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A study of the limited capacity model: the effect of cognitive fatigue on memory while viewing video

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ABSTRACT

This study used the limited capacity model in an experimental design to test the effects of cognitive fatigue on memory for watching a video. A treatment and control group was each shown the same 19-minute video, with the treatment group verbally instructed to remember all they could about the video. The control group was told simply to watch the video. The study hypothesized the treatment group's overall memory for the video would be better than the control group, but the treatment group's memory would decline as cognitive fatigue hindered the memory process for information found in the last part of the video. Results indicated that the treatment group scored slightly but not significantly higher overall in the true-false memory test, and both groups suffered a decline in memory.

INTRODUCTION

Since the 1980s when they first started to become popular for home entertainment, VCRs have also become a valuable classroom tool. Less expensive to purchase and maintain than film, videocassettes provide teachers with a visual and aural supplement to their lesson plans. In the past decade, video use among college faculty has increased while the cost of VCRs and televisions has decreased, and studies on media usage have reported an increase in the classroom use of VCRs and videos (Houston 2000). With the quickly emerging technology of DVDs, the quality, durability, and interactive qualities will bring a higher potential for instruction and learning through video (Crawford 1999).

With the increasing use of video as an instructional tool, it will continue to be important that it be used effectively. Teaching methods have even been modified to more efficiently incorporate visual media into the classroom. "Active learning" is a method of teaching that promotes student interaction, discussion, and engagement outside of traditional lecture. It also suggests video should be coupled with opportunities for student response and as a focal point for teaching interactive techniques such as laboratory work (Bonwell & Eison 1991).

Teachers need to make sure they are using video to its potential. That is why research of individual-level processing of televised images is important. Learning how we watch videos may lead to better techniques for teaching with video. Attention, processing, and memory are three important stages of comprehending a moving image (Basil 1994). This study focuses on students' memory for watching classroom video and looks at whether verbal instructions have the capability of increasing viewers' memory for information found in the video.

This study concerns the individual's mode of processing when watching the video, specifically determined by the verbal instructions given to students before they watch. This is similar to priming theory, which has its origin in cognitive psychology. Priming theory is based on "priming," a general cognitive process. This process suggests that certain ideas and concepts are stored as a node in a network. This network leads to related ideas or concepts. "Priming" occurs when a node is activated by an external stimulus. "The activated node may function as a filter, an interpretive framework, or a premise for further information processing or judgement formation" (Pan & Kosicki 1997, 9). Pan and Kosicki applied this theory to the mass media and public opinion of President George Bush, Sr. They found a priming effect in the media, which associated Bush's approval rating based on media coverage of the Gulf War and the poor economy. While priming may work at a subconscious level of associating two or more ideas or concepts, this study looks at a more direct, conscious approach to viewer's processing of a television message.

For the purpose of this study, the limited capacity model was applied. This model was chosen because it attempts to explain what happens when we absorb information as we attend to a medium. This model suggests that as students watch a video, they will have only a finite capacity to attend to, process, and remember the information (Lang 2000). This study attempts to ascertain whether verbal cues or instructions given to students before they watch a video have any affect on the students' memory of the video content.

This study has both practical and theoretical value. Conclusions from this study may be directly applied to how videos are shown in the classroom. If verbal instructions toward watching a video have an effect on students' memory, it may yield a new technique for instruction. Findings could be applied not only to the traditional classroom, but also to instruction within job environments where videos are used for training. Results could also have implications for advertisers or any other organizations that depend on viewers' memory for a given message.

Theoretically, results will add to the literature on the limited capacity model and video. Previous limited capacity model studies have looked at the effect of changes in the medium itself on processing. Lange et al. (1993) studied the effects of related and unrelated cuts on viewers' attention, processing capacity, and memory. Reeves and Thorson (1986) looked at the effects on attention and memory based on a number of variables including stimulus duration, stimulus complexity, and stimulus content. Lange et al. (2000) used the limited capacity theory to look at the effect of a video's rate of edits on physiological arousal, self-reported arousal, and memory.

These studies focus on the medium itself as the manipulated variable while measuring for memory, processing, attention, or arousal. Basil (1994) varied from this by looking at viewers' processing of audio and video channels according to not only the amount of information, but also viewers' instructed focus. Whereas Basil studied the effect of instructed focus on viewers' attention, this study will focus on viewers' memory.

LITERATURE REVIEW

The limited capacity model states that people have a limited number of resources they can allocate to watching television (Lang 2000). When these resources are depleted, memory for the viewed program decreases. Theoretically, viewers can allocate more resources to a program if the program is complex or if they believe they will be tested on program content. Therefore, depending on what the viewers' goals for watching are, different levels of processing occur. Different levels of processing could result in different levels of memory from the message viewed.

In 1995, Lang studied the effect of emotional arousal and valence (how positive or negative a message is) on memory. Results showed that when valence was controlled, emotionally arousing messages were recalled better than calm ones. When arousal was controlled, positive messages were remembered better than negative ones. Results also indicated that capacity allocation is a function of valence and arousal. Viewers allocated the most capacity to positive arousing messages and the least to negative arousing messages (Lang et. al 1995).

Similarly, the limited capacity model has been applied and supported in the field of psychology. Martens, Wolters, and van Raamsdonk (2002) showed when two words are presented in succession within 500 ms, subjects often miss the second word. Researchers call this "attentional blink," which reflects a limited capacity in attention to incoming information.

Another attentional blink study concluded that subjects couldn't easily ignore distractors presented within the attentional blink, despite subjects anticipating a future target display. This supports the notion that attentional resources are required for visual marking (Olivers & Humphreys 2002).

A 2002 study used the limited-capacity information processing perspective to analyze attention of computer users. Structural features such as text style (plain, boxed), warnings, and animated or non-animated banner ads were measured for their ability to elicit slowing of the heart rate, or cardiac orienting. Results suggested only warnings and animated ads had effect on orienting behavior (Lang, Borse, Wise & David 2002).

Giesbrecht, Dixon and Kingstone (2001) experimented with limited-capacity processing mechanisms as applied to cued shifts of visual attention and rapid encoding of visual information. In the study, subjects participated in a dual-task paradigm. One task was a simple visual discrimination task, the second a partial-report task. Supporting the limited capacity model, task two accuracy declined as the temporal overlap between the two tasks increased. The observed interference of the two tasks resembled a processing bottleneck.

Several authors have applied limited capacity to communications. However, the literature applying it to TV memory is still narrow. An in-depth look at the framework of the limited capacity model and its application to television memory follows.

Limited capacity model and communication

The limited capacity model is an information-processing model. Its goal is to help explain how people process mediated messages. The model has two major assumptions. The first is that people are information processors. People perceive sensory information, turn them into mental representations, do cognitive work on these representations, and reproduce the work later in the same or altered form (Lang 2000).

The second assumption is that one's ability to process information is limited. The model proposes that an individual's pool of resources is limited and perhaps fixed. One may attempt to listen to the radio, watch television, and read a book at the same time, but resources to do so will become overloaded, and cognitive performance will suffer.

In this model there are three subprocesses that occur during information processing: encoding, storage, and retrieval. The processes are simultaneous and continuous (Lang 2000).

Encoding is the work of getting the message out of the medium (i.e. television, radio, book) and into the brain. This step is comparable to exposure, but more complicated than simply attending to a message. There are three subprocesses in encoding: perception, momentary sensory store, and selection. Perception is the act of physically seeing or hearing the information. Sensory store is the temporary retention of this information in our brain, registering it in our senses. Selection is the passive or active process of deciding, out of all the information one has just perceived, what is valuable and encoded for further processing. Only a fraction of the information moves from the sensory store, which holds all information exposed to, in to the short term or active memory. The third step, selection, can be controlled-selection, which reflects the viewer's goals (e.g., watching a television show to see a favorite actor), or it can be automatic selection, which is unconscious and activated by a stimulus. Stimuli can be "information that is relevant to the goals and needs of the individual," such as a goal to make sense of a program, or it can be "information that represents change or an unexpected occurrence in the environment" (i.e., novelty) (Lang 2000, 49).

