Simultaneous Media Usage: Effects on Attention

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ABSTRACT

Media layering, the simultaneous use of multiple unrelated media sources, has been documented as an increasing behavior trend (Roberts, Foehr, & Rideout, 2005) that marks a qualitative and quantitative difference in the way media is experienced. Presently, the impact on consumers from media layering is unknown. A strong theoretical foundation of human information processing theory predicts negative consequences in terms of performance cost in learning, and degradation of attention. Related research on dual task performance and multiple-channel processing demonstrates a decline in performance. This study compared sustained attention performance on a cancellation task, the d2 Test of Attention (Brickenkamp & Zillmer, 1998), in four varying media conditions. Performance scores were evaluated to determine the effect of degrees of extraneous media saturation and media interaction on attention task performance.

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1. Introduction

The term “multitasking” is commonly used to describe the behavior of managing multiple tasks simultaneously, a ubiquitous part of life, perhaps since the beginning of time. However, a particular form of multitasking has attracted attention as an emerging behavior pattern. Media layering, the combining of multiple sources of unrelated media, is an increasing trend in media use among consumers in general, but particularly among American youth, who report often using two, three or more sources of unrelated media simultaneously (Roberts, Foehr, & Rideout, 2005). Consumption of media occupies a larger slice of time than ever before; the layering of multiple media sources marks a significantly different qualitative aspect of media use as well as the way media is consumed changes with this pattern of behavior.

Media layering refers to the simultaneous use of and/or exposure to multiple sources of disparate electronic and non-electronic media, some of which are interactive. A crucial component of this definition is that the media inputs are distinct, not complementary or related. A typical scenario involves a user combining layers of resources, attempting to monitor, interact and generally engage with them all, seemingly at once. Common uses of electronic media that are frequently combined include telecommunications (e.g. Internet browsing, text messaging, email, social computing, Web creation, telephone), video or computer gaming, computer productivity applications, digital photo or video editing, digital music management, television viewing, or listening to music. Non-electronic media use includes reading or viewing print media or images, and handwritten composition. An example of a typical scenario is an individual attending to multiple text messages while browsing the Internet, talking on the phone, selecting files and monitoring downloading while watching TV.

The Kaiser Family Foundation, a non-profit organization which provides information and analysis on health care issues, has conducted two nationally representative studies of youth and media. The latest study, in collaboration with researchers from Stanford University, was designed to find out everything possible about the media use and media environment in the lives of youths ages of 8-18. The survey of over 2000 participants finds, "although not a new behavior, simultaneous use of multiple media is a practice that appears to be increasing substantially" (Roberts et al., 2005, p. 35). While time spent engaged in media averages almost 6.5 hours, the actual amount of media exposure due to media layering is much longer, clocking in at a little over 8.5 hours per day (p. 36). The difference in media use behavior is that this age group reports decreasingly attending to one source of media, say, watching a movie on television. Increasingly, these consumers are layering media, for instance, watching the movie, while text messaging, browsing email, perhaps using a search engine or seeking and downloading music. This age group hasn't reduced their use of *old media*, such as television, but rather appears to have layered *new media,* such as Internet, on top of old. Considering media exposure is likely to occupy more time than any activity other than sleep, these findings document a significant behavioral trend that is particularly important as it impacts the young.

In general, youth tends to embrace new technologies with a greater comfort level than their elders. Whether due to lessened inhibition, greater flexibility or the urge for independence, young adults, particularly college students, tend to be positioned at the leading edge in taking up new technologies (Alperstein, 2005; Jones & Madden, 2002). A driving force behind the development of new technologies appears to be the appetite of media consumers of all ages to use devices simultaneously. Consumers are invited to use mobile technologies without interrupting other goal directed behaviors, as wireless connectivity enables novel options for use that are both convenient and exciting. The widening possibilities for media use in combination with other activities makes media consumption all the more complex (Alperstein, 2005). The widening options for use are unprecedented, "the ubiquity, pervasiveness and mobility of new technologies encourage a simultaneity of activities that goes beyond anything our culture has heretofore ever known" (Hembrooke & Gay, 2003, p. 2).

What is the impact of media layering? Are there consequences for this behavior? Does layering of unrelated media affect attention? These questions are unanswered; however, it is clear media consumption has changed both quantitatively and qualitatively in an unprecedented manner. Both the volume of media use and the way that media is used have changed dramatically. Yet there remains a dearth of research that explores the potential impact of this significant trend in media use. This behavior is an area of concern to educators, technology leaders, instructional designers and consumers as it impacts the media environment and shapes the way media is consumed.

This phenomenon is counter-intuitive to the principles of information processing theories founded on the limitations of working memory. The theoretical foundation of research on competing task scenarios and multiple-channel processing limitations predict negative consequences resulting from media layering. When one attempts to attend to multiple tasks, the demands on the information processing system exact a toll. Decades of research on dual task conditions yields robust findings for a performance cost when tasks are attempted simultaneously; when two tasks are presented in rapid succession, a delay in reaction time occurs for the second task (Arnell & Duncan, 2002; Levy & Pashler, 2001; Lien, McCann, Ruthruff, & Proctor, 2005; Lien, Ruthruff, & Johnson, 2006; Pashler, 1984; Ruthruff, Pashler, & Hazeltine, 2003; Telford, 1931; Tombu & Jolicœur, 2004; Welford, 1952). The shorter the interval between task presentations, the greater the increase in response time for the secondary task. This delay, known as the psychological refractory period (PRP), represents a fundamental limitation in the information processing system (Carrier & Pashler, 1995; Telford, 1931; Tombu & Jolicœur, 2004).

The human brain is not a parallel processor; it takes extra time to switch from one task to the other. Brain imaging using functional magnetic resonance imaging (fMRI) provides insight into brain activity during dual task conditions and provides innovative evidence to support a structural limitation model of information processing (Jiang, Saxe, & Kanwisher, 2004). Although one may think they can do two things at once, when in reality, "...carrying out two tasks concurrently is almost as difficult as finding 48 hours in a day" (p. 390). Even with strategizing, the brain simply cannot multitask in a parallel manner like a computer.

The capacity for processing information is highly limited making the simultaneous processing of multiple sources of information inherently problematic. The nature of the information processing system involves a high capacity for perception in the sensory register, constrained by limited capacity for processing in short term memory (Atkinson & Shiffrin, 1971; Baddeley, 2006; Broadbent, 1958; Lachter, Forster, & Ruthruff, 2004; Sweller, 1994). We are highly restricted in the number of inputs we can attend to at once; the capacity for holding and processing information governs the information processing system (Baddeley, 1994; Carrier & Pashler, 1995; G. A. Miller, 1956).

Multiple channel learning theories caution that overloading the cognitive system with unrelated inputs of stimulation causes interference and information overload resulting in decreased performance (Broadbent, 1958; Mayer & Moreno, 2003; N. E. Miller, 1957; Moore, Burton, & Myers, 2004; F. Paas, Renkl, & Sweller, 2003; Paivio, 1990; Treisman, 1960). Learning can be enhanced by the presentation of supportive, related information through multiple channels. When unrelated, competing information is presented simultaneously the demands on working memory to select and coordinate information are extreme resulting in information interference and conflict (Miller, 1957).

Cognitive load theory (Sweller, 1994) emphasizes the capacity limitations of working memory. We are limited in how much we can process at any one time (Mayer, 2001). If the mental effort required for learning information, or the cognitive load, exceeds working memory limitations, cognitive overload results and learning suffers. Cognitive load is additive, therefore extraneous stimulus contributes to the overall load. Extra stimulus takes away from successful processing of information. A “stepped-up” media presentation that includes unnecessary stimulus can tax the processing system with incidental processing caused by extraneous material (Mayer & Moreno, 2003). The addition of “bells and whistles” detract from learning in multimedia materials.

Media use and multitasking trends have not gone unnoticed. The popular press is full of cautionary articles and alarming headlines that warn of a new generation of kids “too wired for their own good” (Wallis, 2006). Recent studies find a significant and important association between the impact of media on attention (Christakis, Zimmerman, DiGiuseppe,

& McCarty, 2004; Geist & Gibson, 2000; Zimmerman & Christakis, 2005). Media use trends have captured the attention of the medical community and calls for further research into the impact of media increase (Christakis & Zimmerman, 2006; Healy, 2004). The chairperson of the American Academy of Pediatrics' Committee on Communications warns, the use of several electronic appliances simultaneously "…is an area of media use that has leapfrogged to the forefront of concern related to the potential effect of partial and simultaneous attention on learning capability and cognitive function" (Shifrin, 2006, p. 449).

Potential concerns of the consequences of media multitasking are not limited to reduced learning and performance. Environmental models of attention emphasize the adaptive nature of attention and implicate media exposure as having a potential impact on attention (Jensen et al., 1997). Instead of considering behavioral responses such as short attention spans as symptoms of attention disorders, they may reflect adaptive responses to environmental demands. Researchers hypothesize that scanning or shifting attentional systems can be "up-regulated" or set on "high-scan" due to increased media stimulation (1997, p. 1677). The environmental model of attention shaping raises important questions about changes in attentional focus and vigilance as resulting from environmental exposure.

This significant behavior trend is shaping the media consumption habits of learners. Understanding of the potential cognitive cost of habitually splitting attention in media layering is not yet clear. It is imperative that research provides an informed perspective on the impact of this phenomenon. The purpose of this study is to provide knowledge that can contribute to understanding the potential consequences of media layering, a significant trend in media consumption.

Our culture of technology creates new challenges that call for a continual advancement in skills, knowledge and reassessment of best practice. Understanding the cognitive impact of media multitasking can lead us to refine effective use guidelines for the vast resources so readily available and increasingly portable. Innovative research is needed to assess the impact of media layering so we may define practices of excellence to effectively deal with technology's advancement.

2. Literature Review

At the present, the research base for the impact of media layering is inadequate for determining the cognitive effect of this emerging phenomenon. However, examination of the extensive existing literature in cognitive psychology that examines human limitations in attempting to perform simultaneous tasks provides a strong theoretical foundation for understanding potential consequences of this behavior.

Cognitive theories of information processing predict this behavior holds negative consequences. A guiding theoretical principle in cognitive research is that the human processing system is highly constrained by strict capacity limitations that make us inherently unable to cope with an overload of simultaneous stimuli (Atkinson & Shiffrin, 1971; Broadbent, 1958; Deutsch & Deutsch, 1963; Lachter, Forster, & Ruthruff, 2004; Moore, Burton, & Myers, 2004). This overarching limited capacity assumption of working memory provides the foundation for other theories of information processing (Miller, 1956).

The Sensory Register and Working Memory

The memory process is divided into three interrelated main components for the processing and subsequent storage of information. Incoming stimuli enter the sensory register where they can either be passed on for processing or dropped. Although sensory memory is unlimited in capacity (Atkinson & Shiffrin, 1971), the ability to perceive information is highly limited. A vast array of raw stimuli are sensed in one's immediate surroundings, but only that which garners attention has a chance for selection (Moore, Burton, & Myers, 2004). Attentional selection is necessary due to capacity limitations, therefore some stimuli are selected at the expense of others (Anderson, 2005). In the sensory memory stage, there is only an instant to attend to what is sensed, or it is lost for good (Atkinson & Shiffrin, 1971).

In terms of instinct, the sensory registry (SR) is hard wired to attend to those things needed for survival. Attention focuses on stimuli that have potential biological or motivational importance for the organism (Anderson, 2005). Initial perception is influenced by proximity and organization or pattern. Stimuli that are close in proximity may be immediately threatening, and are more likely to command attention. Attention also focuses on stimuli that approximate recognition; if the stimulus pattern is not recognized, it is lost (Lachter et al., 2004; Moore et al., 2004). Those stimuli that are matched will be passed on to short term or working memory for additional processing. A change takes place in the matching process, as once a raw stimulus is recognized it is converted to its recognized form. For example, a letter or numeral is not held as an array of lines, but in its recognized identified form (Moore et al., p. 980).

The short term (STM), or working memory (WM) stage is where information is processed. The scanning of raw stimuli in the sensory register results in a pattern match; raw stimuli, now recognized, are further evaluated for relevance (Deutsch & Deutsch, 1963). Unless it is determined that information is important enough for an investment of effort, it will only stay in working memory for a brief time, a period controlled by the learner (Atkinson & Shiffrin, 1971). To keep from losing information in working memory, processing is required, using methods such as rehearsal, organization or elaboration. Working memory "...the collection of cognitive systems that maintain task-relevant information in an active state during the performance of a task" (Ruchkin, Grafman, Cameron, & Berndt, 2003, p. 709) is just that, the place where the work of processing is done. Probes are sent back and forth between working memory and long term memory to access existing knowledge, stored in the form of schemata, which match the new information. Relevance is then determined and decisions are made about suitability and to determine what level of processing is needed.

Working memory, truly the work horse of the information processing system, is highly constrained by its ability to handle incoming information. It is notably the stage with the most limited capacity—about 7 +/- 2 elements of information (Miller, 1956). The limitation of working memory poses a real problem in terms of the amount of information that can undergo processing. When the SR is dealing with a large amount of raw stimulation, it is the capacity of working memory that sets the limits—a kind of gatekeeper that regulates incoming stimuli. The separation of stimuli that make the cut from those which will be lost is determined by attention, the mechanism that controls selection (Anderson, 2005). Meaning is a key to this process—a recognized order or organization, such as a pattern, sequence, cause and effect, or connection. Meaning is needed to engage attention in order for information to be processed into long term memory with the possibility of later retrieval (Atkinson & Shiffrin, 1971). Because learning depends on processing, the learner's active engagement with information must precede the successful transfer of information to long term memory storage. Meaningful learning is characterized by the active processing of the learner (Mayer & Moreno, 2003). Processing requires available resources in working memory.

Attentional Limitations: Capacity Models

Clearly the mismatch between the sensory register's unlimited capacity and the highly limited capacity of working memory provides a significant restriction to processing ability (Baddeley, 2006; Mayer, 2005c; Sweller, 1994). The sensory register has an unlimited capacity; therefore, in terms of media layering, media saturation is not initially problematic. However, the complex nature of the selection process (Deutsch & Deutsch, 1963) that is constantly at work sorting out environmental inputs (Anderson, 2005) leads one to question whether simply the selection process itself, in a saturated media environment, impacts cognitive processes in some manner.

