmentation principle of the cognitive theory of multimedia learning (Mayer, 2005), students who engage in segmented multimedia tutorials should achieve significantly higher on recall and transfer assessments than students who engage in non-segmented multimedia tutorials. The segmentation principle was not confirmed for recall (see Table 3), resulting in no statistically significant main effect for the segmented group, $F(1, 210) = .96$, $p = .33$. Similarly, the segmented group showed no statistically significant main effect for transfer, $F(1, 210) = .16$, $p = .69$. These results are inconsistent with the predictions of the segmentation principle within the cognitive theory of multimedia learning.

Table 3

Means and Standard Deviations for Recall and Transfer Scores for Non-Segmented and Segmented Instruction

	Recall		Transfer	
	M	*SD*	*M*	*SD*
Non-Segmented	3.56	1.73	2.59	1.43
Segmented	3.29	1.62	2.48	1.28

Note. Max recall score = 8 Max transfer score = 8
* p < .05

Analysis of Immediate and Delayed Assessment of Recall and Transfer

The second research question was what are the effects of immediate and delayed assessment on recall and transfer in a multimedia environment. There was no statistically significant difference between segmented groups on immediate and delayed recall and transfer assessments. However, there were differences between the segmented and non-segmented groups on immediate and delayed recall and transfer assessments. There was a significant difference on recall between the immediate and delayed assessment groups (see Table 4), resulting in a significant main effect for the non-segmented group, $F(1, 210) = 20.53$, $p = .00$: $d = .64$. Similarly, there was a statistically significant main effect for immediate and delayed assessment on transfer for the non-segmented group, $F(1, 210) = 21.45$, $p = .00$: $d = .65$. These results demonstrated that statistically significant differences occurred between immediate and delayed recall and transfer groups.

Table 4

Means and Standard Deviations for Recall and Transfer Scores for Immediate and Delayed Assessment

	Recall		Transfer	
	M	*SD*	*M*	*SD*
Immediate	3.93	1.73	2.95	1.25
Delayed	2.89	1.46	2.10	1.34

Note. Max recall score = 8 Max transfer score = 8
* p < .05

Analysis of Interaction Effect

The third research question addressed whether non-segmentation and segmentation had differential effects on immediate and delayed transfer; that is, if there are any interaction effects between the groups (see Table 5). No interaction effect was found for recall, $F(1, 210) = 2.46$, $p = .12$. Similarly, no interaction effect was found for transfer, $F(1, 210) = 1.21$, $p = .27$.

Table 5

Means and Standard Deviations for the Interaction Between Segmentation and Immediate/Delayed Assessment

	Recall				Transfer			
	Non-Segmented		Segmented		Non-Segmented		Segmented	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Immediate	4.17	1.72	3.61	1.72	3.06	1.27	2.80	1.24
Delayed	2.83	1.46	2.96	1.47	2.04	1.43	2.16	1.26

Discussion

The goal of this research was to add to the literature on multimedia learning by determining the effects of segmentation on immediate and delayed recall and transfer in a multimedia learning environment. The study utilized a multimedia tutorial to provide instruction on how car brakes work and was based on the segmentation principle of the cognitive theory of multimedia learning (Mayer, 2005).

The effects of segmentation were measured by immediate and delayed recall and transfer assessments. Participants were assessed on their ability to both remember and apply information from the tutorial to answer recall and transfer questions. Specifically, the independent variables of segmentation, non-segmentation, immediate and delayed transfer were manipulated to assess the effects of segmentation on the participants ability to recall and transfer information regarding how brakes work during periods of immediate and delayed assessment.

The following discussion of the findings and conclusions is based on results from statistical analyses reported in this study. The section on extending the findings is grounded in the segmenting principle, cognitive theory of multimedia learning, transfer literature and the evidence presented in the results of the present study and other research findings (Mayer & Chandler, 2001; Mayer & Moreno, 2003; Aly, Elen, & Willems, 2005; Hasler, Kersten, & Sweller, 2007; Moreno, 2007; Moreno & Valez, 2007; Lusk, et al, 2008) regarding the segmenting principle and recall and transfer in multimedia learning environments.

Findings and Conclusions

The first research question sought to investigate the effects of segmentation on recall and transfer in a multimedia learning environment. The recall and transfer assessments revealed that segmentation did not significantly effect recall and transfer. The segmentation effects analysis showed that there were no significant differences on recall and transfer test scores between participants who viewed segmented or non-segmented multimedia tutorials. To be more precise, participants who viewed a segmented tutorial did not score significantly higher on recall and transfer assessments when compared to participants who viewed non-segmented tutorials. Based on these findings, it can be determined that segmentation of this multimedia tutorial did not significantly help or hinder learning.