Encoding, therefore, does not produce a one-to-one correspondence between the mental representation and the original message. The encoded message is not an exact replica, but rather a distinct representation constructed by the viewer. Furthermore, it only contains a small fraction of the total information contained in the original message. (Lang 2000)

Storage is a second subprocess in information processing. This model uses a general associative network model of memory, which means memories are connected to other related memories by associations. When a memory is in use, it is considered active. This is similar to schema theory (Graber 1984). Schema theory states that to process information, people use a "schema," which is a "cognitive structure consisting of organized knowledge about situations and individuals that has been abstracted from prior experiences" (Graber 1984, 23). Schemas help people deal with complex and new information by analyzing it in terms of existing knowledge. It is described as "active-strategic," whereas one actively seeks information and strategically process that information based on previously formed schemas (Housel & Acker 1981, 23).

Schema theory is also based on the notion of limited capacity according to Graber (1984). "People are 'cognitive misers' whose limited capacity for dealing with information forces them to practice 'cognitive economies' by forming simplified mental models … about the world" (Graber 1984, 24).

While schema theory focuses more on categorizing information based on content to help evaluate new information, fill in gaps of missing information, using schema to solve problems, or determining what information will be processed, the limited capacity model focuses on the idea that people can only process a certain amount of information at a time before their cognition reaches its capacity (Graber 1984).

According to Lang (2000), the limited capacity model does not draw a major difference between short- and long-term memory. "Short-term or working memory is conceptualized as activated memories within the larger inactive (or long-term) memory" (Lang 2000, 49).

During encoding, the mental representation of the message is constructed in working memory. The newly encoded "message information" is activated but has links only with the other information concurrently active in short-term memory. The more the person thinks about the message, the more associations between the "new" information and the old information are formed. The more links, the better the information is stored. Storage is the process of linking newly encoded information to previously encoded information (Lang 2000).

The process of reactivating a stored mental representation is the final subprocess, retrieval. Lang (2000) states, "retrieval is the process of searching the associative memory network for a specific piece of information and reactivating it in working memory" (p. 50). The greater number of associative links to a piece of information, the more thoroughly it has been stored, and the more readily retrievable it is (Lang 2000).

Not only can retrieval occur hours, days, or weeks after we view the message, but retrieval is also an ongoing process as we view the message. We retrieve relevant information from memory in order to comprehend new information. Therefore, retrieval plays a role in the storage process as well, affecting the activation of old and new information.

Lang (2000) goes on to state that "how thoroughly a subprocess is performed and how many resources are allocated to the subprocess affect the likelihood that subsequent or concurrent subprocesses will be performed thoroughly. Memory for a message is, therefore, a composite of the outcome of all three subprocesses" (p.50). In other words, if one of the first two processes is hindered, memory will suffer because it is not properly stored.

What happens when we watch TV

There are two features of television that affect ability to process the information within: content and structure. Content is what the program is about or has in it, such as sports, news, violence, or comedy. Structure is the more technical information contained within the program, such as edits, music, sound effects, narrative structure, zooms, pans, graphics, color, or pacing. Both content and structure influence our ability to allocate resources. A program can be structurally complex with many cuts and sound effects, or it can have complicated dialogue or story. The three subprocesses, encoding, storage, and retrieval will now be applied to television viewing. Studies examining these effects will then be presented.

Encoding

People are continuously encoding information. While watching television, information that is most likely to be encoded into memory is what is relevant to the goals of the individual, novel, unexpected, new, or arousing. When one views or hears something unexpected, relevant to his or her goals, novel, new or arousing, an orienting response occurs. An orienting response is a physiological and behavioral response to a signal or novel stimuli. "When an orienting response occurs, the viewer orients his or her sensory receptors toward the stimulus that caused the response, and an organized set of physiological responses accompanies this behavioral response" (Lang 2000, 52). One physiological response used by researchers to identify an orienting response is the slowing of the heart. Communication scholars use heart rate to measure attention or interest in a certain message. As attention occurs, the heart slows down. On the other hand, emotional images cause an increased heart rate. This phenomenon has been successfully demonstrated in the research setting by Lang (1990) and Thorson and Lang (1992). Orienting response, cueing a decreased heart rate, is an involuntary response to changes in the environment. "The orienting response is primarily an adaptive survival response. It functions to alert a person to change in the environment that may require a response" (Lang et al. 1993, 5).

As heart rate slows due to an orienting response, says Lang, the number of processing resources to the task of encoding increases. The orienting response is a sort of "attention-getter," so when the viewer is oriented to the message, the viewer is interested in processing and comprehending the message. Theoretically the viewer will allocate more resources to this goal in so far as he or she has sufficient available resources. For example, for viewers consciously paying attention to their favorite actor in a certain program, the actor would be the signal stimulus. Whenever the actor appears, viewers will orient themselves to the actor, additional resources will be allocated to encoding the actor, and the viewers will encode more information about the actor than viewers who have not made this strategic choice.

Storage

Storage, as mentioned earlier, is determined by both automatic and controlled responses. This model proposes that storage is affected by individual differences and by resources limitations of the information processing system. In other words, different individuals have different amounts of storage and processing capacity depending on how many stimuli they are attending to or even due to their own level of cognitive capacity. The model also proposes that encoding and storage can limit one another. For example, if there are many orienting responses to a message, more resources may be allocated to the encoding process, decreasing the amount of resources that are available for storage (Lang 2000).

The goals of the individual affect resources. "A person who is watching primarily for entertainment, for example, may not be purposely allocating his or her limited processing resources to storage. This person is 'running on automatic.'" (Lang 2000, 53). In turn, theoretically, only information that is necessary to follow the plot will be stored (Lang 2000).

A person who knows that he/she will be tested on what he/she watches consciously allocates resources to storage so the information is retrievable. Lang says that in such cases, complex structural features as quick cuts can "steal" resources from storage in order to allocate them to encoding the content. Additionally, the tested viewer is likely to allocate more resources to retrieval, integrating the "stored" information with long-term memory. "This viewer is much more likely to run into a resource-limited situation than the person watching to be entertained, since this viewer is purposely allocating resources to storage and retrieval in order to learn and retain the content of the message" (Lang 2000, 53). However, Lang hypothesizes that the viewer who knows he or she will be tested will process the message more fully than the viewer watching to be entertained. This is because the tested viewer is allocating more resources to storage and concurrent retrieval than the entertained viewer. On the other hand, the tested viewer may approach resource capacity, and resources may become limited (Lang 2000).

Retrieval

Lang lists two aspects of the retrieval process: later retrieval of content and concurrent retrieval of known information. Later retrieval is considered properly stored into memory when it is selected from sensory store, encoded into working memory, and thoroughly stored. It differs from encoding and storage in that it occurs after viewing, not during. Later retrieval is not necessarily constrained by time and resources as encoding and storage may be. Thorough encoding and storage are both required steps for later retrieval to occur (Lang 2000).

Concurrent retrieval is the process of continuously retrieving previously stored information during viewing to aid comprehension and storage. Concurrent retrieval can be constrained by time and resource availability. According to Lang, the demand placed on resources to retrieve information from long-term memory can deplete resources required to process a message and in turn decrease the resources available to properly encode and store the message.

If a certain program requires the retrieval of many facts the viewer is not expert on, the program will put more strain on resource allocation, limiting the ability to learn new information. If the viewer is expert in the information demands made by the program, for example, a Civil War buff watching a documentary on the Civil War, the viewer should have more resources available for encoding and storage of that program.

There have been several studies exploring the limited capacity model in search of evidence of its effects. Lang et al. (1993) measured the effects of related and unrelated cuts on subjects' attention, processing capacity, and memory. In other words, they tested the effect of the structural feature of "cuts" on cognitive resources. However, "a structural feature has both a perceptual component and a higher order meaning component" (Lang et al. 1993, 5). This means that cuts are processes at both the level of perception and the level of cognition. Lang's theory is that unrelated cuts will have a measurable effect on memory. She says unrelated cuts will have more of an effect than related cuts, since related cuts shouldn't take more resources to process.