The capacity limitation of WM acts as a fundamental governor that limits what can be processed (Anderson, 2005; Atkinson & Shiffrin, 1971; Baddeley, 1994; Deutsch & Deutsch, 1963; G. A. Miller, 1956; Moore et al., 2004; Sweller, 1988). The selection process is constantly at work, a fundamental necessity due to the limited nature of cognitive capacity. Attention orients the information processing system to select stimuli that are potentially relevant, to the exclusion of all other stimuli, for processing (Anderson, 2005, p. 258). Attention may be thought of as the mind's eye—the orientation of interest and awareness that enables one to make sense of the surrounding world. It is the prerequisite for processing; it is what guides and directs one as goals are pursued.

From the ancient contemplations of philosophers such as Aristotle to the highly sophisticated brain imagining done in neurological labs today, attention has been a focus of study, research and thought. Near the turn of the twentieth century, William James heralded in the modern era of attention research with the first formal theory of human attention.

> "Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of several simultaneously possible objects or trains of thoughts. Focalization [and] concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others" (James, 1890).

The limitations of attention force us to withdraw from some stimuli in order to effectively attend to the most important cues from the environment. Attention is “the mechanism by which information is selected or not selected for further perceptual processing...” (Anderson, 2005, p. 258). This essential limitation in attending to simultaneous stimuli has differing theoretical explanations.

Filter Theory

Filter theories explain processing limitations in terms of information prioritization and selection. Selective attention works like a filter as it focuses on selected stimuli while screening out all extraneous stimuli (Broadbent, 1958; Deutsch & Deutsch, 1963; Treisman, 1960). Selection is based upon an orientation toward some stimuli to the exclusion of others. This filtering mechanism is in the best interest of the organism—the stimuli that are potentially threatening or useful for survival must garner attention (Anderson, 2005). The discriminative system responsible for selection is complex, highly sensitive to novel stimuli that arouse or spark curiosity (Deutsch & Deutsch, 1963)

Filtering reduces incoming stimuli to provide the opportunity for highly important information to get through (Deutsch & Deutsch, 1963; Treisman, 1960). Filtering theories differ in assigning the locus of the filtering process; it can take place early in the information processing system or late. Early selection theory places the limitation at the level of perception (Broadbent, 1958), while late selection refers to filtering at the response level (Deutsch & Deutsch, 1963; Treisman, 1960).

In early filter models stimuli are selected or filtered directly in the sensory register by a perceptual filter mechanism. Broadbent’s influential selective filter theory of attention

(1958) relies on a single stage model of perception, whereby all stimuli are initially processed. Incoming stimuli are briefly held in the pre-attention sensory register where they are scanned on the basis of their physical characteristics, such as pitch, color and orientation. This selective filter does not scan for meaning; semantic scanning will occur later in the STM stage. Physical feature representations of stimuli are temporarily housed in immediate memory; selected stimuli are filtered into a single channel (Lachter et al., 2004). The selective filter is needed to separate potentially valuable stimuli from irrelevant stimuli. This prevents an overload of stimuli from the unlimited storage capacity of the sensory register to proceed to the highly limited capacity of working memory's processing stage. Due to the disparity of capacity limitations, most incoming stimuli will be blocked.

Broadbent's model is a single channel system that can be conceptualized as separate channels from SR that limit stimuli selection to just one channel at a time—a "Y" type system that filters out irrelevant stimuli to allow selected stimuli to pass into STM for processing (1958). Broadbent conceptualized that people attend to only one specific stream of information, or channel, defined by its physical characteristic. This channel of information, when selected, prevents all other types of information from getting through. Channel selection may be guided by current goals as well as stimulus intensity (Lachter et al., 2004). An early filter model, Broadbent proposed that selection is done in stages, with filtering taking place before stimuli have been identified. The central claim in Broadbent's model, that identification requires attention, has held up well through additional research over the years (p. 880). The single selected channel allows only one piece of information into working memory at a time. Switching between channels can take place, but it requires time for the shift. This is an "all or nothing" model that does not allow any unselected stimulus to get through.

Broadbent's (1958) dichotic listening task studies demonstrate this model. Dichotic listening tasks have been reproduced with variations; however the basic design asks subjects to listen to different information in each ear, producing an overload of stimuli. Subjects are asked to attend to the stimulus in one ear, then to report as much as possible afterward. Results show reporting was primarily limited to the attended voice in one ear. The recall of information from the unattended ear tends to be highly limited. Shadowing studies involve subjects being instructed to attend to only one of the voices, and to repeat word for word what is said while they are listening. The results show that subjects are unable to report content information from the unselected ear. Recall frequently is limited to whether the voice is human or just noise, and if human, the gender of the voice, but not the topic or language of the unattended voice.

Some issues with Broadbent's selective attention model (1958) have been addressed by an extension of early filtering in Treisman's attenuation model (1960). Broadbent's model, an all or nothing model of selection, posits that stimuli in the sensory register that are not selected are completely unavailable for processing in short term memory. This does not explain how some information actually does get through the early filter. For example, some information is able to supersede selection and move right into processing. The "cocktail party" effect is most often cited as an example: while engaged in conversation, when one hears their own name mentioned in an unattended conversation, attention immediately switches to their name, often resulting in recall of information given just before the mention of their name. This would indicate that filtering may not completely block unselected information (1960).

Treisman's (1960) attenuation model is a two stage filtering process. Incoming stimuli in the sensory register are analyzed by an attenuation filter on the basis of rough physical characteristics. This information will be retained even if not selected. Selected stimuli are further filtered by a "dictionary" of threshold settings, a second stage filter between the sensory register and short term memory. The dictionary attenuates the threshold sensitivity to words—a type of subjective loudness. Highly relevant information has a low or sensitive threshold for activating awareness. This stimulus easily commands attention, even when other processing is taking place. A low threshold enables attracting attention even if the stimulus is low in volume. Those stimuli that are selected in the second stage filter are then transferred into short term memory. Some items in the dictionary will vary depending on the current goals of the listener and accumulated experiences (Treisman).

Treisman (1960) supported his model with a shadowing task that resulted in findings that when the message in separate ears was transferred from one ear to the other, the subject followed the message across ears. In other words, they switched selected attention based on meaning. Attention focuses on criteria that matches priority and decreases attention for irrelevant messages. This result demonstrates that semantic evaluation takes place prior to the STM stage (Treisman).

Late selection filter theories place the filtering process in the working memory stage, that is, after pattern recognition, or the assignment of meaning. In the response selection theory of attention, almost all information in the sensory register receives a fairly high discrimination level whether it has garnered attention or not (Deutsch & Deutsch, 1963). Late selection theories differ from early selection theories in both the locus of filter mechanisms and assumptions made about short term memory. While early selection theories are based on a highly limited capacity in working memory, 7 +/- 2 elements (Miller, 1956), late selection models conceptualize working memory as larger in capacity yet constrained by how many items can be simultaneously processed. Stimuli that arouse awareness set a standard for the moment in time—setting a variable benchmark for selection based upon current needs and goals. Those stimuli that are highly arousing will command attention for processing; those that fall below the benchmark are lost to decay (Deutsch & Deutsch).

Cognitive Limitations: Cognitive Load Theory

In terms of information processing, working memory provides the greatest constraint to the system due to the highly limited capacity (Atkinson & Shiffrin, 1971; Baddeley, 1994; Miller, 1956). However, cognitive load theory (CLT) assumes these limitations are unique to novel information; no known limitations restrict WM when dealing with information retrieved from LTM (Ericsson & Kintsch, 1995).

When information is transferred to long term memory for storage, the nature of that information is altered. Long term memory holds information in integrated units or schemata; these are chunks of information that are constructed over time, assimilating new information and developing in varying levels of complexity (Paas, Tuovinen, Tabbers & Van Gerven, 2003; Paas, van Merrienboer & Adam, 1994; van Merrienboer & Ayres, 2005a; van Merrienboer & Sweller, 2005b). The “chunking” of information significantly reduces the load for working memory by reducing even complex concepts to one element, instead of multiple small bits of information (G. A. Miller, 1956, p. 83). Schemata lift the limitations of working memory as they organize information and knowledge that will be transferred back to working memory for processing (Sweller, 1994). A key feature of processing limitation in working memory is the enormous number of possibilities for organizing and combining information; the limitation of possibilities through the reduction of information units contribute significantly to reducing information load (van Merrienboer & Sweller, 2005b). In this sense, one may consider long term memory schemata as pre-processed information for working memory.

Schemata facilitate problem solving by enabling learners to recognize a specific type of problem as belonging to a category of similar problems and access previously applied strategies that will be effective in providing a solution (Sweller, 1988, p. 259). Novices, who lack schema for a learning task, are forced to attempt general problem solving methods to determine effective solutions; this is an inefficient system that requires a great increase in working memory resources. Sweller posits that schema acquisition is a primary factor for problem solving ability (p. 260). Expert-novice research suggests "...domain specific knowledge, in the form of schemata, is a distinguishing factor between novice and expert learners in problem solving skills" (p. 259). The distinguishing difference between experts and novices is that a novice has not developed the schemata that an expert has acquired through prior learning experiences. An expert is able to proceed through problem solving without the errors a novice must work through in order to progress to a solution (Sweller).

The construction of schemata and their repeated use serves to automate those actions that are present across varied problem situations. With practice, schemata based processes can proceed automatically, with high reliability and a minimum of effort, that is, without conscious awareness of the process itself that is required for the task (Sweller, 1994). Automation bypasses working memory, and aids the allocation of resources for novel or unique situations (Paas et al., 2003). Automatic processes occur with time and practice;

strategic processes, on the other hand, require attention and conscious effort for reliable completion. A strategic process that is frequently used will build schema and can become automated over time (Sweller, 1988).

Cognitive load refers to the total amount of mental energy required of working memory at a point in time (Sweller, 1994). A multidimensional construct, cognitive load represents the load imposed on the cognitive system due to performing a particular task (Paas et al., 1994, p. 64). At the heart of cognitive load is the limited capacity of working memory. Cognitive load theory is primarily focused on the degree of difficulty required for learning novel information, or put another way, “the ease with which information may be processed in working memory”(van Merrienboer & Ayres, 2005a, p. 6). Total cognitive load is divided into three additive components: intrinsic cognitive load; extraneous cognitive load; and germane cognitive load. The goal of instructional design is to reduce total cognitive load to ease learning. The correct balance of the three components is crucial to easing difficulty while enhancing authentic learning.

Intrinsic cognitive load (ICL) is the level of complexity or degree of difficulty of the material itself for the learner (van Merrienboer & Ayres, 2005a, p. 6). ICL is determined by the interaction between the capability level and prior knowledge of the learner and the nature of the materials being learned. This boils down to how many elements the learner must simultaneously process in working memory. A high degree of difficulty or interactivity means a high level of ICL. The use of schemata can reduce this number and ease ICL. Expertise and learner experience equate to prior knowledge. Prior knowledge promotes schemata construction. ICL needs to be held to a level that neither frustrates the learner with extreme demands, nor under stimulates the learner by covering material in which proficiency has been achieved (Sweller, 1988).

Extraneous cognitive load (ECL) refers to the degree of difficulty imposed by the manner of learning (van Merrienboer & Ayres, 2005a). This is an instructional issue that is not a necessary component of learning. ECL involves the learning environment, instructional strategies, learning materials, interface design, etc. Poorly designed instruction requires additional processing by learners, thus squandering working memory resources which could have been used for learning. If instruction is designed with too much information in either the auditory or visual channel it can cause an information overload and increase ECL. Cognitive load theory seeks to reduce extraneous cognitive load as much as possible. Since it is not a part of learning, well designed and implemented instruction should impose a minimum of ECL (2005a).

Germane cognitive load (GCL) refers to processes that are directly related to learning. It is the mental investment of the learner in the learning tasks; it is the engagement of the learner in learning. A necessary component of learning, GCL may be translated as the active processing of the learner. GCL also refers to the learner's motivation for learning, and the inclination of the learner to invest mental effort. Schemata construction and automation free up WM resources to enable use for processing novel materials (Sweller, 1988). GCL is valuable as it directly impacts the process of learning.

The instructional goal of cognitive load theory is to keep the total cognitive load at levels that will optimize learning, in part by, reducing extraneous cognitive load and increasing germane cognitive load to a point which will allow the necessary intrinsic cognitive load without overloading the system (Sweller, 1988). However, learner motivation is a crucial element that makes a significant contribution to the success of the learner. The dynamics between learner investment of mental effort, motivation and performance indicate that lower task involvement stems from a lower investment of mental effort and results in lower performance. Higher task involvement is associated with a higher investment of mental effort and yields higher learner performance (Paas, Tuovinen, van Merrienboer & Darabi, 2005). The learner must invest the mental energy gained from reduction of extraneous cognitive load into mental effort invested in the process of learning (germane cognitive load.) Instruction designed to enhance motivation of the learner to apply processing resources to construction of schemata and increase automation will generate more germane cognitive load and produce increased learning.

Dual Coding

The dual code hypothesis is grounded in the premise that images and verbal information are distinctly different in origin. The human information processing system processes the codes for images and verbal information through two separate subsystems. These systems operate independently to encode information; one for sensory images or non-verbal information, the other for verbal language (Mayer & Anderson, 1991; Najjar, 1996). Although independent, these systems are interconnected, and can share codes for certain information. Non-verbal images are automatically encoded by both the verbal and non-verbal channels. Verbal information is based on language, that is, words, either spoken or in text. It is possible for it to be encoded by both systems, but the process is not automatic, and depends on other factors, such as the prior experiences of the learner.

Based on this model, dual code theory supports the instructional premise that related information presented in both verbal and non-verbal codes will result in learning gains beyond those from presentation through either the verbal or non-verbal channel alone (Moreno & Valdez, 2005). Referential processing, that is, information that is processed through both channels, has an additive effect on recall (Mayer & Anderson, 1991). Referential processing may produce an additive effect on recall due to the creation of additional cognitive paths that can be followed to assist in retrieval (Najjar, 1996). Presentation through both processes results in stronger encoding by the learner, with the following conditions: the information is integrated to avoid the splitting of attention, and information in verbal and non-verbal channels is not redundant (Moreno & Valdez, 2005; van Merrienboer & Ayres, 2005a). Structuring information to take advantage of increased processing through the use of both subsystems promotes active learning yielding greater germane cognitive load.

Limitations of the information processing system restrict the advantages of dual code learning. Preventing cognitive overload is a strong consideration when structuring learning to draw information through multiple channels. Based on the limited capacity of working memory, the processing demands of dual code materials must maintain an acceptable level. “Each working memory channel can process only a limited amount of information at any time...” (Moreno & Valdez, 2005, p. 37). The processing demands of instructional materials must not exceed the capacity of working memory, or learning will be decreased.

