OVERLOADED: INVESTIGATING THE EFFECTS OF WORKING MEMORY AND PERCEPTUAL LOAD ON ATTENTION AND MEMORY FOR ONLINE NEWS PUSH NOTIFICATIONS

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ABSTRACT

OVERLOADED: INVESTIGATING THE EFFECTS OF WORKING MEMORY AND PERCEPTUAL LOAD ON ATTENTION AND MEMORY FOR ONLINE NEWS PUSH NOTIFICATIONS

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In an emergency, journalists are on the front lines of communication as they relay breaking news to the public. Recently, news organizations promoted mobile and personal computer (desktop and laptop) applications that enable push notifications for breaking news alerts. In United States, over 60 % of adults use the Internet to watch videos (Olmstead, Mitchell, Holcomb & Vogt, 2014). Among them, 36% watch news videos (Olmstead et al., 2014). With diversification of news format, and despite their best intentions, viewers are still missing key visuals, such as push notifications and alerts (Cunningham, 2016). The current study uses Lang's (2000) Limited Capacity Model of Mediated Motivated Message Processing (LC4MP) and Lavie and Tsal's (1994) Load Theory of Attention to understand the complexities of emerging news delivery and exposure formats. This study employed a 3 (working memory load: control vs. low vs. high) x 2 (perceptual load: low vs. high) x 9 (video repetitions) x 6 (working memory load repetition) x 3 (video order) nested within-subject experimental design to investigate the effects of working memory load and perceptual load on visual attention and memory for news alerts. The study's significance stems from comparing two competing theoretical frameworks – the LC4MP and LTA – to assess the effectiveness of a novel news delivery format. Findings are expected to help newsmakers and sociotechnical producers better assess the value and effectiveness of innovative news delivery forms.

Keywords. Perceptual load, cognitive load, working memory load, attention, memory

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

In an emergency, journalists are on the front lines of communication as they relay breaking news to the public. Communication to the public can include notifications, warnings, and messages that provide information, recommendations, and guidelines about specific emergencies (Reynolds & Seeger, 2005). In a journalistic context, breaking news is the fastest form of communication—where new information is disseminated as the situation or event is unfolding (Saltzis, 2012). With rapid technological advances, notifications commonly seen on different platforms may not be noticed.

News formats are changing. From 2014 to 2015, there was a 10% increase in traditional newspapers' digital audience, thus amounting to 179.3 million unique adult visitors (Conaghan, 2015). This is double the growth rate for overall Internet use (5%) (Conaghan, 2015). More news seekers are turning to digital platforms to get their news, therefore understanding how individuals process breaking news presented via new news formats is essential.

The growing popularity of non-traditional news formats has led in some cases to information-overload. As of 2015, 10-12 breaking news stories happen every day and this trend has led to consistent updates over the last several years (Camelia, 2015). Sampling 44 breaking news stories from July 2009 to July 2011, a quarter of updates to an initial breaking news story happened within 30 minutes of the original post (Saltzis, 2012). Two-thirds of these second update posts were to clarify the original report (Saltzis, 2012).

In a web-based self-report survey of 767 adults in August 2010, Holton and Chyi (2012) found that gender, news interest, and the use of specific news platforms and outlets predicted the degree of information overload from news outlets. Those who viewed news through computers, e-readers, and Facebook were more likely to feel overload with information when asked, "Would you say you often feel overloaded with the amount of news available these days, or not?" than those who use televisions or iPhones (Holton & Chyi, 2012). The question, then, becomes: how do breaking news communicators cut through the clutter of everything else with which media consumers are engaged to grab their attention for breaking news alerts?

An emerging format for delivering breaking news alerts is through push notifications, where messages are sent directly to a viewer without the need to take action or open an application (Nations, 2016). Push notifications are thought to increase user engagement and loyalty to a publication by providing alerts directly to a person's app or web browser (Woods, 2014). Since 2009, push notifications allow for direct communication to the viewer, even when engagement with the message was not sought after (Woods, 2014).

On a computer screen, push notifications typically enter in a corner of the screen and then exit from same corner. The default notification style is called a "banner" which enters for a short period of time and then exits the screen. Other notification styles can be set to an "alert" mode, as the notification enters the screen and will stay on screen until the user dismisses it (Durhams, 2015). That same location and entrance can be found on PC Windows devices (Inside Breaking News, 2013). These notifications can range from social media updates to emergency alerts. Notifications can link to different web browsers as well (e.g. Google Chrome, Mozilla's Firefox, Safari) (Durhams, 2015). The BBC and other news outlets (e.g., CNN, The New York Times) allow for breaking news alerts on the news website, and provide alerts to a viewer's news app, email alerts, and twitter alerts (BBC News Alerts, 2015). In the case of emergency alerts, like breaking news, capturing the viewer's attention is imperative. Without gaining a viewer's attention, responding to an alert in an adaptive manner is not possible.

Communicating emergencies is a concern at Michigan State University. According to Michigan State University Alert website, “One of the mandates of the [Clery] Act is to provide these Timely Warnings and Emergency Notifications to the campus community. These warnings…can be delivered via three main platforms: voice messages to phones, e-mail and SMS text messaging.” To help reach more people in an emergency, the MSU Police Department has created new desktop push notifications. According to the MSUPD’s website, MSU has a new community software package from Alertus Desktop Alert. This feature can run in the background of a personal or school computer and then launch messages to communicate about an emergency.

In a personal contact, MSUPD’s Support Services Division Commander, Dr. Penny Fischer said, “in my work in emergency management for more than a decade, communications are the number one need; and the number one failure. Letting communities know how to manage a disaster impacts lives, property and our environment.” One of Dr. Fischer’s concerns when designing the notifications was that viewers would not pay attention to them. Dr. Fischer feared that if those on campus are not notified of an emergency that disasters can escalate. She said the alerts only are affective if people pay attention to them and react to the messages.

Even when viewers try to be aware of their surroundings, they frequently miss key visuals even thought they are in their perceptual view; so-called inattention blindness (Mack & Rock, 1998). Several studies have investigated the role that introduction of new objects, changes in video pacing, screen size, task orientation, distractor’s onset, and the environment of the stimuli play in creating inattentional blindness (e.g., Abrams & Christ, 2003; Cunningham, 2014a, 2014b, 2016; Horstmann, 2002; Lang, 2000; Simons, 2000; von Muhlenen, Rempel, & Enns, 2005). Despite multiple video manipulations, like video pacing and introducing new objects, viewers missed key objects in their viewing area. In the case of breaking news alerts, missing objects translates into viewers overlooking important or potentially life-saving information.

The attention and subsequent memory of these breaking news alerts are influenced by cognitive factors, such as cognitive load, according to the Limited Capacity Model of Mediated Motivated Message Processing (LC4MP) (Lang, 2000). Cognitive load is defined as the amount of resources needed to process a message entirely (Lang, 2000). Additionally, other studies have reported that working memory and perceptual load influence attentional capture, according to the Load Theory of Attention (LTA) (Lavie & Tsal, 1994). These theories guide two veins of research; both to be considered here.

Three studies I have recently conducted attempted to replicate the LC4MP effects through the use of more realistic, media experiments testing attention and memory (Cunningham, 2014a, 2014b, 2016). The studies in review have shown that even when a person's attention is on a secondary object, their memory may serve them to know they have given their visual attention to the object. That is, viewers visually attended to secondary objects, but failed to remember the objects. The differences between attention and memory have various reasons, which I explore in this paper. Specifically, I look to compare load theory of attention to the limited capacity model in regards to cognitive load's effect on attention (inattention blindness) in a real world scenario. The current study manipulates the level of working memory load for participants during exposure to news content that varies in perceptual load with interval breaking news alerts presentation via personal computer push notifications format. Working memory load is the level of cognitive processing brought on by a task that influences selective attention when there are both relevant and irrelevant stimuli (de Fockert & Lavie, 2001). This study is manipulating working memory load because computer users or other media users are more frequently tasked with switching not just between devices, but also within devices (Yeykelis, Cummings, & Reeves, 2014).

In a recent study, researchers used computer monitoring software and physiological measures to see how arousal, task content, and task-switching changed over the viewing time (Yeykelis, Cummings and Reeves, 2014). Researchers found that one in five of all content viewed lasted for five or fewer seconds. Additionally, three-fourths of participants viewed a single piece of content for a less than a minute (Yeykelis, Cummings and Reeves, 2014). Because of cognitive overload, only a small number of tasks could be handled at once and thus viewers engaged in task switching (Yeykelis, Cummings and Reeves, 2014), which leads to increased levels of working memory load.

LC4MP mainly deals with mediated communication, specifically the media-human interaction. Many studies using LC4MP manipulate perceptual load to show how viewers process mediated messages under different media viewings conditions. Perceptual load is the amount of effort required for processing that ranges from early to late stage processing based on the difficulty of complex or simple visual stimuli, respectively (Lavie & Tsal, 1994). More recently, LC4MP has been expanded to include dynamic modeling. Dynamic modeling includes motivational and physiological measures over time. Although, these measures can account for much of the mediated communication variances, current study sought to test both perceptual load and working memory load in a media condition. It is hoped that the manipulation of these two loads will ultimately add to a better understanding of visual attentiveness, memory encoding, and memory storage through the use of attention and memory measures to the push alerts.

The current dissertation uses both communication and psychology theories in order to identify real world implications of missing key visual information while watching videos online. Chapter 1 discusses cognitive processing as it relates to attention and specifically details the connections between attention, visual attention, and inattention blindness. Chapter 2 focuses on how cognitive load influences a video viewers' processing and the competing theories on cognitive load, perceptual load, and working memory load. Chapter 3 describes the method used in the study and details the data-analytic plan. Finally, Chapter 4 and Chapter 5 provide overviews of the expected outcomes and potential implications for the study.

CHAPTER 1: COGNITIVE PROCESSING

This chapter will define cognitive processing within the context of visual attention through automatic and controlled processes. Then, this chapter will detail the different approaches (bottom-up and top-down) to the visual attention processes and how these approaches interact with each other. Finally, the chapter will discuss the problem of inattention blindness that causes viewers to miss out on important visual information.

"Cognitive processing of mediated content broadly refers to the mental act of attending to and remembering information presented through some form of medium" (Potter & Bolls, 2012, p. 68). This is operationalized by observable and measureable biological or physiological activity, including eye-tracking measures (Potter & Bolls, 2012). Information processing through our senses (sensory information) varies based on the content's motivational/emotional significance (Potter & Bolls, 2012). This perspective is called motivated attention, which states that attention is modulated by motivational/emotional significance of the stimuli (Potter & Bolls, 2012). Cognitive and emotional processes are seen as interactive and contribute together to how information is processed (Potter & Bolls, 2012). Information has both content (cognitively processed) and meaning (emotionally processes) and especially in the context of media, the two dimensions work together to drive processing. Despite the interconnectivity of the dimensions in the brain during media exposure, cognitive and emotional processes are distinct and can be measured as such (Potter & Bolls, 2012). Specifically, the attending to and remembering of stimuli is different than the meaning derived from the content. The first stage of cognitive processing is attention to the medium (Potter & Bolls, 2012), which is conceptualized next.

There are several ways to attend to media such as auditory attention, which is tuning one's selective hearing to a specific sound (Acoustical Society of America, 2012) or task-driven attention, which is choosing to focus on specific object (Wilson, Baack, & Till, 2015). However, for the purpose of this study, I examine visual attention in a television media context. In television news media, video is used to show movement and motion to mimic everyday life and engage the viewer with the informational content (Frechette, 2012). Motion can attract attention to a message and thus instigate in-depth cognitive processing (Healy & Enns, 2012). Without attention to a specific stimulus, a viewer will not be able to cognitively process the stimuli and in the case of news, will not be able to process important breaking news information. Viewers must first visually attend to news videos.

Visual Attention and the Environment

Visual attention is “a mechanism that turns looking into seeing” (Carrasco, 2011, p. 1484). Broadly, the scope of attention includes two components: 1) conceptual and 2) perceptual attention. In the context of visual attention this means conceptual attention is the likelihood of processing (Martindale, 1981), while perceptual attention is the ability of processing (Posner, 1987). Both of these include selection of an object and processing of that object.

The selection process is what makes the difference between simply casting view onto an area/object versus paying visual attention. There are four specific components to visual attention: 1) regional selection in the visual field, 2) feature dimension and values of interest selection, 3) informational flow control through the neuro-visual system, and 4) the shift from one region to another (Tsotsos, Culhane, Kei Wai, Lai, Davis, & Nuflo, 1995). Regional selection says that there needs to be a specific area in which ones’ eye can direct their focus to (Tsotsos et al., 1995). Feature dimension and values of interest selection says that the visual attention can be directed to a specific object when there are visual contrasts between the object and background (Tsotsos et al., 1995). Information flow control says that complexity in visuals in processed in a “pyramid” style, where information is imputed to a neural network and reiterated through many subhierachies (Tsotsos et al., 1995). Finally the shift from one region to another says that selective attention can be given to one area, but as that area is being processed no other regions can until the focus shifts spatially (Tsotsos et al., 1995).

In the case of visual attention, fixation can result from focusing on one object over other objects. This is when a personal visual attention falls to a specific area. Visual attention is precursor to a person is processing a message, like news alerts. Visual attention to an object is required before a person can consciously recognize and process the information fully (Duncan, 1999).

When visual attention is given to a stimulus, the person can recognize and engage in adaptive behavior, among other tasks (Palmer, 1999). In the case of news alerts, this adaptive behavior can lead to safer outcomes during an emergency. Adaptive behavior is an evolutionary feature that allows humans to attend to the stimulus and then recognize and react to it (Palmer, 1999). One example of this is seeing a bear running toward you. You will instinctively process that danger is coming and you will then react in either a fight or flight mode (Palmer, 1999). Although the object itself is important to inducing attention, the environment in which the object exists is also important in influencing attention.

A viewer’s environment is everything they perceive minus the stimulus that occupies one’s present attention (Duncan, 1999). An example can be found in the child’s book, “Where’s Waldo?” In the book, the environment or picture is where Waldo lives. Once the viewer finds Waldo, Waldo will still exist in the picture, but will not be part of the environment. Instead, Waldo becomes the stimulus. This means Waldo exists as a stimulus separate from the environment when he is the focus of attention (Duncan, 1999).

According to Anderson and Kirkorian (2006), reducing distractions in the environment increases the propensity of attention. This means that when, for instance, a stimulus is on a plain white background it will be more likely to receive attention than if it were placed on a busy, patterned background. When the background or environment is too overpowering, it can cause a decrease in contrast between the background and the stimulus.

In order for a stimulus to become the object of attention, it needs to overcome its surrounding environment. Lang and colleagues (1999) showed that with an increase in rapid pacing among the visual content on the television screen, participants exhibited a decrease in attention as measure by both a self-reported and physiological arousal measures. This change of attention in different pacing conditions demonstrated that the environment could lessen the intensity of a stimulus.

An example of this can be found at an electronics store. In this environment a person's focus may be on Stimulus 1, such as the camera section, and not on the entire store. However, if the computer section has a flashy new sign, then the person's focus may never arrive at Stimulus 1 as the environment has become too overpowering. This shows that environment and stimulus are closely linked and will affect each other when it comes to attention.

In the case of stimulus-driven attention (attention that is drawn to an object by external factors), attention is gained through automatic (bottom-up) processing. Attention can also be garnered as a result of controlled (top-down) processes, such as when a person decides to read a book. In the next section, I detail the differences between automatic and controlled processes as they relate to attention.

Automatic/Bottom-up and Controlled/Top-down Processes

There are two types of processes for gaining a person's attention, automatic and controlled (Palmer, 1999). Allocation of cognitive resources through automatic processing is through a bottom-up approach to attention, while a controlled processing is through a top-down approach to attention. When attention is gained without the person's intentional influence, this is called automatic (Simons, 2000). Controlled processes are intentional acts that require effort (Bargh & Chartrand, 1999). Both approaches require attentional engagement (Carrasco, 2011).

One key distinction between automatic and controlled processes is the amount of effort involved in each process. Controlled processes require more effort and thus take more time than automatic processes (Bargh & Chartrand, 1999). Automatic processes are effortless and take less time (Bargh & Chartrand, 1999). In a series of experiments, conducted by Bargh and Chartrand (1999), priming of goals, evaluations, and perceptual constructs were manipulated and then reactivated in participants. These manipulations and reactivations were conducted in several different experiments that included 1) goal activation and conscious choice, 2) intentional and unintentional situational experiences that resulted in automatization, and 3) internal and external sources of behavior-relevant cognitions to result in behavior (Bargh & Chartrand, 1999). Since resources are considered limited, it is important to know that these different processes require different levels of effort and thus their processing time and route is different (Bargh & Chartrand, 1999). In summary of the studies, the authors concluded that automatic responses could be caused by the several different mechanisms including automatic effects of perception on action.

Automatic Visual Attention. Automatic reactions can occur even when a person does not intend for the automatic reactions to happen. An example is when a person raises his/her hand. Instinctually, a person may raise their hand when they know an answer to a question. In contrast, when voting on a topic, a person is thoughtful about their actions when they choose to raise their hand for or against an action. The two behaviors result in the person's physical position being altered, but the motivations behind them are different, automatic and controlled.

It is important to distinguish between the two attentional mechanisms (automatic vs. controlled) to better inform the conceptualization and operationalization of attention. The following section focuses on the ways in which humans allocate cognitive resources to processing external stimuli.

Bottom-up approach. Palmer (1999) argues that the bottom-up approach to attention is stimulus driven, meaning a person's attention is drawn by outside forces (Palmer, 1999). This is an automatic response. In a person's perception of the outside world, there is a continuous input of information that is then processed through the brain (Gibson, 1979). Gibson (1979) talks about his ecological approach to perception. He says that perception is a continuous input of information. He says our perceptual system is actively gathering information and that information is not being sent to our passive selves (Gibson, 1979).

> A perceiver can keep on noticing facts about the world she lives in to the end of her life without ever reaching a limit. There is no threshold for information comparable to a stimulus threshold. Information is not lost to the environment when gained by the individual; it is not conserved like energy. (Gibson, 1979, p.87)

Gibson's approach is thought of as the bottom-up approach where our world is stimulus driven.

One can think of this as a constant monitoring of the environment. A bottom-up approach is activated by a stimulus in the visual field that activates a biological response. The biological response can activate visual attention and direct a person's attention to the object. An example of this is when a car passes by your window. The car may have nothing to do with the task at hand, but you may look to see what the motion is. Motion is a pre-attentive quality of a stimulus that can drive attention. In this case, the car is the object that influences the person's attention.

In a media context, animation in web banners can evoke a bottom-up approach. Heo and Sundar (2000) altered web page banners – some stagnate and some moving – and found that animated ads, ads with motion, elicit higher arousal responses. From their higher arousal responses, along with supported work by Lang (2000), Heo and Sundar (2000, p. 9) conclude, "the result suggests that animation can serve as a legitimate basic perceptual cue or feature [of the stimulus] that can capture users' immediate attention and generate involuntary responses during the early stages of information processing."