Another effect measured in this study was attention. Lang hypothesizes that unrelated cuts should have an orienting response, as something novel to the viewer. Lang also hypothesizes that the increase in attention should also help the viewer process and remember the message.

Lang et al. tested 58 advertising students. The researchers measured processing by reaction time to a secondary task, in this case, responding to a tone. Orienting response, or attention, was measured by cardiac deceleration. "Heart rate was collected beginning with the onset of each cut for 7 seconds. If an orienting response occurred during this time, the cardiac response curve will show a deceleration in heart rate for 3 to 4 seconds following the cut followed by a return to the baseline rate" (Lang et al. 1993, 14). Memory was tested by using a four-alternative multiple-choice test. For each cut chosen for analysis, there were four questions. Two questions pertaining to information before the cut, and two questions after the cut.

The stimulus material was a tape comprising 12 segments separated by black. Six segments had unrelated cuts, and six segments had related cuts. All the segments were from regular occurring network television programs. They came from situation comedies, hour-long dramas, movies, commercials, and news.

Related cuts were defined as cuts occurring between scenes that are related by visual information, such as from one camera to another camera within a scene, or by audio information, such as a cut from one scene to another, but was expected by a prefacing in the audio channel. Unrelated cuts were defined as cuts between scenes that are completely unrelated to one another by audio content, message content, or visual setting. They were always associated with an abrupt and unexpected change in program and message.

Results showed that cuts elicited orienting responses in attentive viewers, unrelated cuts required more processing capacity than related cuts, and memory was better for information surrounding related cuts than unrelated cuts. Not supported was the hypothesis that unrelated cuts elicit larger orienting responses than related cuts.

Lang et al.'s study supported a limited capacity theory of television viewing. "It suggests that, although paying attention is important to the process of remembering television information, it is not the whole story. The amount of processing capacity required to process the message fully and store it is equally important" (Lang et al. 1993, 26). The result is that although short-term attention can be manipulated by structural features such as cuts, attention does not necessarily help one to remember. Whether increased attention helps memory depends on the amount of processing capacity already being occupied by the message and the amount of processing capacity required to process the structural feature.

In 2000, Lang et al. conducted another study on the effect of edits on arousal, attention, and memory. Their hypothesis was that as the number of edits in a message increases, attention, memory, and arousal would also increase (Lang et al. 2000). In this study, Lang et al. called unrelated cuts "cuts" and related cuts (within a scene) edits. This study did not predict that increased edits would overload resources, but instead increase attention. More edits within a scene means a quicker pacing, which means more stimulation and novelty and orienting responses, but because the edits are related and not unrelated, resources should not be overwhelmed.

Lang et al. showed 39 subjects, all communications majors, 20 one-minute television messages from different genres. Messages were chosen for four levels of edits, slow, medium, fast, and very fast.

The study found that,

> "As predicted, increasing the number of edits in a television message increases viewers' attention and arousal during viewing of the message as well as their ability to remember the message at a later time. This provides evidence for the limited capacity approach to television viewing, which suggests that putting orienting eliciting structural features that do not increase cognitive load into a message can increase the levels of attention and arousal elicited by messages without overloading the limited capacity processing system. As a result, encoding of the message (indexed by recognition memory) is improved" (Lang et al. 2000, 105).

In 1995 Lang looked at audio/video redundancy and memory. Lang notes that although there have been past studies dealing with audio/video redundancy, the results have been conflicting as to whether it improves or hurts memory. This could be because of different definitions of redundancy, lack of control for attention, and a focus on memory for factual information, which is found mainly in the audio track. Lang's analysis aimed to create a more consistent framework for redundancy studies (Lang 1995).

The possible amount of audio/video redundancy can fit along a continuum, ranging from very redundant, where the audio and video exactly match (e.g. a talking head in which the audio is the spoken word) to not redundant at all (e.g. a scenic view of mountains in the video channel and the sound of city noises or other conflicting audio). The limited capacity model predicts that more redundant messages will take less processing resources, and thus be more easily remembered.

Lang divided redundancy operationally into four categories: single-channel, multiple-channel redundant, multiple-channel conflicting, and talking heads. Memory was defined as "recognition (audio, video or mixed), cued recall (audio, video or mixed), and free recall" (Lang 1995, 97). Recognition is considered to index how well the information is encoded. Cued recall measures how well information encoded is rehearsed and stored. Free recall measures whether the stored information can be retrieved.

Single channel messages should be the easiest to process because there is only one channel. On the other hand, the single-channel messages contain less information, are less structurally complex, and have fewer structural features to elicit orienting responses. Therefore, they may be less intrinsically interesting and attention grabbing. Despite their low resource usage, they might not receive as much attention as multiple channel messages.

Lang analyzed several studies that used recognition, cued recall and free recall in redundancy studies in an attempt to synthesize the data. She found that the data strongly suggest "multiple-channel redundant presentations are better than single-channel presentations at every level of processing" (Lang 1995, 111). Also, memory for visual information is not very affected by audio/video redundancy at any processing stage. On the other hand, memory for audio information is compromised when redundancy between the two channels falls. Lastly, "having pictures- even conflicting pictures- appears to have the largest impact at retrieval" (Lang 1995, 112). It is not clear if this is because visual processing is more automatic or if more visual information is encoded and therefore stored and retrieved. Evidence for the limited capacity model in respect to redundancy and structural complexity was supported.

In these studies, viewers were instructed to pay close attention to the program, as they would be tested on it at a later time. Therefore, viewers were likely allocating extra resources to storage, which may reduce the resources available to encoding. "It would be interesting to see if viewers instructed to watch and be entertained would show these same deficits. It seems likely that in that case, encoding of information following structural features might be much better than it is in the previous experiments because viewers would not be using controlled processes to reserve some portion of their resources for storage" (Lang 2000, 60).

Basil's Multiple Resource Theory

Lang's three steps of the limited capacity model, encoding, storage, and retrieval, are similar to Basil's three processes of a model very close to the limited capacity model, which he calls the multiple resource theory.

While Lang's description of encoding is both physiological and psychological, Basil calls this step "attention," and describes it as a cognitive process. Early researchers believed that attention was a filter that sifted out only relevant information. Later studies showed that people could respond to signal stimulus from non-attended channels. This seems to rule out the all-or-nothing filter in favor of a resource allocation theory. "Mental resources are shifted among modalities. According to this approach, modalities that receive more resources are processed more fully" (Basil 1994, 180). Attentional effects are observed, resource models say, because mental energy is limited. People can only attend to information as far as mental capacity allows. When capacity is exceeded, information is missed. "Attention is seen as the process of allocating resources to a stimulus or attributes of a stimulus. In this way, attention is seen as the amount of resources people devote to stimuli" (Basil 1994, 180).

The second task of mental processing under this theory is meaning processing. This task is the comprehension of words and pictures. For example, when we watch a television program, we attend to the images and words presented. After and while attending to them, our mental process interpret the images and sounds for meaning. Meaning is a process because it draws upon and synthesizes the new information with previously stored information and knowledge. Different levels of meaning can be derived depending on level of processing. Basil says although there are separate visual and auditory modalities (channels), there is a shared analysis mechanism for meaning (Basil 1994).

In order to derive meaning from words, symbols, and pictures, new incoming information is compared with mental models. "Processing 'decodes' a message for meaning. Mental resources, in the form of time and energy, are believed to be necessary for this process to occur. More extensive processing leads to better memory for information" (Basil 1994, 182).

According to Basil, there is evidence that appears that subjects' capacity to effectively process meaning is limited to one message at a time. This is different than when subjects are simply asked to detect a signal stimulus, in which subjects are able to monitor several channels simultaneously. This is because meaning processing requires more resources than sensory processing (Basil 1994).