The second research question sought to investigate the effects of immediate and delayed assessment on recall and transfer in a multimedia environment. The recall and transfer assessments revealed that immediate and delayed assessment did significantly effect recall and transfer. The analysis revealed that there were significant differences between participants who took the recall and transfer assessments immediately after viewing the tutorial and participants who took the recall and transfer assessments after a delayed period of one week. To further explain, participants who viewed the tutorial and immediately took the recall and transfer assessments scored significantly higher than participants who took the recall and transfer assessments one week after viewing the tutorial. Based on these findings, it can be determined that the time at which the assessments were taken (either immediately after viewing the tutorial or one week after viewing the tutorial) had a significant effect on participants ability to remember and apply information.

The third research question sought to investigate whether interaction effects occurred between segmentation and transfer. There were no interaction effects between the segmented or non-segmented groups and the immediate or delayed transfer groups. Specifically, the transfer tests scores of participants who took the transfer assessment either immediately or one week (delayed) after viewing the tutorial were not affected by whether the tutorials were segmented or non-segmented. Based on these findings, it can be determined that segmentation and immediate and delayed transfer were not significantly related.

In summary, the results of the present study yielded two main findings. First, segmentation of multimedia tutorials did not result in significant differences in recall or transfer. Secondly, the time period between when a tutorial was viewed and when the recall and transfer assessments were taken did significantly affect participants ability to recall and transfer information presented in the tutorial.

Extending the Results

The first goal of this study was to determine if segmentation had an effect on recall and transfer. The segmenting principle within the cognitive theory of multimedia learning states that segmenting information in a multimedia environment can reduce cognitive overload on working memory (Mayer, 2005). It is assumed within the cognitive theory of multimedia learning, that individuals who view segmented tutorials will be better able to recall and transfer this information compared to individuals who view non-segmented tutorials. The results of this study did not support this assumption.

This study found evidence that segmentation did not significantly affect immediate or delayed recall and transfer. These results are similar to previous findings in which segmentation’s effect on recall and transfer was inconsistent (Mayer & Chandler, 2001; Mayer &

Moreno, 2003; Aly, Elen, & Willems, 2005; Hasler, Kersten, & Sweller, 2007). Some research in the area of multimedia learning has supported the segmenting principle (Mayer & Moreno, 2003; Moreno, 2007; Lusk, et al, 2008). However, effects of segmentation have not always been found. A study by Mayer & Chandler (2001) found that segmentation increased transfer, but not recall. Similarly, Hasler, Kersten, & Sweller, (2007) found that significant differences for segmentation groups only occurred in questions that were considered more difficult (high cognitive load). The results of this study, along with other findings (Mayer & Chandler, 2001; Hasler, Kertsen, & Sweller, 2007) support the concept that segmentation used in short (60 second) multimedia tutorials do in significantly increase recall and transfer. The segmentation principle appears to be applicable in longer length tutorials.

The second goal of this study was to determine the effects of immediate and delayed assessment on recall and transfer. Mayer's studies use transfer as a dependent variable and focused on immediate transfer (Moreno & Mayer, 2000; Mayer & Chandler, 2001; Mayer & Moreno, 2003). The present study differed from Mayer's studies and other multimedia studies in that transfer was an independent variable. This study differs from previous studies because different levels of transfer, both immediate and delayed were explored. Previous studies focused only on immediate transfer.

The independent variables of segmentation, non-segmentation and immediate and delayed assessments were investigated to determine their effects on recall and transfer. The prediction of the second research question was that immediate and delayed assessment would affect recall and transfer. This prediction was grounded in the literature regarding the limitations of working memory, cognitive load theory and individual differences principle within the cognitive theory of multimedia learning. The results of this study did support this prediction, revealing differences between immediate and delayed assessment.

The present study found evidence that students performed better on immediate transfer assessments than delayed transfer assessments. This finding is important because research studying differences between immediate and delayed transfer in multimedia learning environments are rare. Research in the area of delayed transfer has been rare and inconsistent. Moreno and Valez (2007) found no significant differences between immediate and four week delayed transfer groups, when used as a dependent variable. However, Fong & Nisbett (1991) found that transfer did decrease over a delayed period of two weeks. However, because the study looked at the differences between abstract learning and memorization, theories as to why the delayed transfer decrease compared to immediate transfer was not a focus. This has been a trend in the area of transfer. Because transfer is often used as a dependent variable, and studied immediately after learning occurs, studies specifically focusing on why and how transfer decreases over delay periods have been few in number. This may be due to difficulties involved in studying assessments over delayed periods, such as: participant attrition; maturation effects; along with difficult decisions of just what length of delayed period should be assessed.

In summary, the findings of the present study were consistent with previous research. Segmentation effects have been found to occur in multimedia learning environments, but not with consistency. This study found that segmentation had no effect on transfer and recall. This was consistent with previous findings, which suggest that variables such as length of segments (Hasler, Kersten, & Sweller, 2007) and type of tutorial, such as cause-and-effect (Mayer, 2005), may play a role in segmentation's effect on learning. Therefore, segmentation effects appear to be significant for longer length multimedia tutorials, but not significant for short duration (60 second) multimedia tutorials. This study also found that recall and transfer decreased over a delay period. This was not surprising because memory is believed to decay over time. However, because delayed transfer was assessed only one time, after a week, it is not known how a longer delayed period would compare to these findings.