There are two types of visual automatic processing: orienting and alerting. Orienting attention refers to selecting "specific information from among multiple sensory stimuli" (Raz & Buhle, 2006, p. 372). Mezzacappa (2004) describes orienting as attention that is driven by an external stimulus. A person's attention is directed to a specific place or at a specific stimulus among the environment. Alerting attention is related to instances when the individual is maintaining a high vigilance of the environment (Posner, 1980). Alerting attention can be found in children as young as three months (Mezzacappa, 2004). This mechanism serves an evolutionary purpose by drawing attention to peripheral events quickly and automatically (Yantis, 1998; Hill & Barton, 2005). In the case of alerting attention, humans are constantly monitoring their environment in preparation of information processing (Mezzacappa, 2004). Orienting and alerting can be carried out through separate mechanisms. Orienting attention deals with spatial precision, while alerting attention deals with overall awareness of the visual field (Fernandez-Duque &Posner, 1996).

When a viewer focuses on a single point or stimulus, they are engaging in orienting attention. Here the person has put the stimulus in a top priority amongst other stimuli in the surrounding environment. This means the original stimulus or initial target is more effective at attracting attention than the surrounding environment and is engaging the viewer as such. It is only when a second stimulus from the environment changes (e.g. changes in size or color) will the viewer's attention be taken off the initial stimulus and directed towards the second stimulus.

An example of a change from orienting to alerting attention can be represented with some simple examples. Suppose a viewer is watching a black and white television set and a ball and a balloon are on the screen. The viewer's attention (orienting) is on the ball, but then the balloon starts to grow. This change of size activates the aversive system and redirects the person's attention from the ball and onto the balloon. This redirection is because the balloon's growing magnitude generates greater arousal than the ball. In this case, the orienting attention is being overcome by the magnitude of the second stimulus and the alerting attention has become dominant.

If the balloon's growth is less arousing than the ball, the person's attention will stay on the ball. This means that one's orienting attention to the ball is dominant. The orienting attention will continue to override the alerting attention. Furthermore, if no attention is being directed to the television screen, when movement on the screen starts to occur, the viewer will be likely to start watching the screen (Alwitt et al., 1980).

As previously mentioned, in addition to automatic visual attention processes, there are controlled visual attention processes. Controlled visual attention processes are not key to this study, but important to note otherwise.

Controlled Visual Attention. Executive attention goes by many names and it involves planning or decision making, error detection, anticipating consequences, modifying behavior, new or not well-learned responses, conditions judged to be difficult or dangerous regulation of thought and feelings, and the overcoming of habitual actions (Raz & Buhle, 2006; Mezzacappa, 2004). Executive function is a process that is a product of the viewer's choice and thus will be less likely to be influenced by a secondary task. For example, if a person is focused on reading a book, he or she will be less likely to be influenced by wanting to sing a song if their primary task is reading the book.

Executive function and cognitive control mechanisms specifically for attention are made up of "goal-directed behaviors, including planning actions, anticipating consequences, selecting among competing demands and responses, initiating and maintaining purposeful behavior, monitoring the outcome of behavior, and interrupting or modifying behavior" (Mezzacappa, 2004, p. 1373). This has been found in computerized testing in children's learning exercises (Mezzacappa, 2004).

Top-down approach. The top-down approach is an assumption that attention is driven by internal factors, like a person's goal (Awh, Belopolsky, & Theeuwes, 2012). Gregory (1980) argues that visual object engagement is internally motivated (Gregory, 1980). Gregory (1980) says that information reaches the eye, but much of the information is lost by the time it is processed in the brain. Thus, a viewer's top-down processing uses context to recognize patterns, and make sense of the outside world (Gregory, 1980).

Unlike the bottom-up approach, the top-down approach assumes attention is not instinctive or automatic responses to external stimuli (Lester, 2010). Thus, per the top-down approach, attention is influenced by other emotional, or secondary processes like predispositions, liking, etc. (Lester, 2010). A person's motivation can promote engagement or understanding of a stimulus. This motivation is referred to as the top-down approach (Awh, Belopolsky, & Theeuwes, 2012). An example of this is the goal of memorizing a list of items. The person decides to engage with the list through a top-down approach to cognitive resource allocation.

The bottom-up and top-down approaches can happen simultaneously. In one study showing the interaction of top-down and bottom-up approaches, 18 adults were monitored by scalp electroencephalography while they performed a new paradigm to activate bottom-up and top-down attention (Bidet-Caulet, Bottemanne, Fonteneau, Giard, & Bertrand, 2014). Participants were given an auditory task that either included a trial with an informative cue and no distracting sound or a trial with uninformative cue and a distracting sound (Bidet-Caulet et al., 2014). Researchers recorded scalp electroencephalography to assess distractions, top-down and bottom-up mechanisms. An increased task load in top-down attention decreased distracting sound, but failed to override bottom-up attentional capture (Bidet-Caulet et al., 2014). Bottom-up attentional capture by distracting sounds could disturb top-down mechanisms by lengthening target processing and detection (Bidet-Caulet et al., 2014). Additionally, the bottom-up distracting sounds slowed target reaction times for top-down tasks (Bidet-Caulet et al., 2014). This study shows that reaction times are different for top-down and bottom-up tasks and thus, these mechanisms may be working separately.

Another study also supported the findings that bottom-up and top-down approaches influence one another (Pinto, van der Leij, Sligte Lamme, & Scholte, 2013). In two tasks (top-down search task and object capture bottom-up attention task), participants were able to quickly find the target in a search task and were slowed by distracting objects (Pinto et al., 2013). The data was recorded using eye trackers (Pinto et al., 2013). The authors postulated that attention and consciousness might be intertwined in a different way for top-down than bottom-up attention since reaction times are different during the different orientations (Pinto et al., 2013). As this study shows, bottom-up and top-down types of attention can be influenced by the directed task, in this case, a goal.

When highly salient stimuli are present, top-down processing can be disrupted (Corbetta & Shulman, 2002). This means goal-driven attention (during top-down processing) may be stopped and attention may be refocused by object/stimulus-driven attention (Corbetta & Shulman, 2002). For example, when a person is reading a book, he/she is engaged in top-down attention to process the information presented in the book. If while reading the book, the person sees a flash out of the corner of his/her eye, then that flash will activate bottom-up saliency causing him/her to stop reading and reallocate his/her cognitive resources (or attention) to process the flash. Also, important to note, that a different goal-driven task can disrupt the original task. An example of this disruption would be when a person is internally motivated to accomplish a second task and end the first goal-driven task.

Alerting attention plays a significant role in directing a person's orienting attention when no top-down processing cue is given. For example, goal-driven orientations or lack of goals can change the way visual attention is being given to a certain stimuli (orienting attention). In a recent banner ad experiment, 329 participants were randomly assigned to three goal-orientation conditions: narrow goal orientation (seeking a specific answer), broad goal orientation (preparing for a group talk), and exploration orientation (no specific instructions) (Heinz, 2013). Upon viewing the website in one of the three conditions, participants were asked whether or not they recalled the secondary stimulus – the banner ad. The goal orientation was used as a moderator. The results showed that the orientation to the task (narrow goal-driven, broad goal-driven, and not goal-driven) moderated the memory measures for the banners, such that those in the non-goal driven condition had a better memory for the banner ads that in the other conditions. However, for recall, there were not differences between congruent and incongruent conditions, but the congruent condition was higher for recognition rates (Heinz, 2013).

Like narrow goal orientation, search tasks employ a top-down approach that filters out misguiding object features in order to orient to the target object (Egeth and Yantis, 1997). In a search task, the bottom-up approach is not dominant. Although prompting a person to search for a specific object can be a useful way to see how salient the stimuli is to the viewer, this prompt, however, does not allow researchers to see how viewers react when they are not given a goal-driven direction (Becker, Bello, Sundar, Peltier, Bix, 2015). In the case of breaking news alerts, most viewers will not be searching for alerts to appear on their screen and thus, it is important to avoid explicit instructions for viewers to be aware of the alerts (Becker, Bello, Sundar, Peltier, Bix, 2015; Cunningham, 2014a, Cunningham, 2015b). When the viewer is an aware of a goal, they are in "natural viewing."

In both a natural viewing task and a search task, viewers can miss key objects in both their primary and secondary tasks; the so-called inattention blindness (Mack & Rock, 1998).

Inattentional Blindness

Inattentional blindness happens when a viewer is focused on a target (or a primary task) and misses a distractor (secondary task) within their visual field (Mack & Rock, 1998). When a person's attention is directed to a stimulus, the likelihood of seeing other stimuli is reduced, thus leading to inattentional blindness (Simons, 2000). Inattentional blindness varies in degree and is based on the visual similarities of the target and the distractor (Koivisto et al., 2004). The mere presence of a distractor is not sufficient enough to evoke attention and may result in inattentional blindness (Simons, 2000).

One popular demonstration of the inattentional blindness phenomenon is shown in the “Gorillas in our Midst” short film (Simons & Chabris, 1999). In the classic study, participants viewed a video where three people wearing white and three people wearing black passed a basketball to each other. Video viewers were told to count the number of passes made by one of the teams or both of the teams. In the middle of the video, 45 seconds into the content, a woman in a gorilla suit walks across the screen. A post-experiment survey showed 46% of participants failed to see the gorilla (Simons & Chabris, 1999). This study is now widely used as a way to show inattention blindness and has become a viral video (Choi, 2010).

Inattentional blindness has also been shown in common scenarios like cell phone use and distracted driving (Hyman et al., 2010; Strayer, Drews, & Johnston, 2003). One study, looking at the use of cell phone distractions and impaired driving and their affects on attention to traffic signs, the authors concluded that cell phone conversations decreased recognition memory for roadside billboards by mediating driving performance and visual attention (Strayer, Drews, & Johnston, 2003).

Inattentional blindness is also found in the form of banner blindness relevant to Internet advertising or online communication context. Banner blindness happens when webpage readers ignore or do not perceive the banner ad messages because they have become too familiar with the placement on the webpage (Benway, 1998). The information in the standard ad placements (the sides of the page and the top or header of the page) tends to be ignored (Benway, 1998). Even when messages fall into typical ad spaces, there is a historical bias that the space is filled with irrelevant information (Benway, 1998).

Inattentional blindness is one of the biggest challenges facing breaking news communicators, like banner alert producers. Alerts can come into a viewing area on a computer. If allowed by the user, news network can activate the alerts. The alerts enter the screen in the upper right hand corner and then exit on that same corner. A banner alert, in many screen-viewing cases, acts as a distractor and simply adding it to the screen may not be an effective way to direct attention to the notification.

Overcoming Inattentional Blindness. There are two ways to overcome inattentional blindness: motivational activation and secondary task manipulation. These ways are preattentive and can therefore guide attention to a specific object. These ways are reviewed in this next section.

One way to overcome inattentional blindness is through motivational activation. Wang et al. (2011) identified three basic mediated message motivational variables: arousing content, positivity (appetitiveness), and negativity (aversiveness). A dynamic model was developed to test these motivation variables on the output measures: heart rate, skin conductance level, corrugator activity, and zygomatic activity (Wang et al., 2011). When it comes to attention, these three components are what make the stimulus interesting, or at a cognitive level, worth viewing (Wang et al., 2011). It is through these motivational variables that a producer can alter the magnitude of the stimulus to better communicate.

One motivational variable, appetitiveness, promotes engagement with stimuli (Cacioppo, Gardner, & Berntson, 1997). Pleasing stimuli evoke appetitive activation, while displeasing stimuli evoke aversive activation (Bradley & Lang, 2000). Aversiveness is an evolved process that moves a person away from danger (Wang et al., 2012). Images that are positive can be like seeing a friendly face or two lead characters kissing. Images that evoke aversiveness can be like is a news update or a notification. Collectively, the two systems can also be called valence (Wang, Lang, & Busemeyer, 2011). Breaking news alerts may not be appetitive, but instead on evoke averseness.

These two motivational systems, appetitive and averse, are derived from evolution, designed to promote survival (Wang, Lang, & Busemeyer, 2011). They help prepare a person to interact with and respond to stimuli from the external environment. Schneirla (1959) explains it is these factors (appetitiveness and aversiveness) that influence every type of behavior. Because both are not mutually exclusive, they can both occur at the same time (Wang et al., 2012). An example of this can be seen in a bittersweet moment on the television screen, where there is a negative, yet positive image.

The third component of motivation is arousing content, which determines the intensity of the emotional response (Wang et al., 2012). Arousing content can also be simply labeled arousal (Wang, Lang, & Busemeyer, 2011). There are varying degrees of arousal. One example of varying arousal is a gun. When a viewer sees a stagnate image of a gun on the television screen little arousal is predicted, however, if the gun is fired this could cause greater increase in arousal.

All three components – positivity, negativity, and arousing content – elicit psychophysiological responses indicative of attention and emotional responding (Wang et al., 2012). In Wang and colleagues' (2012) study, 59 participants watched two pretest PSA videos followed by twelve stimulus PSA videos, during which heart rate, zygomatic electromyography, and skin conductance level data were collected. These measures showed that positive and negative content in the videos induced more attentional capture than the viewer's past association of drug experiences depicted in the PSAs. It is through this elicitation that a communicator may evoke attention from a viewer. This then can help the viewer process the message.

Another way to overcome inattention blindness is by manipulating the secondary task's relationship to the primary task (e.g. Simons, 2000; Koivisto et al., 2004). Unexpected stimuli (secondary task objects) are easier to detect when categorized in a similar fashion as the object for which they were instructed to search (Koivisto et al., 2004). Other preattentive features of a stimulus that attract attention include: "orientation, length, closure, size, curvature, density, number, hue, luminance, intersections, terminators, 3D depth, flicker, direction of motion, velocity of motion and lighting direction" (Healy & Enns, 2012, p. 3).

One example of preattentive stimulus features that attract attention is motion (Abrams & Christ, 2003). In a series of three experiments, participants were found to be more likely to identify target letters among distractors when the targets had changed from static to moving, as compared to continuously moving targets (Abrams & Christ, 2003). A feature of an object is a component of a stimulus that can be processed in low-level vision (Healey & Enns, 2012). Thus, if it is a crisis communicator's job to increase citizens' attention, than the communicator needs to enhance the differences between the primary and secondary task.

Mezzacappa (2004) suggests that attention can be drawn away from the viewer's main visual task to secondary notifications. Using an eye-tracker and a post-experimental survey Josephson and Holmes (2006, p. 155) found that screen design altered the "distribution of fixation time" on the interest areas. When both a headline and a crawler were used, visual attention was directed to the crawl (Josephson & Holmes, 2006). Josephson and Holmes' (2006) research helped to demonstrate that the influences of multiple messages (headlines, crawlers) can change the way people view their screens.

Despite preattentive features (e.g., motion, size) and motivations (e.g., internal, task), objects can still fail to be fully processed, resulting in inattention blindness. Previous studies showed that three-quarters of participants did not recall seeing a secondary task in the form of a weather alert during television viewing (Cunningham, 2014a). The studies tested three different types of pre-attentive motion types (new object, unique event, and behavioral urgency) in weather alert icons to see which motion type best attracted attention and was later recalled. About 75% of viewers' did not recall the icons (Cunningham, 2014a). These results were also supported in a second experiment where viewers viewed the television shows on different devices (television, laptop, and cell phone) (Cunningham, 2014a, b). Again, about three-quarters of participants did not recall the weather alerts on any of the platforms (Cunningham, 2014a, b). These studies demonstrate that some preattentive manipulations can lead to inattention to secondary tasks.

Most recently, a study focused on investigating ways in which secondary task objects are attended to and remembered better by audience members (Cunningham, 2016). Testing different cueing and cognitive load conditions with the use of an eye tracker and a post-experiment survey, the researcher found that when viewing a television film, cognitive load changes viewers' recognition and memory secondary tasks (weather alerts), but not of the main content. Cueing was defined as a visual stimulus that disrupts the visual area by introducing a new object (Horstmann, 2002) and was operationalized by a wipe across the screen with a red graphic. Cognitive load was defined under LC4MP's initial definition and was operationalized by changes in pacing of video cuts (Lang, 2000) and information introduced (i^2) (Fox et al., 2007). Cueing influenced visual attention fixation but not other attention or memory measures (Cunningham, 2016). The findings support the idea that secondary tasks attracted viewers' attention, but was deemed incongruent with the main film and thus was not further processed (Cunningham, 2016).

Taken together, the three studies that I previously conducted (Cunningham, 2014a, 2014b, 2016) have shown deterioration in information between attention and memory. Specifically, this misalignment, when it comes to cognitive load, has several different reasons, which I explore in this dissertation. Evidenced from the eye-tracking data, participants exhibited visual attention to the secondary tasks (weather alerts), yet their processing seemed to have halted and did not further process into memory outcomes. There are different plausible explanations for this trend of findings: One reason may be that the weather alerts were easily comprehended after multiple repetitions, as shown in the order influences. Another reason is that viewers attended to the weather alerts, but found them not to be important or congruent with the film's content and thus they dismiss the weather alerts. I look to explore alternative conceptual definitions of cognitive load and how this is influenced by other variables defined in other disciplines, including perceptual and working memory load. These are outlined in two different theories: LC4MP and the Load Theory of Attention.

In review, this chapter detailed cognitive processing and how it is influenced by visual attention. Specifically, this chapter discussed the relationship of bottom-up and top-down pathways to attention and the structural and motivational influences of stimuli to attention. Finally, this chapter discussed the problem of inattention blindness when it comes to communicating important information visually. Next, I will discuss how a person's cognitive load is defined in both communication and psychology and how this load influences what and how information is processed.

CHAPTER 2: COGNITIVE LOAD

In the previous chapter, I discussed cognitive processing as it relates to attention, memory, and inattention blindness. The current study manipulates cognitive load in two distinctive ways. In this chapter, I review relevant literature on cognitive load and its influence on what and how information is processed. First the chapter examines the ways in which communication theoretical frameworks conceptualize cognitive load, specifically the LC4MP, to explain how viewers encode, store, and retrieve information. Second, the chapter discusses perceptual load and its possible differences and similarities to cognitive load. Finally, this chapter turns to the Load Theory of Attention (LTA) to define and operationalize working memory load for cognitive processing. This chapter concludes with hypotheses derived from this and the previous literature review.

Attention is closely tied to memory. According to a review by Fougnie (2008), bottom-up attention, or visual spatial attention, is related to the encoding of information. When a person views an object from a stimulus-driven perspective, the stimulus needs to be interpreted or commonly referred to as encoding (Fougnie, 2008). Working memory, encoding, and memory mechanisms are at the core of the LC4MP (Fougnie, 2008).

There are several factors that may influence the allocation of cognitive resources to encoding, including cognitive load. As previously mentioned, cognitive load is defined as the amount of resources needed to process a message entirely (Lang, 2000). As cognitive load increases, cognitive processing of visual stimuli can become inefficient. Cognitive loads vary based on primary and secondary stimuli, as well as an individual's appetitive (approach) and aversive (avoidance) motivation to process the message. For example, a slow-paced documentary may be less cognitively taxing than a fast-paced action movie.

The effect of cognitive loads from fast paced production has also been seen in communications studies. One study used the LC4MP to investigate how arousing content and fast paced production affects visual processing during television viewing (Lang, Bolls, Potter, & Kawahara, 1999). The number of cuts in a video manipulated the video's pace, and arousing content was manipulated through "the emotional arousal level of the message content" (Lang et al., 1999, p. 451). Results indicated that fast pace and arousing content increase cognitive loads and demand more attentional resources (Lang et al., 1999). This meant that participants had lower recognition and lower cued recall for the message's content.