Lang calls the third mental process retrieval. Basil labels it memory. Basil says memory can be stored episodically if it is organized temporally. Memory is semantic if it is organized by meaning. Either way, Basil says memory appears to involve some form of compression or simplification. As a result, "memory for meaning is consistently better than memory for actual wording" (Basil 1994, 182). This suggests that memory for the gestalt program is better than memory of specific images, words, or symbols. For example, after we view an hour-long police drama such as "NYPD Blue," we will be more likely to remember the overall story of the program rather than specific details such as names, dates, street names, or other fragments of information mentioned throughout the show. Basil says that this is true regardless of the original channel the information was presented in; whether it was auditory or visual. Visual data such as what a character was wearing or what color a particular building was may be forgotten but the show still makes sense. The sum of all parts is recalled better than specific details. If we tried to remember all these small details, our attentional and meaning processing resources would suffer. When attention and meaning suffer, memory in turn suffers as well.

"According to multiple resource theory, resources are sometimes shared among tasks that are performed" (Basil 1994, 184). Performing one task may reduce resources available to a second task. Basil points out the possibility that there are multiple resource pools to draw from. "Only when information makes significant demands on these pools *and* both the auditory and visual modalities share a common resource pool would processing one modality affect the second modality" (Basil 1994, 184). If insignificant resource demands exist or auditory and visual modalities have their own resource pool, then people should be able to attend to both modalities simultaneously. If limitations do arise, then it is likely that viewers might focus attention on one modality and ignore information in the other.

Possible limitations include not having sufficient resources to attend to both audio and video information at the same time. Another limitation may be when information is meaningful and must be processed for content. Basil says insufficient resources for semantic processing would limit comprehension or limit the type of processing that is performed before storage. Third, limitations may occur in the memory task. People might have enough resources to process other tasks but not have enough remaining to store the information. The hampering of resources during any one of the tasks can limit the viewers' ability to pay attention, process for meaning, or store information. Any three of these processing shortfalls could reduce memory of information (Basil 1994). In addition to these situations, Lang says that external features such as content and structural features of the program would add to the limitations of processing (Lang 1993).

This point can be applied to Lang's model. Earlier, Lang was cited as stating that a viewer who knows he or she will be tested will likely allocated more resources to memory. However, if resources are consciously allocated toward memory, they may diminish from encoding and retrieval (or Basil's attention and meaning processing). If overall long-term memory is constrained because encoding and storage resources were not properly available, then the viewer's goal of viewing for memory might actually be hurting his or her memory. More succinctly, a viewer who is trying to devote energy to memory may actually become cognitively "tired" or "fatigued," resulting in less memory. Information stored before this fatigue point should still be intact, but information attempted to be stored after this point should not be fully stored for retrieval.

Based on the studies cited in the literature review, this researcher posits the following hypotheses for study:

H1: Subjects told they will be tested for memory about a TV program will allocate more cognitive resources to watching the video, resulting in better overall memory compared with those who aren't allocating resources to memory.

H2: Subjects watching a TV program for "normal" entertainment goals (i.e., not consciously allocating resources for memory) should have generally equal memory for information found through all parts of the video.

H3: Subjects told they should try to remember all they can and will be tested on a TV program will allocate resources to memory to the point of overload, resulting in a decline in memory for information found in the later part of the program. The decline will not occur for subjects who are not given this instruction.

METHODOLOGY

This study is an experimental design with a treatment group and a control group. The manipulated variable is the verbal instructions given to each group before viewing a video. The experiment tests the effect of cognitive fatigue on memory while watching a video.

Subjects

Subjects for this study were students in Journalism 201. Since the subjects were picked from this class, it is a convenience sample and not random. A total of four sections of 201 students were selected for the experiment. Each section comprised 18 students, however not all students came to class the day the experiments were held. There were a total of 30 students in the control group and 32 students in the treatment group.

Stimulus

The stimulus was a 19-minute segment from a video called "The Grand Circle." The video goes into detail about national parks and landmarks of the southwestern United States called the Grand Circle. The video portion, consisting of images of nature, is accompanied by a voice narration giving descriptions and facts about the Grand Circle. The visuals consist of simple camera-on-tripod shots of the landscape. Some shots are static (stationary camera), others have a slow pan or zoom. The structural features of the video likewise are basic: virtually no quick cuts or special effects. The majority of the video program consists of "long shots" or "extreme long shots" of the landscape with minimum numbers of medium shots and close-ups of birds, lizards, trees, and rocks. Transitions between shots are either a simple cut or a dissolve. There are no close-ups of human beings. There are no "talking heads" of people speaking. The audio track contains only voice-over narration and soft, slow-tempo background music. The narrator is never seen.

This promotional/informational video has a very small chance of being previously viewed by the subjects, so none of the subjects should have been exposed to it before. Subjects may have an easier time remembering the content if the stimulus was something they had been previously exposed to.

The video was chosen for several reasons. The information-based genre of this video made it easier to test for memory with true-and-false questions based on facts stated in the narration compared to a prime-time drama or sitcom commonly seen on TV. Also, the documentary-style content is more representative of a typical video program that would be shown in the classroom.

Instrument

The questionnaire was divided into two sections. The first section consists of 32 true-and-false questions relating to information found in the video. These questions measured the dependent variable, memory. Questions were based on facts stated in the audio track of the video, although the facts narrated are redundant with the video shown in the visual portion of the track. For example, question number 20 pertains to "Bryan's Head Resort," but in the video there is a sign in the visual track clearly showing "BRIANHEAD," making the correct answer "false." Question 15 pertains to the cone-shaped Checkerboard Mesa, stating that it is made up of "almost all white Navajo sandstone." In this instance, the audio track states this fact and the visual track has a medium of the white sandstone to reinforce this information.

The second section of the questionnaire is demographic information. Data on age, gender, year in school, and number of hours of television watched per day were gathered.

Procedure

Four class sections were used, and each section was randomly assigned a control or treatment group. The random order resulted in control, treatment, treatment, control.

The first section was on Wednesday, April 2, 2003. The second and third sections were on the next day, Thursday, April 3. The fourth section was scheduled to be on the following Monday, but the class was cancelled by instructor due to bad weather. The fourth and final section of the experiment was then held on Wednesday, April 9, seven days from the first section. Ideally, the sections should be tested in the mostly timely fashion possible to avoid sensitization by subjects' talking about the experiment outside of class.

The experiment was administered at the beginning of class. Once the students arrived, the professor introduced the researcher who read the introduction and instructions. Students had no prior knowledge from the professor about the experiment. See Appendix B. for experiment script.

The control group was verbally given this set of instructions:

"Please watch this video as you would a normal television program."

The treatment group was given this set of instructions:

> "While watching the video, please concentrate on remembering all the information you can. Try to remember every detail possible about the places, names, locations, and other facts stated in this video. After watching, you will be tested for memory to see how well you can remember the facts and statements found in the video."

The researcher then dimmed the lights and started the video. The volume was at a consistent level for all four sections, which were held in the same room. When the video was done playing, the researcher stopped the video, turned up the lights, and handed out the test. The researcher announced that when the subjects were done, they should raise their hand and the questionnaire would be collected. Students were given as much time as they needed to complete the questionnaire. This was done so subjects did not feel rushed while taking the test, and to allow subjects to complete every question to have as much data possible available for analysis. After all the subjects finished, they were debriefed about the nature of the experiment. For the debriefing script, see Appendix B. The subjects and professor were then thanked, debriefed, and the researcher exited the classroom.

Pilot Test

Before the experiment, a pilot test was done with a 10-minute video segment from the show "Living in Iowa." The segment, entitled, "Space Pioneer," is about the life and accomplishments of Iowa physicist Professor James Van Allen.

Subjects for the pilot test were 16 students in a Journalism 306 class. Before the video, subjects were each given a slip of paper with instructions on how to watch the video. Eight students were given a slip that said,

> "Please watch the following video to be entertained."
>
> The other eight students were given a slip that stated,
>
> "While watching the video, try to remember everything you can about it. After viewing the video, your memory will be tested. You will be tested on information found in the audio and video portions in the video."