Split Attention and Redundancy Effects

With a basis in cognitive load theories, the effects of split attention and redundancy are negative as both impose unnecessary load on information processing, albeit in different ways. These concepts are used frequently in reference to the presentation of information through the visual and auditory channels. The split attention effect refers to the decrease in learning outcomes when multiple information inputs are presented in only one channel, such as a visual representation accompanied by text (Mayer & Moreno, 1998). This requires learners to initially attempt to represent both imagery and text in visual working memory. The working memory capacity of the visual channel is likely to be overloaded. The learner is required to split their attention between both sources of information in one channel, rather than accessing additional working memory resources from another channel. While trying to maintain both inputs in one channel, the learner is likely to miss some pieces of information; full attention to either text or imagery leaves insufficient working memory resources to attend to the remaining information.

In contrast, dual coding theory posits when related information is presented in two channels, typically auditory and visual, the effect is to enhance learning by using the full resource power of both channels for learning (Paivio, 1990). The modality effect offers a way to maximize WM by utilizing resources from both the visual and auditory channels rather than splitting the resources available in just one channel (Mayer, 2005c). The logical relation between the sources of information is critical; the desired effect is not obtained unless the sources of info rely on each other in order to make sense. When presentations are made in a single mode, such as pictures presented with text, learning is decreased; if the text were replaced by auditory information, a narrative of the text, both the visual and auditory channels could contribute full working memory resources. (Mayer, 2005a; Mayer &

Anderson, 1991). The more processing resources available for incoming information, the better the learning outcome; active learning, wherein the learner accesses and uses a variety of cognitive processes to make sense of information, yields valuable, meaningful learning (Mayer & Moreno, 2003).

Adding superfluous elements fails to promote learning; in fact it wastes valuable processing resources thereby depleting resources needed for learning.

Multiple-Channel Communication

Research findings on cognitive load and dual coding point to a general conclusion that when information is presented in a manner that makes effective use of multiple sensory channels, such as audio and visual, learner processing is increased and learning outcomes are improved (Mayer & Anderson, 1991; Mayer & Moreno, 2003; Moreno & Valdez, 2005; van Merrienboer & Ayres, 2005a) . The term “effective” means, in part, that information must be “closely related, supportive information”(Najjar, 1996, p. 130). The use of visual and auditory channels in a coordinated manner can facilitate learning; however, presenting verbal and visual explanations without connecting them is much less helpful (Mayer & Anderson, 1991).

Multiple-channel communication produces a negative impact on leaning when information is unrelated. Both Broadbent (1958) and Treisman (1960) supported their theories with dichotic listening tasks, wherein subjects were exposed to unrelated stimuli in each ear. Although their models differ in terms of the processing system, they share some consistent findings: exposure to competing simultaneous unrelated stimuli does not enhance recall, in fact it hampers it.

Extraneous information places an extra burden on the working memory resources with incidental processing (Mayer, 2005a, 2005b; Sweller, 1994). When extraneous media inputs are added to multimedia learning materials, the added stimuli impose an increased cognitive load for processing and result in a decrease in learning performance (Mayer, 2005b; Mayer & Moreno, 2003; Moreno & Mayer, 2000). Extraneous inputs arouse learners and compete for attention; although they may provide increased entertainment, they impose an added processing cost that takes away from the limited resources needed for problem solving, recall and transfer (Moreno & Mayer, 2000).

What are the implications of exposure to simultaneous unrelated sources of media stimulation? In terms of the information processing system, capacity limitations provide an overarching governor of how much an individual can process at any given time. “The human information processing system appears to function as a multiple-channel system until the system capacity overloads. When the system capacity is reached, the processing system seems to revert to a single channel system. In other words a fixed cognitive capacity limits the absolute amount of information that the individual can handle” (Moore et al., 2004, p. 998).

Performance Deficits

The research base does not support the beneficial use of multiple sources of dissimilar media; however, research that assesses the impact of media layering is still emerging. A strong theoretical foundation of information processing theory predicts negative consequences in terms of performance cost in learning, and degradation of attention.

PRP Paradigm

The psychological refractory period (PRP) paradigm has been widely recognized as accounting for performance deficits in terms of reaction time delay when dual tasks are presented within a short period of time (Telford, 1931). Task response times are performed and measured separately to provide a baseline for comparison; then tasks are presented at a variable interval, or stimulus onset asynchrony (SOA). Baseline reaction times and the SOA reaction times are compared. When the SOA is short, the processing of both tasks (T1 and T2) must proceed simultaneously. The results, replicated numerous times, consistently show T2 response time is lengthened; the shorter the time interval between tasks, the longer the delay in T2 response time. (Ruthruff, Pashler, & Hazeltine, 2003)

Central Bottleneck

The central bottleneck theory (Welford, 1952) explains the PRP effect in terms of stages of processing. When processing dual tasks with a short SOA, the response time for T2 is subject to a delay until the response to T1 has reached a point of automation at the final stage of processing (Levy & Pashler, 2001). The bottleneck model assumes three stages of processing. In the pre-bottleneck stage, the perceptual encoding of the task stimulus takes place. At the second stage, the bottleneck, central processing takes place. This stage is characterized as a decision making stage, when response selection is determined and retrieval of selected responses from LTM commences. The third and final stage, the post-bottleneck, is the stage at which response processing takes place (Lien, McCann, Ruthruff, & Proctor, 2005).

It is the central processing stage, the bottleneck, which is unable to accommodate simultaneous processing of multiple tasks. Until T1 has completed or nearly completed this crucial stage, T2 may be encoded, but is on hold, unable to simultaneously reach its own crucial stage of processing (Carrier & Pashler, 1995). The shorter the SOA, the longer the delay; reaction time delay can be avoided if the SOA is long enough to allow adequate time for the central processing stage to complete the decision making process. Although the existence of the PRP effect is generally agreed, the nature of the performance delay is a source of debate.

Research using neuroimaging provides new evidence to support performance delay as a result of structural limitations of the information processing system in dual task conditions. Instead of delay resulting from increased processing time, as posited by central executive models, fMRI studies explain the passive nature of task delay in the PRP effect. Response for task 2 is delayed by the central bottleneck that is occupied with task 1; task 2 is on delay by passive-queuing until the bottleneck is released from task 1 (Jiang, Saxe, & Kanwisher, 2004). Subjects were unable to perform dual tasks in parallel, even when instructions prompted them to actively reduce delay between task response times and attempt to perform both tasks simultaneously (2004, p. 395). Brain imaging shows the interaction effect of two tasks even with conscious effort to give equal weight to both tasks. This research provides evidence beyond observable behavior and supports the structural limitation model of the PRP effect.

Recent Studies in Dual Task Conditions

A substantial body of research on multitasking, or dual-task situations, underscores consistent conclusions: performance is diminished when individuals engage in more than one simultaneous task (Arnell & Duncan, 2002; Atkinson & Shiffrin, 1971; Broadbent, 1958;

Carrier & Pashler, 1995; Lachter, Forster, & Ruthruff, 2004; Lien, Ruthruff, & Johnson, 2006; Meyer & Kieras, 1997a; Pashler, 1984, 1994; Telford, 1931; Tombu & Jolicœur, 2004; Treisman, 1960; Welford, 1952). While the application of classic research provides a foundation for determining the impact of media layering on learning, research directly addressing media layering is emerging, with a limited number of studies at this point in time.

The classic model for studying the impact of multitasking involves subjects trying to perform a primary task while simultaneously monitoring a secondary task for specific information. Standing up to years of replication, results show a decrease in performance due to simultaneously performing multiple tasks. “The finding of a performance decrement under divided attention conditions is so robust as to consider it a guiding theoretical principle in these various fields of attention, learning and memory” (Hembrooke & Gay, 2003, p. 4). Performance deficits include a decrease in response time (Telford, 1931) or recall or an increase in error rate.

Dichotic listening tasks measure the extent to which attention can be focused on unrelated separate information presented in each ear. These auditory channel tasks have been used to support selective filtering theories by demonstrating inability of subjects to attend to unrelated information simultaneously presented in each ear (Broadbent, 1958). Many variations of this experimental model have produced robust findings: severe limitations exist in recalling information in the unattended ear (Lachter et al., 2004).

A variation of dichotic listening tasks, shadowing, adds the element of having subjects repeat verbatim what they hear as they hear it in the attended ear. This continuous task is intended to keep subjects on track in attending to the selected ear exclusively. The message is then switched form one ear to the other. Listeners shift their attention may from one ear to the other to follow the message (Treisman, 1960). This model supports the attenuation theory of selective listening proposed by Treisman (1960).

Both examples of dichotic listening tasks produce consistent findings that underscore the severe limitations of the information processing system in handling multiple unrelated inputs. These findings provide a basis for an arguable presumption that media layering may degrade performance or learning competence.

Dual Tasking in an Instructional Setting

Based on traditional multitasking research a relevant application conducted in a college classroom demonstrates the impact of electronic media use during instruction (Hembrooke & Gay, 2003). Although the method and materials differed from existing research on divided attention, the essence of these classic studies was preserved. The results were not surprising as findings showed a performance decrement consistent with traditional research results (p. 13).

College students were provided wireless laptop computers with Internet access and encouraged to use them during lecture style instruction. Laptop activity was monitored through a proxy server that documented all computing applications including Internet browsing, online messaging and email. Using proxy logs and focus group interviews, researchers were able to monitor the relevance of Internet browsing during instruction, as well as the amount of time spent engaged with on-line media. Researchers noted that both relevant and irrelevant computing activities were taking place during instruction (Hembrooke & Gay, 2003, p. 7).

Manipulation was done in one class session when half the students were randomly assigned to report to a separate room for a related activity; the other half remained in the classroom for a 30 minute typically structured lecture. As usual, laptop use was encouraged with students free to choose their own computing activities. Next the groups switched places for an equivalent lecture with one exception—this treatment group was asked to keep their laptops closed during the entire 30 minute lecture. A brief quiz containing both multiple choice (recognition) and short answer (recall) questions was administered to each group immediately following instruction. The results were consistent with previous multitasking research findings: the multitasking group (laptops open) scored significantly lower on the assessment than the laptop closed control group (Hembrooke & Gay, 2003, p. 8).

A replication of the study two months later yielded equivalent findings. Subjects originally assigned to the control group (closed laptop) were assigned to the laptop open condition; subjects were unaware of their participation or group assignment in either experiment. A between subject comparison "...revealed a significant effect of condition on total and recall test score measures, with students in the open laptop condition performing significantly poorer than those in the closed laptop condition (Hembrooke & Gay, 2003, p. 8).

Broadbent's theory of selective attention (1958) contributes to a theoretical foundation for the research findings in the Hembrooke and Gay study (2003). A classic model in attentional limitation, Broadbent's theory of selective attention is based on a limited processing channel through which incoming stimuli must travel en route from the sensory register to short term memory. The channel acts as a filter that limits incoming stimuli to one element at a time.

In the Hembrooke and Gay study (2003) students attempting to attend to information on the laptop and the lecture simultaneously showed a decrease in learning achievement of lecture content, the primary task (p. 8). The limitations of working memory prevent simultaneously processing both sources of information. Learners who attempt to attend to multiple sources of information at once are likely to be rapidly shifting attention from one selected source of information source to another (Kieras, Meyer, Ballas, & Lauber, 2000; Lachter et al., 2004; Rubinstein, Meyer, & Evans, 2001). The result is a loss of information or decrease in performance as only one selected information source can be processed.

While the findings in the Hembrooke and Gay study (2003) were consistent with the existing research base and therefore "...extend historical theoretical precedence to a more applied setting..." (p.9), the researchers sought to further evaluate their data for a deeper understanding of media use in the classroom context. A further analysis of laptop activity was done in order to characterize the dynamics of the type of media use and its relative impact on performance. Using proxy logs, researchers examined the content of student online activity during class including the amount of time spent on class related and unrelated sites, the total amount of class time spent on-line and the amount of time spent per Web page. Subjects were classified as "browsers" or "seekers" based on their engagement with course related Internet content. "Browsers" spent at least 50% of their online class time on Websites that were not related to class content; "seekers" spent at least 50% their online class time on class content related Websites (p. 11).

Researchers determined a significant difference between groups in terms of the efficiency of online usage styles. Subjects in the seeker group tended to spend more time engaged in the content of the online resources they visited; however, when seekers went off task, they spent an inordinate amount of time on unrelated sites. Conversely, browsers spent less time online and therefore, less time away from the primary task of attending to the lecture (Hembrooke & Gay, 2003, p. 11).

A surprising finding was that seekers scored significantly lower than browsers on the post instruction assessment. Seeking Internet related content during instruction did not enhance learning; instead, it had a negative impact on learning achievement. However "...performance on the learning assessment appears to be based not on relevance but the proportion of time spent away from the primary task..." (Hembrooke & Gay, 2003, p. 11).

Hembrooke and Gay (2003) also emphasize the role of learner engagement with online media as a factor in learner performance, regardless of its relevance to the class topic (p.14). The difference between browser and seeker group performance was moderately attributed to the style of online use, that is, the level of sustained distraction of subjects with the online content. "Browsers appear not to have been 'pulled in' by sites they visited, allowing them to allocate their resources more equally between the two inputs, minimizing the potentially distracting effects of the laptop" (p.14).

The limited capacity of attention in underscored in selective attention models for learning: there is a finite quantity of cognitive resources that may be drawn upon for processing. A variable of interest in the current study is the automaticity involved in Internet browsing. Subjects classified as browsers relied on an automatic process of rapidly clicking and scanning, without attentive engagement with the online content (Hembrooke & Gay, 2003, p. 14). Seekers, on the other hand, spent more time engaged in both media that supported or extended the topic of classroom lectures, and that which was unrelated. This group's sustained attention to online media garnered their full attentional resources, preventing them from engaging in the content of the class lecture.

Brain Imaging During Learning

Other studies that contribute to understanding the dynamics of media layering include recent research on brain function during learning and how multitasking impacts learning on a qualitative level. Brain imaging technology has enabled researchers to document brain activity in a way that provides insight into how the brain is actively involved in learning and competition for working memory resources in dual task settings. Different types of learning and memory are attributed to separate brain systems, with declarative memory reliant on the medial temporal lobe (MTL), and habit learning on the striatum (Foerde, Knowlton & Poldrack, 2006). Although many questions persist in how these systems function to optimize learning, this study contributes findings that support the view that declarative and habit learning compete to mediate task performance—either the striatum or MTL can support learning depending on the task conditions (p. 11778).

