2014

Inattentional blindness and auditory attention: effects of cognitive load on visual awareness

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INATTENTIONAL BLINDNESS AND AUDITORY ATTENTION: EFFECTS OF COGNITIVE LOAD ON VISUAL AWARENESS

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Arts

in

The Department of Psychology

by
Dillon James Cornett
B.A., University of Nebraska – Lincoln, 2011
May 2014

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ABSTRACT

The current study investigated the effects of cognitive load, in the presence or absence of distractors, during a dynamic inattentional blindness (IB) task on IB rate. IB is a phenomenon where one fails to notice an unexpected object (UEO) or event (UEE) that is in full view while attention is occupied. In the present study, the presence of distractors was manipulated (present/absent) to investigate the effects of selective attention in inattentional blindness when inhibition of distractors is required or not required. Undergraduates at Louisiana State University completed a visual task while listening to music embedded with sine wave tones (low load), or completed the same task and reported (via button press) when they heard a tone (medium load) or, in addition to reporting the occurrence of tones, participants reported the number of tones that occurred (high load). Predictions for results were discussed based on load theory of selective attention and cognitive control (Lavie, Hirst, de Fockert, & Viding, 2004) and general capacity theory (Engle, Cantor, & Carullo, 1992; Conway & Engle, 1996). The current study attempted to replicate and extend previous knowledge regarding how working memory (WM) and selective attention influence IB rates by replicating conditions present in previous studies, and including new conditions of greater load. Mixed support for load and general capacity theories was found. Participants were less likely to notice an unexpected object in the low load condition when distractors were present compared to absent.

CHAPTER 1 INTRODUCTION

The visual world is rich and dynamic, but perception is much less precise than most may believe (Evans & Treisman, 2005). Inattentional blindness (IB) is the phenomenon where one fails to perceive an unexpected object (UEO) or event (UEE) in full view while their attention is occupied (Mack & Rock, 1998; Most, Scholl, Clifford, & Simons, 2005; Simons & Chabris, 1999). An example of IB in the real world would be the failure to notice an unexpected jaywalker while driving. Failures of attention can be inconsequential (e.g., failing to notice your friend waving at you in a crowded movie theater) or fatal (e.g., failing to notice a child running out in front of your car), and thus understanding when and how failures of attention occur is an important psychological endeavor. In fact, a recent study examining automobile accidents found that almost two-thirds of crashes were due to driver inattention (Beanland, Fitzharris, Young, & Lenné, 2013). The current research question concerned whether failures of attention are more likely when selective attention is necessary in tasks of varied difficulty.

CHAPTER 2 REVIEW OF LITERATURE

Attention

IB tasks are often employed to study failures of attention. IB tasks are applied to examine failures of attention because IB tasks are able to assess awareness for unexpected events. Before a description of the IB task and failures of attention is possible, the concept of attention must be introduced. Attention has been described broadly as the process that pulls a stimulus into consciousness allowing the individual to notice something (Mack & Rock, 1998). There are also many ways of allocating attention including selective attention (i.e., attending to some stimuli while ignoring other stimuli) and sustained attention (i.e., continuously monitoring some stimulus). Different attention tasks are utilized to assess various forms and failures of attention.

Attention is measured in a multitude of tasks, but it is often measured with cueing (Posner, 1980), attentional blink (Raymond, Shapiro, & Arnell, 1992) and IB tasks (Mack & Rock, 1998). Cuing tasks typically require participants to respond to a target presented on one side of a display or the other. However, a cue (e.g., presentation of a box on either side of the display or the other) can be valid (appearing where the target will later appear) or invalid (appearing on the opposite side of where the target will appear). Results from this task have shown that reaction times are faster for valid trials than invalid trials (Posner, 1980). The attentional blink task, on the other hand, measures attention by presenting a number of stimuli to observers in a rapid succession (i.e., Rapid Serial Visual Presentation: RSVP). During the RSVP task, the time between the first target and presentation of a second target is varied. If the second target is presented during a certain period soon after the first, the target is often not perceived because the first target is still being processed. This is said to demonstrate the limits of attention over time (Raymond et al., 1992). However, the most appropriate task employed to study failures of attention may be the IB task.