Subjects were then shown the video. To measure memory for the video, subjects were given a 34-question true-false test when the video concluded. Questions were based on statements and images found in the video. Questions were split into 4 sections: section one had 8 questions from the first 2 minutes and 30 seconds, section two had 8 questions from the second 2 minutes and 30 seconds, section three had 10 questions from the third 2 minutes and 30 seconds, and section four had 8 questions from the last 2 minutes and 30 seconds of the video. Question order was randomized in order to evenly distribute questions from each section throughout the entire test. Question randomization was done to account for test fatigue. If all of the questions from Section A were toward the beginning and questions from Section D were toward the end, scores for Section D may be lower due to subjects' testing fatigue.

Results indicated a difference in memory between the two groups. The treatment group consistently had a better score on each memory section. Results weakly suggested a decline in memory for the treatment group, which would have supported the hypothesis. Based on this finding, it was deemed that a stronger treatment was needed. It was decided a longer video was needed to amplify the "fatigue factor" for the treatment group. Changes based on the pilot test include a longer vide and slightly reworded ,verbal instead of written instructions.

After the first pilot test, a second, informal pilot test was done with the Grand Circle video to make sure the questions made sense and weren't extremely difficult or too easy. Test subjects commented that the questions were quite difficult, and modifications were made to several of the questions, making them less difficult. The final questionnaire used is found in Appendix A.

RESULTS

A total of 62 subjects participated in the study. The control group consisted of 30 subjects and the treatment group comprised 32 subjects. There were 23 sophomores, 25 juniors, and 14 seniors. There was a total of 13 males and 49 females. Table 1 shows responses to hours of TV watched per day.

Table 1. Response to hours of television watched per day (n = 62)

TV watched per day (hours)	Number of subjects
0-1	27
1-2	20
2-3	10
3-4	2
4-5	3
More than 5	0

Memory was measured by subjects' score on questions 1-32, the "true and false" portion of the questionnaire. Overall scores on this section were computed by totaling the number correct out of 32 and dividing by 32. This number can be made a percentage by multiplying by 100. The treatment group had a mean score of 58.1% correct. The control group had a mean score of 54.9% correct (Table 2).

Table 2. Mean number of correct answers of both groups on true-false memory test (n = 62)

Group	Number of subjects	Mean score (percent)
Control	30	54.90
Treatment	32	58.11

True and false questions were split into four sections. Section "A" pertained to information found in the first quarter of the video (minutes 00:00 to 04:45). Section "B" pertained to information found in the second quarter of the video (minutes 04:45 to 09:30). Section "C" tested information found in the third quarter of the video (minutes 09:30 to 14:15). Section "D" tested information found in the last quarter of the video (minutes 14:25 to 19:00). Table 3 displays scores by the treatment and control group on each section of the video.

Table 3. Score (percent) on true-false memory test by section

	n	Section A	Section B	Section C	Section D
Control group	30	63.8	53.8	55.0	47.1
Treatment group	32	63.7	59.4	56.6	52.7

Testing Hypotheses

The first hypothesis states:

H1: Subjects told they will be tested for memory about a TV program will allocate more cognitive resources to watching the video, resulting in better overall memory compared with those who aren't allocating resources to memory.

To test this hypothesis, several different statistical tests were used. An independent samples *t*-test was used to compare the control and treatment groups' scores section-by-section.

As Tables 4 and 5 show, while the treatment group scored better on sections B, C, and D, the difference was not found to be significant.

No significant difference was found for between the total score for the control and treatment group. One explanation for this may be that the true-and-false questions were too

Table 4. Independent samples *t*-test of the difference in section score between the control and treatment groups

	n	Mean	Std. Deviation	Std. Error Mean
Section A				
Control	30	.638	.143	.192
Treatment	32	.637	.167	.143
Section B				
Control	30	.538	.147	.147
Treatment	32	.594	.173	.173
Section C				
Control	30	.550	.172	.172
Treatment	32	.566	.138	.138
Section D				
Control	30	.471	.171	.171
Treatment	32	.527	.176	.176
Total Score				
Control	30	.549	.091	.017
Treatment	32	.581	.095	.017

Table 5. Results of Independent samples *t*-tests comparing difference of section score between groups

	t	Df	Sig. (2-tailed)
Section A	.018	60	.986
Section B	-1.370	60	.176
Section C	-.4140	60	.680
Section D	-1.386	60	.171
Total Score	-1.358	60	.179

difficult, resulting in both groups scoring similarly poorly. Another explanation may be that the subjects did not have enough motivation to try hard on the test, resulting in low scores. A third reason may be that subjects did not pay very close attention to the video, even when told they were going to be tested on it. Since the test had no effect on their grade in class, subjects had little incentive to put effort into doing the best they could. Further discussion about these rival hypotheses is found in chapter five.

Hypothesis Two states:

> H2: Subjects watching a TV program for "normal" entertainment goals (i.e., not consciously allocating resources for memory) should have generally equal memory for information found through all parts of the video.

To test memory decline, the control group subjects' scores on sections A and D were compared. A one-sample *t*-test on means was done to look for significance in the difference between these scores. The mean score for Section D was compared to the mean score for Section A. If the hypothesis is supported, the scores would be similar enough to yield no significance. However, significance was found, opposite of what was predicted (Table 6).

A paired-samples *t*-test (Table 7) was also used to compare the scores. A paired-samples *t*-test is typically used to compare scores between two tests of a group in a "before"

Table 6. One-sample *t*-test comparing scores on sections A and D for control group

	n	Mean	Std. Deviation	*t*	Sig.
Section A	30	.6375	.1924		
Section D	30	.4708	.1419		
Section A compared to Section D				4.746	.000*

* Significance found at the 0.01 level (two-tailed)

and "after" situation. A pre-test is administered, followed by a stimulus or duration of time, followed by a post-test. A paired-samples *t*-test is then run to compare the means (McMillan & Schumacher 2001). In this case, there is no pre-test or post-test, but only a single, sectioned test, with the duration of the video being the stimulus.

Table 7. Paired samples *t*-test for control group comparing score on Section A and Section D

	n	Mean	Std. Deviation	*t*	Sig.
Section A	30	.6375	.1924		
Section D	30	.4708	.1419		
Section A compared to Section D		.1667	.2352	3.881	.001*

* Significance found at the 0.01 level (two-tailed)

Results from both tests show significance between the two sections for the control group, but no support for the hypothesis. The tests suggest a significant drop-off in score for the control group, suggesting a decline in memory. One rival hypothesis for this result may be that attention to the video started high and then decreased as time went on, resulting in poor scores on Section D. Another possible explanation is that the questions in Section D were inadvertently more difficult than the questions in Section A.

Hypothesis Three states:

> H3: Subjects told they should try to remember all they can and will be tested on a TV program will allocate resources to memory to the point of overload, resulting in a decline in memory for information found in the later part of the program. The decline will not occur for subjects who are not given this instruction.

Since Hypothesis Three predicts a decline in score for the treatment group, a comparison was done on the difference in mean score for Section A and Section D. A one-sample *t*-test on means for the treatment group's scores on Sections A and D was calculated. The purpose of this test was to determine if there was a drop-off in score between these sections of the test.

The one-sample *t*-test showed significance of difference of scores between Section A and Section D for the treatment group (Table 8). Significance is in the predicted direction. As with the control group in Hypothesis Two, a paired-samples *t*-test was run as

Table 8. One-sample *t*-test comparing Section A and D for treatment group

	n	Mean	Std. Deviation	*t*	Sig.
Section A	32	.6367	.1433		
Section D	32	.5273	.1760		
Section A compared to Section D				4.321	.000*

* Significance found at the 0.01 level (two-tailed)

Table 9. Paired sample *t*-test comparing Section A and D for treatment group

	n	Mean	Std. Deviation	*t*	Sig.
Section A	32	.6375	.1433		
Section D	32	.4708	.1760		
Section A compared to Section D		.1094	.2413	2.564	.015*

* Significance found at the 0.05 level (two-tailed)

well (Table 9).