In another study, Lang and colleagues studied the change in the rate of edits (related scene changes) in a video in a controlled experiment. The manipulation showed that edits increase arousal (physiological and survey) and memory (Lang et al., 2000). Changes from an already establish scene, like edits, influenced the attention measure differently than changes from scene to scene, like cuts (Lang, Zhou, Schwartz, Bolls, & Potter, 2000). The higher arousal and increased memory measures (e.g., recall) suggest that edits can increase encoding (i.e., recognition) (Lang et al., 2000). This is different than cuts (unrelated scene changes) where encoding can be decreased. *Encoding* is the process of selecting stimuli and processing it to working memory (Lang, 2000). The allocation of the cognitive resources can be seen through the extent of the *recall* (storage) and *recognition* (encoding) measures (Lang, 2000).

The LC4MP has five basic assumptions: 1) human's ability to process information is limited; 2) humans have two motivational systems – appetitive and aversive systems; 3) media is continuous interpreted using differing sensory channels; 4) cognitive and affective responses take place over time; and 5) communication is a dynamic connection between the medium and the message receiver (Lang, 2000). The model explains that as a person takes in information, each piece goes through a three-step process: 1) encoding, 2) storage, and 3) retrieval (Lang, 2000).

Encoding

Encoding is defined as “the act of creating a mental representation of a stimulus” (Lang, 2000, p. 59). This is the act of sensory input to the brain (Lang, 2000). Fixation is one way to show encoding. Fixation is often of measures of attention and by extension, encoding (Poole & Ball, 2006). This paper uses eye-tracking measures to show where viewers’ attention is through time to first fixation and gaze duration. This is a method of measuring encoding.

Another way to measure encoding is through recording secondary task reaction times (STRT) (Lang, Bradley, Park, Shin, & Chung, 2006). STRT measures the time between introduction of a secondary task while focused on a primary task and an action indicating attention (e.g., click on a certain key on a keyboard) has been used often as a measure of encoding while watching television advertisements (Lang, Bradley, Park, Shin, & Chung, 2006). One flaw in STRT, however, is that it requires the viewer to move into a search task mode (Lang, 2000). It requires the viewer to respond during a task of viewing which activates a seek-and-hunt or goal-driven mentality (Palmer, 1999).

In an experimental design where viewers are not asked to engage in a search task, time to first fixation can be measured for secondary stimuli. Time to first fixation or reaction time to fixation (RTF) is the time that takes for gaze to be near the center of an area of interest (Pel, Manders, & van der Steen, 2010). In a recent study, time to first fixation, along with other eye tracking measures, was analyzed. In an experiment of 35 children who watched short movies, the eye tracking data showed that most children’s time to first fixation for the cartoon stimuli occurred between 210 and 570 milliseconds. This measure can demonstrate how visually attentive the participant is while engaged with a stimuli by showing how long it takes them to react to the onset of a new stimulus.

With the advancement of technology, gaze and fixation from eye trackers have been used to operationalize visual attention (Poole & Ball, 2006). An eye tracker allows researchers to see what is being attended to in the person's visual field in unobtrusive ways (Merle, Callison, & Cummins, 2014; Poole & Ball, 2006). Fixation frequency is the number of times the viewer's eye is stationary in a defined area, while the gaze duration is measured as the total time for these fixations (Poole & Ball, 2006). Time to first fixation is the measurement of time after the stimulus is displayed, but before the fixation occurs (Lee & McPeek, 2013). Fixation measurements are unspecified in several studies (e.g., Owens, Chaparro, & Palmer, 2011; Ozcelik, Karakus, Kursun, & Cagiltay, 2009), but a common way to define fixation is as two successive eye positions that vary only slightly in degrees from each other (Becker, 2010). These degrees range from a half to one degree (Becker, 2010; Sanchez, Vazquez, Gomez, & Joormann, 2014). Gaze durations also vary in duration as a function of the task (Holmes, Josephson, & Carney, 2012). In a study looking at the visual demands of second-screen viewing application, participants watched two television shows while using the television show's personalized app (Holmes, Josephson, & Carney, 2012). Researchers found that even with and without push cues to view the app, participants' gaze duration increased with the app and decreased with the television (Holmes, Josephson, & Carney, 2012). The location of a gaze is often an indicator of the locus of attention and can be used to infer the information that is being processed by an observer (Carrasco, 2011). Gaze duration is the length of time visual attention is directed to the alert (Poole & Ball, 2006). This measure shows how long a person's attention is on the alert.

H1: Participants will exhibit longer gaze duration for breaking news alerts appearing in videos with low than high perceptual.

Time to first fixation is the time from when the alert enters to the screen to the first time the person's eye fixates on the alert (Lee & McPeek, 2013). This measure shows how aware the viewer is.

H2: Participants will exhibit faster time to first fixation for breaking news alerts appearing in videos with low than high perceptual load.

According to LC4MP, recognition is a measure of encoding (Lang, 2000). This measure will show if the information of the alert was encoded.

H3: Participants will have higher information recognition for breaking news alerts appearing in videos with low than high perceptual load.

The current study includes both recognition and eye-tracking measures. According to LC4MP attention starts with encoding, and the next, deeper processing level is storage (Lang, 2000).

Storage

According to LC4MP, storage takes place in working memory by linking new information with old information (Lang, 2000; Zechmeister & Nyberg, 1982). Storage can be evaluated by cued recall (Zechmeister & Nyberg, 1982). The cognitive load the viewer is under can affect storage. As cognitive load increases, storage capabilities decrease. One study used the LC4MP to look at performance of drivers under heavy cognitive loads (Ross, Jongen, Wang, Brijs, Brijs, Ruiter, & Wets, 2013). Participants in a car driving simulation were asked to change lanes when they saw posted signs to do so, which reflected the manipulation of visual working memory. Participants were also asked to talk on the phone during the driving simulation, as a way of manipulating cognitive load. Ross et al. (2013) showed that those with higher visual working memory could handle a higher cognitive load when driving than those with lower visual working memory. According to Ross et al. (2013), visual working memory capacity, which contains storage, may affect attention to secondary tasks thus the limited capacity model is a good predictor of attentional resource allocation. Cued recall measures storage, which shows, what information is processed into storage for the viewer (Lang, 2000).

H4: Participants will have higher cued recall for breaking news alerts appearing in videos with low than high perceptual load.

Beyond storage, there is the final step of retrieval.

Retrieval

Retrieval is when information is stored in detail enough that encoded information can be drawn back out and articulated later without cued recall (Lang, 2000). This study does focus on retrieval due to the fact that for breaking news, news producers do not need viewers to remember breaking news long term (Lang, 2000). Instead, viewers need to be able to react and understand in the short term what is going on in a breaking news situation.

All three sub-processes (encoding, storage, and retrieval) take up valuable cognitive resources (Lang, 2000). This means that some cognitive resources may be used more for encoding, leaving fewer resources for the other processes (Lang, 2000). Just like some visuals are processed automatically, while others are not; stimuli vary in the degree of cognitive resource allocation to encoding and storage processes (Lang, 2000). One example of automatic processes is emotional stimuli. Stimuli that elicit emotion tend to demand more resources from storage. Controlled processes have top-down influences that have a heavier task load (Lang, 2000). If there are insufficient resources available for processing, then parts of the processing will suffer.

One of the ways to manipulate cognitive load is through varying the pacing of the stimulus (Lang et. al, 1999). Production pacing contributes to high cognitive loads, such that pacing of the stimulus increases the cognitive load (Lang et. al, 1999). This is the opposite for low cognitive loads (Lang et. al, 1999). Although other elements, like arousal, can contribute to the cognitive load, this study will look to only manipulate cognitive load as a function of pacing (Lang et. al, 1999). In addition pacing/cuts, videos can also be analyzed on a seven-point per camera change as explicitly described in Fox et al. (2007). This analysis shows the changes in bits of information (i^2) and total frames per video adding to the cognitive load (Fox et al., 2007).

Perceptual Load

Load theory of attention (LTA) parses out the broad term: cognitive load. Commonly combined in the communication literature, "cognitive load," fits into two distinct load categories: working memory load and perceptual load (Lavie & Tsal, 1994). Lang's definition of cognitive load seems to mimic Lavie's definition of perceptual load and I hypothesize that the two are measuring the same thing.

Lavie and Tsal (1994) argue that an individual will try to process all external information automatically with the brain's limited capacity (Lavie &Tsal, 1994). As stated previously, perceptual load is the amount of effort required for processing that ranges from early to late stage processing based on the difficulty of complex or simple visual stimuli, respectively (Lavie &Tsal, 1994). Perceptual load is operationalized by two variables: 1) the number of units in a visual area, and 2) the "nature of processing is required for each unit" (Lavie & Tsal, 1994). The secondary task's interference with a search task for the primary task was only influential under low-load conditions (Lavie, 1995). Lavie (1995) concludes that since the distractor was spatially separate from the target, that distance from a target is not a condition for selective perception.

Additionally, a perception overload is needed to decrease the distractor's influence (Lavie, 1995).

Another consideration with perceptual load is the interaction with task-relevant and irrelevant stimuli. In high perceptual load conditions, the task-irrelevant distractor's effect should be decreased or eliminated (Lavie, 2010). This decrease of the distractor's effect allows for swifter processing and faster reaction times of the main target. In a low perceptual load, the distractor's effect is increased for both the task-relevant and irrelevant stimuli (Lavie & Tsal, 1994). Since the distractor is effective in the low perceptual load condition, the task interaction effect is not clear (Lavie & Tsal, 1994). The distractor's influence on attention is significantly reduced in high perceptual load (Cartwright-Finch & Lavie, 2007).

The main purpose for making the perceptual distinction, according to Lavie and Tsal (1994, p.185) was to "settle the debate between early and late selection by showing that results supporting early selection have been obtained under conditions of high perceptual load, whereas results consistent with late selection have typically been obtained with low perceptual load." Early selection of a target in a search task works only when the perceptual load of processing is high enough to approach or exceed capacity (Lavie & Tsal, 1994). Late selection of target in a search task occurs when the perceptual load and irrelevant processing of the distractor happens, slowing the search for the target.

I postulate that the perceptual load concept aligns with Lang's LC4MP's definition of cognitive load. Perceptual load are self-admittedly not defined well according to the Load Theory of Attention authors (Lavie & Tsal, 1994). The main consensus with Lavie's experiments is that more objects in the visual area increases the perceptual load. I extrapolate that Lang's use of cuts, as a way of manipulating cognitive load, is primarily a manipulation of perceptual load.

The manipulated cuts (few or many) in LC4MP are similar to the number of objects (few or many) used in LTA. Thus, this paper argues that Lavie's perceptual load concept and Lang's cognitive load concept are results of similar perceptual manipulations. "[Load theory] showed that [increased] perceptual load decreased distractor interference" with the reasoning that the brain is too tasked to be distracted by distractors (Koshino & Olid, 2015, p. 135). This consistency with LC4MP supports the above hypotheses.

Furthermore, it is important to note the nature of both theoretical frameworks is usually conducted under a search task. LTA has distinct methodological differences, yet how are these differences influenced when placed in a more realistic visual attention scenario? Traditionally, a flanker task is used when a person is given a target and then must decide if the target is in the correct condition or not. While a search task is not indicative of how people naturally view their screens, when viewing videos, goal-driven orientations, like searching, can cause visual filtering and skew the way a person's would naturally view a video (Bix, Sundar, Bellow, Peltier, Weatherspoon & Becker, 2015). Thus, in this study, I use natural viewing of the videos, which includes no prompts other than to watch the video. Beyond the influence of perceptual load (load influences existing externally), there is believed to be an internal cognitive load influencing processing. This internal load in other literature is referred to as the working memory load.

Working Memory Load

Under LTA, working memory load is the level of cognitive processing brought on by a task that influences selective attention when there are both relevant and irrelevant stimuli (de Fockert and Lavie, 2001). Most frequently, working memory load tasks use basic math or counting tasks. Executive function is often thought to affect goal-directed control of attention and operationalized as working memory (Baddeley, 1996; Desimone & Duncan, 1995; Lavie 2010).

The working memory model says that central executive is the main part of the working memory (Baddeley & Hitch, 1974). This executive component is in complete control of the other actions, which include phonological loop, visuo-spatial sketchpad, and episodic buffer (Baddeley & Hitch, 1974). The phonological loop stores auditory information (Baddeley & Hitch, 1974). The visuo-spatial sketchpad stores visual information (Baddeley & Hitch, 1974). The episodic buffer stores short-term episodic memories, links all information together, and then enables information to be moved to long-term memory (Baddeley, 2000).

Working memory load is operationalized in many studies as a memorization of numbers. Low working memory requires a participant to memorize one digit to then be recognized post experiment, while the high working memory requires a participant to memorize six digits to then be recognized post experiment (Lavie & de Fockert, 2005). This has also been used with just the numbers zero, one, two, three, and four with order changed to increase working memory load (Lavie & de Fockert, 2005). The researchers found that attentional capture by the distractor depends on the available resources for working memory. Specifically, when working memory is high, capture increases, because processing for the primary task cannot be contained (Lavie, 2000). Thus, the viewer is more susceptible to distractors—both irrelevant and relevant (Lavie, 2000; De Fockert et al., 2008).

In another study, researchers looked at the effects of working memory load while participants viewed a Flanker-task (Burnham, 2010). Through three experiments, researchers found that attentional capture effects differ in single and dual-task conditions, but only when the distractor is a color not associated with the target (Burnham, 2010). These experiments show that a higher working memory load does not necessarily lead to different effects in attentional capture for the secondary task (distractor). Thus, it is the distractor itself, and not just the working memory load, that can influence attentional capture.

Traditionally, researchers postulated that viewers are limited to three or four visual events simultaneously before their visual working memory is overloaded (Van der Burg, Awh & Olivers, 2013). Van der Burg, Awh, and Olivers (2013) found that when it comes to audiovisual processing, only one audiovisual event can be processed at a single time. This suggests that audiovisual orienting is different in its capacity limit than just pure viewing.

Although these studies on working memory load have been tested several times, the experiments themselves have very low external validity. Such studies are usually conducted using psychology-specific software that makes use of flanker-tasks or fixation crosses as stimuli. In contrast, the LC4MP uses stimuli that demonstrate a higher external validity (e.g., films, commercials, news clips).

In the case of working memory, the LC4MP does not make any predictions about working memory. According to LTA, an increase in working memory load increases distractor processing. Thus, LTA guides the working memory hypotheses.

H5: Participants will exhibit shorter gaze duration for breaking news alerts when working memory load is low than high.

H6: Participants will exhibit slower time to first fixation for breaking news alerts when working memory load is low than high.

H7: Participants will have lower information recognition for breaking news alerts when working memory load is low than high.

H8: Participants will have lower cued recall for the alerts when the working memory load is low than high.

Working Memory And Perceptual Load Interaction

The LC4MP defines cognitive load as the amount of resources needed to process a message entirely (Lang, 2000). As cognitive load increases, cognitive processing of visual stimuli can become inefficient. This conceptualization aligns with the LTA for cognitive load, however, unlike the LTA, the LC4MP does not differentiate between cognitive load and perceptual load. Instead, the LC4MP operationalizes cognitive load by manipulating video edits. Through the perspective of LTA, the LC4MP's operational definition of cognitive load changes would change the perceptual load, but not the working memory load. Thus, cognitive load as defined by the LC4MP is specific only to the perceptual load when viewed in light of the LTA.

The LTA says that distractor interference is decreased on under high perceptual load and increased under high working memory load (Lavie, 2010). There should also be consideration given to the two theories' attentional resource predicted outcomes. Since the LC4MP does not predict for perceptual load (but operationalizes it), the model predicts that task reaction time will be faster in a low load video. This too is supported by the LTA's perceptual load STRTs, but the LTA predicts an opposite effect for the cognitive load. This proposal will test LC4MP through the lens of the LTA, using high external validity experiments. This test should indicate if the LC4MP needs to have more specific conceptual and operational definitions or that the LC4MP's effects hold due to the external validity of the tests. It is important to note that traditional psychology stimuli (Healy & Enns, 2012) are less complex than media stimuli. Thus, the stimuli used in this study operationalizes perceptual load with more complex measures including pacing of video cuts (Lang, 2000) and information introduced (i^2) (Fox et al., 2007).

LC4MP makes no predictions about working memory load (Lang, 2000), and thus working memory load has yet to be tested under the Load Theory framework for LC4MP-like conditions (Lavie & Tsal, 1994). LC4MP does not take into account working memory load as defined by load theory, despite the fact that the three sub-processes of encoding, storage and retrieval are thought to occur within working memory. LC4MP says that the perceptual changes influences working memory and this I do not disagree with, however, I postulate manipulating the working memory load through memorization and tasking the cognitive processing with additional tasks will influence the perceptual changes in video viewing. According to LTA, "working memory load increased distractor processing". Although, Lavie & Tsal (1994) did not find an interaction between working memory and perceptual load, their results may be different under a different task. In short, perceptual load in this study relates to the structural features of the media stimuli in relation to cognitive processing, whereas working memory load deals with non-media related tasks that are primarily happening in working memory.

I predict that the low perceptual load and low working memory load conditions will result in faster time to first fixation, longer gaze durations, and increased information recognition and cued recall of the alerts. I predict that high perceptual load and high working memory load conditions will result in slower time to first fixation, shorter gaze durations, and decreased information recognition and cued recall of the alerts. In the low perceptual load/high working memory load and the high perceptual load/low working memory load, I believe the results for time to first fixation, gaze durations, information recognition, and cued recall of the alerts will be the same (greater than in the high/high condition, but less than in the low/low condition). Because the interaction of these theories is not clearly defined and the interactions are not fully supported in the literature, the following research questions are proposed:

How will the interaction between working memory and perceptual load affect (RQ1) gaze duration, (RQ2) time to first fixation, (RQ3) information recognition, and (RQ4) cued recall for breaking news alert?

Table 1.
Summary of Hypotheses

H#	IV	DV
H1	Perceptual load	Gaze duration
H2	Perceptual load	Time to first fixation
H3	Perceptual load	Information recognition for alerts
H4	Perceptual load	Cued recall for alerts
H5	Working memory load	Gaze duration
H6	Working memory load	Time to first fixation
H7	Working memory load	Information recognition for alerts
H8	Working memory load	Cued recall for alerts
RQ1	WML x PL	Gaze duration
RQ2	WML x PL	Time to first fixation
RQ3	WML x PL	Information recognition for alerts
RQ4	WML x PL	Cued recall for alerts

CHAPTER 3: METHOD

Design

To test the study's hypotheses, the study employed a 3 (working memory load: control, low, high) x 2 (perceptual load: low vs. high) x 9 (video repetitions) x 6 (working memory load repetition) x 3 (video order) nested within-subject design. This design is depicted in Figure 1. The design had a total of eighteen videos played in each order condition.

Condition A	L1	L2	L3A	H1	H3A	H2	L4	L6A	L5	H4	H5	H6A	L7	L8	L9A	H7	H9A	H8
	0	0	0	0	0	0	1	1	1	1	1	1	6	6	6	6	6	6
Condition B	H1	H2	H3A	L1	L3A	L2	H4	H6A	H5	L4	L5	L6A	H7	H8	H9A	L7	L9A	L8
	1	1	1	1	1	1	6	6	6	6	6	6	0	0	0	0	0	0
Condition C	L1	L3A	L2	H1	H3A	H2	H4	H5	H6A	L4	L5	L6A	L7	L8	L9A	H7	H9A	H8
	6	6	6	6	6	6	0	0	0	0	0	0	1	1	1	1	1	1

Figure 1. Experimental design where L stands for low perceptual load, H stands for high perceptual load; 0,1,6 stand for the amount of numbers shown in the working memory load conditions; and A stands for an alert was shown during that video.