Functional magnetic resonance imaging (fMRI) was used to compare brain activity and function during two learning conditions: sessions with distraction (dual task) and without distraction (single task) (Foerde et al., 2006). Subjects performed probabilistic classification tasks (PCT) that relied on feedback to facilitate mastery. Although activation of the MTL is not required for some degree of learning in the tasks, engagement of the MTL results in a qualitative difference in task learning outcomes. Declarative learning, associated with the MTL, is characterized by the acquisition of flexible knowledge that may be readily applied to new applications (p.11778).

Researchers hypothesized that competition between MTL and striatum-dependent learning, that is declarative learning and habit learning, could be manipulated with dual task distraction (Foerde et al., 2006). The addition of a distracting secondary task would use working memory resources, leaving decreased resources for the PCT completion. This would result in a decrease of elaborative encoding and influence learning to rely on the habit memory mechanism associated with the striatum. Habit learning is associated with automated learning processes that require a decreased amount of working memory resources. Results showed that while learning in the single task mode, that is, without a distracter task, the MTL was active. In contrast, the dual task trials, learning with distraction, did not involve the MTL, only the striatum showed activity. Results demonstrate the fundamental difference in sensitivity to distraction between learning supported by the MTL and the striatum (p. 11782). From a cognitive limitation perspective, the brain may revert to using procedure learning to conserve resources. When the storage capacity for working memory is overloaded, the use of automated functions reduces the processing load, freeing up needed resources.

In follow up sessions, participants who learned without distraction were able to recall more information about the task, such as details about the materials they were using. Subjects who learned with distraction had a reduction in knowledge about the learning task. They were unable to extrapolate, an indication their knowledge was less flexible, less likely to be used for application (Foerde et al., 2006). This research shows distractions affect the way people learn, making the knowledge they gain harder to use later on. Although one can learn while distracted, knowledge gained is less flexible, less easily applied to unique problems in new contexts (p.11778). These findings reveal a change in how learning is affected during distraction, yielding knowledge that is less apt to be transferred to solve new problems and applied to novel situations.

Declarative learning, associated with the MTL, involves learning active facts that can be recalled and applied flexibly in new contexts. Procedure learning, associated with the striatum, results from practice until the task can be completed automatically or with a minimum of conscious effort (Foerde et al., 2006). Distraction during the learning process causes these two types of learning to compete, with habit learning tending to overcome declarative learning. Results from this study show either the MTL or the striatum can support learning in the PCT; the use of a distracter task alters the engagement of these systems (p. 11781).

Implications from this study contribute to emerging research on media layering. Although this study was not specifically designed to address this phenomenon, findings of dual task interference are applicable. The impact of multitasking on quality of learning raises questions about how knowledge may be applied later on and how useful it may be (Foerde et al., 2006). This study raises questions about performance that are more complex than existing research that considers recall, reaction time or recognition. Although treatment groups with and without distractions were able to learn their tasks with similar accuracy, it was in the application of knowledge that a performance decrement was found. Therefore, while a learner who is media layering may perform adequately on an assessment measure, the hidden decrement in performance lies in how that knowledge has been learned and how it can later be applied.

Driving and Cell Phone Use

Recent research that examines the impact of cell phone conversation on driving performance emphasizes the cost of dividing attention between tasks. The increasingly common use of mobile technologies has prompted research on in-vehicle technology and driving safety in distracting conditions. Research finds the cognitive demands of using technologies are at the heart of decreased driving performance (Strayer & Johnston, 2001).

Once considered a problem of visual or manual demands, new research finds the limitations of human performance undermine driving safety regardless of using hands free devices (Lee & Strayer, 2004). The tacit assumption that driving interference resulted from dialing or holding cell phones has given way to research that shows it is the attentional interference that degrades performance (Strayer & Johnston, 2001). Active engagement in cell phone conversation creates a dual-task condition which competes with cognitive resources needed for driving performance. Driving performance decrements occur when drivers are engaged in cell phone conversation, with drivers missing twice as many simulated traffic signals and demonstrating increased reaction times (Strayer & Johnston, p. 465). The data support an "...attention-based interpretation in which the disruptive effects of cell-phone conversations on driving are due primarily to the diversion of attention from driving to the phone conversation itself" (Strayer & Johnston, p. 465).

A contributing factor to driving performance degradation is the ease of use of mobile technologies (Lee & Strayer, 2004). Devices, such as hands free cell phones, designed to reduce distraction at the operational level tend to encourage use; users erroneously assume risk has been reduced or eliminated. The *usability paradox* occurs when drivers take advantage of increased ease of use and engage with in-vehicle technologies more often (Lee & Strayer, p. 585). The role of cognitive distraction is not as intuitive as manual or visual distraction in driving performance. Drivers denigrate the impact of attention and concentration during driving tasks; this lack of understanding the fundamental limitation of human performance encourages simultaneous task conditions (Lee & Strayer). Research demonstrates driving performance is impaired in cell phone use due to the competition for limited cognitive resources, not the inherent difficulty of handling and manipulating a hand held phone (Beede & Kass, 2006).

Media Layering

When inputs compete for attention, they incur some form of cost. The cost of performance in dual task situations has been well documented (Ruthruff et al., 2003; Telford, 1931; Tombu & Jolicœur, 2004; Welford, 1952). The role of attention in dual task conditions provides a foundation for research on media layering, a distinctly unique form of dual task condition. There remains a scarcity of studies that apply theoretical principles of information processing to this emerging behavior.

This study examined how attention responds in the face of multiple sources of unrelated stimulation, and simulated interactive conversation. Theory tells us that even when one appears oblivious to stimuli in the environment, that stimuli still impacts the information processing system—a system that ultimately is limited in capacity (Deutsch & Deutsch, 1963). Whether the sorting out of stimulus that competes for attention is the result of Broadbent's early filter model (1958) or Treisman's two-stage attenuation filter (1960), each incoming stimulus undergoes some evaluative monitoring that determines its relative importance. Deutsch comments on the complexity of the system that handles the selection of inputs for processing, "...the content of the two messages is analyzed prior to the acceptance of one and rejection of the other" (1963, p. 81). This implies an active mechanism that works in the background to regulate incoming stimuli. If the sensory register is saturated with disparate stimuli, which must be managed to prevent them from impinging on a limited capacity information processing system, a logical consideration is, “at what cost?” This study focuses on the cognitive cost of media layering on attention.

Research Hypotheses

The research hypotheses for this study are based on cognitive theories of information processing which predict that extraneous media stimulation will negatively influence performance on the cancellation task due to the overarching limitation of working memory capacity. Performance on the d2TA will decrease as the conditions of media saturation increase. The demands imposed on working memory by the incidental processing of extraneous stimuli will diminish resources needed for performance of the cancellation task. The performance decrement will be demonstrated by significantly lower scores. The addition of the interactive component will provide the greatest decrease in task performance.

Research hypothesis 1: Performance on the d2TA will be significantly decreased in the conditions containing the interactive component (MM-I and MS-I) compared to the counterpart conditions with no interactive component (MM and MS). The addition of an interactive component will increase demands of working memory, resulting in a decrease of working memory resources available for the cancellation task. This will decrease task performance, thus lowering the attention score.

Research hypothesis 2: Performance on the d2TA in the media minimized (MM) conditions will be significantly greater than in the other three conditions (MM-I; MS; MS-I). The optimal media condition for sustained attention is with no extraneous media added. This allows participants access to full working memory resources, resulting in the highest attention scores.

Research hypothesis 3: Performance on the d2TA in the media saturated condition with interactive component (MS-I) will be significantly lower than the other three conditions (MM; MM-I; MS). (4) < (1, 2, 3). The least desirable condition for sustaining attention is that in which there are both extraneous auditory and visual stimuli, plus an interactive verbal component. The inclusion of these elements will impose the greatest demands for working memory resources and thus reduce the resources available for the cancellation task resulting in the greatest decrease in attention performance

3. Methodology

This study assessed participants' sustained attention in four varying media conditions. Participant groups were randomly assigned to one of the four conditions which varied in media intensity, from a media minimized condition with no extraneous media stimulation to a high media saturated condition which included an interactive verbal component.

A cancellation task of attention and concentration, the d2 Test of Attention (d2TA) (Brickenkamp & Zillmer, 1998) was used to assess selective attention in each condition.

Participants and Setting

The sample was comprised of 95 college students from a major land grant public university in the southeast. Participants were recruited primarily from summer and fall undergraduate courses; a small number of graduate students and faculty were also used in the sample. The sample was composed of 33 males and 62 females ranging in age from 18 years to 54 years. The mean age of the whole sample was 25.2 years, the median was 21.0 years, and the mode was 19 years of age. Participants were randomly assigned to one of the following media conditions: a media minimized condition (MM); a media minimized condition with an interactive component (MM-I); a media saturated condition (MS); or a media saturated condition with an interactive component (MS-I.) The mean age of each condition sample was as follows: MM—27.95 years; MM-I—25 years; MS—27.5 years; MS-I—20.38 years.

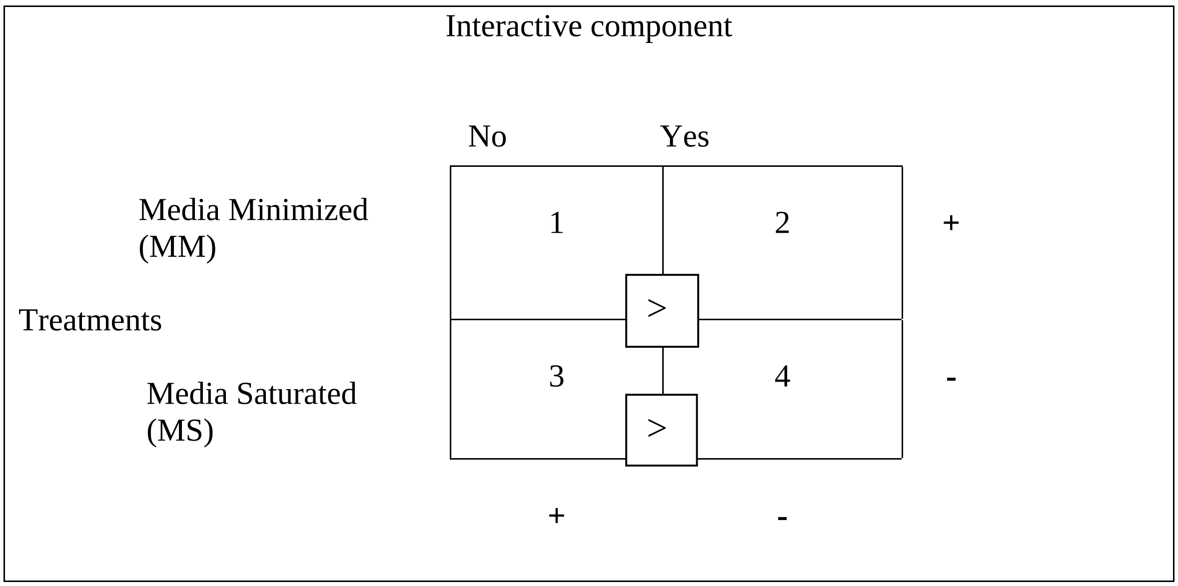
Treatments were randomly scheduled for study time slots, occurring at various times between the hours of 10:00 a.m. and 6:00 p.m. Students had no prior knowledge of when a treatment condition would be assigned, but signed up for scheduled time slots based on their own convenience. Time slots were limited to eight participants or less; all participants within a time slot were subjected to the same treatment condition. Following IRB approval (see Appendix 1), the study was piloted for a two week period. Minor changes in the study interface and procedure were made based on participant feedback and researcher experience gained during piloting. Data collection then proceeded for approximately six weeks. The sample size per condition was as follows: media minimized condition (MM) N=22; media minimized with interactive component (MM-I) N=23; media saturated (MS) N=26; media saturated with interactive component (MS-I) N=24.

Data was collected in a typical classroom setting that was modified in layout to meet the needs of the study. The room was quiet with minimal ambient noise; the lighting was adequate. Participants were seated at tables arranged to face the front of the room enabling an unobstructed view of a 40" white board. A data projector was mounted from the ceiling to project on the white board; an instructor workstation with a computer and external speakers was adjacent to the white board. Participants were within 15 feet of both the white board and speakers. Each participant had a Macintosh G4 laptop computer with a headset.

Data Analysis and Design

A quantitative 2 X 2 between-subjects research design was used (see Table 1). The dependent variables in this study were the mean performance scores of attention from the d2 Test of Attention (d2TA) (Brickenkamp & Zillmer, 1998); the independent variables were media condition and the interactive component. Performance scores on the cancellation task were analyzed using a one way analysis of variance (ANOVA) followed by post hoc multiple comparison analyses. Data was also analyzed using a two-way ANOVA to test for any significant differences between main effects of each independent variable, media condition and interactive component, on the mean d2 Test of Attention performance scores. Analysis further tested for any significant interaction between the two independent variables of media condition and the interactive component.

Table 1: Research Design



Task sheets were hand scored by the researcher in accordance with the d2 Test of Attention instructions (Brickenkamp & Zillmer, 1998). Scoring key overlays were used to identify the Total Number of Items Processed, both correctly and incorrectly (TN), Errors of omission (E_1) and commission (E_2), and Total Relevant Items Processed (TR). Raw scores were recorded on each task sheet then entered into a Microsoft Excel spreadsheet where computations of total scores for each participant were calculated. Calculations based on TN, E_1 and E_2 were used to determine the mean performance scores for each condition, Total Number of Items Processed Minus Errors and Concentration Performance (see Appendix 2).

TN-E, the Total Number of Items Processed Minus Errors, provides a measure of the quantity of work completed but corrected for the total number of errors. It provides a valuable assessment of rate and precision of performance and sustained attention. TN-E is normally distributed, highly reliable and has been used as a major index for test validation studies, experiments and diagnostic work (Brickenkamp & Zillmer, 1998, p. 11). Shortcomings of the TN-E score are that it tends to overestimate performance in those participants who leave out or skip over sections of the task trials.

Concentration Performance (CP) was computed from the Total Relevant Items Processed (TR), minus the total Errors (E). The CP score of overall performance has advantages over TN-E as it cannot be distorted by haphazard skipping of sections of individual trial rows, or crossing out characters indiscriminately (Brickenkamp & Zillmer, 1998, pp. 11-12). CP is the most recently introduced d2TA performance score and allows a more accurate estimation of concentration; it is normally distributed, highly reliable and an excellent tool for assessing performance speed and accuracy (p. 11).