As Table 9 shows, significance was found. This finding supports Hypothesis Three in the predicted direction. A third test was done to compare the difference in test scores in Section A and Section D between the treatment and control groups. Results (Table 10) show no significance was found.

Two out of three statistical tests support Hypothesis Three; therefore Hypothesis Three is partially supported. The hypothesis predicted a significant difference in score between Section A and Section D. Statistical results partially support the possibility of cognitive fatigue.

Table 10. Independent samples *t*-test on mean difference of score of Section A and Section D for treatment and control groups

Group	n	Mean difference	F	Sig.	*t*	Sig. (2-tailed)
Control	30	.1667				
Treatment	32	.1094				
Total Difference	62		.139	.710	.946	.348

Post Hoc Analysis

Post hoc analyses were done to look for unexpected factors that may have affected the outcome of the study. Variables tested include age, gender, year in school, and hours of television watched per day.

Table 11. Pearson correlation of age and difference in score for Section A and Section D

	Pearson Correlation	Sig. (2-tailed)	n
Total Score	.102	.430	62
Difference in Section A and Section D	-.175	.174	62

A Pearson correlation comparing age to total score and the difference in score between Section A and Section D yielded no significance (Table 11).

The same test was done to look for significance of gender effects. No significance was found in this Pearson correlation (Table 12).

A Pearson correlation was run comparing score and year in school. Again, no significance was found (Table 13).

Finally, a Pearson correlation was run comparing score and hours of television

Table 12. Pearson Correlation of gender and difference in score for Section A and Section D

	Pearson Correlation	Sig. (2-tailed)	n
Total Score	.177	.169	62
Difference in Section A and Section D	-.016	.904	62

Table 13. Pearson Correlation of year in school and difference in score for Section A and Section D

	Pearson Correlation	Sig. (2-tailed)	n
Total Score	-.158	.219	62
Difference in Section A and Section D	-.024	.853	62

watched per day. This test included both the treatment and control groups, and significance was found in the score difference of Section A and Section D as Table 14 shows. Since the correlation was negative, this suggests that for both groups, students who watched more television had a steeper drop-off in score between Section A and Section D.

Further investigation of this finding was done, running the correlation test on both the control group and treatment group separately (Tables 15 and 16). A negative correlation with significance was found in the control group, but not the treatment group.

Table 14. Pearson correlation of all subjects for hours of television watched per day

	Pearson Correlation	Sig. (2-tailed)	n
Total Score	-.008	.950	62
Difference in Section A and Section D	-.275	.031*	62

* Correlation is significant at 0.05 level (2-tailed)

Table 15. Pearson correlation of hours of television watched per day for control group

	Pearson Correlation	Sig. (2-tailed)	n
Total Score	.089	.640	30
Difference in Section A and Section D	-.370	.044*	30

* Correlation is significant at 0.05 level (2-tailed)

Table 16. Pearson correlation of hours of television watched per day for treatment group

	Pearson Correlation	Sig. (2-tailed)	n
Total Score	-.098	.595	32
Difference in Section A and Section D	-.196	.281	32

An independent samples *t*-test was run combining both treatment and control groups, comparing students who indicated they watched a "low" amount of television to students who watched a "moderate" amount of television. "Low" amount was defined in this study as "0-1" or "1-2" hours of television per day and moderate was defined in this study as subjects who answered "2-3," "3-4," or "4-5" hours per day. There were no answers of more than five hours per day. Low and moderate subjects' difference in score on Section A and Section D were compared using an independent samples *t*-test on means (Table 17).

When both groups were combined, significance was not found with an independent samples *t*-test between low and moderate viewers for difference in score for Section A and Section D. Significance was found with a Pearson correlation for both groups (Table 14) but with a weak negative correlation ($r = -.275, p < 0.05$). The negative correlation was slightly stronger when only the control group was analyzed ($r = -.370, p < 0.05$).

Results indicated that for subjects who watched the video without specific "memory"

Table 17. Independent samples *t*-test comparing differences of Section A scores to Section D scores between low and moderate viewers

	n	Mean	Std. Deviation	*t*	Sig. (two-tailed)
Section A score (low viewers)	47	.6516	.1767		
Section D score (low viewers)	47	.4947	.1496		
Section A score (moderate viewers)	15	.5917	.1291		
Section D score (moderate viewers)	15	.5167	.1997		
Difference of Section A and Section D (low viewers)	47	.1569	.2367		
Differences of Section A and Section D (moderate viewers)	15	.0750	.2400		
Difference of Section A and Section D Equal variances assumed	62			1.163	.249

instructions, those who watched a moderate amount of television had less of a drop-off in score than those who watched less television. Although the moderate TV-watchers scored lower on Section A, their drop-off was not as sharp as the students who watch a low amount of television (Figure 1).

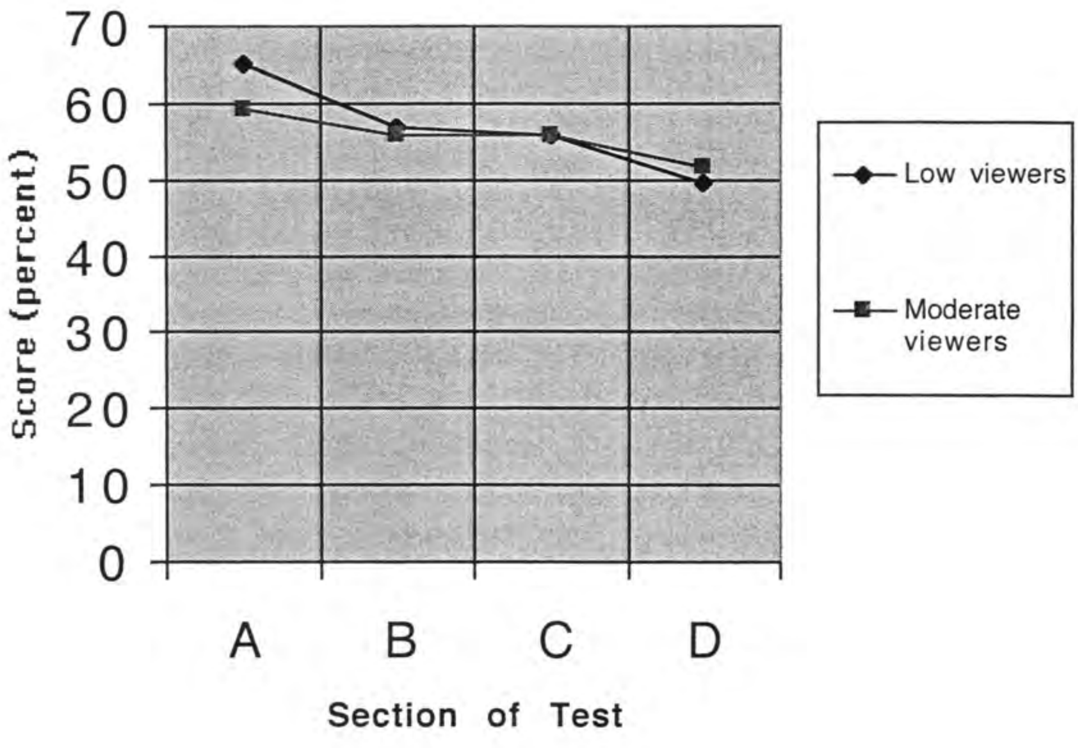

Figure 1. Mean scores of low and moderate viewers (both treatment and control) by section (n = 62)

DISCUSSION

Results from the statistical analyses did not point to significance in support of Hypotheses One or Two. Significance in two of three tests was found when testing for the difference in score between Section A and Section D for the treatment group, which would partially support Hypothesis Three. Hypothesis Three predicted the treatment group's scores would decline but the control group's scores would not decline between each section. Since the same significant decline was found in the control group, support for Hypothesis Three must be viewed with suspicion. Both the treatment and control groups' scores were higher for information found in the first part of the video compared with information found in the last part of the video.