Alerts were placed either in the second or third video of each block. Perceptual load and the working memory load were manipulated within subjects.

Independent Variables

Work memory load. The working memory load was manipulated by a response-competition task, identifying whether true or false that a number after the video was seen before the video. Participants were asked to memorize the set of either zero (control), one (low) or six (high) digits presented at the start of each video (Lavie & de Fockert, 2005). At the end of each video, participants were asked if they saw a number. This second number probe was a single number that has or has not been presented among the digits presented prior to the video (Lavie & de Fockert, 2005). The number probe was not used for the control condition. Viewers were told that if there is no number before the video there would be no numbers after the video.

Based on the accuracy measure of the working memory manipulation, the means for correct answers stayed steady (N= 62: M_{Low1} = .94, SD = .25; M_{High1} = .90, SD = .30; M_{Low6} = .94, SD = .25; M_{High6} = .90, SD =.30). This accuracy measure was the number of correct responses (present: yes or no) to the working memory manipulation (0,1,6 digits memorized). A repeated measures ANOVA showed the correctness of the working memory load task did not vary as a function of perceptual load, ($F(1, 61) < .001$, *ns*), working memory load, $F(1, 61) = 0.80$, *ns*), or the interaction between them, $F(1, 61) = < .001$, *ns*).

Perceptual load. Per Lang et al. (1999), the number of cuts in a certain period of time can influence the level of cognitive load in an audiovisual clip, where low cognitive load clips have zero to one cuts every 30 seconds and high cognitive load clips have eleven or more cuts every 30 seconds (Lang et al., 1999). These amounts of cuts are typically found in commercials, but are very unusual for television news segments. So, in this study, low cognitive load videos had one to three cuts per minute, while high cognitive load ones had five to nineteen cuts per 50 seconds. A pretest (N = 29) was conducted with 36 news clips selected from 54 to ensure that the selected stimuli are comparable in emotional valence across the different perceptual load conditions, and vary as a function of perceptual load. From the 36 videos, following the pretest, eighteen videos were selected (nine low and nine high) (See Figure 2). In addition to counting the cuts, which was conducted during the selection of the pretest stimuli, the selected videos were content-analyzed using a 7-point per camera change as explicitly described in Fox et al. (2007). This content analysis revealed the changes in bits of information (i^2) and total frames per video (Fox et al., 2007).

Low perceptual load videos (M = 1.8, SD = .44) had significantly fewer cuts than high perceptual load videos (M = 11.22, SD = 4.52), t (16) = - 6.24, $p < .001$. Additionally, low perceptual load videos (M = 2.22, SD = 1.48) had significantly less bits of information (i^2) than high perceptual load ones (M = 12.56, SD = 3.21), t (16) = -8.78, p < .001 (See Appendix D). These results show that both cuts and i^2 were different between high and low conditions, accomplishing a change in perceptual load. Additionally, the selected news clips were comparable on valance and arousal (described in the stimuli section below).

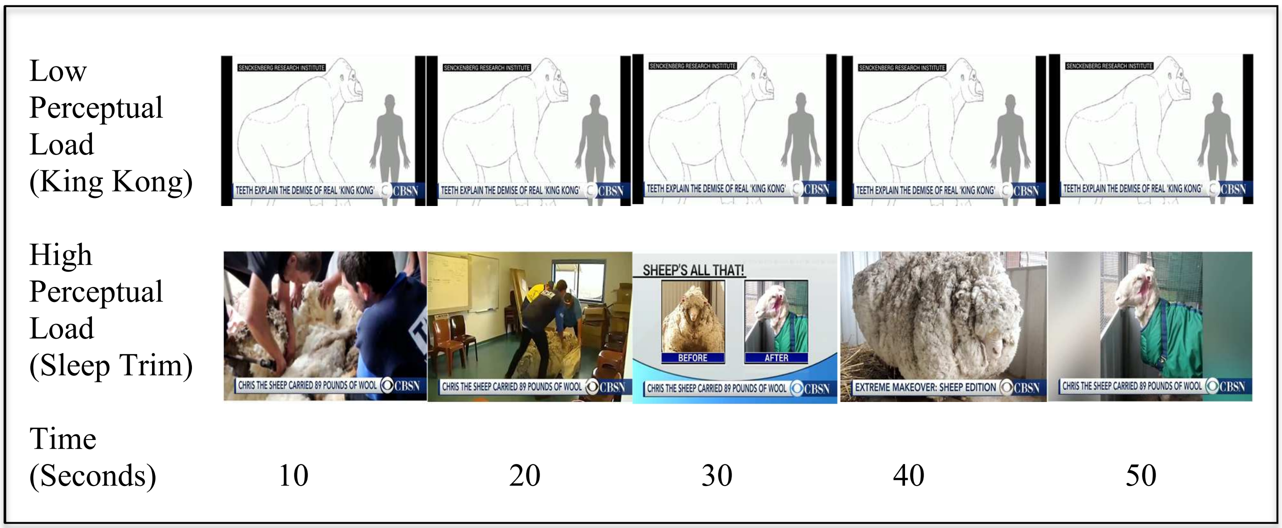

Figure 2. Sample low and high perceptual load videos across the 50-second time span.

Dependent Variables

Gaze duration and time to first fixation for the alert. Gaze duration and time to first fixation for the alert were collected using the Tobii Pro TX300, where eye-tracking data were captured at 300 Hz, at a sampling variability rate lower than .3%, and at a 1.0 to 3.3 millisecond processing latency. Gaze duration was operationalized as the length of time a person's visual attention stayed in the areas of interest (AOIs) during the six-second timeframe. Time to first fixation was operationalized as the length of time the AOI was displayed until the visual fixation is directed to the AOIs in the six-second timeframe.

Information Recognition for the alert. Participants were asked twelve True/False questions (six hits and six foils) related to the alert that they viewed. For example, one question asked, "One alert said there was a water leak. T / F." For recognition in all forms and with all DVs, correct answers on hits and foils were coded as "1" and incorrect answers were coded as "0" to calculate a percentage score for recognition accuracy.

Post-hoc analyses, to confirm the findings, included calculations of signal detection theory measures of sensitivity and criterion bias, which have a curvilinear relationship (Shapiro, 1994). In addition to calculating raw scores (percentages) for hits and foils, recognition sensitivity and criterion bias from signal detection theory (SDT) was calculated. Recognition sensitivity or A' (A-prime) and criterion bias or B" (B-double prime) was also analyzed. A' measured the sensitivity of a participant's "yes" responses to hits and false alarms (Macmillan & Creelman, 2005). When hits (H) are greater than false alarms (F), the A' measure was calculated by the following equation:

$$A' = 1/2 + [(H-F) * (1+H-F)/4H(1-F)] \tag{1}$$

(Macmillan & Creelman, 2005, p. 371)

In cases, where F was greater or equal to H, the following formula was used:

$$A' = 1/2 - [(F-H) * (1+F-H)/4F(1-H)] \tag{2}$$

(Macmillan & Creelman, 2005, p. 371)

B" measured a participant's response bias to answer either "yes" or "no" to both hits and false alarms (Macmillan & Creelman, 2005, p. 371). When hits are greater than false alarms, this formula was used:

$$B'' = [H(1-H) - F(1-F)] / [H(1-H) + F(1-F)] \tag{3}$$

(Macmillan & Creelman, 2005, p. 371)

Otherwise, when hits are less than false alarms, the following formula was used:

$$B'' = [F(1-F) – H(1-H)] / [H(1-H) + F(1-F)] \quad (4)$$

(Macmillan & Creelman, 2005, p. 371)

Cued Recall for the alert. Participants were asked to respond to six fill-in-the-blank questions for the alert. For example, one question asked, “The alert talked about _____ street being closed.” For cued recall questions, a coding rubric was devised. A correct recall of the item as coded as “1” and an incorrect recall was coded as “0.” Misspellings were handled as such: if the misspelling changes the word entirely then they were counted as incorrect, but if the misspelling were only slightly off, they were counted as correct. A single coder was used for the cued recall.

Participants were asked to complete the cued recall and information recognition, respectively r to guard against contamination of encoding and storage measures.

Participants

Using a repeated measures ANOVA with within factors power analysis with an effect size of .23 ($\eta^2_p = .05$), power of .95, and alpha level of .05 indicated that 54 participants were required for this main study. There were 68 participants with a mix of student and community members in the sample. The study was announced to students and community members from the College of Communication Arts and Sciences and the Greater Lansing community through the online subject pool (SONA). Participants were compensated with $10 or 1.25 SONA credits.

Of the 68 participants, 74% were female and 26% were male. The average age of the participants was 30.7 (11.8) years old, ranging from 20 to 73 years old. The average participant had 17.30 (2.57) years of formal education not including kindergarten. The sample consisted of 34% were employed part time, 29% were employed full time, 28% students, not working for wages, 6% unemployed and 3% retired. The majority of participants reported they were White or Caucasian (63%), followed by Black or African American (21%), Asian (12%), Native Hawaiian or Other Pacific Islander (1%), and American Indian or Alaskan Native (1%) (More than one racial category could be selected). Only 6% of participants reported themselves as Hispanic or Latino. The majority of participants reported being 72% single or never married, followed by 22% who reported being married or living with a partner, followed by 4% who reported being divorced or separated and 2% a widow or widower. The majority of participants (82%) were U.S. citizens. The average family household income was in the range of $10,000 to $49,999.

Outlier cases were removed from some statistical analyses if the cases existed outside of the normal curve or two standard deviations. There were six outlier cases for gaze duration and six outlier cases for time to first fixation, thus bringing the sample size for these two analyses to 62 for each.

Stimuli

Pretest. The videos were pooled from recent newscasts, specifically, the online news network CBSN, which serves to enhance the study's external validity. Videos were pretested for high and low perceptual load, defined by two different variables. First the videos were chosen based on the number of cuts in a 50-second segment and also on their i^2 value (see Independent Variables section).

From those results the videos were narrowed down to 18 videos (9 low and 9 high). Originally, the sample was tested to reduce the video to nine from eighteen in each group, by taking videos that were one standard deviation above or below the respective mean group. This procedure failed and resulted in significant differences between the two groups for positivity and negativity.

This procedure was deemed unsuccessful at controlling the variance between the two samples. Thus, the videos were re-chosen to reflect no statistically significant difference between the high or low groups for just valance (positivity and negativity dimensions). Arousal measures varied between groups. Since arousal changes were inherent with cuts and i^2 changes, arousal cannot be controlled for in the stimuli. Thus, in the main test arousal was a covariate.

Using a repeated measures ANOVA, there were no statistical difference samong pretest videos for valance: positivity, F (1, 9)= 0.01, *ns*, and negativity, F (1, 9)= 0.09, *ns*; but there was a difference for arousal, F (1, 9)= 6.47, $p < 0.05$, *partial* $\eta^2 = 0.19$. The means show that the high perceptual load videos were rated as more arousing than the low perceptual load videos ($M_{low} = 3.68$, $SD_{low} = 0.24$; $M_{high} = 4.03$, $SD_{high} = 0.27$) (See Appendix D). This reanalysis allowed for both groups to be statistically equal in positivity and negatively. However, the downside to this reanalysis was that there was more variance among valance and arousal in each group. This was a limitation of the study that uses actual videos produced by the news. Also, arousal level differences between the two groups, support LC4MP's assumption that faster paced videos (greater cuts and higher i^2s) created more arousal than slower paced videos (Lang et al., 1999).

Finally, breaking news alerts were pretested for their relevance to participants (See Appendix A and B). Past research predicted that weather alerts might not have been salient enough for participants (Cunningham, 2016). Thus, the alerts were attended to, but not processed further. After reviewing the four different alerts on a three 5-point scales (usefulness, interest, and liking behavioral change), it was decided that gas alerts ($M = 3.43$, $SD = 1.15$) would cause the most immediate reaction while being believable by the viewer compared to alert about dangerous weather in Ingham county ($M = 3.76$, $SD = 1.17$), alert about trash removal in East Lansing ($M = 2.04$, $SD = 1.02$), and alert about tuition increases at MSU ($M = 3.67$, $SD = 1.36$).

Main Test. The stimuli included 18 50-second videos. As alert (distractor) was added to six videos in using three random orders (see Figure 1). Participants were not asked to view the alert. It simply entered the screen viewing area as participants watched the video. To align with true real-world conditions set in place by the Michigan State University Police Department, the alert entered from the bottom right-hand corner and exited from that same corner (see Figure 3).

Figure 3. This figure shows how the alert was displayed to the audience members when they were viewing videos. Pictured above is the "Silence of the Lambs" video.

Procedure

Main Test. Participants were invited to a research lab and were provided with a printed consent form and were asked to carefully read and sign it to indicate consent of their participation in the study. Participants, run one a time, were seated in front of a 23" computer screen equipped with the Tobii ProTX 300 eye-tracking system. Stimuli were shown using the Tobii Studio software that requires no additional apparatuses. Eye movement signals were converted to visual fixation data using Tobii Studio software. Upon completion of data collection, areas of interest (AOIs) were identified for each alert displayed. AOIs were deemed to be the area and time in which the alert was visible (lower-right hand corner for six seconds). Among the 68 participants, the eye tracking calibration accuracy averaged 85% (SD = 14%) and ranged from 32% to 98%.

Stimuli were presented to participants in 18 trials (plus two practice trials) that varied by the factorial combination of perceptual load, working memory load, and order (see Figure 1). In each trial (except for those in the control working memory treatment level), participants were instructed to memorize one or six digits, followed by a static image, a 50-second video, another static image, and a screen requesting the participant to indicate whether or not a number belongs to the set he/she was asked to remember at the beginning of the trial by pressing “Y” (yes) or “N” (no) (see Figure 4). The 50-second videos varied in perceptual load, and also, for six of them, included an alert that appeared at the bottom right corner of the screen for six seconds.

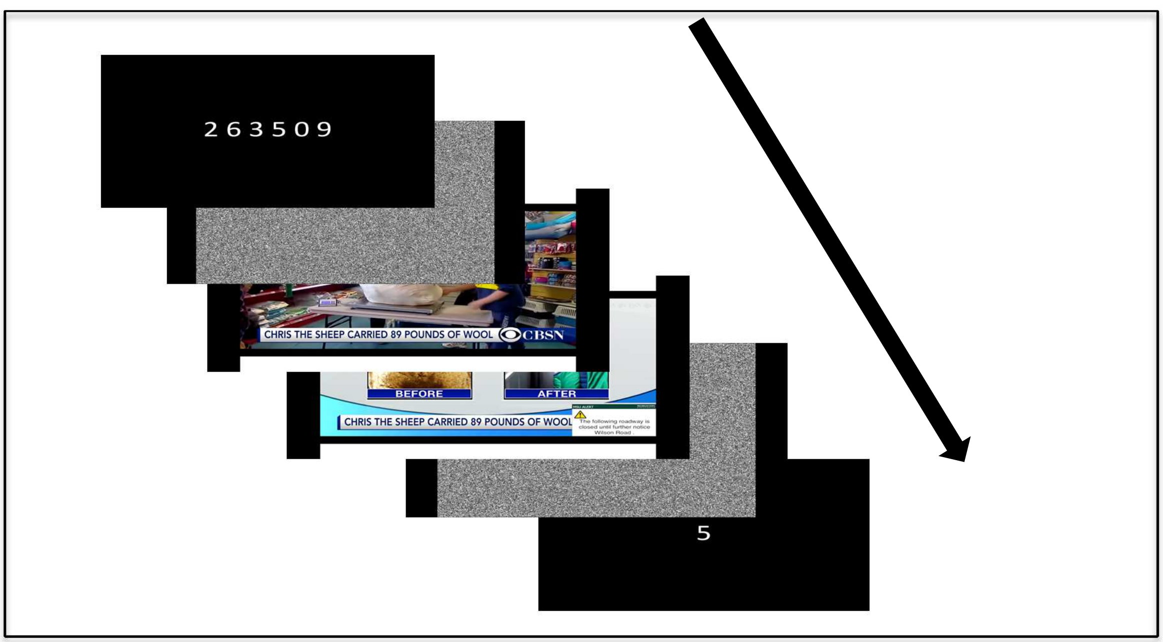

Figure 4. This is figure showing the study’s design across time.

At the conclusion of the experimental process, participants were asked to provide information recognition and cued recall measures, and demographic information to include: age, gender, income, and race. The cued recall measures were asked first and in such a way that did not influence the information recognition T/F questions. The participants were then be briefed, thanked, and dismissed.

Data Analysis

As previously mentioned, normality did not exist for the dependent measures of gaze and time to first fixation. There were 6 outlier cases were removed for gaze duration and time to first fixation, thus bringing the sample size for these two analyses to 62 for each.

All calculations used repeated measures ANOVA with arousal, positivity, and negativity as covariates and order between subjects. Pairwise comparisons were used for all significant main and interaction effects. Additional, sensitivity and criterion bias calculations were used as an additional check per Signal Detection Theory (Shapiro, 1994).

CHAPTER 4: RESULTS

The current study included four different dependent variables that were grouped by the IVs and their interactions into four groups. The set of hypotheses entailed testing of the main effects of perceptual load of the alert (H1- H4) and working memory load (H5-H8) and the interaction between perceptual load and working memory load (RQ1-RQ4). Hypotheses sets were organized by the dependent variables (gaze duration, time to first fixation, information recognition, and cued recall).

Table 2.
Summary of Results by Hypothesis/Research Question

H#	IV	DV	Hypothesis Support
H1	Perceptual load	Gaze duration	Not supported*
H2	Perceptual load	Time to first fixation	Not supported
H3	Perceptual load	Information recognition	Supported*
H4	Perceptual load	Cued recall	Not supported
H5	Working memory load	Gaze duration	Not supported
H6	Working memory load	Time to first fixation	Not supported
H7	Working memory load	Information recognition	Not supported*
H8	Working memory load	Cued recall	Not supported
RQ1	WML x PL	Gaze duration	*
RQ2	WML x PL	Time to first fixation	Not significant
RQ3	WML x PL	Information recognition	*
RQ4	WML x PL	Cued recall	Not significant

Notes. * denotes a significant effect.

Gaze Duration

H1, H5, RQ1 investigated the main effect of perceptual load (H1), the main effect of working memory load (H5), and the interaction between perceptual load and working memory load (*RQ1*) on gaze duration for the news alert. To this end, gaze duration data was submitted to a 3 (working memory load: control, low, high) x 2 (perceptual load: low vs. high) x 3 (video order) ANOVA with repeated measures on working memory load and perceptual load, and with arousal and valance measures as covariates.

H1 predicted participants would exhibit longer gaze duration for breaking news alerts when perceptual load is low than high. The main effect of perceptual load on gaze duration for the alerts was significant, $F(1,41) = 4.57$, $p < 0.05$, *partial* $\eta^2 = 0.10$. Participants exhibited longer gaze duration (cumulative seconds) for alerts appearing in the high ($M_{high} = 0.18$, $SD_{high} = 0.05$) than low ($M_{low} = 0.16$, $SD_{low} = 0.04$) perceptual load videos. *H1* was not supported because the data were not in the hypothesized direction (see Figure 5).