Materials

Dependent Measures

This study used the d2 Test of Attention (Brickenkamp & Zillmer, 1998) a cancellation task which measures processing speed, rule compliance and quality of performance through the discrimination of similar visual stimuli. This task is designed to assess selective attention by demonstrating the subject’s ability to visually search for a specified target and to mark or cancel all matching targets amid an array of distracter symbols. The d2 Test of Attention (d2TA) also measures a related construct of selective attention, the ability to maintain an engaging activity over a period of time (Brickenkamp & Zillmer). Considered a standard instrument for measuring concentration, processing speed and selective attention in Germany, the d2TA was adapted for use in English speaking populations with U.S. normative data in 1998 (Brickenkamp & Zillmer).

The d2 Test of Attention (d2TA) is a paper and pen task composed of rows of the lowercase letters “d” and “p” with one, two, three or four dashes arranged either individually or in pairs, placed above and below each letter. There are 658 total items in the test, arranged in 14 rows of 47 characters per row. The task is timed, allowing 20 seconds per row. Participants visually scan each line and use an ink pen to mark all “d’s” with two dashes. The d2TA task is printed on both sides of 8 ½” by 11” white paper. The front side contains blanks for relevant information about the participant, including age, sex and dominant hand, plus samples of the task targets and a practice line. The back side of the paper contains the actual task, with the 14 trials arranged in numbered rows.

The d2 Test of Attention (d2TA) was selected for this study as it has been shown to be an effective standardized measure of concentration (Brickenkamp & Zillmer, 1998). Concentration, or selective attention, can be defined as the ability to sustain focus on targeted stimuli while suppressing awareness of other distracting stimuli (Zillmer & Spiers, 1998). Comparison between the d2 Test of Attention (d2TA) and the Wechsler Adult Intelligence Scale-Revised (WAIS-R) have demonstrated discriminant validity between measures of intelligence and the d2TA’s measure of selective attention (Davis & Zillmer, 1998).

In cross-validation studies, performance scores of the d2 Test of Attention (d2TA) were correlated with other concentration tests noted for validity in assessing complex attention and “necessitate the use of concentration and attention as a prerequisite for good performance" (Brickenkamp & Zillmer, 1998, p. 22). The salient scores of the d2TA were significantly correlated with all measures of complex attention (p. 21). Cross validation findings have suggested good construct validity of the d2TA with other established tests of attention and concentration (p. 22).

Reliability studies have demonstrated very high reliability of the d2 Test of Attention. Split-half methods, using both first and second half and correlation of odd and even lines, assessed the equivalence of test sections. Findings have shown high internal consistency ($r > .90$), a major measure of reliability of the whole test (Brickenkamp & Zillmer, 1998, pp. 17-18).

Treatment Conditions

Subject groups completed the d2TA in one of four randomly assigned treatment conditions that varied in level of extraneous auditory and visual stimulation and interactivity. Each participant was seated at Mac G4 laptop computer with access to the experiment Website for session sign in, completion of a survey of media use and delivery of appropriate auditory and/or visual stimulus for the assigned condition. To ensure consistency of participants' workstation displays, laptop screen resolutions were uniformly set to 800 X 600 pixels and energy saving settings and screen saver settings were set to "never" display. Each participant wore headsets with built in microphones connected to their laptop. Volume settings on laptops were uniformly set and volume controls on headsets were set to maximum volume; the controls were taped in place to prevent adjustment. Each participant completed the d2TA task trials on paper using an ink pen. Recording blanks attached to clip boards were placed on plastic trays that fit over laptop keyboards. This ensured the task workspace was consistently in close proximity to the laptop monitor.

Materials for all conditions included the following basic equipment: paper cancellation task recording blanks and two ink pens for each participant; recorded timed task trial intervals of 20 seconds with start and stop signals played on a computer with external speakers, backup timer; a Macintosh G4 laptop computer workstation for each participant with study Website access for task registration and administration of added media conditions; headsets with built in microphones; elevated plastic trays (18” x 12” x 2.5”) and clipboards to provide a work surface placed over each participant’s laptop keyboard.

In the media minimized (MM) environment, the room remained quiet throughout this condition with no extraneous media stimuli. Participants simply completed the d2TA task with the same timing conventions and signaling used throughout this study. Laptop workstations were set up with elevated trays and headsets in the same manner as all other conditions.

The media minimized environment with interactive component (MM-I) included the same treatment conditions and materials as the media minimized environment (MM), except for the addition of the interactive audio component. A recorded interactive conversational input was delivered from the study Website and started after participants clicked the “continue” prompt as instructed. Participants listened to the audio stimulus through their computer headsets and were instructed to respond to the questions by speaking into the headset microphones. See Appendix 3 for the interactive component questions.

The media saturated environment (MS), did not include the interactive component, but added three media components delivered during cancellation task trials. Current action/adventure movie trailers that included dialog played on participants’ laptops from the study Website. A lower volume popular music selection with lyrics was layered with the movie audio soundtracks. All audio was delivered through the headsets. A photographic slide show of human interest pictures was projected from a computer and displayed at the front of the classroom on the white board. Pictures included celebrities, humorous animal shots, action scenes, and miscellaneous pictures chosen for their potential to engage observers.

Additional materials for the media saturated (MS) and media saturated with interactive component conditions were: computer with slide show presentation software, video projection device and 40” white board, and the three media components described above (digital human interest photographs, movie trailers with layered popular music selection at a lower volume delivered through the study Website).

The media saturated environment with an interactive component (MS-I) included the same three media components as the media saturated (MS) condition, plus the same interactive component as used in the media minimized with interactive component condition (MM-I). The audio portion of these components was layered over one another, with the interactive component recorded at a higher volume adjusted so participants were able to hear it over the movie trailer soundtracks and music. The media and interactive components were delivered in the same manner as in the other conditions.

Procedure

Conditions

Undergraduate students scheduled participation in the study via an online registration system; graduate students and faculty voluntarily signed up for available time slots with the researcher. The researcher randomly assigned conditions to scheduled timeslots prior to participants arriving. The study was conducted in a well lighted, comfortable classroom containing a ceiling mounted data projector and white board. Computers were arranged on tables in the classroom so that participants were seated facing the front of the room where the white board was mounted. Participants read and signed a consent form. The researcher read from the prepared set of instructions for the current condition. Questions were encouraged and answered.

Participants were queried about their dominant hand; those that reported being left handed had their laptop and workspace adjusted for comfort. Participants completed an on-line questionnaire about their media usage. As participants finished, the researcher placed a white plastic tray over the laptop keyboard and placed a clipboard on top with the d2TA task attached. The front of the sheet contained an anonymous ID number that specified a numeric code for the treatment condition, blanks for brief demographic information; examples of the task targets and a practice trial.

Prepared instructions were read to participants to ensure consistency between participant groups and between treatment conditions. Instructions for each of the four treatment conditions varied only in providing appropriate information and procedures for the media and interactive differences between conditions.

The researcher directed participants as per instructions to complete a short practice trial of one line from the d2TA for a fixed time of 20 seconds. The practice trial included no extraneous stimulus. The purpose of the practice trial was to ensure that participants understood how to do the task, were introduced to the start and stop prompts, and understood the task instructions in general.

In the media minimized condition (MM), participants received no auditory input in their headsets and no visual stimulation on their laptops. They completed the cancellation task with no extraneous auditory or visual stimulus. Although participants completed the task on the same elevated work space arrangement and wore the headsets as in the other conditions, no added media played on the laptop, headphones remained silent and participants were not instructed to speak into microphones.

The media minimized plus interactive component condition (MM-I) added a recorded interactive conversational input delivered via computer headphones during the cancellation task trials (Appendix 3). Questions were spaced at an intermittent pace in each trial; pauses after each question allowed sufficient time for participants to provide answers. Participants were instructed to answer questions, speaking clearly and audibly into their headset microphone. Questions continued without interruption through the breaks between cancellation task trials. Participants listened for start and stop signals delivered by computer speakers at the front of the room. The volume of start and stop signals was set so it could be heard over the audio stimuli.

Participants in the media saturated condition (MS) received three different media components while completing the cancellation task trials. First, movie trailers played on each participant's laptop with the visual input displayed on the monitor and the audio track, including dialog, sound effects and music, played through the headsets. A second unrelated musical input was delivered via computer headset from each individual computer station (musical selection was a popular piece that included lyrics.) Lastly, visual inputs consisting of a variety of human interest photographs selected for this demographic were displayed as a computer slide show presented at the front of the room via a data projector on a 40" white board. Computers were arranged so that the projected images were displayed in front of the participants; participants needed to look up to see the visuals. All media components played for 10 seconds before the first signal to start the first task trial and were played continuously during the entire task series including the breaks between task trials. Participants were directed to look up from their task recording blanks during the trial breaks.

Participants in the media saturated condition with interactive component (MS-I) received all the stimulus of the media saturated condition, with the addition of interactive questions delivered through the headsets. Participants responded verbally through the built in microphone in their headsets.

Cancellation Task

The researcher read the instructions found in the appendices to groups as specified and monitored participants to ensure they were following directions. Instructions were consistent between conditions, with only those differences that related specifically to the treatment condition. (See Appendix 4: Media Minimized; Appendix 5: Media Minimized with Interactive Component; Appendix 6: Media Saturated; Appendix 7: Media Saturated with Interactive Component.) As per instructions, the researcher invited and answered questions as needed and prompted for questions before moving ahead in instructions.

A practice trial was used to familiarize participants with the task. The practice trial consisted of one line of the d2TA characters and was timed for a total of 20 seconds. The d2TA consists of a total of 14 trials of 1 line each with a fixed time of 20 seconds per trial. Trial rows were numbered. The researcher read all instructions for the entire task; provided opportunities for questions to be answered; started and stopped computer slide show; played the timing recording for task trials; monitored trial progress; observed participants and assisted as needed; and collected task trial sheets at the conclusion of the experiment.

The beginning of each time interval was signaled by a recorded whistle blast; the end of each timed interval was signaled by a recorded tone. Breaks occurred between each timed interval, each lasting between 10 and 20 seconds. A recording of signaled time intervals and breaks was be used to ensure consistency of timing and signal audibility between all groups (See Appendix 8). The trial timing recording was created using Audacity software and saved as a .wav file. The trial timing recording was played on a computer located within 15 feet of all participants and played with adequate speaker amplification for participants to hear it above all other audio from their assigned media condition.

All laptops were set at the same volume level; headphones were turned up to maximum volume and volume controls were taped to prevent adjustment. Computer and headset volume was checked prior to each study time slot; participants were questioned regarding comfort levels before the first trial signal was given. Pilot testing the study provided participant feedback about sound volume, start and stop signal volume, and audibility of the interactive component. Adjustments were made prior to data collection to ensure effective sound levels for headsets that allowed participants to hear the recorded signals. The researcher moved among participants in order to monitor their understanding of the task procedure and compliance with the start and stop signals, assisting with hand gestures during the first three trials to reinforce prompt compliance.

4. Data Analysis

Process

This study examined the impact of media exposure on sustained attention in order to better understand potential implications of current trends in media use. The simultaneous use of multiple sources of disparate media, or media layering, is an emerging behavior trend in media consumption (Roberts, Foehr, & Rideout, 2005). The purpose of this study was to determine if there was a significant difference in sustained attention as measured by performance on a cancellation task in four varying media conditions designed to simulate degrees of media layering. The dependant variables in this study were mean scores for Concentration Performance and Total Items Processed Minus Errors from the d2 Test of Attention. The independent variables were the four media treatment conditions: media minimized (MM), media minimized with interactive component (MM-I), media saturated (MS), and media saturated with interactive component (MS-I).

Study participants were randomly assigned to one of the four media conditions and then completed the d2 Test of Attention cancellation task on paper. Task sheets were coded for the media condition, then scored by the researcher in accordance with the d2 Test of Attention manual (Brickenkamp & Zillmer, 1998). D2 Test of Attention transparent scoring keys were used to score task sheets by hand. Use of the scoring keys minimized scoring errors by providing numbered grids for determining total numbers of processed answers. Two answer keys blocked out irrelevant characters, allowing the scorer to easily find and count applicable responses for errors of omission and commission. To further minimize scoring error, a volunteer college undergraduate student was trained in scoring and checked the researcher's scoring of task sheets and on later transfer of raw scores into spreadsheet and from spreadsheet to statistical analysis program.

Scoring the task sheets consisted of determining four scores for each trial row: Total Number of Items Processed per row, two types of errors per row (E_1 and E_2), and Total Relevant Items Processed per row (Brickenkamp & Zillmer, 1998). Total Number of Items Processed is the sum of all characters, both relevant and irrelevant, that were processed in each row. This score was determined by the position of the last character either correctly or incorrectly marked in each row. Error Type 1 (E_1) for each row is the number of omissions of correct characters that should have been marked, but were not. Error Type 2 (E_2) are errors of commission, the total number of incorrect characters marked in each row. The Total Relevant Items Processed for each row was determined by the number of relevant characters, whether marked or not marked, within the boundary of characters processed (pp. 11-12).

In each of the rows, the last marked character determined the border for the amount of work completed by the participant. The Total Number of Items Processed (TN) for each participant is the sum of the TN's for each row. It is the grand total of items processed per task sheet—an overall measure of allocation of attentional resources, processing speed and the amount of work completed (Brickenkamp & Zillmer, 1998, p. 11). It does not account for accuracy or rule compliance, but is vital in computing more sensitive performance scores.

Errors were identified in two separate categories: E_1, errors of omission and E_2, errors of commission. Errors of omission are the most commonly occurring type of mistake, resulting when a targeted character, a "d" with two dashes, is not marked. Errors of omission scores are sensitive to attentional control, rule compliance, accuracy of visual scanning and quality of performance (Brickenkamp & Zillmer, 1998, p. 11). Errors of commission are less common and occur when irrelevant characters are marked. That is, any “p” regardless of the number of dashes, or “d” that had fewer or greater than two dashes. Errors of commission are related to inhibitory control, rule compliance, accuracy of visual scanning, carefulness, and cognitive flexibility (p. 11). Total Errors (E) is the sum of both types of errors from all rows. This raw score is used with TN in calculating Total Number of Items Processed Minus Errors, “…a measure of attentional and inhibitory control and the relationship of speed and accuracy of performance” (p.11).