Methodological Implications

One explanation for the control group's decline in score may be that question difficulty was not consistent throughout the test. If this occurred, it would account for the decline in score for both groups. If questions are unfairly difficult, the treatment applied will not have significant effect on scores. The pilot test for this study should have identified such questions, but it is possible that question difficulty was not consistent throughout. Further pilot testing would help eliminate this problem in a future study.

Another explanation for a decline in score for both groups is that the control group suffered a decrease in attention. The treatment group's scores were predicted to decrease because of cognitive fatigue due to attempting to remember as much as possible. The control group's memory was predicted to be consistent, but results showed those scores declined as well. It is possible that the control group's attention to the 19-minute video were initially strong and decreased as the video progressed. Perhaps the content of the video was not "compelling," although this is a subjective statement. Subjects might have lost interest in hearing about National Parks in the Southwestern U.S., and their focus may have drifted elsewhere as the video continued. This would account for higher scores relating to information in the beginning of the video and lower scores for information found later.

Hypothesis Two was also not supported by the statistical analysis of test scores. This hypothesis stated that the control group's score should be consistent for information throughout the video. Explanations stated above may also be applied to why Hypothesis Two was not supported. An additional explanation may be that the control group also experienced cognitive fatigue. Even though this group was not specifically instructed to remember everything about the, the fact that the video was shown in a classroom setting and the students knowing they were part of an experiment may have motivated them to try to remember the video's content. This may have happened either consciously or subconsciously. If true, it could be considered a "subject effect." "If subjects have some idea of the purpose of the study or the motivation for doing 'well,' they may alter their behavior to respond more favorably" (McMillan & Schumacher 2001, 192). Although the researcher was careful not to suggest that the control group's memory for the video would be tested, some students, knowing they were participating in an experiment, may have altered their behavior and paid unusually high attention to the video, resulting in cognitive fatigue similar to the treatment group.

Hypothesis One stated that the treatment group's overall score would be better than the control group, suggesting a stronger overall memory for video content. Again, results showed no statistical significance between the two groups' scores, although the treatment group's average 58.11% was higher than the control group's average 54.9%. Explanations previously stated may apply to this result. Another possible explanation is that the treatment was not strong enough. In other words, simply using a verbal instruction on the treatment group, telling the students to remember all they could about the video, did not motivate the subjects sufficiently. This might result in some treatment subject's less than maximum effort into remembering the information in the video.

To combat this effect in future studies, a stronger treatment may be used. One possibility would be to use an incentive for the treatment subjects. By offering a prize or reward for the top scores, subjects would have more motivation to do well on the test and may exercise optimum effort toward memory. Subjects may have exerted sufficient effort into remembering the video, but didn't have enough motivation. The incentive proposal should solve this.

Testing of data gathered from the questionnaire not relating to the hypothesis yielded significance in one area. A Pearson correlation on all subjects found a negative correlation between hours of television watched and difference in score on Section A and Section D. As the number of hours of television increased, the difference in score between section decreased. For all subjects, the mean score for Section A was higher than the mean score for Section D. However, the test shows that the score drop-off was less severe for subjects who reported watching a higher number of hours of TV per day.

One possible explanation for this phenomenon may be related to the theory of attentional inertia. This theory states that attentional engagement increases over time during a constant "look" at television (Burns & Anderson 1993). A "look" is defined as a sustained visual orientation. A look ends when the viewer glances away from the television, rapidly ending any built-up inertia. The inertia is then created fresh again when the viewer returns his or her attention to the television. The theory states that over time, if a medium has held a person's attention, "a generalized tendency develops to sustain attention to that medium" (Burns & Anderson 1993, 778). Burns and Anderson (1993) found higher memory levels for television content in subjects who kept sustained levels of attention.

Although the theory applies to viewers at a specific television viewing session and not over long periods of time, it may be possible that subjects who watch more TV have developed a level of attentional inertia for watching TV in general. Television watching in greater amounts may be a sort of "workout" for the brain. A viewer who is accustomed to watching more hours may be able to sustain a more consistent attention and orientation to the 19-minute video than someone who is not used to watching as much TV. Metaphorically speaking, this would be like comparing two typists, one accustomed to typing eight hours a day and one with little or no experience. The experienced typist would be able to sit and type for a short amount of time with no problem. The same typist likewise would be able to go for long periods without a break. The novice typist, by contrast, would need frequent rest breaks because he/she would be unaccustomed to such activity. However, these possible attentional inertia findings are strictly post hoc, and would require an entirely new study to make any sort of suggested finding.

Theoretical Implications

The methodological implications give several reasons why results were not as predicted yet do not invalidate the limited capacity model's theoretical base. For example, if both the treatment and control groups suffered from cognitive fatigue, it would explain the decline in score for both groups, which would still keep the model intact. Also, if the treatment were not strong enough to evoke limited capacity effects, this could be another explanation. If the treatment were indeed sufficiently strong and the control group did not suffer from fatigue effects or attention decline, it may be possible that the structural features of the video, e.g. the number of cuts, dissolves, music, and colors, did not put sufficient strain on subjects' resources to trigger cognitive fatigue. Lang (2000) says that such structural features can "steal" resources from storage in order to process the message more effectively. In this case of this study, the number and quality of structural features may not have been sufficient to steal resources.

However, assuming the findings were correct, the results of Hypothesis One and Two being unsupported and Hypothesis Three being partially supported conflict with part of the limited capacity model. Since both the treatment and control groups' scores declined, it may be concluded that both groups suffered from cognitive fatigue, despite only the treatment group being instructed to watch with the goal remembering information about the video. Lang (2000) states that goals of the individual affect resources. One who watches for entertainment may not deliberately be allocating resources to storage. However, results from this study indicate that subjects watching with no specific goal may suffer memory deprivation for information found in the later part of the video. If they are not deliberately allocating resources as Lang says, subjects should not reach their capacity for processing and storage should not be negatively influenced. The results of this study suggest subjects do indeed store the information, whether they are consciously allocating resources or not, and after a certain point, resources may become depleted, resulting in memory decline.

Results showed the control group's score declined more than the treatment group's (63.8% down to 54.9% for the control group, 63.7% down to 58.1% for the treatment group). This was the opposite of what was predicted. These results indicate that because the treatment group was instructed to remember all it could, subjects did indeed allocate the appropriate resources to storage, but instead of the result being cognitive fatigue and declining memory, subjects may have experienced stronger memory and resource allocation throughout the duration of the video compared to the control group. This resulted in less of a decline in memory than the control group. It may be, as stated earlier, that a stronger treatment is needed to heighten the fatigue effect. In this study, the instructions to remember helped subjects' memory. It may be possible the treatment group outperforms the control group for a certain length of time, but once the treatment group reaches a resource saturation level, their scores take a steep decline compared the control group, which may have a slower overall decline.

Limitations

There were several limitations to this study. As stated above, a convenience sample was used, limiting the generalizability of the study. The class selected for this study, Journalism 201, also yielded 49 females and only 13 males. Although gender was not considered to be a factor in this study, a more even distribution of gender would have been ideal. Furthermore, experiments held in these classes were done at different times of the day, according to when the class met. One class was in the early morning at 8, two were afternoon classes, and one was in the early evening. A future study may hold experimental sessions at a consistent time period to account for subjects' level of alertness, which may fluctuate throughout the day. Of course level of alertness will vary from subject to subject, but a similar experiment schedule for each group may help level the playing field.

In addition to experiment sessions at different times of the day, the sessions were held over the course of a week. Ideally, experiment sessions should have been held in the smallest possible time frame to avoid subject sensitization.

Another limitation of the study is that the true-false questions pertained to mainly information found in the audio track. While the information presented in the audio track was redundant with the visuals, this test is oriented towards memory for audio information. To test visual memory, a recognition test would be appropriate. In this type of test consists of showing the subject 6 frames of video. The video is either an image (freeze frame) from a video the subject has been exposed to, or a "foil" image, which the subject has not been exposed to. The subject then reports whether it is a new image or one that he or she has seen before (Lang 1993). Subjects with better memory for the visual portion should be able to identify the foils as new and the already-been-seen freeze frames as old. This visual type of test would supplement the written audio-based test to measure memory based on both types of exposure.