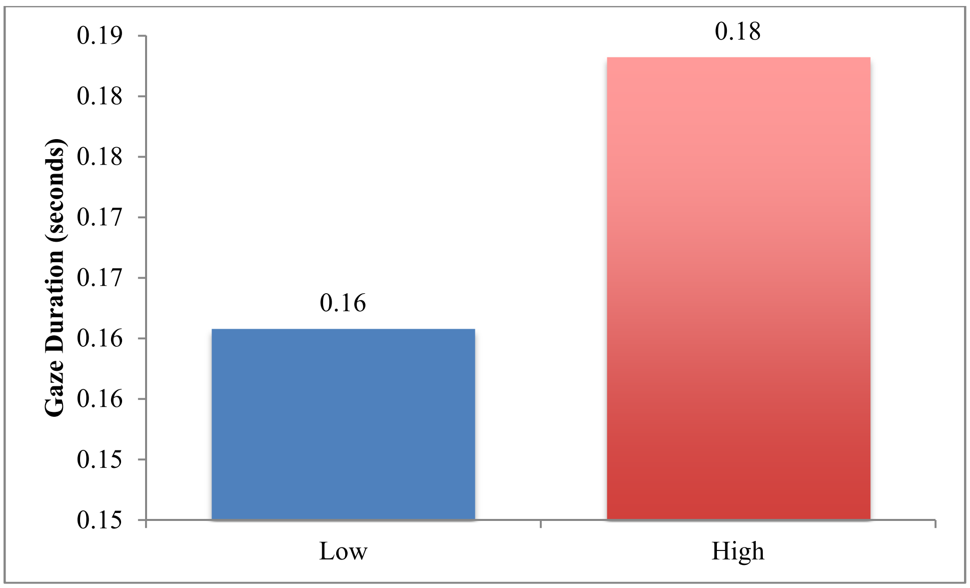

Figure 5. Main Effect of Perceptual Load on Gaze Duration.

H5 predicted that participants would exhibit shorter gaze duration for breaking news alerts when working memory load is low than high. The main effect of working memory load on gaze duration for the alerts was not significant, $F(1,40) = .16$, *ns*. Participants' gaze duration varied only slightly across working memory loads ($M_0 = 0.17$, $SD_0 = 0.06$; $M_1 = 0.17$, $SD_1 = 0.05$; $M_6 = 0.17$, $SD_6 = 0.05$). *H5* was not supported. (See Appendix E).

RQ1 asked about the effect of the interaction between working memory and perceptual load on gaze duration for the breaking news alert. The effect of the interaction between perceptual load and working memory load on gaze duration for the alerts (*RQ1*) was significant**,** $F(1,44) = 5.53$, $p < .05$, partial $\eta^2 = .11$. No other interactions were significant. The mean difference shows that perceptual load influenced gaze duration ($M_{Difference} = -.02$, $SD_{error} = .01$, $p < .005$).

Pairwise comparisons showed that when participants were not instructed to remember any number (control working memory load), there was no significant difference in gaze duration for alerts between low (M= .17, SD= .08) and high (M=. 17, SD= .06) perceptual load videos, $t(53) = .21$, *ns*. With regard to instances when participants were under low working memory load (asked to remember one number), gaze duration was significantly different between low (M= .15, SD= .07) and high (M= .18, SD= .07) PL videos, t (55)=-.3.04, $p < 0.005$, *Cohen's d* = |.43|. Finally, when participants were asked to remember six number (high working memory load), they spent more time gazing on the alert when the video was high (M= .15, SD= .05) than low (M= .20, SD= .08) perceptual load, t (56) = -.3.44, $p < 0.001$, *Cohen's d* = |.75| (See Figure 6).

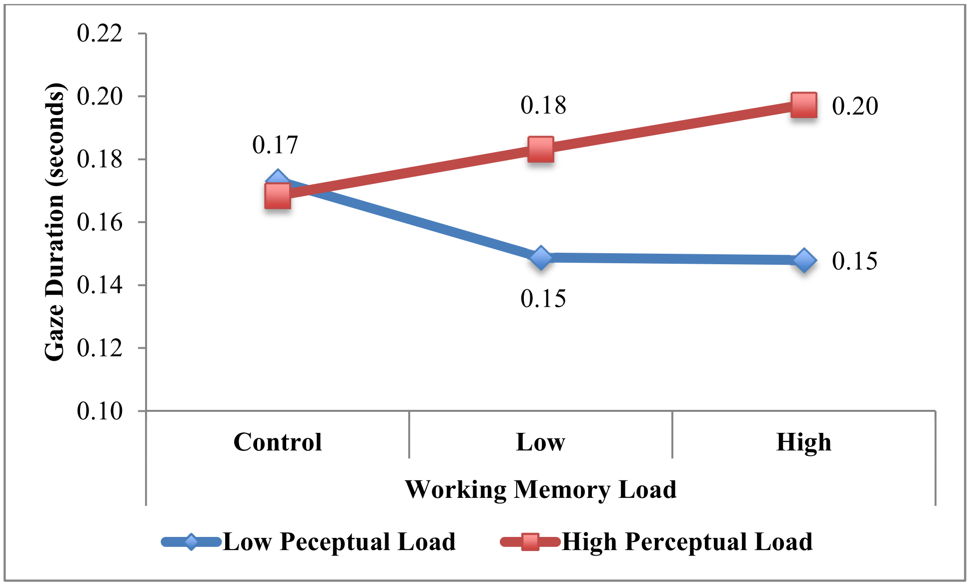

Figure 6. Two-Way Interaction Effect between Perceptual Load and Working Memory Load on Gaze Duration.

Time to First Fixation

H2, H6, RQ2 investigated the main effect of perceptual load (*H2*), the main effect of working memory load (*H6*) and the interaction between perceptual load and working memory load (*RQ2*) on fixation for the news alert. Data for fixation were submitted to a 3 (working memory load: control, low, high) x 2 (perceptual load: low vs. high) x 3 (video order) ANOVA with repeated measures on working memory load and perceptual load, and with arousal and valance measures as covariates. The time to first fixation was after 31 seconds (when the alert entered the screen).

H2 predicted that participants would exhibit faster time to first fixation for breaking news alerts when perceptual load is low than when perceptual load is high. Results showed the main effect of perceptual load on time to first fixation for the alerts was not significant, $F(1,41) = 2.18$, *ns*. *H2* was not supported. The time to first fixation was counted from the when the alert fully appeared on screen. The means confirm no statistical differences between perceptual load conditions, (M_{high}= 31.63, SD_{high}=.50; M_{low}= 31.48, SD_{low}=.25).

H6 predicted that participants would exhibit slower time to first fixation for breaking news alerts when working memory load is low than when working memory load is high. The main effect of the working memory load on time to first fixation for the alerts was statistically significant, $F(1,40)= 3.55$, $p <.05$, partial $\eta^2 = 0.15$. The means show small differences, (M_0= 31.56, SD_0=.64; M_1= 31.51, SD_1=.34; M_6= 31.61, SD_6=.36). A more detailed analysis on the influence of working memory load on time to first fixation in a pairwise comparison shows no statistical difference between the control condition and the low condition ($M_{Difference}$ = -.02, SD_{error} =.06, *ns*). While there are larger differences in between the control condition and the high condition ($M_{Difference}$ = -.13, SD_{error} =.05, *ns*) and between the low condition and the high condition ($M_{Difference}$ = -.11, SD_{error} =.05, *ns*), but not significant. Based on this, H6 is not supported (See Figure 7).

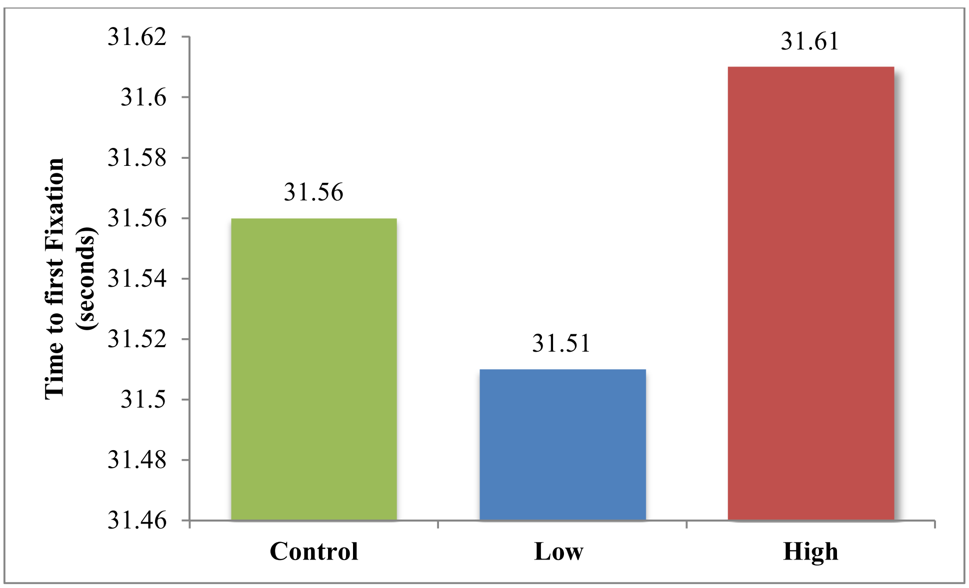

Figure 7. Main Effect Of Working Memory Load On Time To First Fixation.

A quadratic interaction effect between working memory load and order was significant, $F(2,41)= 12.35$, $p < 0.001$, partial $\eta^2 = 0.38$. Order 1, 2, and 3 did not differ in the control condition, but then order 1 decreases substantially in the low working memory load condition. In the high working memory condition, order has a greater variance with some time for fixations increase (order 1 and order 3), while order 2 decreased. (See Figure 8).

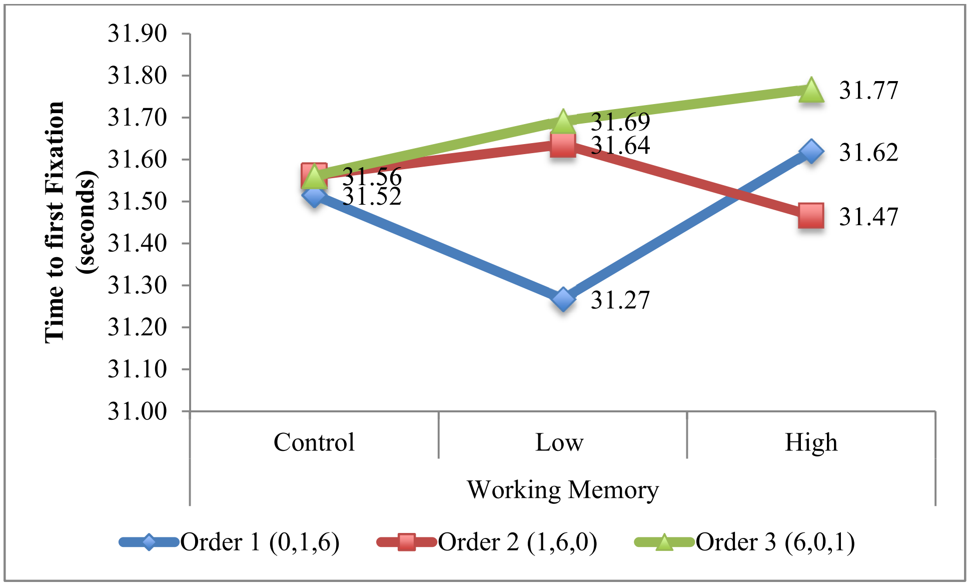

Figure 8. Two-Way Interaction Effect Between Working Memory Load And Video Order On Time To First Fixation (News Alert was presented at second 30 of the video).

R2 asked how would the interaction between working memory and perceptual load affect the time to first fixation on the alert. The effect of the interaction between perceptual load and working memory load on fixation for the alerts (*RQ2*) was not significant, $F(1,40) = 0.01$, *ns*. The effect of a three-way quadratic trend for the interaction among perceptual load, working memory load, and positivity was significant, $F(1,41)= 4.74$, $p < 0.05$, partial $\eta^2 = 0.10$. Perceptual load, working memory load and order interaction as a quadratic trend was significant, $F(2,41)= 16.26$, $p < 0.001$, partial $\eta^2 = 0.44$. (See Appendix E). No other interactions were found to be significant.

Many participants had high rates of time to first fixation counts and gaze duration counts. Of the alerts, 1 person (1.6%) fixated on only 2 alerts, 2 participants (3.2%) fixated on 4 alerts, 12 participants (19.4%) fixated on 5 alerts, and 47 participants (75.8%) fixated on all 6 alerts. The gaze duration count was submitted to 3 (working memory load: control, low, high) x 2 (perceptual load: low vs. high) x 3 (video order) ANOVA with repeated measures. The results show no statistical significance in any of the main or interaction effects. Of the alerts, 1 person (1.6%) gazed on only 2 alerts, 3 participants (4.8%) gazed on 4 alerts, 11 participants (17.7%) gazed on 5 alerts, and 47 participants (75.8%) gazed on all 6 alerts. The gaze duration count was submitted to 3 (working memory load: control, low, high) x 2 (perceptual load: low vs. high) x 3 (video order) ANOVA with repeated measures. The results show no statistical significance in any of the main or interaction effects.

Information Recognition

H3, H7, RQ3 investigated the main effect of perceptual load (H3), the main effect of working memory load (H7) and the interaction between perceptual load and working memory load (*RQ3*) on information recognition for the news alert. To this end, the correct hits (recognition accuracy), A', and B" were submitted to 3 (working memory load: control, low, high) x 2 (perceptual load: low vs. high) x 3 (video order) ANOVAs with repeated measures. For information recognition, correct answers on hits and foils were coded as "1" and incorrect answers were coded as "0" to calculate a percentage score for recognition accuracy. Post-hoc analyses included calculations of signal detection theory measures of sensitivity and criterion bias (Shapiro, 1994).

H3 hypothesized participants would have higher information recognition for breaking news alerts when perceptual load is low than when perceptual load is high. The main effect of perceptual load on information recognition for the alerts was significant, recognition accuracy (hits): $F(1,62) = 16.39$, $p < .001$, partial $\eta^2 = .21$; false alarms, $F(1,62) = 5.75$, $p < .05$, partial $\eta^2 = .09$; A': $F(1,62) = 18.41$, $p < .001$, partial $\eta^2 = .23$; B": $F(1,62) = 5.89$, $p < .05$, partial $\eta^2 = 0.09$. *H3* was supported for hits where participants had higher recognition accuracy in the low than high perceptual load condition (M_{low}= .84, SD_{low}=.37; M_{high}= .71, SD_{high}=.40) (see Figure 9). The False alarm rate decreased with the perceptual load increase (M_{low} = .81, SD_{low} = .39; M_{high} = .69, SD_{high} = .42). Recognition sensitivity (A') decreased as the perceptual load increased (M_{low} = .56, SD_{low} = .05; M_{high} = .54, SD_{high} = .06). partial η^2 =.17. Criterion bias (B") became more conservative with the increase of perceptual load (M_{low} = -.09, SD_{low} = .44; M_{high} = .07, SD_{high} = .41). The interaction of perceptual load and order for false alarms was also significant, F (2,62) = 6.41, p <.005,

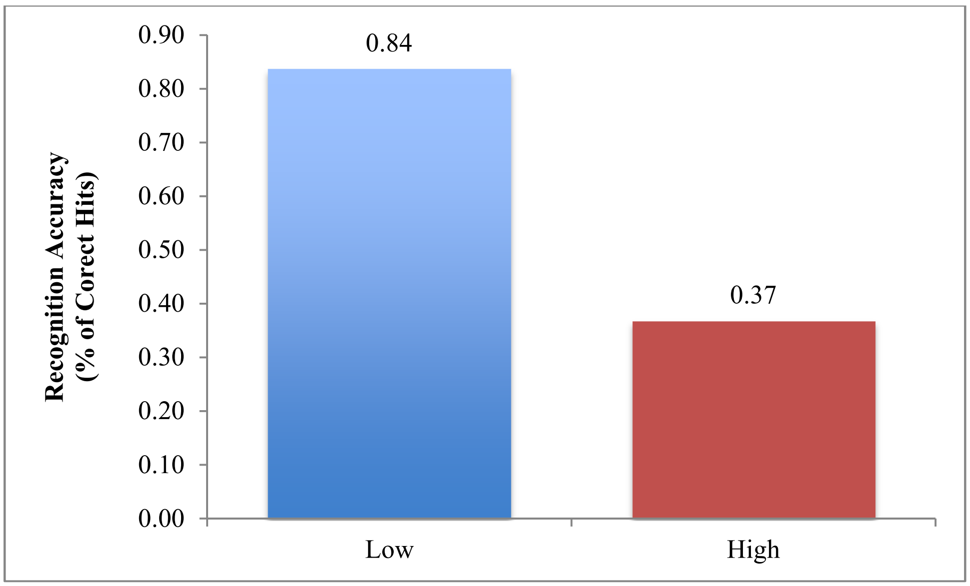

Figure 9. Main Effect Of Perceptual Load On Recognition Accuracy (Hits).

H7 hypothesized that participants would have lower information recognition for breaking news alerts when working memory load is low than when it is high. The main effect of working memory load on recognition for the alerts was significant for recognition accuracy (hits), F(1,61)= 9.06, p < .01, partial η^2 =0.11; false alarms, F (2,61) = 5.27, p <.05, partial η^2 =.15; and B", F(1,61)= 5.49, p < .01, partial η^2 =0.15; but not for A', F(1,61)= .15, p =.86, partial η^2 =.01. Participants' recognition accuracy was highest for the low WML condition (M_1= 0.86, SD_1=0.24), followed by the high WML (M_6= 0.81, SD_6=0.35) and the control ((M_0= 0.65,

SD_0=0.35) condition. However, pairwise comparisons showed that there were no statistical differences in the recognition accuracy between the low and the high working memory load, (t (67) =1.04, *ns*). It is worth mentioning that recognition accuracy was significantly different between the control and high working memory load (t (67) = -3.20, p < .005) and between the control and low working memory load (t (67) =-3.70, p < .001). Based on this, H7 was not supported (see Figure 10). The false alarm rate was lowest in the low working memory load condition (M_0 = .87, SD_0 =. 34; M_1 = .65, SD_1=. 44; M_6 = .74, SD_6 = . 44). Mean comparisons show recognition sensitivity (A') holding steady, (M_0 = .55, SD_0 =. 05; M_1 = .55, SD_1 =. 06; M_6 = .55, SD_6 =. 06). Mean comparisons show criterion bias (B") at its most liberal in the low working memory condition, (M_0= .06, SD_0=. 33; M_1= -.12, SD_1=. 49; M_6= -.01, SD_6=. 48). The interaction of working memory load and condition for false alarms was also significant, F (4,1224) = 5.25, p <.001, partial η^2 =.15.