The Total Relevant Items Processed for each row was determined by the number of relevant characters, whether marked or not marked, within the boundary of characters processed in each row. The scoring key contained numbered blanks for each relevant character that should be marked, allowing the scorer to record the number of the last relevant character marked in each row. This score was used to find the more valuable performance score, Concentration Performance (Brickenkamp & Zillmer, 1998, pp. 11-12).

The four raw scores, Total Number of Items Processed, Errors of omission, Errors of commission and Total Relevant Items Processed, were recorded on each task sheet for each of the 14 task trials (rows) and then entered into a Microsoft Excel spreadsheet where computations of total scores and more sensitive performance scores for each participant were calculated. Two overall performance scores were calculated for each participant: The Total Number of Items Processed Minus Errors and Concentration Performance. The Total Number of Items Processed Minus Errors was computed to measure the quantity of correct work. This score does not allow correction for those participants who skip through portions of the task trials and achieve extremely high Total Number of Items Processed scores. A more recently devised d2TA score, Concentration Performance, cannot be skewed by participants skipping portions of trial rows. This score was calculated by determining the Total Relevant Items Processed and subtracting total errors (Brickenkamp & Zillmer, 1998, pp. 11-12). Concentration Performance corrects for overestimates of performance and provides a more accurate measurement of concentration.

Mean scores and variances for Total Number of Items Processed Minus Errors (TN-E) and Concentration Performance (CP) were calculated for each participant. TN-E and CP sums, overall means and variances were calculated for each of the four treatment conditions. Total scores of each participant for Total Number, Total Errors, Total Number of Items Processed Minus Errors and Concentration Performance from the spreadsheet were imported into SPSS 12.0 for data analysis. Calculated within condition sums, means and variances in SPSS matched those calculated on the spreadsheet giving further assurance of the correct transfer of data from spreadsheet to SPSS.

Results

This experiment examined the effect of varying media conditions on sustained attention as measured by mean scores of Concentration Performance and Total Number of Items Processed Minus Errors on the d2 Test of Attention (Brickenkamp & Zillmer, 1998). The research hypotheses predicted a significant decrease in performance in those conditions that included the interactive component. In addition, a significant decline in performance was anticipated as the media conditions intensified with expectations that the highest performance would occur in the media minimized (MM) condition, declining to the lowest performance in the media saturated with interactive component (MS-I) condition.

A one-way Analysis of Variance (ANOVA) revealed significant differences between the four treatment conditions in mean Concentration Performance scores, $F(3, 91) = 14.969$

($p<.05$) and in Total Number of Items Processed Minus Errors scores, $F(3, 91) = 12.548$ ($p<.05$). (See Table 2.)

Table 2: ANOVA for Concentration Performance and Total Number of Items Processed Minus Errors for All Treatment Conditions

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
CP	Between Groups	67716.157	3	22572.052	14.969	.000
	Within Groups	137224.579	91	1507.962		
	Total	204940.737	94			
TN.E	Between Groups	227119.774	3	75706.591	12.548	.000
	Within Groups	549054.163	91	6033.562		
	Total	776173.937	94			

CP = Concentration Performance
TN.E = Total Number of Items Processed Minus Errors

The first research hypothesis, *performance scores in the conditions containing the interactive component (media minimized with interactive component, MM-I, and media saturated with interactive component, MS-I) would be significantly decreased compared to their counterpart conditions with no interactive component (media minimized, MM, and media saturated, MS)* was supported by a visual inspection of the treatment condition mean scores. Both the Concentration Performance and Total Number of Items Processed Minus Errors scores decreased when the interactive component was added to the media minimized and media saturated conditions. The mean Concentration Performance score of 211.23 in the media minimized condition (MM) dropped to 151.70 when the interactive component was added (MM-I). In the media saturated condition (MS), the mean Concentration Performance score of 210.92 dropped to165.00 when the interactive component was added (MS-I). The mean Total Number of Items Processed Minus Errors scores dropped from 519.77 in the media minimized condition (MM) to 407.04 when the interactive component was added (MM-I) and from 508.15 in the media saturated condition (MS) to 426.54 with the interactive component (MS-I) (see Table 3.)

Table 3: Descriptive Statistics for Concentration Performance and Total Number of Items Processed Minus Errors for All Treatment Conditions

Descriptives

						95% Confidence Interval for Mean			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
CP	MM	22	211.23	27.685	5.903	198.95	223.50	166	271
	MM.I	23	151.70	37.086	7.733	135.66	167.73	68	235
	MS	26	210.92	48.843	9.579	191.19	230.65	79	270
	MS.I	24	165.00	36.848	7.521	149.44	180.56	61	228
	Total	95	185.05	46.693	4.791	175.54	194.56	61	271
TN.E	MM	22	519.77	49.171	10.483	497.97	541.57	419	610
	MM.I	23	407.04	73.495	15.325	375.26	438.83	271	554
	MS	26	508.15	93.596	18.356	470.35	545.96	244	605
	MS.I	24	426.54	83.520	17.049	391.27	461.81	181	540
	Total	95	465.75	90.869	9.323	447.24	484.26	181	610

CP = Concentration Performance
TN.E = Total Number of Items Processed Minus Errors
MM = media minimized condition
MM.I = media minimized with interactive component condition
MS = media saturated condition
MS.I = media saturated with interactive component condition

Post hoc contrasts using Scheffe and Bonferroni analyses revealed significant differences with lower scores occurring in media conditions that included the interactive component than in their counterpart conditions without the interactive component. Both Scheffe and Bonferroni analyses yielded identical results. Concentration Performance scores in the media minimized with interactive component condition (MM-I) were significantly lower than media minimized (MM) condition scores, with a mean decrease of 59.532 ($p<.05$). Mean Concentration Performance scores in the media saturated with interactive component condition (MS-I) were significantly lower than those in the media saturated condition (MS), with a mean decrease of 45.923 ($p<.05$). Total Number of Items Processed Minus Errors (TN-E) scores in the media minimized with interactive component condition (MM-I) were significantly different with a mean decrease of 112.729 ($p<.05$) from the media minimized condition (MM). In the media saturated with interactive component condition (MM-I) the mean Total Number of Items Processed Minus Errors scores were significantly lower than in the media saturated condition (MS), with a mean decrease of 81.612 ($p<.05$) (see Appendix 9.)

The first research hypothesis was fully supported by these findings: mean performance scores were significantly decreased in the conditions that contained the interactive component as compared to their counterpart conditions.

The second research hypothesis, *performance on the d2TA in the media minimized (MM) conditions will be significantly greater than in the other three conditions (media minimized with interactive component, MM-I; media saturated, MS; media saturated with interactive component, MS-I),* was not fully supported by findings. Both Scheffe and Bonferroni analyses yielded the same results (see Appendix 9), as described in the previous discussion, performance scores in the media minimized (MM) condition were significantly greater than in the counterpart condition with the interactive component (MM-I) with a mean difference of 59.532 in CP scores and 112.729 in TN-E scores ($p<.05$). Performance scores in the media minimized (MM) condition were also significantly greater than the media saturated with interactive component (MS-I) condition with a mean difference of 46.227 for

Concentration Performance and 93.231 for Total Number of Items Processed Minus Errors ($p<.05$). However, no significant difference was found between the media minimized (MM) condition and the media saturated (MS) condition.

Therefore the second research hypothesis was not supported by the data: the mean performance scores in the media minimized condition were not significantly greater than all of the other three conditions.

Likewise, the third research hypothesis, *performance on the d2 Test of Attention in the media saturated with interaction condition (MS-I) will be significantly lower than the other three conditions (MM; MM-I; MS)*, was not fully supported by these research findings. Contrasts using Scheffe and Bonferroni analyses revealed that although mean performance scores for both Concentration Performance and Total Number of Items Processed Minus Errors were significantly lower in the media saturated with interactive component condition (MS-I) than in the conditions that lacked the interactive component (MM and MS) (see Appendix 9), no significant difference was found between the media saturated with interactive component condition (MS-I) and the media minimized with interactive component condition (MM-I).

A significant decrease was found in media saturated with interactive component (MS-I) mean performance scores compared to media minimized (MM) scores. The Concentration Performance mean score of 165.00 in the media saturated with interaction condition (MS-I) was significantly lower than the mean for the media minimized condition (MM) at 211.23 ($p<.05$; see Table 4), with a mean difference of 46.227 ($p<.05$; see Appendix 9). The mean Total Number of Items Processed Minus Errors score in the media saturated with interaction condition (MS-I) was 426.54, which was significantly lower than the media minimized condition (MM) mean score of 519.77 ($p<.05$; see Table 4), with a mean difference of 93.231 ($p<.05$; see Appendix 9). As previously reported, the mean Concentration Performance score in the media saturated with interaction (MS-I) condition was 165.0, significantly lower than the media saturated (MS) condition mean score of 210.92 ($p<.05$; see Table 4) with a mean difference of 45.923 ($p<.05$; see Appendix 9). The mean Total Number of Items Processed Minus Errors score for the media saturated with interaction (MS-I) condition of 426.54 was significantly lower than the mean score of 508.15 ($p<.05$; see Table 4) for the media saturated (MS) condition, a difference of 81.612 ($p<.05$; see Appendix 9).

Table 4: Homogenous Treatment Condition Subsets for Concentration Performance and Total Number of Items Processed Minus Errors

CP

	Cond	N	Subset for alpha = .05: 1	2
Scheffe[a,b]	MM.I	23	151.70	
	MS.I	24	165.00	
	MS	26		210.92
	MM	22		211.23
	Sig.		.709	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 23.660.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

TN.E

	Cond	N	Subset for alpha = .05: 1	2
Scheffe[a,b]	MM.I	23	407.04	
	MS.I	24	426.54	
	MS	26		508.15
	MM	22		519.77
	Sig.		.862	.966

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 23.660.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

CP = Concentration Performance TN.E = Total Number of Items Processed Minus Errors
MM-I = media minimized with interactive component condition
MS-I = media saturated with interactive component condition
MS = media saturated condition
MM = media minimized condition

However, no significant difference was found between performance scores in the media saturated interactive (MS-I) condition and the media minimized interactive (MM-I) condition. The data from this study did not support the role of media saturation alone in producing a significant difference in either mean scores for Concentration Performance (CP) or Total Number of Items Processed Minus Errors (TN-E). The third research hypothesis was not supported by findings in this study: the mean performance scores in the media saturated with interactive component condition were not significantly lower than all of the other three conditions.

Further analysis using a two way ANOVA revealed that no significant interaction effect existed between media condition and the interactive component in either mean Concentration Performance scores or in mean Total Number of Items Processed Minus Errors scores. No significant difference was found in the media condition alone for either Concentration Performance scores or in mean Total Number of Items Processed Minus Errors scores. The significant differences were limited to those conditions that contained the interactive component: CP scores ($F(3, 91) = 43.621$, $p<.05$; see Appendix 10) and TN-E scores, ($F(3,91) = 37.027$, $p<.05$; see Appendix 11).

5. Discussion

The research hypotheses for the present study were based on cognitive theories of information processing that emphasize the overarching capacity limitation of working memory (G. A. Miller, 1956; Sweller, 1994). Performance scores on the d2 Test of Attention (d2TA) cancellation task were expected to decrease as the conditions of media saturation increased. The demands imposed on working memory by the incidental processing of extraneous stimuli were predicted to diminish cognitive resources needed for the cancellation task, resulting in decreased performance. The addition of the interactive component was expected to engage participants' attention, thus provide the greatest decrease in task performance.

This study demonstrated a significant decrease in performance from participants who completed the d2 Test of Attention (d2TA) in those conditions that included the interactive media component. In evaluating mean scores for Concentration Performance and Total Number of Items Processed Minus Errors, participants were found to score significantly lower in those conditions that included interaction. Mean performance scores in both the media minimized with interactive component (MM-I) condition and the media saturated with interactive component (MS-I) condition fell significantly below both mean media minimized (MM) and media saturated (MS) condition scores: MM-I < MM and MS ($p<.05$); MS-I < MM and MS ($p<.05$).

Findings from the present study are consistent with dual task research which demonstrates diminished performance when individuals engage in more than one simultaneous task (Atkinson & Shiffrin, 1971; Broadbent, 1958; Carrier & Pashler, 1995; Lachter, Forster, & Ruthruff, 2004; Lien, Ruthruff, & Johnson, 2006; Meyer & Kieras, 1997a; Pashler, 1994; Telford, 1931; Tombu & Jolicœur, 2004; Welford, 1952). Performance scores on the d2TA cancellation task decreased when participants engaged with the interactive component. These findings demonstrate that when participants divided their attention between the cancellation task and participation with the interactive component, their performance scores on the task were significantly decreased.

This result from the present study suggests that interaction requires the allocation of attention, thus decreasing attention needed for performance on the cancellation task. This finding is consistent with Anderson's work on attention and awareness. Anderson posits that attention must be allocated to a stimulus in order for it to be processed and thus, reach awareness (Anderson, 2005, p. 258). Due to the limited capacity of working memory, attentional selection of some stimulus is given at the expense of other stimulus (Anderson). Findings from this study support the premise that when participants interacted with media during the cancellation task, the allocation of attention toward the task was reduced, resulting in degraded performance.

The role of interaction in this study is consistent with research findings on driving impairment due to cell phone conversation. The attentional demands of interaction in cell phone conversation were found to degrade driving performance in studies using hands free phone devices. Active engagement in cell phone conversation created attentional interference that degraded performance; decrements were not due to the visual distraction or manual manipulation of the phone itself (Beede & Kass, 2006; Lee & Strayer, 2004; Strayer & Johnston, 2001). Driving performance decrements did not occur when drivers listened to audio books or the radio, but interacting in phone conversation resulted in significant interference in driving performance (Strayer & Johnston, 2001). These findings correspond with an attention-based interpretation that interaction diverts attention from the driving task and undermines performance (p. 465).

In this study, conditions which varied only in the degree of media stimulation resulted in no significant difference in d2TA cancellation task performance scores for either Concentration Performance or Total Number of Items Processed Minus Errors. The media minimized (MM) condition, in which no extraneous media was added to the d2TA task, yielded performance scores that were not significantly different than performance in the media saturated (MS) condition, which contained music, video and images. Likewise, mean performance scores in the media minimized with interactive component (MM-I) condition were not significantly different from scores in the media saturated with interaction (MS-I) condition.