The instrument was also limited by the amount of pilot testing. For the final instrument, only an informal pilot test was done. The instrument could have been pilot tested further to make sure all the questions were at a consistent difficulty level.

The classroom setting of the experiment may have also contributed to the control group inadvertently becoming cognitively fatigued. Therefore, the experiment setting itself was a limitation in this study. A more neutral environment may yield different results.

Future research

A future study may research the possible level for resource saturation in the treatment group mentioned in the theoretical implications. The study may examine the length of the video or complexity of the visual and audio channels to determine how much information it takes to reach a fatigue level where the treatment group begins to decline faster than the control group.

Additionally, future studies could try to account for methodological threats to validity. A stronger pilot test process could be done to meticulously purge unusually difficult questions. An incentive could be added to the treatment group to increase its motivation to do well on the test. To measure whether lack of attention is affecting scores, a measurement of attention could be applied to both groups. This could be done with either self-report questions on the survey, a qualitative-type discussion after the experiment, or monitoring the heart rate of subjects during the experiment. The technique of monitoring heart rate to measure attention has been used by Lang et al. (1993, 2000) in past limited capacity studies.

A larger, random sample size in future studies would increase the generalizability. The current study looked only at Journalism 201 students, which is not representative of adults or college students.

Future studies could also look at the effect of different video lengths. Similar experiments could be conducted with a 10-minute or even 30-minute video to see if there are differences in score. A shorter video may decrease any attention-deficit effects while a longer video may increase the cognitive fatigue by presenting more information to remember. Different genres and content may also be examined. Documentaries as well as sitcoms, dramas, movies, or even news programs could be studied to detect to what degree the content is a factor. Content should also be categorized as male-oriented, female-oriented, or gender neutral to account for gender preferences. Females watching a video that is oriented towards males may score lower based on the content, aside from any cognitive fatigue effects.

Questions added to the survey may probe for more specific data regarding television viewing: during what hours TV is watched, what type of shows are watched, and average viewing session may yield data that could further explain the finding in this study of moderate TV viewers having less of a drop-off in scores than low TV viewers. However, it may be possible that an entirely new study may be necessary to investigate these findings further.

Another future study may add a third group to the experiment. This third group would be an "audio only" group which hears the same information that the control and treatment group hear, but is not exposed to the visual portion. The purpose of this test would be to discover whether the visual segment has an effect on subjects' cognitive fatigue. By having an audio-only group, it could be determined how much effect the visuals have on subjects' ability for memory. Of course questions for this test must be based solely on information found in the audio track.

Finally, another test that could be done would be a time gap study. One group of subjects would be tested immediately after the video, another group after a certain period of time, for example two weeks later. This type of study would more closely examine the differences between immediate recall and recall after a longer period of time, which would be more representative of a quiz or test taken in a real classroom environment.

In summary, the current study – although not supporting the posited hypotheses – tends to lend credence to the validity of the limited capacity model. Future studies such as the ones previously mentioned are needed to determine what variables have an affect on memory while watching a video.

APPENDIX A. QUESTIONNAIRE

Questionnaire

By answering the following questions and returning this survey, you give your consent for this information to be used as research in a Master's thesis.

<u>The following are questions about information found in the video you have just viewed. Please circle "T" for True and "F" for False.</u>

1. T F The bristle-cone pine attributes its longevity to its efficient use of resources- it retains its needles for decades and in times of drought grows even faster to collect more water.

2. T F Located 1/4 mile from the visitors center, the Emerald Pool Trail along the Virgin River offers visitors a view of an overhanging cliff face.

3. T F Bryce canyon is not really a canyon, but a series of spectacular amphitheaters created by eons of erosion.

4. T F "The Narrows" is a 16-mile one-way trip- sometimes taking hikers wading through water.

5. T F Capital Reef Park got its name nearly two centuries ago because of the gray-white domes resembling the U.S. Capitol building.

6. T F Dead Horse Point State Park overlooks the Green River, and offers one of the "most spectacular visitor viewpoints in the United States."

7. T F According to the video, Bryce Canyon is geographically "softer" resulting from more rapid erosion.

8. T F Zion canyon boasts 3000 foot high walls, an example of the extraordinary forces of nature.

9. T F The lizard, raven, snake, and desert big-horn are just a few of the creatures in the Colorado plateau area.

10. T F North of Highway 24 is Cathedral Valley, with its spires stretching 500 feet into the sky.

11. T F All the areas in this video combine to be known as the "Great Circle."

12. T F The region's origin historically lies at the same time of the formation of the Rocky Mountains, 500 million years ago.

13. T F The "Great White Throne" reaches 2000 feet above the Virgin River.

14. T F Zion boasts over "270 species of birds and a smaller, but interesting mix of mammals."

15. T F The cone-shaped Checkerboard Mesa is made up of almost all white Navajo sandstone.

16. T F The Bryce Natural Bridge spans 125 feet above the gully below.

17. T F Running along the Freemont River, Interstate 24 is the main access road to the Parks.

18. T F Strike Valley in the Great Water Pocket Fold runs 100 miles, forming a rock backbone, of which Capitol Reef is only a small part.

19. T F Zion was established in 1909 but it wasn't until 1919 that it became one of the premiere national parks.

20. T F Located at 10,000 feet, Bryan's Head Resort provides some of the world's finest cross-country and downhill skiing.

21. T F The nearly 4-mile long Peekaboo Trail originates at Bryce Point.

22. T F The first visitors to the Capitol Reef were Indians who planted maize, made pit houses, and lived in cliff dwellings.

23. T F The Colorado and Green Rivers are cruised by tour boards by various groups, sometimes traveling a total of 100 miles across the two rivers.

24. T F Zion usually receives between 20 and 30 inches of rain annually, but strong torrents of rain can turn small streams into torrents.

25. T F According to the video, typical summer recreation in Cedar Breaks includes hiking, bicycling, and swimming.

26. T F Bryce Canyon, at an average elevation of 8500 feet, is slightly higher in elevation than Cedar Breaks.

27. T F According to the video, Bryce Canyon National Park is about the same age as Zion.

28. T F Where the Freemont River and Sulfur Creek meet, Mormon settlers formed the town of "Fruita."

29. T F At one time, Capitol Gorge was one of only two state roadways across central Colorado. Today, the road is gone but hikers remain.

30. T F Along the Colorado River is the mysterious Goblin Valley, with thousands of eerie sandstone structures.

31. T F At one time the Colorado Plateau was a vast inland sea. As waters retreated, so did the dinosaurs that once lived there.

32. T F A turn-of-the-century cable structure helped lower lumber into the Virgin River.

Please answer the following demographic questions.

33. What is your year in school?

A. Freshman
B. Sophomore
C. Junior
D. Senior
E. Graduate

34. What is your gender? M / F

35. What was your age on your last birthday? __________

36. Approximately how many hours of television do you watch per day?
A. 0-1
B. 1-2
C. 2-3
D. 3-4
E. 4-5
F. Over 5

APPENDIX B. EXPERIMENT SCRIPT

Introduction

My name is Andy Langager and I am a graduate student here in the Greenlee School. I am conducting a study for my Thesis research. I am hoping to get your participation in this study, however, it is entirely voluntary. You may decline to participate at any time without penalty. This study has no effect on your grade in this class. If you choose to participate, you will be kept completely anonymous.

The study consists of watching a video about national parks and monuments found in the Southwestern United States, which I will start momentarily. After viewing the video, you will fill out a questionnaire.

Instructions for control group

Please watch this video as you would a normal television show.

Instruction for treatment group

While watching the video, please concentrate on remembering all the information you can. Try to remember every detail possible about the places, names, locations, and other facts stated in this video. After watching, you will be tested for memory to see how well you can remember the facts and statements found in the video.

Debriefing

The purpose of the experiment you have just participated in is to determine what happens when different instructions are given to students when they watch a video and its effect on their memory for information in the video. Again, the results will be kept anonymous. Thank you very much for your participation.

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