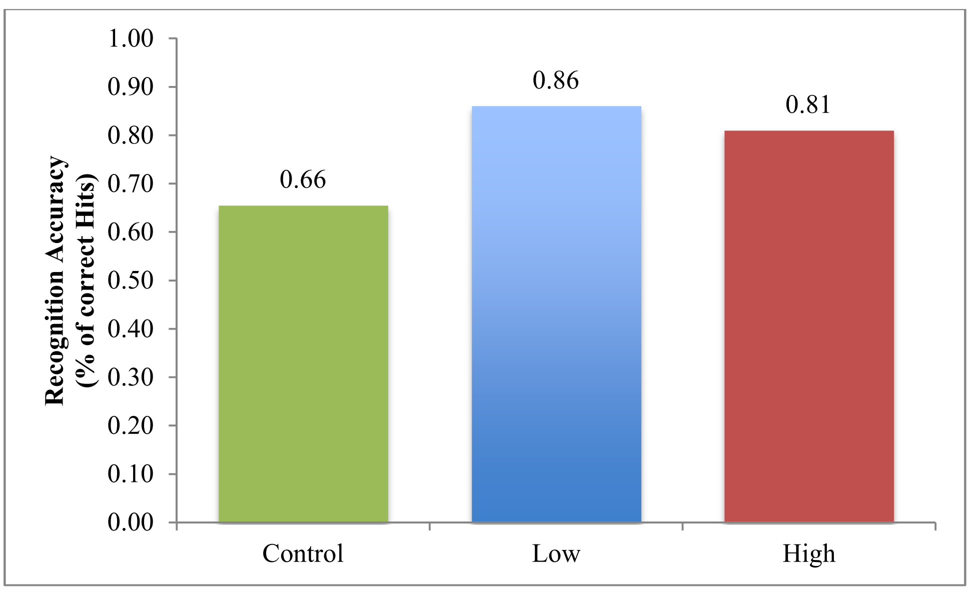

Figure 10. Main Effect Of Working Memory Load On Recognition Accuracy (Hits).

RQ3 asked about the effect of the interaction between working memory and perceptual load on information recognition of the alert. The perceptual load and working memory load interaction had a significant quadratic trend effect on recognition accuracy (hits), $F(1,62) = 33.49$, $p < 0.001$, *partial* $\eta^2 = 0.35$; false alarms, $F(2,61) = 7.42$, p <0.001, *partial* $\eta^2 = 0.20$; and B”, $F(1,61) = 7.71$, p <0.001, *partial* $\eta^2 = 0.20$; but not for A’, $F(1,61) = 0.82$, p = 0.44, *partial* $\eta^2 = 0.03$. In the control WML condition, participants exhibited greater recognition accuracy when the video was low ($M = .84$, $SD = .37$) than high ($M = .47$, $SD = .50$) in perceptual load, t (67) = 5.58, $p < .001$, *Cohen’s d* = |.84|. When participants were asked to remember one number (low WML), they exhibited greater recognition accuracy for the news alert when the video was high ($M = .93$, $SD = .26$) than low ($M = .79$, $SD = .41$) in perceptual load, t (67) = -2.25, $p < .05$, *Cohen’s d* = |.41|. Finally, in the high WML condition, participants exhibited greater recognition accuracy when the video was high ($M = .88$, $SD = .33$) than low ($M = .74$, $SD = .44$) perceptual load, t (67) = 3.40, $p < .001$, *Cohen’s d* = |.36|.

Table 3.
Mean Comparisons For Working Memory Load And Perceptual Load On Recognition Accuracy (Hits), A’, And B”

Perceptual Load	Working Memory Load		
	Control	Low	High
Recognition Accuracy (% of Correct Hits)			
Low PL	0.84	0.79	0.88
High PL	0.47	0.93	0.74
False Alarms (% of False Alarms)			
Low PL	0.84	0.82	0.76
High PL	0.9	0.47	0.71
Recognition Sensitivity (A’)			
Low PL	0.56	0.56	0.56
High PL	0.52	0.54	0.54
Criterion Bias (B”)			
Low PL	0.12	-0.34	-0.05
High PL	0.07	0.11	0.04

Table 4.
Pairwise Comparisons Of Hits, A', And B" For Each Of The Information Recognition Conditions.

	Working Memory Load		Mean Difference	Std. Error	Sig.
Recognition Accuracy (% of Correct Hits)	Control	Low	-0.21	0.05	< .001*
		High	-0.15	0.05	<0.01*
	Low	High	0.06	0.05	0.7
False Alarms (% of False Alarms	Control	Low	0.22	0.05	< .001*
		High	0.13	0.05	< .05*
	Low	High	-0.08	0.05	0.32
Recognition Sensitivity (A')	Control	Low	0	0.01	1
		High	0	0.01	1
	Low	High	0	0.01	1
Criterion Bias (B")	Control	Low	0.21	0.04	< .001*
		High	0.1	0.05	0.08
Table 4 (cont'd)	Low	High	-0.11	0.05	0.12

	Perceptual Load		Mean Difference	Std. Error	Sig.
Recognition Accuracy (% of Correct Hits)	Low	High	0.13	0.03	< .001*
False Alarms (% of False Alarms	Low	High	0.12	0.03	< .001*
Recognition Sensitivity (A')	Low	High	0.02	0	< .001*
Criterion Bias (B")	Low	High	0.16	0.04	< .001*

Notes. * denotes a significant effect.

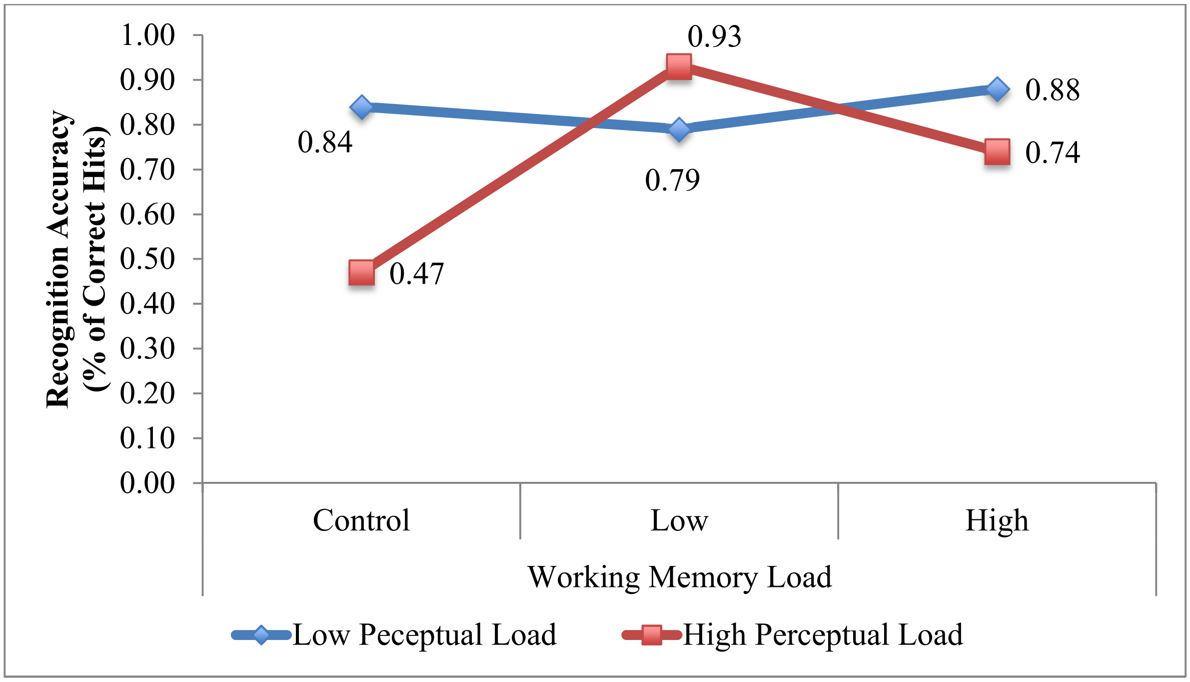

Figure 11. The Mean Comparisons Of Perceptual Load And Working Memory Load For Information Recognition Hits.

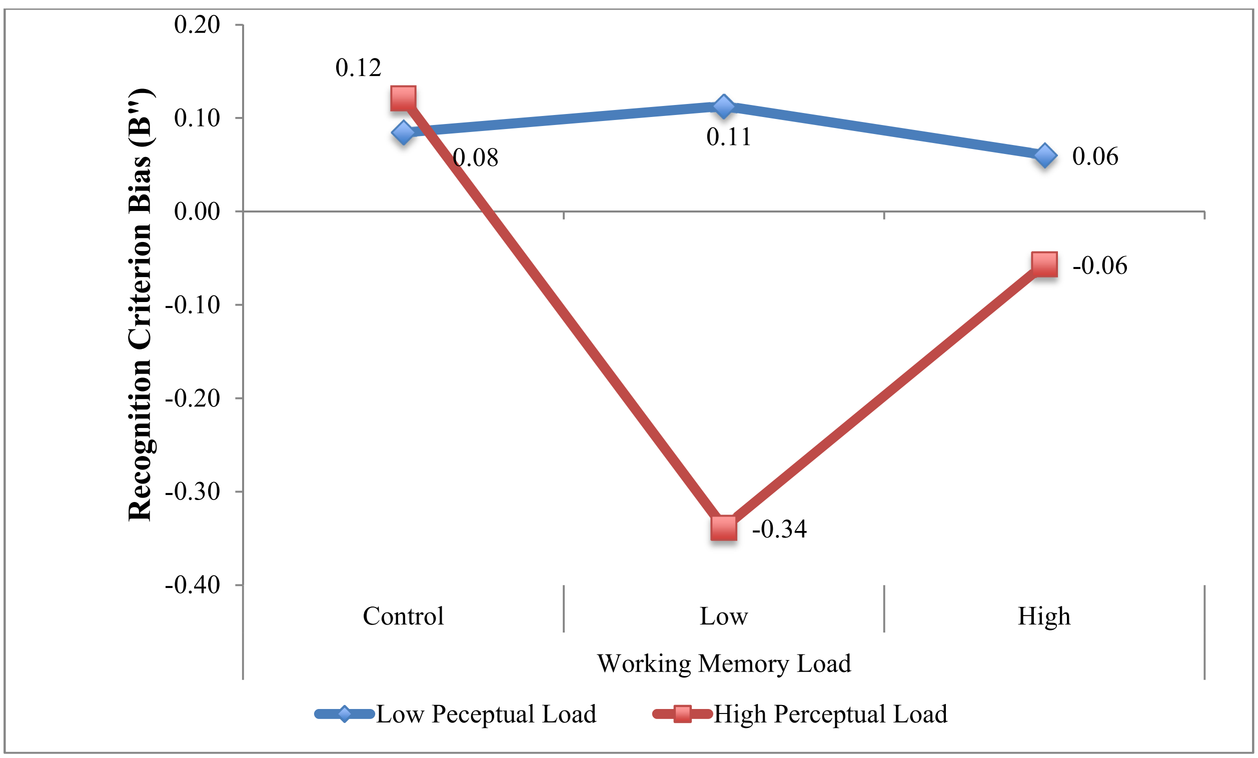

Figure 12. The Mean Comparisons Of Perceptual Load And Working Memory Load For B" Criterion Bias.

There were several other interactions that were significant including a quadratic two-way interaction between working memory load and order, $F(2,62)= 8.18$, $p <0.001$, partial $\eta^2 =0.21$; a quadratic three-way interaction among perceptual load, working memory load, and order quadratic, $F(2,62)= 16.78$, $p <0.001$, partial $\eta^2 =0.35$; perceptual load by order linear, $F(2,62)= 9.06$, $p <0.001$, partial $\eta^2 =0.23$ (see Appendix F). The interaction of perceptual load, working memory load, and order were statistically significant for false alarms, $F(4,124) = 6.14$, $p <0.001$, *partial* $\eta^2 = 0.17$. No other interactions were significant.

Cued Recall

H4, H8, RQ4 investigated the main effect of perceptual load (*H4*), the main effect of working memory load (*H8*) and the interaction between perceptual load and working memory load (*RQ4*) on cued recall for the news alert. To this end, the number of correct hits was submitted to 3 (working memory load: control, low, high) x 2 (perceptual load: low vs. high) x 3 (video order) ANOVA with repeated measures.

H4 predicted that participants would have higher cued recall for breaking news alerts when perceptual load is low than when perceptual load is high. The effect of perceptual load on cued recall was not significant (H4), $F(1,62) = 0.88$, *ns*. *H4* was not supported. The means confirm no statistical differences between perceptual load conditions, ($M_{high} = 0.58$, $SD_{high} =0.32$; $M_{low} = 0.64$, $SD_{low} = 0.30$).

H8 predicted that participants would have lower cued recall for the alerts, when the working memory load is low than when working memory load is high. The main effect of working memory load on cued recall (H8) was not significant, $F(1,61) = 0.30$, *ns*. *H8* was not supported. The mean comparison showed that the cued recall varied only slightly across working memory loads, ($M_0 = 0.60$, $SD_0 = 0.33$; $M_1 = 0.62$, $SD_1 = 0.38$; $M_6 = 0.60$, $SD_6 = 0.37$).

RQ4 asked, how will the interaction between working memory and perceptual load affect the alert in cued recall? The effect of the interaction between perceptual load and working memory load on cued recall of the alerts (*RQ4*) was not significant: $F(1,61) = 1.34$, *ns*. Other significant interactions were perceptual load by order, $F(1,62) = 11.80$, $p < 0.001$, partial $\eta^2 = 0.28$; perceptual load, working memory load by negativity $F(1,62) = 4.10$, $p < 0.05$, partial $\eta^2 = 0.06$; and perceptual load , working memory load by order $F(2,62) = 3.54$, $p < 0.05$, partial $\eta^2 = 0.10$ (See Appendix F). No other interactions were significant.

CHAPTER 5: DISCUSSION

Summary of Findings

The current study investigated the effects of perceptual load and working memory load on processing breaking news alerts presented during online video news viewing. In review, significant findings included the perceptual load's influence on gaze duration and information recognition for the alerts. The perceptual load on gaze duration, however, was not in the hypothesized direction. Working memory was significant for information recognition, but not in the hypothesized direction as well. The interaction of working memory load and perceptual load on gaze duration and information recognition for the alerts was significant. No fixation or cued recall hypotheses were supported.

Visual Attention to the Breaking News Alerts

In the current study, visual attention to the breaking news alerts was conceptualized in two ways: time to first fixation on the alert and total gaze duration on the alert. Each of these measures reflects a different aspect of quantifying visual attention not only in relation to the news alert (distractor from the video), but rather in relation to the amount of cognitive effort give to the primary task; watching the online news video story, in this case.

With regard to the current study, and given that we did not vary the features of the breaking news alerts, time to first fixation can be regarded as a measure of the amount of cognitive resources allocated to the primary task, which influences the amount of resource remaining to encode the new (distracting) information presented in the form of the breaking news alert. As evidenced by the study's findings, there were no significant effects related to time to first fixation, neither in relation to the main effect of perceptual load and working memory load, nor in the form of their interaction. A plausible explanation for this trend of effect is that despite the fact that the current study used only a visual distractor to present the breaking news alert (as opposed to one with an audio component), it is possible that the placement of the news alerts appearing from the right-bottom corner of the screen is strategically effective in grabbing participants' attention regardless of the task they are performing in relation to their visual perceptual and working memory loads. Despite the perceptual load of the video and the working memory load, participants first looked at the news alerts at roughly .5 seconds beyond its presentation (given that it took 1 second for the alert to crawl in to the screen and get full display). The presentation of the alert in this particular location on a personal computer equipped with Windows operating system potentially corresponds with the habitual behaviors exhibited by participants when using a desktop computer. This particular placement also includes important software and hardware alerts. To this end, the findings from this study, given this particular explanation, point to the effectiveness of the alert placement in the lower right corner of the screen in terms of notification noticeability, which was not variably influenced by perceptual load and working memory load.

The second component of visual attention deals with total gaze duration, which refers to the total amount of time participants spent on the alert during the six seconds of its presentation throughout the online video watching experience. Gaze duration indicates the amount of cognitive effort allocated to the distractor (alert) as a function of the amount of resources remaining from processing the primary task (news video, in this case) (Poole & Ball, 2006). A significant finding that was not predicted by the hypotheses was perceptual load's influence on gaze duration for the alerts. Contrary to the study's hypothesis, participants spent a longer amount of time on the alert when the primary task (news video) had high rather than low perceptual load. There are two plausible explanations for this finding. First, it is possible that when the video's perceptual load was high, participants were easily distracted by the alert and unable to get back to the primary task. In other words, the high perceptual load in the video possibly led to a state of cognitive overload that made the secondary task (distractor: news alert) more appealing. Another plausible explanation stems from a similar logic. When participants are watching a high perceptual load video, they could be using a larger amount of resources to process the video (primary task), and even though they notice the news alert (given no differences in time to first fixation), they find it harder to fully process the news alert, thus spend more time processing it when the perceptual load is high than low. A third plausible explanation is that participants' state of arousal is heightened by high perceptual load videos compared to low perceptual load ones. In this case, participants' appetitive motivation might increase as a function of the high perceptual load videos, therefore giving the chance for greater environmental appraisal and ability to efficiently and thoroughly process information from multiple resources.

In looking at the effect of the interaction between working memory load and perceptual load, we see that variations in working memory – that were not effective on their own without considering the effect of perceptual load – lead to variability in gaze duration when comparing low and high perceptual load videos. The difference between high and low perceptual loads in gaze duration as a function of working memory load is evident in the low (remember 1 number) and high (remember 6 numbers) working memory load conditions. One thing to note is that the effect size of these differences increases with working memory load increase (low = |.43| vs. high: |.75|). Here we can incorporate two of the aforementioned explanations for the effect of perceptual load on attention to the alert. It is possible that the combination of high perceptual load and low working memory load elicited a state of arousal that enabled parsing the pool of cognitive resources efficiently among the different cognitive tasks (primary vs. secondary).

However, the larger effect in the case of high working memory load points to the possibility that the combination of high perceptual load and high working memory load could have resulted in cognitive overload, thus withdrawing resources completely from the primary task (news video) and investing more resources in processing the secondary task (news alert).

A similar effect, supporting these current results, was also found in an eye tracking study (Wang, Yang, Liu, Cao, Z., & Ma, 2014). In a study with 42 college students, participants were asked to surf different websites (high and low perceptual load complexity) and complete either simple or complex tasks (Wang, Yang, Liu, Cao, Z., & Ma, 2014). The study showed that task complexity moderates perceptual load's effect on fixation duration, such that when a participants were engaged in a complex task on a website with medium perceptual complexity fixation duration total for the website was at its highest (Wang, Yang, Liu, Cao, Z., & Ma, 2014). The authors attribute these findings to align with LTA with the addition of the task complexity moderator (Wang, Yang, Liu, Cao, Z., & Ma, 2014). Like the current study, gaze duration was higher in conditions with high working memory and higher perceptual load.

Memory of the Breaking News Alert

In the current study, memory to the breaking news alerts was conceptualized in two ways: encoding (information recognition) and storage (cued recall). Each of these measures reflects a different level of cognitive processing of the alert displayed. Encoding is the initial stage of memory processing and was measured through information recognition. The next, more in-depth memory processing is called storage and was measured through cued recall.

Consistently, information recognition for the news alert was lower when the alert appeared with a high than low perceptual load video, suggesting that participants were becoming cognitively overloaded under high perceptual load. Cognitively overloaded means that the available resources were outnumbered by the current demand on resources. Participants encoded less of the news alert in high perceptual load conditions than in low perceptual load conditions. This may mean that viewers were so engaged with the primary video in with high perceptual load that they were unable to allocate adequate cognitive resources to encoding information for the news alert.