An IB task is generally defined by having participants perform a task (e.g., line length discrimination or object tracking) where responses are made for targets and, unexpectedly, during one trial an event occurs or an additional object is presented. The IB task measures the extent to which objects that are not directly relevant to the task receive attentional resources. IB results are often applied to real-world settings such as motor-vehicle driving (Pizzighello & Bressan, 2008; Beanland, Allen, & Pammer, 2011). Regarding IB research and the distribution of attention, Beanland and Pammer (2012) postulate that often in IB paradigms that employ stationary, or static, stimuli and no distractors, inhibition of task-irrelevant stimuli is not required. That is, attention must be engaged on the task, but there is nothing in the display that must be ignored. Ignoring or suppressing some information in favor of other information requires the use of selective attention. Thus, attention is always required of an observer when conducting goal-directed behavior. However, when irrelevant stimuli must be ignored an observer uses selective attention to decide what to ignore. In studies using static displays it is generally assumed that everything presented to the participant is task relevant, thus inhibition of distractors is not necessary (Beanland & Pammer, 2012). On the other hand, studies using moving (i.e., dynamic) stimuli typically require the observer to ignore something, requiring selective attention.

When an observer is asked to ignore a certain category of stimuli and use selective attention, as is typically required in an IB study using dynamic stimuli, the observer adopts an “attentional set” where to-be-ignored items are classified as distractors and task irrelevant (Most et al., 2005). An attentional set, then, is a specific type of stimuli the observer adjusts their attention towards or away from, essentially changing their selective attention (or what they are selectively attending to). An observer's attentional set, or how they decide what to attend, is a critical component for whether they will notice a UEO in IB paradigms with dynamic stimuli. A UEO is more likely to be detected if it shares perceptual features with the targets in the primary task (Simons & Chabris, 1999; Most et al., 2001; Most, et al., 2005).

Furthermore, an observer can adopt a strong or weak attentional set characterized by how specific they have geared their attention. A strong attentional set would be characterized as more specific than a weak attentional set. When a person adopts a strong attentional set they decide to select what to attend and what to ignore (e.g. attend to black shirt team and ignore white shirt team). However, a weak attentional set is more general and would not specify what to attend and/or ignore (e.g. attend to black team). Beanland, et al. (2011) explained that a weak attentional set would decrease the rate of IB due to increased distractor processing. This is because distractors are not specifically being ignored. Conversely, a strong attentional set would increase the rate of IB due to decreased distractor processing. This is because the UEO, based on primary task demands, is classified as an irrelevant distractor.

The IB Paradigm

In the classic IB paradigm participants are engaged in an attentionally demanding task (called a primary task); for example, counting the number of times white objects bounce off the edge of a screen. After several trials, an UEO appears or an UEE occurs during a "critical trial". When observers are engaged in the primary task, many fail to notice the UEO or UEE. Often, over half of the participants do not report seeing the UEO (Neisser & Becklen, 1975; Beanland, et al., 2011). However, when the same observers are allowed to view the display without completing the primary task during a "full-attention" trial, the UEO or UEE is much more likely to be reported as being perceived. This effect is consistent, regardless of the stimuli used: geometric shapes (e.g., Cartwright-Finch & Lavie, 2007; Koivisto, Hyona, & Revonsuo, 2004; Mack & Rock, 1998; Most et al., 2005; Most et al., 2001), human subjects (Simons, 2000), and a human in a gorilla suit (Simons & Chabris, 1999). Traditionally there are two types of IB studies: static and dynamic.

There are two subsets of the classic IB paradigm: static IB tasks and dynamic IB tasks. Dynamic IB tasks have examined many of the same questions as static IB studies. A series of studies (Neisser & Becklen, 1975; Neisser & Dube, 1978, as cited in Neisser, 1979) found results that were consistent with static IB studies. A study conducted by Neisser and Becklen (1975), found that 50% of their participants were blind to the UEO and those who did notice something usually could not correctly report details of the UEO (e.g., shape and color). Similarly in a later study, Neisser (1979) reported that 79% of participants failed to see the UEO among dynamic stimuli. However, when observers did not engage in the primary task (during a full-attention trial) all participants noticed the UEO. IB has been said to occur because either attention is directed away from the UEO or attentional resources are disrupted or otherwise unavailable (Most, 2010).