Implications for Future Research or Theory

Previous research on the cognitive theory of multimedia learning environments and the results of the present study have raised many questions regarding segmentation and transfer in multimedia learning environments. Although this study did use segmentation within multimedia tutorials, the length these tutorials may have played an important role in the results. Both the segmented and non-segmented tutorials were 60 seconds in length and no segmentation effect was found. If the length of the tutorials were increased, then findings with regard to the segmentation effect may vary.

Although a delayed period of one week was used in this study, more research involving longer delayed periods will be important to help determine the effects of segmentation on delayed transfer. Studying how transfer is affected over varying delayed periods can help increase our understanding of not only memory, but also how the transfer of knowledge changes over periods of time.

Although the present study did find an effect for segmentation on recall and transfer, segmentation is an area of multimedia learning that must be further investigated. By better understanding how segmentation of information affects recall and transfer, instruction can be designed to create environments that promote learning by having a positive impact on recall and transfer.

Limitations

The present study did face some limitations. First, the multimedia tutorial on how car brakes work is short in length and is a cause-and-effect lesson. A tutorial longer in length or a tutorial presenting information that is not primarily cause-and-effect may produce different results relating to the segmentation principle and recall and transfer assessments. Second, the delayed period was one week. Studies using delayed periods of varying length may see different results on recall and transfer assessments. Third, the transfer assessments consisted of four questions. Transfer assessments consisting of more questions may produce different results. Finally, the participants within the study were given extra credit for participation. If the information in the tutorial is related to participants coursework and directly related to a course grade, then the information may be more relevant and meaningful to the participants, resulting in different results.

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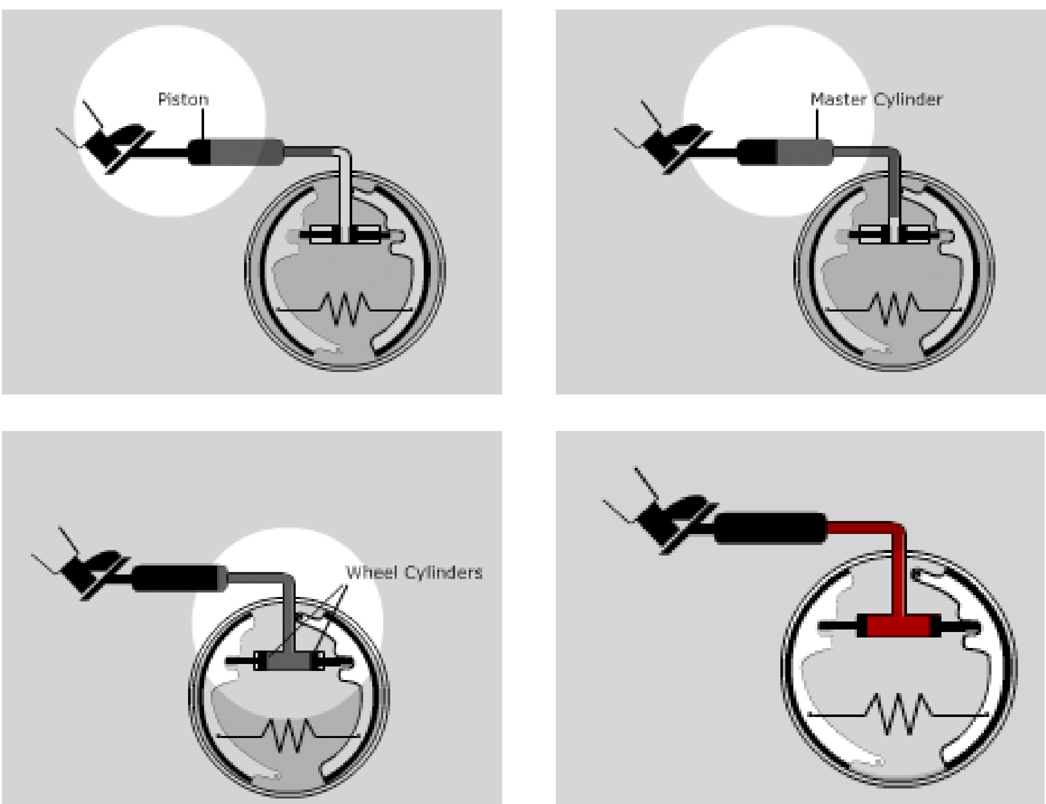
Appendix A

Verbal and Pictorial Content for Multimedia Animation

Verbal Content: How does a car brake work?

When the driver steps on the car’s brake pedal, a piston moves forward inside the master cylinder. The piston forces brake fluid out of the masters cylinder and through the tubes of the wheel cylinders. In the wheel cylinders, the increase in fluid pressure, makes a set of smaller pistons move. These smaller pistons activate the brake shoes. When the brake shoes press against the drum, both the drum and the wheel stop or slow down. (Mayer & Anderson, 1992, p. 446)

Pictorial Content: How does a car brake work?



(Sample Animation Screen Captures)