A recent study of cognitive load (defined similarly to perceptual load here) found the same effects. In a series of experiments, participants were shown two faces to memorize (manipulating working memory load) (Minamoto, Shipstead, Osaka, & Engle, 2015). Then participants were asked to make judgments on the color of a target dot as they ignored face distractors (Minamoto, Shipstead, Osaka, & Engle, 2015). Distractors inference with the target judgment was lowest in the high perceptual load conditions (Minamoto, Shipstead, Osaka, & Engle, 2015). The main effect that distractors (or breaking news alerts) are more likely to be processed into memory in low perceptual load conditions and are less likely to be processed into memory in high perceptual load conditions.

The interpretation for the main effect of working memory load on information recognition is more complex. The working memory load asked participants to temporarily remember no numbers, a 1-digit number or a 6-digit number before each video. The thinking was that high working memory load would take up more cognitive resources and, in this study, was shown to influence encoding, but not in the predicted linear fashion. Before discussing the results of the working memory load on information recognition it is important to talk about the working memory manipulation itself.

Based on the accuracy measure of the working memory manipulation, the means for correct answers were (N= 62: M_{Low1} = .94, SD =.25; M_{High1} = .90, SD =.30; M_{Low6} =.94, SD =.25;

M_{High6} =.90, SD =.30). The means show that participants were very engaged with the working memory task and performed well at the task, regardless of whether they were instructed to remember one or six numbers, and also despite the level of perceptual load. A repeated measures ANOVA showed the correctness of the working memory load task did not vary as a function of perceptual load, ($F(1, 61) < .001$, *ns*), working memory load, $F(1, 61) = 0.80$, *ns*), or the interaction between them, $F(1, 61) = < .001$, *ns*). At the outskirt of this discussion, this confirms the quality of the working memory load manipulation in that participants actively engaged in the task, which also confirms that participants' ability to perform well on the working memory load task could not, in any possible way, influence the outcome variables (attention and memory).

Results of the main effect of working memory load show statistically significant differences in information recognition accuracy (hits) and recognition criterion bias (B") between the control condition (no number to remember) and the each of the low (remember one number) and high (remember six numbers) working memory load conditions. The differences between the low and high conditions were not significant. Additionally, the main effect of working memory load on recognition sensitivity (A') was not significant.

Specific to the main effect of working memory load on information recognition accuracy (hits), the values were statistically significant, but not in the hypothesized direction. The hypothesis predicted that information recognition would be greater in the high working memory load condition than the low. Instead, the results showed that information recognition accuracy for was the lowest in the control working memory load condition, but equally higher in the low and high working memory load conditions. This may mean that when viewing a news video without having to entice working memory, participants remained focused on the task of watching the video instead of attending to processing the news alert. Interestingly, the difference in recognition accuracy and criterion bias was not significant between the low and high working memory tasks, yet both of these conditions were significantly different from the control, where participants were not tasked with remembering any number. It is plausible that the shear activation of working memory in a dual task with news video viewing made it easier for participants to switch from focusing on the primary (video and WML) to the secondary (news alert) task. Another plausible explanation is that participants in the control condition were given a single primary task to perform – watch the news video, yet in both the low and high working memory load conditions, that primary task became a dual task, where participants were carrying out two tasks at the same time, while also being confronted with a secondary task of attending to the news alerts. In this case, either participants were overloaded – as suggested previously – when carrying out the dual task, thus making it easier to withdraw resources from the dual task to the distractor (news alert) or in the case of activating two forms of cognitive load, participants are already in a mindset of task switching, therefore, they were able to enlarge their pool of cognitive resources to the three tasks at hand.

A possible explanation for the trend in main effect results for the working memory load on information recognition may be that the working memory manipulation was too different from the alerts to cause a conflict in processing. A conflict in processing would be the same channels of information are being overloaded and information cannot be processed efficiently. In a recent matching task experiment, participants were told to remember two faces (working memory load) that contained house peripheral distractors (Park, Kim, & Chun, 2007). Then the participants were shown two target faces with house peripheral distractors and asked if they were different or the same (Park, Kim, & Chun, 2007). In another condition, the houses were central and the faces were peripheral. In the cases where the working memory load manipulation did not match the target, the distractors interference decreased (Park, Kim, & Chun, 2007). The authors suggested amending Lavie's load theory, "According to our specialized load account, the critical distinction is not just between working memory and perceptual load but, rather, between different types of dissociable processing mechanisms, each with independent, limited capacity (multiple resources)" (Park, Kim, & Chun, 2007, p. 1071). In the case of this current study, the alert and the working memory manipulation may not have been in conflict and thus the alerts may have been easily processed in higher working memory conditions.

For the interaction of perceptual load and working memory load, the results showed that information recognition accuracy (hits) was lowest in the high perceptual load and control working memory load conditions, yet the difference in criterion bias between high and low perceptual load conditions in the control working memory condition was not significant. As for the comparison between low and high working memory load conditions in relation to perceptual load, we see that in the low working memory load condition recognition accuracy was higher for high than low perceptual load, and an opposite trend is observed in the high working memory load (low > high perceptual load). However, in looking at criterion bias results, we see despite the fact that participants became more liberal in their answers when videos were high than low on perceptual load across low and high working memory load conditions, the difference between the low and high perceptual load videos was larger in low than high working memory load conditions. While participants performed better at recognizing information from the alerts when working memory load was low and perceptual load was high, in this same instance, they were more liberal in their answers, yet they performed worse when their working memory load was high and perceptual load was high than when it was low, while maintaining greater liberal bias in the high than low perceptual load.

One possible reason for this is that participants in the low working memory load condition remembered the single number and then moved on to the primary video watching tasks. From there, depending on the low perceptual load or high perceptual load of the video, participants were either more liberal or stayed the same on their criterion bias. In a low perceptual load condition, participants could have still been able to fully process the alert message and been able to be more rigorous with their judgment of the true/false statement. In the high perceptual load condition, participants were exerting all of their efforts into processing the alert and video and then became more likely to say a statement was true. i.e. When participants are cognitively overloaded, they tend to lean more liberal because they have opened themselves up more to the possibility they have missed information presented to them. This criterion bias finding is supported by past research, “When viewers process complex messages that produce cognitive overload, they shift resources from the primary task, freeing up available resources for the secondary task” (Fox, Park, & Lang, 2007, p.290).

This reasoning is supported by another recent study. In a study, structural complexity and information density (i^2) measures were altered to see how those variables influenced signal detection measures and secondary task reaction times (Fox, Park & Lang, 2007). Results reveal that for signal detection measures, memory sensitivity and criterion bias dropped in cognitive overload conditions (Fox, Park & Lang, 2007). Interestingly, the study also says that the more liberal shift of criterion bias started before the overload happens (Fox, Park & Lang, 2007). The Fox, Park & Lang study (2007) study supports the current study’s findings. Perhaps the data reflected in this paper shows the initial stages before overload occurs.

Another interesting finding, specific to the interaction of working memory load and perceptual was B”. The data shows A’ prime was maintained over all conditions, while B” was at its lowest in the low working memory load and high perceptual load conditions. This means participants' answers became most liberal with the combination of low working memory and high perceptual load while maintaining recognition sensitivity.

The second component of memory is storage; this can be measured through cued recall (Zechmeister & Nyberg, 1982). In this current study, cued recall was not significantly different between the high and low perceptual loads. This paper postulates that participants simply did not engage in this more in-depth level of processing to storage (Reisberg, 2015). Despite the process of gaze duration and information recognition being different, the end result for memory storage is the same across all conditions. The results of this study show that over the course of attention and memory processing, viewer start the same way (no differences in fixation), but process the information differently in different conditions (differences in gaze duration and information recognition). By the later stages of processing, like storage (cued recall), the information is the same.

Theoretical Implications

This current study shows the interaction of working memory and perceptual load on a secondary task. Additionally, this study includes comparisons of theories across disciplines to indicate how the two interact and influence any experimental results. This study showed that LTA's working memory load is an added factor to cognitive processing, which has not, to date, been fully explored in the LC4MP literature. LTA and LC4MP use two very different types of stimuli. This current study identifies how the medium can change the way people attend to and remember objects. For example, this current study used television news and breaking news alerts where LTA has traditional used flanker tasks. Past LTA studies have shown no interaction between working memory load and perceptual load. This current study, however, does show those interactions. The results may have varied due to the medium type.

Additionally, this study extends both theories by moving this from a search task to a natural viewing task. This movement depicts how viewers function under different task loads. In a recent study, 329 participants participated in three groups in a recalling banner ads experiment (Heinz, 2013). The three groups were divided by the involvement of the website that was being viewed. Through the narrow goal orientation (seeking a specific answer), the broad goal orientation (preparing for a group talk), and the exploration orientation (no specific instructions), all participants were asked to view a website and then recall if they saw the secondary stimulus, which was a banner ad. The results indicated that the orientation to the task moderated the recall of the ad so that those who were not goal orientated were less likely to recall the web ad (Heinz, 2013). This mediator is identified as "goal orientation." In this current study, the exploration task mode is used because this mode is most similar to how viewers naturally watch television.

Practical Implications

This study is designed to show the most effective way to manipulate perceptual load under differing levels of working memory load. This study demonstrated that by using relevant alerts, message creators could capture attention and induce processing among viewers in a variety of conditions. Although working memory will be hard to control for, knowing how people function under different working memory loads will help shape future studies on load manipulation.

For the MSUPD alerts, the results show that when a viewer's attention was directed toward the screen, the viewer would attend to and recognize the alert. An important consideration for MSUPD would be how to get people to react and induce behavioral change.

This study stops short of requesting behavior change of the participants, but future studies should consider messages that evoke an “act now” response from viewers.

This study suggests that multitasking should also be taken into consideration. Future studies should look at how multitasking is affecting both the perceptual and working memory loads. As multitasking’s popularity increases, so do the chances for inattention blindness to important messages. This study suggests there is more research to be done on ways to capture attention when all conditions are working against attentional capture for a distracting alert.

This study has three practical recommendations for alert message creators that may contribute to better processing of the alerts. First, the alerts should be consistent in size and location. It seems that the alerts were expected to show up in the lower right-hand corner and thus, viewers were able to quickly process them. Order effects (discussed in more detail in the limitation section) also show that viewers are responsive to predictable alerts. Second, although alerts were noticed and processed by the viewers, there was no call for action (discussed in more detail in the limitation section). Some viewers did not feel the need to react to the alerts because the alerts did not ask any action of the viewer. Future alerts should not only provide information, but detail to the viewer that behavior they should engage in. Third, alerts may need to come with other preattentive qualities to evoke the most attentional resources to the secondary tasks. Although not directly tested in this current study, viewers’ attention can be allocated elsewhere and not at the screen. When attention is not on the screen, a simple visual alert may not evoke attentional resources. Instead, alert producers should consider other preattentive elements, like sound (discussed in more detail in the limitation section).

Limitations

Although the research tried to minimize confounds, there were limitations to this study. One limitation is that LTA works with still-image stimuli in past research. A still image may yield different results than video. Another limitation is that LC4MP and LTA are usually measured with reaction times (either to the primary or secondary task). This study did not employ the reaction time measure, as it would induce a search mode mentality by the participant. As previously cited, the two theories used in support of this experimental design implement a search task. Inherently, search tasks are different from that of natural viewing. This limitation may be due to the current research is not done in an exact spirit of the theory.

Another confound many have been the video content itself. The video content was news related and so was the alert. The video content may have put participants at a heightened state of alert to information seeking and processing messages. Unlike, primetime shows, the news videos are used to provide information and thus viewers may be more engaged with seeking out and remembering information. Additionally, the videos themselves varied in content, pacing, and arousal. Additional analyses revealed that despite the pretesting for positivity and negativity confounds, the videos did vary on those two conditions too. These are all limitations to using real newscast videos. Perhaps future studies should create their own videos to control for these varying components.

Another confound was the within-subject design. Although, a within-subject design can lead to a more powerful analysis, the order of the conditions did seem to have an effect on processing. In several cases, the order influenced the way the information was processed, which may be due to latency effects. The order effects can also be linked to the possibility of habituation (Lee, Ahn, & Park, 2015). Participants may have been trained after the first couple of alerts to encode the alerts when they appear (Lee, Ahn, & Park, 2015). Perhaps future studies should vary location or add audio to see how this influences habituation when the alerts cannot be predicted. Ideally, the design would be truly randomized to avoid order effects. However, the eye tracking software for this study did not allow for a true randomization of order.

A limitation in this study was also the alerts themselves. The MSUPD alerts were perhaps too relevant and due to the lab setting participants were able to figure out this was test. One plausible explanation for the results may be that the participants felt the alerts were real. As mentioned previously, push notifications are becoming more common, and specifically, MSUPD push notifications have been publicized around our geographical area. Perhaps the alerts are so salient to participants that they were able to overcome any perceptual load or working memory load effects and were able to attend to the alert. Once processing the alert as an immediate threat or not, the participants moved back to the main video content. Since, the alert is notifying participants of a danger that is not an immediate threat to them, they only processed the information enough for the initial stages of memory. This is supported through the high number of participants who fixated and gazed at all if not most of the alerts.

If participants know that push notification alerts are being used more often, they may be more aware and react to them without time to fixation delays. In support, many participants verbally expressed their noticing of the alerts, but without care. One participant said, "I thought they were real, but I figured you would tell me if something was really wrong." While other participants asked, "Are these real things or are they part of the videos?" Another participant said, "The alert said it was on Wilson Road by the Cyclotron, so I figured we were safe." Of the 77 participants in the study, only 2 stopped the study to ask about the alerts. These reactions support the notion that the alerts were in fact read, but not processed long-term. Future research should consider changing alert types to see if there are different attention and memory outcomes for different types of alerts (immediate and not immediate).

Another limitation is the participant sample. Although a community pool was used, the demographics are skewed to more educated (M =17.3 years of formal education) and younger (M=30.7 years old) participants. These demographics, point to the Millennial generation who are more technology savvy and perhaps are used to notifications and pop-ups on screens. In fact, around 90 percent of Millennials watch videos online (Olmstead, Mitchell, Holcomb, & Vogt, 2014). Thus, they are more likely to be exposed this kind of information and may have found a way to tune-out distractor cues leading to phenomena like banner blindness. Future studies including populations used to single information streams, like older adults or those with less technology experience, may lead to different information processing results.

I believe the present study is a valuable contribution to the science of knowledge and the further defining of the two competing theories while utilizing a high external validity environment.

CHAPTER 6: CONCLUSION

This study explored the relationship between working memory load and perceptual load across two disciplines. The study was informed by LC4MP and LTA to determine how viewers' attention and memory measures to the secondary task are influenced by different conditions of working memory and perceptual load in an experimental, exploratory-view setting. The study's significance stems from comparing two competing theoretical frameworks – the LC4MP and LTA – to assess the effectiveness of a novel news delivery format.

This study employed a 3 (working memory load: control vs. low vs. high) x 2 (perceptual load: low vs. high) x 9 (video repetitions) x 6 (working memory load repetition) x 3 (video order) nested within-subject experimental design. Specifically, perceptual load and working memory load were manipulated to see the changes in attention (visual fixation and gaze duration) and memory (information recognition and cued recall).

Participants were asked to remember a 0, 1, or 6-digit number while viewing different news videos. After each of the 18 videos viewed through an eye tracker, participants were probed on the number. The videos varied in perceptual load through the use of high/low cuts and i^2 . Six of the videos also contained breaking news alerts with messages mocked from really MSUPD desktop alerts. At the end of the all the video participants were asked about their memory of the alerts displayed in 6 of the videos.

The results show that cognitive processing was different for gaze duration and encoding (information recognition) among the different conditions, but the start (fixation) and the end (cued recall) of the cognitive process was the same. Variance in memory processing was limited to the initial stage (encoding) and was equal across all conditions by the secondary stage (storage). This study shows that perceptual load and working memory load influence cognitive processing, but not in the way traditionally predicted.

APPENDICES

APPENDIX A

Surveys

Pretest Survey

Participants will agree to consent and watch 36 videos that were content analyzed for high and low pacing.

These were randomized after each video:

Please indicate how the video made you feel.

Not at all aroused o o o o o o o Extremely aroused

Not at all positive o o o o o o o Extremely positive

Not at all negative o o o o o o o Extremely negative

These were presented 1 time at the end of the survey.

Please rate the alerts by how useful they are to you.

1 (Not at all useful) o o o 5 (Very useful)

Alert about a gas leak on MSU's campus.

Alert about dangerous weather in Ingham county.

Alert about trash removal in East Lansing.

Alert about tuition increases at MSU.

Please rate the alerts by how interesting they are to you.

1 (Not at all interesting) o o o 5 (Very interesting)

Alert about a gas leak on MSU's campus.

Alert about dangerous weather in Ingham county.

Alert about trash removal in East Lansing.

Alert about tuition increases at MSU.

Please rate the alerts by how likely your behavior would change because of them.

1 (Not at all likely) o o o 5 (Very likely)

Alert about a gas leak on MSU's campus.

Alert about dangerous weather in Ingham county.

Alert about trash removal in East Lansing.

Alert about tuition increases at MSU.

This is the last part of the study. Please answer the following demographic questions.

What is your gender?

Male

Female

What year were you born?

(SCROLL OF BIRTH YEAR)

Not including kindergarten, how many years of formal education have you completed?

(PLEASE ENTER THE NUMBER OF YEARS OF FORMAL EDUCATION IN THE BOX BELOW)

Do you consider yourself to be Hispanic or Latino?

Yes
No
Don't Know

Which of the following racial categories describes you? You may select more than one.
American Indian or Alaskan Native
Asian
Black or African American
Native Hawaiian or Other Pacific Islander
White or Caucasian
Other (PLEASE SPECIFY)

What is your marital status?
Single, never married
Married or living with a partner
Separated or divorced
Widow or widower

Which of the following best describes your employment status?
Employed full time
Employed part time
Homemaker, not employed outside home
Student, not working for wages
Unemployed
Disabled, not working outside home
Retired

Which of the following best describes you? I'm a...
U.S. Citizen/Permanent Resident
Non-Resident Alien
Other, please specify

What is your total annual household (FAMILY) income?
Less than $10,000
$10,000 to $49,999
$50,000 to $74,999
$75,000 to $99,999
$100,000 to $149,999
$150,000 or more

Main Survey

Below are examples of main survey. These will change as the pretest information the main survey.

In the next section sometimes you will be exposed to 0, 1, or 6 numbers. You will then watch a video. After some videos you will see another number. You are asked to select “Y” if that number was in your previously remembered number or “N” if it was not part of your previously remembered number.

TWO EXAMPLES WILL BE SHOWN.

Arousal measures example:

Please indicate how the video made you feel.
Not at all aroused o o o o o o o Extremely aroused
Not at all positive o o o o o o o Extremely positive
Not at all negative o o o o o o o Extremely negative

Cued recall:

The next questions will deal with your recall of the information from the alerts you just viewed. For each statement, please fill in the blank with one or two words that best complete the sentence based on the videos.

Please fill in the blank.
The alert talked about _____ street being closed.
The alert was about a ____ leak.