This finding provides no support for the premise that extraneous non-interactive stimuli play a significant role in decreasing attention. The findings provide no evidence that extraneous stimuli are transferred beyond the sensory register into working memory. Research emphasizes the disparity between unlimited capacity of the sensory register and limited capacity of working memory as presenting a fundamental restriction in processing ability (Baddeley, 2006; Mayer, 2005c; Sweller, 1994). There is no evidence from this study that extraneous media stimuli, as simulated in the media saturated conditions, attract attention. Participants appeared to generally "tune out" extraneous media without a decrement in performance. This finding is consistent with Moore, Burton and Myers' assertion that although a vast array of raw stimuli may be sensed in one's immediate surroundings, only what captures attention has a chance for selection and processing (2004). The capacity limitation of working memory acts as a fundamental governor that limits what can be processed (Anderson, 2005; Atkinson & Shiffrin, 1971; Baddeley, 1994; Deutsch & Deutsch, 1963; G. A. Miller, 1956; Sweller, 1988).

The results of this study provide no evidence that extraneous environmental stimuli impact attention; only that stimuli which engaged participants made a significant impact on performance scores of attention. This finding is not consistent with research on cognitive load which posits that extraneous information requires incidental processing which contributes an added burden to working memory resources (Mayer, 2005a; Mayer & Moreno, 2003; Moreno & Mayer, 2000).

It can be concluded that media interaction is significant in undermining performance in a task of sustained attention. However, no evidence was found to support a conclusion that the degree of media saturation alone plays a significant role in attention task performance. In addition, no significant interaction effect was found between the media saturation and interaction.

This study contributes information to promote understanding of the implications for attention associated with the emerging media consumption trend of media layering. The working term, media layering, refers to the simultaneous use of and/or exposure to multiple sources of disparate electronic and non-electronic media, some of which are interactive. These findings provide no evidence that exposure to multiple sources of disparate electronic media alone decreases attentional performance, but do provide compelling evidence that interactive media plays a significant role in undermining performance on a task of sustained attention and concentration.

Appendix 1

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FWA00000572(expires 1/20/2010)
IRB # is IRB00000667

DATE: May 10, 2007

MEMORANDUM

TO: Katherine S. Cennamo
Joni Gardner

Approval date: 5/10/2007
Continuing Review Due Date:4/25/2008
Expiration Date: 5/9/2008

FROM: David M. Moore

SUBJECT: **IRB Expedited Approval:** "Media Layering: An Emergent Tread with Implications for Attention" , IRB # 07-257

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of 12 months, effective May 10, 2007.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtained re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

Important:

If you are conducting **federally funded non-exempt research**, this approval letter must state that the IRB has compared the OSP grant application and IRB application and found the documents to be consistent. Otherwise, this approval letter is invalid for OSP to release funds. Visit our website at http://www.irb.vt.edu/pages/newstudy.htm#OSP for further information.

cc: File

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Appendix 2

Spreadsheet Summary of Raw Data by Treatment Condition

Treatment Group Sizes			Mean Age per Treatment GROUP		
	no interaction	interaction		no interaction	interaction
media minimized	22.0	23.0	media minimized	27.95	25.0
media saturated	26.0	24.0	media saturated	27.5	20.38

Treatment Group Score Mean			**Treatment Group Score Variance**		
TN - E	no interaction	interaction	TN - E	no interaction	interaction
media minimized	519.8	407.0	media minimized	2417.8	5401.5
media saturated	508.2	426.5	media saturated	8760.3	6975.7
CP	no interaction	interaction	CP	no interaction	interaction
media minimized	211.2	151.7	media minimized	766.5	1375.4
media saturated	210.9	165.0	media saturated	2385.7	1357.7
E1	no interaction	interaction	E1	no interaction	interaction
media minimized	22.5	33.8	media minimized	415.8	563.9
media saturated	16.2	33.4	media saturated	413.6	475.8
E2	no interaction	interaction	E2	no interaction	interaction
media minimized	2.1	2.0	media minimized	8.6	4.7
media saturated	3.3	1.8	media saturated	50.2	3.1

TN-E = Total Number of Items Processed Minus Errors
CP = Concentration Performance
E1 = Error Type 1: Errors of Omission
E2 = Error Type 2: Errors of Commission

Appendix 3

Recorded Interactive Component Questions

Please answer the questions to the best of your ability. Speak clearly into your mic.

What is your college level?
How many classes do you have this semester?
What are you majoring in?
Do you have a class you dislike?
Is there something common that you typically dislike in a class?
What do you think makes the most difference in liking a course, the teacher or the subject?
What do you think makes the greatest difference in how well you do in the class?
Do you like small classes or large ones?
Do you like classes in the morning or later in the day?
When is the best time for you to study?
When you work, do you like to have anything else going on—like TV, music, IM?
Which is your hardest class?

What do think about Greek life?
Are you or have you ever been in a sorority or fraternity?
Do you live or have you ever lived in a sorority or fraternity house?
How many windows are in your current bedroom?
Who color is the floor/rug in your bedroom?
What side of your bed is your nightstand or table on?
How many doors on your closet?
How many lights in your bathroom?
What's next to your closet?
What color is your desk lamp?
What is on the screen saver of your computer?
Do you have a flash drive, and if so what color is it?

How many years have you or did you live in a dorm?
What do you think is the greatest issue for college freshmen making a good adjustment to dorm life?
What do you think is the most common complaint about dorm life?
Have you ever had a roommate you didn't like?

What town are you from?
Is that larger or smaller than Blacksburg?
Which do you like better, Blacksburg or the town you're from?
Why?
How old is the youngest member of your family?
How old is the oldest member?

How many cousins do you have?
How many of them are in high school now?

Do you like going to the movies or would you rather watch a DVD with friends at home?
Have you been to the new theatre at the mall?
What’s the last movie you saw?
What’s one of you favorites?

When you were in elementary school, what was your favorite television show?
What was your favorite movie when you were a kid?
What kind of learner are you—visual, auditory, kinesthetic...?
Describe how you would study for an exam that covers both lecture notes and assigned readings?

Are you easily annoyed by noise?
Do you like to be in places that are bright and colorful or with low lighting and soothing colors?
Do crowds bother you or do you like them?
Where do you like to shop for groceries?
What is your favorite store to shop for casual clothes?
Describe where you would take your parents out for a nice dinner—you don’t have to name a restaurant, but describe what it is like inside.

In a typical week, how many times do you have to find a place to park on campus?
What is your favorite place to eat on campus?
Where did you buy your last textbook?
About how much did it cost?
Do you use highlighters while doing your schoolwork?
What is your method of studying from a text or notes—such as highlighting, writing in margins, restating in your own words or something else?
When you drove or rode in a vehicle to campus last, what was the last thing you passed before entering campus grounds?

Estimate how many days a week you watch TV?
What is your favorite time to watch TV?
What do you do while watching TV—if you just watch, you can say that, but if you have an activity you often do, tell what that is.
What is your favorite thing to do when using the computer?

Who is your favorite actor or celebrity?
Do you think celebrities get special treatment by the legal system?
Do you think the press unfairly treats celebrities?
Some people complain about how the news covers celebrities and other sensational stories.
Can you name an occurrence when you thought they went too far in covering a news story?
Which do you prefer, local news, national news or 24 hour cable news shows?

Appendix 4

Participant Instructions for the Media Minimized Condition

General Instructions

1. Please read through and sign the consent form. I will be glad to answer any questions you have.
2. Please turn off your cell phone. Is anyone left handed?
3. You'll need to see the laptop monitor clearly, so position it as needed, but do not relocate the laptop itself.
4. Today you are going to complete an on-line survey, then do a paper and pen task.
5. You will receive instructions for everything you do today and we will do one practice round of the task.
6. Right now, you should have 2 pens, 1 sheet of paper, and a headphone/microphone headset.
7. Your computer should be showing a continue button.
8. If you don't have any of these things, or if your computer is not showing the Continue button, please let me know.

Survey Instructions

9. First you are going to complete a survey of media use.
10. This is an anonymous survey that asks you to estimate your use of media, such as television, computers, music, even telephones.
11. Answer the questions to the best of your ability thinking about the time frames that are specified.
12. At the end of the survey, stop at a screen with a blue bar at the top and a CONTINUE button like the one you see now. The instructions "Please wait until you are told to continue" appear at the top.
13. You are to wait at that screen for further instructions.
14. Any questions? Please click CONTINUE and answer each question to the best of your ability.

Practice Trial

15. [Place plastic tray over keyboard] I'm going to modify your work space a bit. The goal is for you to be comfortable with your monitor in clear view and alignment with the clipboard. [Adjust at an angle for maximum comfort.]
16. Today you will complete a paper and ink pen task called a cancellation task.
17. Please fill in your age, gender, left or right handedness and on the far right hand side, today's date.
18. Before we complete the task, we will do a sample round for practice.
19. The task is composed of rows of the lowercase letters "d" as in dog, and "p" as in pig, with one, two, three or four dashes arranged either individually or in pairs.
20. Look at the example in the middle of the sheet. See the three d's that have dashes above and/or below them?
21. Your job is to scan each line of characters and mark all characters like these examples--that is, those that are the lower case letter d with 2 dashes. The example

shows 3 samples of what this can look like--the dashes may be paired above the letter d, below the letter d, or one above and one below the letter d.

22. You will work one line at a time; each line will be timed.
23. A whistle will signal you to START; a tone will signal you to STOP.
24. Any questions before we do the practice line? Ready?

    [BEGIN THE TIMING RECORDING; PLAY THE FIRST TRIAL PERIOD.]

25. Because each line is timed, it is important that you start or stop promptly upon hearing the signal.
26. *If you make a mistake, just move on, don't try to correct it and do not try to look back over your work*.

Media instructions

27. While you are working, you will be wearing headsets; you may or may not hear sounds through the headphones.
28. There will be pauses between the cancellation task lines, during those pauses, please look up--you must not look at your paper.
29. Any questions?

Task Instructions:

30. We are almost ready to begin the task.
31. In a moment you will turn over your paper, clip it to the clipboard and orient it so that the arrow is at the top of the page. You will start with line one.
32. There are 14 rows of characters; remember, your task is to visually scan each line and use the pen to mark all “d’s” as in dog with two dashes.
33. Each line is timed; remember, a whistle will signal you to START; a tone will signal you to STOP.
34. There may be a pause before time to start again. During this pause, look up from your paper, but keep your pen in hand as you wait for the next whistle signal to start
35. When signaled, you will *START ON THE NEXT LINE* whether you completed the previous line or not.
36. It is not uncommon to not finish a whole line, but when the tone signals you to stop, please stop immediately; when the whistle signals again, *START AT THE BEGINNING OF THE NEXT LINE*.
37. <u>Please put on your headset</u> and adjust the mic so it is close to your mouth, but comfortable.
38. Any questions?

Task

43. Please turn over you paper and position it with the arrow at the top left.
44. Please lift the tray and click CONTINUE on your computer screen. Pick up your pen <u>BUT wait for the whistle to signal you to begin.</u>

Appendix 5

Participant Instructions for the Media Minimized with Interactive Component Condition

General Instructions

1. Please read through and sign the consent form. I will be glad to answer any questions you have.
2. Make yourself comfortable at your workstation. Is anyone left handed?
3. You'll need to see the laptop monitor clearly, so position it as needed, but do not relocate the laptop itself.
4. Today you are going to complete an on-line survey, do a paper and pen task and answer some questions.
5. You will receive instructions for everything you do today and we will do one practice round of the task.
6. Right now, you should have 2 pens, 1 sheet of paper, and a headphone/microphone headset.
7. Your computer should be showing a continue button.
8. If you don't have any of these things, or if your computer is not showing the Continue button, please let me know.

Survey Instructions

9. First you are going to complete a survey of media use.
10. This is an anonymous survey that asks you to estimate your use of media, such as television, computers, music, even telephones.
11. Answer the questions to the best of your ability thinking about the time frames that are specified.
12. At the end of the survey, stop at a screen with a blue bar at the top and a CONTINUE button like the one you see now. The instructions "Please wait until you are told to continue" appear at the top.
13. You are to wait at that screen for further instructions.
14. Any questions? Please click CONTINUE and answer each question to the best of your ability.

Practice Trial

15. [Place plastic tray over keyboard] I'm going to modify your work space a bit. The goal is for you to be comfortable with your monitor in clear view and alignment with the clipboard. [Adjust at an angle for maximum comfort.]
16. Today you will complete a paper and ink pen task called a cancellation task and answer some questions through your headset.
17. Please fill in your age, gender, left or right handedness and on the far right hand side, today's date.
18. Before we complete the task, we will do a sample round for practice.
19. The task is composed of rows of the lowercase letters "d" as in dog, and "p" as in pig, with one, two, three or four dashes arranged either individually or in pairs.
20. Look at the example in the middle of the sheet. See the three d's that have dashes above and/or below them?

21. Your job is to scan each line of characters and mark all characters like these examples--that is, those that are the lower case letter d with 2 dashes. The example shows 3 samples of what this can look like--the dashes may be paired above the letter d, below the letter d, or one above and one below the letter d.
22. You will work one line at a time; each line will be timed.
23. A whistle will signal you to START; a tone will signal you to STOP.
24. Any questions before we do the practice line? Ready?
    [BEGIN THE TIMING RECORDING; PLAY THE FIRST TRIAL PERIOD.]
25. Because each line is timed, it is important that you start or stop promptly upon hearing the signal.
26. *If you make a mistake, just move on, don't try to correct it and do not try to look back over your work.*

Media instructions

27. While you are working, you will be wearing headsets and will hear questions.
28. You are to answer the questions through your headset, speaking clearly into you microphone to answer while you are working. If you don't know an answer, simply say, I do not know.
29. Continue to complete the task while answering the questions to the best of your ability.
30. There will be pauses between the cancellation task lines, during those pauses, the conversation will continue, and you need to continue to answer the questions.
31. During the pauses, you will look up from your paper.
32. You will be signaled with a whistle to resume the task, but you must continue following and answering the questions.
33. Any questions?

Task Instructions:

34. We are almost ready to begin the task.
35. In a moment you will turn over your paper, clip it to the clipboard and orient it so that the arrow is at the top of the page. You will start with line one.
36. There are 14 rows of characters; remember, your task is to visually scan each line and use the pen to mark all “d’s” as in dog with two dashes while answering the question clearly and to the best of your ability.
37. Each line is timed; remember, a whistle will signal you to START; a tone will signal you to STOP.
38. There may be a pause before time to start again. During this pause, look up from your paper, but keep your pen in hand and continue to answer the questions as you wait for the next whistle signal.
39. When signaled, you will *START ON THE NEXT LINE* whether you completed the previous line or not.
40. It is not uncommon to leave a line unfinished, but when the tone signals you to stop, please stop immediately; when the whistle signals again, *START AT THE BEGINNING OF THE NEXT LINE*.
41. <u>Please put on your headset</u> and adjust the mic so it is close to your mouth, but comfortable.

42. Any questions?

Task

45. Please turn over you paper and position it with the arrow at the top left.
46. Please lift the tray and click CONTINUE on your computer screen. Pick up your pen BUT wait for the whistle to signal you to begin.

Appendix 6

Participant Instructions for the Media Saturated Condition

General Instructions

1. Please read through and sign the consent form. I will be glad to answer any questions you have.
2. Make yourself comfortable at your workstation. Is anyone left handed?
3. You'll need to see the laptop monitor clearly, so position it as needed, but do not relocate the laptop itself.
4. Today you are going to complete an on-line survey, then do a paper and pen task.
5. You will receive instructions for everything you do today and we will do one practice round of the task.
6. Right now, you should have 2 pens, 1 sheet of paper, and a headphone/microphone headset.
7. Your computer should be showing a continue button.
8. If you don't have any of these things, or if your computer is not showing the Continue button, please let me know.
9. Survey Instructions
10. First you are going to complete a survey of media use.
11. This is an anonymous survey that asks you to estimate your use of media, such as television, computers, music, even telephones.
12. Answer the questions to the best of your ability thinking about the time frames that are specified.
13. At the end of the survey, stop at a screen with a blue bar at the top and a CONTINUE button like the one you see now. The instructions "Please wait until you are told to continue" appear at the top.
14. You are to wait at that screen for further instructions.
15. Any questions? Please click CONTINUE and answer each question to the best of your ability.

Practice Trial

16. [Place plastic tray over keyboard] I'm going to modify your work space a bit. The goal is for you to be comfortable with your monitor in clear view and alignment with the clipboard. [Adjust at an angle for maximum comfort.]
17. Today you will complete a paper and ink pen task called a cancellation task.
18. Please fill in your age, gender, left or right handedness and on the far right hand side, today's date.
19. Before we complete the task, we will do a sample round for practice.
20. The task is composed of rows of the lowercase letters "d" as in dog, and "p" as in pig, with one, two, three or four dashes arranged either individually or in pairs.
21. Look at the example in the middle of the sheet. See the three d's that have dashes above and/or below them?
22. Your job is to scan each line of characters and mark all characters like these examples--that is, those that are the lower case letter d with 2 dashes. The example

shows 3 samples of what this can look like--the dashes may be paired above the letter d, below the letter d, or one above and one below the letter d.

23. You will work one line at a time; each line will be timed.
24. A whistle will signal you to START; a tone will signal you to STOP.
25. Any questions before we do the practice line? Ready?

    [BEGIN THE TIMING RECORDING; PLAY THE FIRST TRIAL PERIOD.]

26. Because each line is timed, it is important that you start or stop promptly upon hearing the signal.
27. *If you make a mistake, just move on, don't try to correct it and do not try to look back over your work*.

Media instructions

28. While you are working, you will be wearing headsets and will hear music through the headsets.
29. There will also be media playing in the room.
30. There will be pauses between the cancellation task lines; During the pauses, you will look away from your paper and view the media in the room.
31. You will be signaled when it is time to resume the task. Any questions?

Task Instructions

32. We are almost ready to begin the task.
33. In a moment you will turn over your paper, clip it to the clipboard and orient it so that the arrow is at the top of the page. You will start with line one.
34. There are 14 rows of characters; remember, your task is to visually scan each line and use the pen to mark all “d’s” as in dog with two dashes.
35. Each line is timed; remember, a whistle will signal you to START; a tone will signal you to STOP.
36. There may be a pause before time to start again. During this pause, look up from your paper, but keep your pen in hand as you wait for the next whistle signal.
37. When signaled, you will *START ON THE NEXT LINE* whether you completed the previous line or not.
38. It is not uncommon to not finish a whole line, but when the tone signals you to stop, please stop immediately; when the whistle signals again, *START AT THE BEGINNING OF THE NEXT LINE*.
39. <u>Please put on your headset</u> and adjust the mic so it is close to your mouth, but comfortable.
40. Any questions?

Task

41. Please turn over you paper and position it with the arrow at the top left.

Please lift the tray and click CONTINUE on your computer screen. Pick up your pen <u>BUT</u>

<u>wait for the whistle to signal you to begin.</u>

Appendix 7

Participant Instructions for the Media Saturated with Interactive Component Condition

General Instructions

43. Please read through and sign the consent form. I will be glad to answer any questions you have.
44. Please turn off your cell phone. Is anyone left handed?
45. You'll need to see the laptop monitor clearly, so position it as needed, but do not relocate the laptop itself.
46. Today you are going to complete an on-line survey, do a paper and pen task and answer some questions.
47. You will receive instructions for everything you do today and we will do one practice round of the task.
48. Right now, you should have 2 pens, 1 sheet of paper, and a headphone/microphone headset.
49. Your computer should be showing a continue button.
50. If you don't have any of these things, or if your computer is not showing the Continue button, please let me know.
51. Survey Instructions
52. First you are going to complete a survey of media use.
53. This is an anonymous survey that asks you to estimate your use of media, such as television, computers, music, even telephones.
54. Answer the questions to the best of your ability thinking about the time frames that are specified.
55. At the end of the survey, stop at a screen with a blue bar at the top and a CONTINUE button like the one you see now. The instructions “Please wait until you are told to continue” appear at the top.
56. You are to wait at that screen for further instructions.
57. Any questions? Please click CONTINUE and answer each question to the best of your ability.

Practice Trial

15. [Place plastic tray over keyboard] I’m going to modify your work space a bit. The goal is for you to be comfortable with your monitor in clear view and alignment with the clipboard. [Adjust at an angle for maximum comfort.]
16. Today you will complete a paper and ink pen task called a cancellation task, enjoy some video and images and answer some questions.
17. Please fill in your age, gender, left or right handedness and on the far right hand side, today's date.
18. Before we complete the task, we will do a sample round for practice.
19. The task is composed of rows of the lowercase letters “d” as in dog, and “p” as in pig, with one, two, three or four dashes arranged either individually or in pairs.
20. Look at the example in the middle of the sheet. See the three d's that have dashes above and/or below them?

21. Your job is to scan each line of characters and mark all characters like these examples--that is, those that are the lower case letter d with 2 dashes. The example shows 3 samples of what this can look like--the dashes may be paired above the letter d, below the letter d, or one above and one below the letter d.
22. You will work one line at a time; each line will be timed.
23. A whistle will signal you to START; a tone will signal you to STOP
24. Any questions before we do the practice line? Ready?
    [BEGIN THE TIMING RECORDING; PLAY THE FIRST TRIAL PERIOD.]
25. Because each line is timed, it is important that you start or stop promptly upon hearing the signal.
26. *If you make a mistake, just move on, don't try to correct it and do not try to look back over your work.*

Media instructions

27. While you are working, you will be wearing headsets and will hear music and questions.
28. You are to answer the questions through your headset, speaking clearly into you microphone to answer while you are working. If you don't know an answer, simply say, "I do not know."
29. Continue to complete the task while answering the questions to the best of your ability.
30. There will be pauses between the cancellation task lines, during those pauses, the conversation will continue, and you need to continue to answer the questions.
31. During the pauses, you will look up from your paper.
32. You will be signaled to resume the task, but you must continue following and answering the questions.
33. Any questions?

Task Instructions

34. We are almost ready to begin the task.
35. In a moment you will turn over your paper, clip it to the clipboard and orient it so that the arrow is at the top of the page. You will start with line one.
36. There are 14 rows of characters; remember, your task is to visually scan each line and use the pen to mark all "d's" as in dog with two dashes while answering the question clearly and to the best of your ability.
37. Each line is timed; remember a whistle will signal you to START; a tone will signal you to STOP
38. There may be a pause before time to start again. During this pause, look up from your paper, but keep your pen in hand and continue to answer the questions as you wait for the next whistle signal,
39. When signaled again, you will *START ON THE NEXT LINE* whether you completed the previous line or not.
40. It is not uncommon to leave a line unfinished, but when the tone signals you to stop, please stop immediately; when the whistle signals again, *START AT THE BEGINNING OF THE NEXT LINE*.

41. Please put on your headset and adjust the mic so it is close to your mouth, but comfortable.
42. Any questions?

Task

43. Please turn over you paper and position it with the arrow at the top left.

Please lift the tray and click CONTINUE on your computer screen. Pick up your pen BUT

wait for the whistle to signal you to begin

Appendix 8

Timing Schedule for Recorded Task Trial Start/Stop Signals

Trial	STOP WATCH Time	Whistle TONE	Time interval (seconds)	Trial	STOP WATCH Time	Whistle TONE	Time interval (seconds)
1	0	*Whistle* for task	20	8	3:50	*Whistle* for task	15
	20	TONE to STOP	10		4:10	TONE to STOP	20
2	30	*Whistle* for task	20	9	4:20	*Whistle* for task	10
	50	TONE to STOP	15		4:40	TONE to STOP	20
3	1:05	*Whistle* for task	20	10	4:55	*Whistle* for task	15
	1:25	TONE to STOP	10		5:15	TONE to STOP	20
4	1:35	*Whistle* for task	20	11	5:25	*Whistle* for task	10
	1:55	TONE to STOP	15		5:45	TONE to STOP	20
5	2:10	*Whistle* for task	20	12	6:00	*Whistle* for task	15
	2:30	TONE to STOP	10		6:20	TONE to STOP	20
6	2:40	*Whistle* for task	20	13	6:30	*Whistle* for task	10
	3:00	TONE to STOP	15		6:50	TONE to STOP	20
7	3:15	*Whistle* for task	20	14	7:05	*Whistle* for task	15
	3:35	TONE to STOP			7:25	TONE to STOP	20

Appendix 9

Post Hoc Comparisons for Concentration Performance and Total Number Items Processed Minus Errors Mean Scores

Multiple Comparisons

Dependent Variable		(I) Cond	(J) Cond	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
CP	Scheffe	MM	MM.I	59.532*	11.580	.000	26.54	92.52
			MS	.304	11.249	1.000	-31.74	32.35
			MS.I	46.227*	11.462	.002	13.58	78.88
		MM.I	MM	-59.532*	11.580	.000	-92.52	-26.54
			MS	-59.227*	11.116	.000	-90.89	-27.56
			MS.I	-13.304	11.331	.711	-45.58	18.97
		MS	MM	-.304	11.249	1.000	-32.35	31.74
			MM.I	59.227*	11.116	.000	27.56	90.89
			MS.I	45.923*	10.992	.001	14.61	77.23
		MS.I	MM	-46.227*	11.462	.002	-78.88	-13.58
			MM.I	13.304	11.331	.711	-18.97	45.58
			MS	-45.923*	10.992	.001	-77.23	-14.61
	Bonferroni	MM	MM.I	59.532*	11.580	.000	28.30	90.77
			MS	.304	11.249	1.000	-30.04	30.64
			MS.I	46.227*	11.462	.001	15.31	77.14
		MM.I	MM	-59.532*	11.580	.000	-90.77	-28.30
			MS	-59.227*	11.116	.000	-89.21	-29.25
			MS.I	-13.304	11.331	1.000	-43.87	17.26
		MS	MM	-.304	11.249	1.000	-30.64	30.04
			MM.I	59.227*	11.116	.000	29.25	89.21
			MS.I	45.923*	10.992	.000	16.28	75.57
		MS.I	MM	-46.227*	11.462	.001	-77.14	-15.31
			MM.I	13.304	11.331	1.000	-17.26	43.87
			MS	-45.923*	10.992	.000	-75.57	-16.28
TN.E	Scheffe	MM	MM.I	112.729*	23.164	.000	46.75	178.71
			MS	11.619	22.501	.966	-52.48	75.71
			MS.I	93.231*	22.927	.002	27.92	158.54
		MM.I	MM	-112.729*	23.164	.000	-178.71	-46.75
			MS	-101.110*	22.235	.000	-164.45	-37.77
			MS.I	-19.498	22.666	.864	-84.06	45.07
		MS	MM	-11.619	22.501	.966	-75.71	52.48
			MM.I	101.110*	22.235	.000	37.77	164.45
			MS.I	81.612*	21.988	.005	18.98	144.24
		MS.I	MM	-93.231*	22.927	.002	-158.54	-27.92
			MM.I	19.498	22.666	.864	-45.07	84.06
			MS	-81.612*	21.988	.005	-144.24	-18.98
	Bonferroni	MM	MM.I	112.729*	23.164	.000	50.25	175.21
			MS	11.619	22.501	1.000	-49.07	72.31
			MS.I	93.231*	22.927	.001	31.39	155.07
		MM.I	MM	-112.729*	23.164	.000	-175.21	-50.25
			MS	-101.110*	22.235	.000	-161.08	-41.14
			MS.I	-19.498	22.666	1.000	-80.63	41.63
		MS	MM	-11.619	22.501	1.000	-72.31	49.07
			MM.I	101.110*	22.235	.000	41.14	161.08
			MS.I	81.612*	21.988	.002	22.31	140.92
		MS.I	MM	-93.231*	22.927	.001	-155.07	-31.39
			MM.I	19.498	22.666	1.000	-41.63	80.63
			MS	-81.612*	21.988	.002	-140.92	-22.31

*. The mean difference is significant at the .05 level.

Appendix 10

Two Way ANOVA for Concentration Performance

Tests of Between-Subjects Effects

Dependent Variable: CP

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	67716.157[a]	3	22572.052	14.969	.000
Intercept	3228972.841	1	3228972.841	2141.282	.000
Interactive	65779.171	1	65779.171	43.621	.000
Media	999.662	1	999.662	.663	.418
Interactive * Media	1095.418	1	1095.418	.726	.396
Error	137224.579	91	1507.962		
Total	3458166.000	95			
Corrected Total	204940.737	94			

a. R Squared = .330 (Adjusted R Squared = .308)

Appendix 11

Two Way ANOVA for Total Number of Items Processed Minus Errors

Tests of Between-Subjects Effects

Dependent Variable: TN.E

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	227119.774[a]	3	75706.591	12.548	.000
Intercept	20496895.457	1	20496895.457	3397.147	.000
Interactive	223402.135	1	223402.135	37.027	.000
Media	367.225	1	367.225	.061	.806
Interactive * Media	5727.353	1	5727.353	.949	.332
Error	549054.163	91	6033.562		
Total	21383632.000	95			
Corrected Total	776173.937	94			

a. R Squared = .293 (Adjusted R Squared = .269)

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