Information recognition:

In the following section, you will be exposed to a number of statements. Some of these statements include information that has been taken from the alerts that you were exposed to, and others have been taken from other alerts that you have not been exposed to. If you think the statement reflects information that you have been exposed to, then please mark it as a true. If the statement does not reflect information that you have been exposed to, then please mark it as false.

Please select true or false.
One alerts said there was a gas leak. T F
One alert said there was a water leak. T F

This is the last part of the study. Please answer the following demographic questions.

What is your gender?
Male
Female

What year were you born?
(SCROLL OF BIRTH YEAR)

Not including kindergarten, how many years of formal education have you completed?

(PLEASE ENTER THE NUMBER OF YEARS OF FORMAL EDUCATION IN THE BOX BELOW)

Do you consider yourself to be Hispanic or Latino?
Yes
No
Don't Know

Which of the following racial categories describes you? You may select more than one.
American Indian or Alaskan Native
Asian
Black or African American
Native Hawaiian or Other Pacific Islander
White or Caucasian
Other (PLEASE SPECIFY)

What is your marital status?
Single, never married
Married or living with a partner
Separated or divorced
Widow or widower

Which of the following best describes your employment status?
Employed full time
Employed part time
Homemaker, not employed outside home
Student, not working for wages
Unemployed
Disabled, not working outside home
Retired

Which of the following best describes you? I'm a...
U.S. Citizen/Permanent Resident
Non-Resident Alien
Other, please specify

What is your total annual household (FAMILY) income?
Less than $10,000
$10,000 to $49,999
$50,000 to $74,999
$75,000 to $99,999
$100,000 to $149,999
$150,000 or more

APPENDIX B

Examples

Examples of alerts for stimuli.
Note: these are actual alerts sent out by MSU police via their Facebook and Twitter pages. Some messages have been truncated due to space constraints.

1. MSU ALERT:
   There is a natural gas leak at Bogue Street and Wilson Road on MSU campus.

2. MSU ALERT UPDATE:
   Cyclotron is evacuated and no other evacuation needed at this time. Please avoid the area.

3. MSU ALERT UPDATE:
   The following roadways are closed until further notice:
   -Wilson Road from Farm Lane to Bogue Street
   -Bogue Street from Service to Wilson.

4. MSU ALERT UPDATE:
   All vehicles leaving parking areas nearby should drive in a direction away from the Cyclotron Building. Pedestrians should avoid the area entirely.

5. MSU ALERT UPDATE:
   The natural gas leak at the Cyclotron Building, located at Wilson Road and Bogue Street, has been repaired.

6. MSU ALERT UPDATE:
   All activity and functions have been returned to normal operation.

Example:

APPENDIX C

Consent Form

Consent form

Research Participant Information and Consent Form
You are being asked to participate in a research study. Researchers are required to provide a consent form to inform you about the research study, to convey that participation is voluntary, to explain risks and benefits of participation, and to empower you to make an informed decision. You should feel free to ask the researchers any questions you may have.

Study Title: TV Viewing
Researcher and Title: Dr. Saleem Alhabash and Carie Cunningham
Department and Institution: Michigan State University, Advertising Department
Address and Contact Information: 313 Communication Arts & Sciences, Michigan State University, East Lansing, MI 48824; sa@msu.edu and cunni290@msu.edu.

1. PURPOSE OF RESEARCH
□ _You are invited to participate in a study conducted by researchers at Michigan State University. You will be asked to watch a video while using a non-invasive eye tracker. Following your viewing of the video, you will answer a short survey about your viewing experience.

• You must be at least 18 years old to participate in this study.
• You have normal or corrected-to-normal vision.
□ _You have been selected as a possible participant in this study because of your participation in the SONA system participant pool.
□ _From this study, the researchers hope to learn more about the psychological processes involved in viewing television programming.
□ _Your participation in this study will take 60 minutes.

2. WHAT YOU WILL DO
□ _You will be asked to watch a brief video that is similar to programming you would see on broadcast television, during which an eye-tracking device will locate where you are looking on the screen. Following your viewing of the video, you will answer a short survey about your viewing experience.

3. POTENTIAL BENEFITS
□ _You will not directly benefit from your participation in this study. However, your participation in this study will contribute to the understanding of television viewing.

4. POTENTIAL RISKS
□ _There are no foreseeable risks associated with participation in this study.

5. PRIVACY AND CONFIDENTIALITY
□ _The data for this project are being collected anonymously; your name and identity will not be linked in any way to your answers. Neither the researchers nor anyone else will be able to link data to you.
□ _Information about you will be kept confidential to the maximum extent allowable by law.
□ _The data collected for this research study will be protected on a password-protected computer or in a locked file cabinet on the campus of Michigan State University for a minimum of three years after the close of the project. Only the appointed researcher's and the Human Research Protection Program (HRPP) will have access to the research data. (HRPP).
_The results of this study may be published or presented at professional meetings, but the identities of all

research participants will remain anonymous.

6. YOUR RIGHTS TO PARTICIPATE, SAY NO, OR WITHDRAW

 _Participation is voluntary. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled.

 _You have the right to say no.

 _You may change your mind at any time and withdraw.

 _You may choose not to answer specific questions or to stop participating at any time.

7. COSTS AND COMPENSATION FOR BEING IN THE STUDY

Participants who consent to take part in this study will be awarded SONA credits through http://msucas.sona-systems.com or $10. Participants will have the choice between either the SONA credits or cash. For SONA credits, it is up to individual course instructors to determine how many points this converts to in their classes (this should be specified in the syllabus for each course). For SONA credit, as the study takes 60 minutes, participants who complete it will receive 1.25 SONA credits. Participation in this study is voluntary. You may withdraw at any time without penalty. This means that no SONA credits will be deducted from your account, nor will withdrawal have any effect on your relationship with any of your instructors. Participants who withdraw partway through the study will be awarded credit based on the portion of the study they complete. Students who view the materials but do not participate in any part of the research will receive 0 SONA credit and will not receive a gift card.

8. CONTACT INFORMATION

If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researchers (Saleem Alhabash, Assistant Professor, Department of Advertising, 313 Communication Arts & Sciences, 404 Wilson, Michigan State University, East Lansing, MI 48824; sa@msu.edu and Carie Cunningham, Doctorial student, Department of Journalism, 376 Communication Arts & Sciences, 404 Wilson, Michigan State University, East Lansing, MI 48824; cunni290@msu.edu).

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at Olds Hall, 408 West Circle Drive #207, MSU, East Lansing, MI 48824.

9. DOCUMENTATION OF INFORMED CONSENT.

Your signature below means that you voluntarily agree to participate in this research study.

____ ____________________ Signature Date

You will be given a copy of this form to keep.

APPENDIX D

Videos Used

Video Used

Table 5.

Mean Comparisons For Videos Used As Stimuli

Condition	Topic	Arousal	Positivity	Negativity	Cuts	i^2
Low	Ants	3.00	4.28	1.97	2	2
Low	BabyBacon	4.34	6.00	1.38	1	1
Low	CallingSick	3.66	4.24	3.17	2	2
Low	Flood	3.72	3.72	3.17	2	2
Low	Internetship	3.97	5.00	2.03	2	2
Low	Karate	4.17	6.31	1.45	2	2
Low	Rapper	4.14	5.55	2.07	2	2
Low	SupremeCourt	2.85	2.23	5.77	1	1
Low	Zombie	3.14	3.72	3.48	2	6
High	Alligator	4.03	3.66	3.28	14	14
High	AprilFools	3.93	3.69	3.45	19	19
High	CarTheft	4.07	2.38	5.17	13	13
High	ObamaTango	3.97	4.97	1.90	7	8
High	PopeRaps	4.41	5.28	1.90	6	9
High	PuppyRescue	4.62	6.69	1.59	5	12
High	SheepTrim	3.69	5.03	1.90	12	13
High	SilenceLambs	3.83	3.93	1.90	11	11
High	Twins	4.10	5.45	1.41	14	14

APPENDIX E

Descriptives

Descriptives

Table 6.
Mean Results for Gaze, Time to First Fixation, Recognition Accuracy "Hits", A', B",
and Cued Recall in the different conditions of perceptual load and working memory load.

	Gaze Duration				Time to First Fixation			
Conditions	***M***	***SD***	***Skw.***	***Kurt.***	***M***	***SD***	***Skw.***	***Kurt.***
Low Perceptual Load								
Control Working Memory Load	0.17	0.08	0.39	-0.33	31.41	0.6	1.21	0.9
Low Working Memory Load	0.15	0.07	-0.1	-0.26	31.49	0.48	0.64	1.21
High Working Memory Load	0.15	0.06	-0.09	-0.03	31.53	0.37	1.09	2.05
High Perceptual Load								
Control Working Memory Load	0.17	0.06	0.41	-0.1	31.64	0.79	2.66	15.17
Low Working Memory Load	0.18	0.07	0.56	0.33	31.48	0.4	1.7	2.8
High Working Memory Load	0.2	0.08	1.49	4.76	31.7	0.56	2.61	8.92

	Information Recognition Hits				A'			
Conditions	***M***	***SD***	***Skw.***	***Kurt.***	***M***	***SD***	***Skw.***	***Kurt.***
Low Perceptual Load								
Control Working Memory Load	0.84	0.36	-2.07	2.34	0.56	0.05	-1.69	1.99
Low Working Memory Load	0.79	0.42	-1.34	-0.2	0.56	0.06	-1.43	0.9
High Working Memory Load	0.88	0.32	-2.51	4.43	0.56	0.06	-1.68	1.66
High Perceptual Load								
Control Working Memory Load	0.47	0.5	0.07	-2.06	0.53	0.06	-0.55	-0.59
Low Working Memory Load	0.93	0.25	-3.63	11.58	0.54	0.05	-0.43	-0.67
High Working Memory Load	0.74	0.45	-1.04	-0.96	0.54	0.06	-0.72	-0.52

Table 6 (cont'd)

	B"				Cued Recall			
Conditions	***M***	***SD***	***Skw.***	***Kurt.***	***M***	***SD***	***Skw.***	***Kurt.***
Low Perceptual Load								
Control Working Memory Load	0.08	0.4	-2.36	3.92	0.58	0.5	-0.34	-1.95
Low Working Memory Load	0.11	0.34	-2.83	6.8	0.66	0.48	-0.7	-1.56
High Working Memory Load	0.06	0.44	-2.03	2.23	0.66	0.48	-0.7	-1.56
High Perceptual Load								
Control Working Memory Load	0.12	0.19	-3.38	18.66	0.63	0.49	-0.55	-1.76
Low Working Memory Load	-0.34	0.63	-0.13	-2.04	0.56	0.5	-0.27	-1.99
High Working Memory Load	-0.06	0.5	-1.34	-0.05	0.55	0.5	-0.2	-2.03

	False Alarms			
Conditions	***M***	***SD***	***Skw.***	***Kurt.***
Low Perceptual Load				
Control Working Memory Load	0.84	0.37	1.58	-1.88
Low Working Memory Load	0.82	0.38	1.04	-1.74
High Working Memory Load	0.76	0.43	-0.38	-1.28
High Perceptual Load				
Control Working Memory Load	0.90	0.31	5.30	-2.67
Low Working Memory Load	0.47	0.50	-2.05	0.12
High Working Memory Load	0.71	0.46	-1.18	-0.92

APPENDIX F

Interactions

Interactions

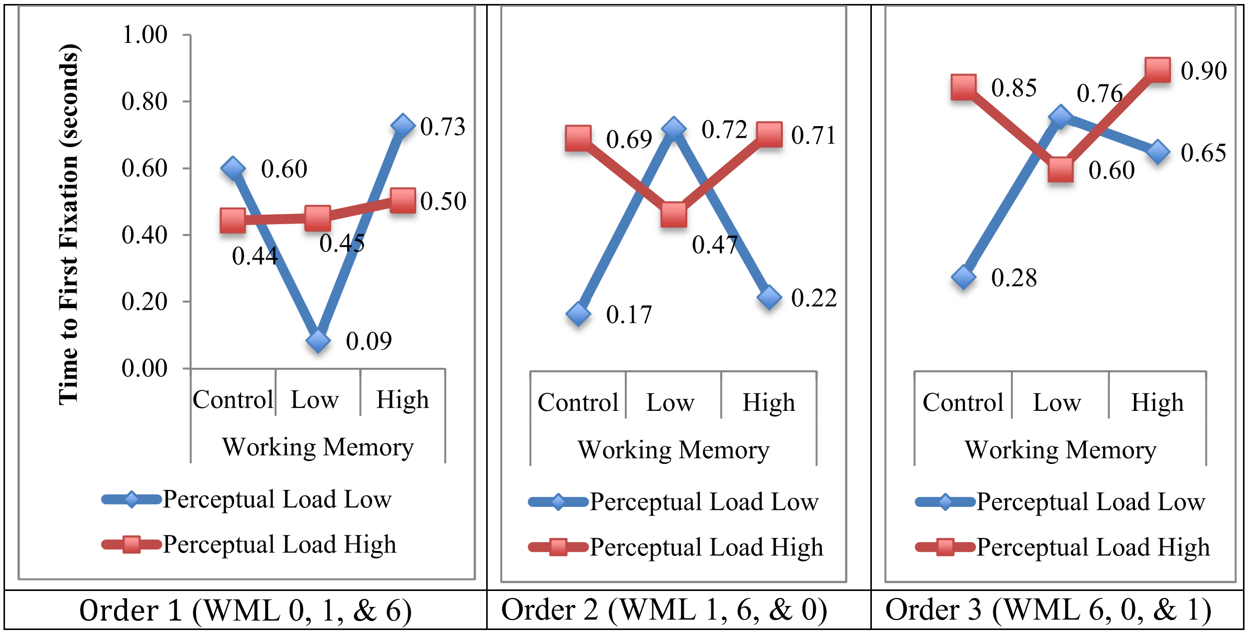

Figure 13. Effect of the three-way interaction among perceptual load, working memory load, and order on time to first fixation.

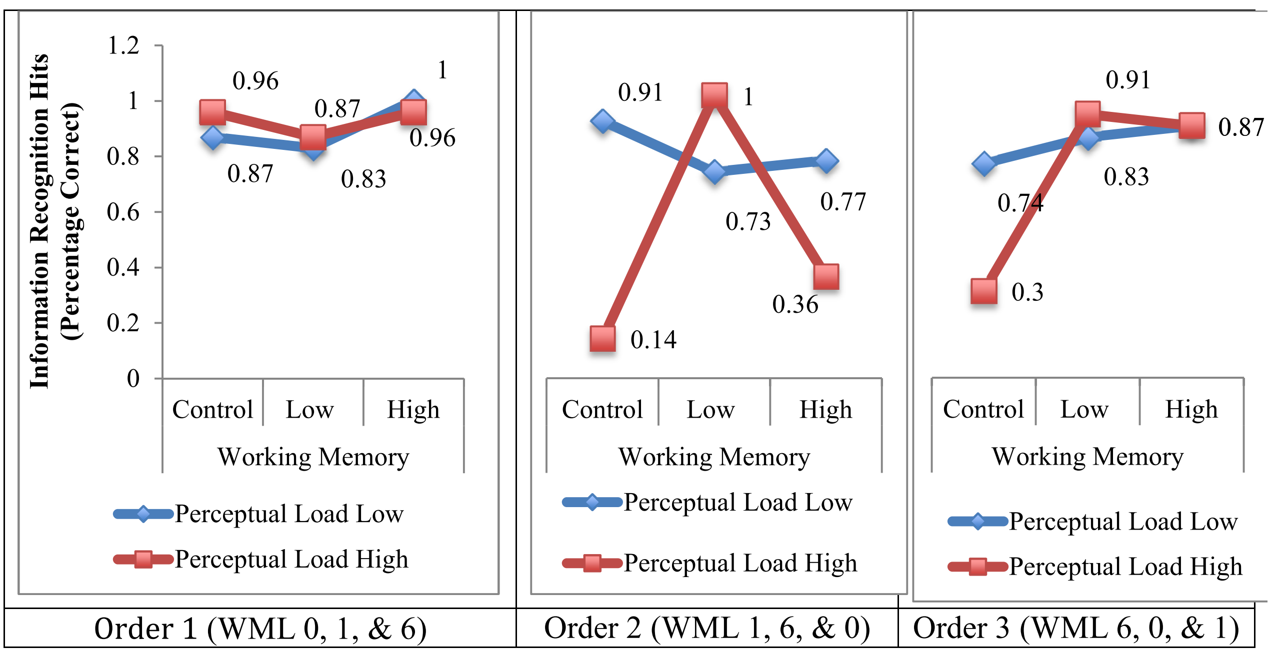

Figure 14. Effect of the three-way interaction among perceptual load, working memory load, and order on information recognition hits.

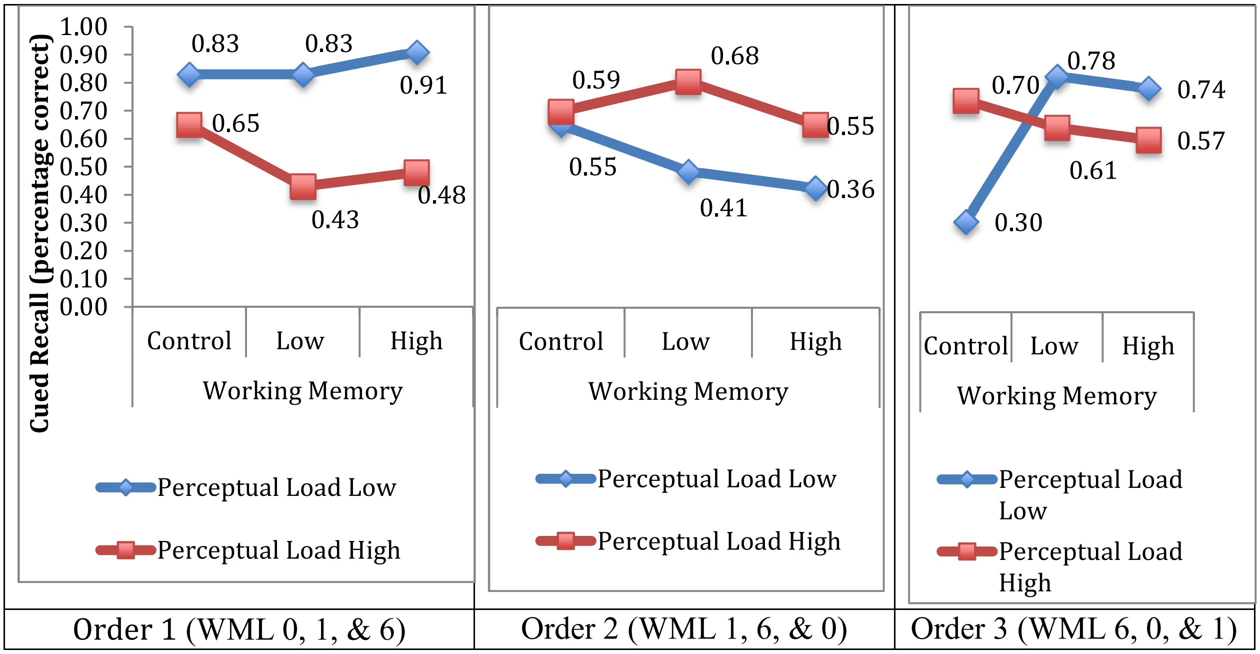

Figure 15. Effect of the three-way interaction among perceptual load, working memory load, and order on cued recall.

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