Spatial inattentional blindness occurs because visual attention is directed away from the UEO (Most, 2010). Attention can be directed either overtly (directing the eyes or turning the head) or covertly (not moving the eyes) away from the UEO. On the other hand, central inattentional blindness occurs when there is a limited availability of attentional resources such as when WM is taxed beyond capacity. When spatial IB occurs, participants are attending to a different area of the display where the UEO is not present. Researchers have found that the further a UEO appears from where an observer is attending; the more likely they will not notice it and thus be inattentionally blind (Mack & Rock, 1998; Newby & Rock, 1998; Most, Simons, Scholl, & Chabris 2000).

Specific theories regarding attention to a given location (Mack & Rock, 1998) propose an attentional zone where stimuli in this zone would be more noticeable and salient. However, objects within this attentional zone still went unnoticed at an average of 25% over a range of stimuli types and experiments (Mack & Rock, 1998). Those authors concluded that items inside the attentional zone are less susceptible to IB, but failures are still present. This conclusion addresses spatial IB however, in regard to central IB; it has been proposed that cognitive resources needed to process the unexpected stimulus are unavailable (Most, 2010). Insufficient resources in this case arise due to the primary task demands or the specific individual's cognitive capacity. Central IB can be further subdivided depending on the processes prompting the IB (e.g., a difficult task or attentional set). Differing types of inattentional blindness suggest that not all results can be generalized across studies. Most (2010) has shown that WM, the system that actively holds and manipulates multiple pieces of information in the mind, does not necessarily predict spatial inattentional blindness, but does influence central inattentional blindness. However it is possible that spatial and central inattentional blindness often occur in conjunction. The design of the current study allowed for an examination of central IB.

A study conducted by Most et al. (2000) employed a task similar to the primary task of the current study. The results of this study showed that IB was lowered, but not eliminated, when the UEO was presented in an area where participants were attending. Most, et al. (2000) conducted an IB investigation using dynamic stimuli where four black and four white "L" and "T" shapes moved randomly around a display. Included in the display was a horizontal line across the center of the screen. The task for observers was to count the number of times the black shapes touched the horizontal line. After participants completed two 15 second trials, a third trial began wherein a light gray cross (the UEO) entered from the right side of the display and moved horizontally across the screen for five seconds in total. A proximity manipulation was applied in this study such that the UEO moved horizontally across the screen on the mid-line, near, far, or very far above or below the mid-line. After the critical trial where the UEO appeared, participants were questioned if they had seen anything besides the black and white Ls and Ts and subsequently were given divided attention and full-attention trials. Findings from this study revealed that 53% of participants were inattentionally blind when the UEO was on the mid-line, and IB increased as the UEO moved farther above or below the mid-line (79% inattentionally blind when UEO very far above mid-line). Different theories have been applied to explain the results of IB studies.

General Capacity and Load Theories

Proponents of general capacity theory (Engle, Cantor, & Carullo, 1992; Conway & Engle, 1996) state that in each individual there is a finite general WM resource that is depleted as task demands increase. In addition, individual differences in this resource exist, and those differences are only found when controlled and effortful processing occurs (Conway & Engle, 1994). For example, as more task-relevant stimuli are added to a task the WM system allows an individual to maintain or manipulate that additional information, and task performance has been found to decrease compared to when WM is less burdened (Pizzighello & Bressan, 2008). A recent study, similar to the current study, reported results that support this general capacity theory (Pizzighello & Bressan, 2008). In a study conducted by Pizzighello and Bressan (2008), it was found that in the absence of focused visual attention, but in the presence of auditory stimuli, participants still reported not seeing the UEO. The results of this study suggest that attentional resources are not subdivided, but can be conceived as a single pool of resources. Support for a general capacity theory has been found in other studies.

Simons and Chabris (1999) conducted a replication of the classic selective looking study by Neisser and Becklen (1975; first reported in Neisser 1979). Participants were presented with a brief video wherein two teams of three basketball players wearing either white or black shirts were passing a basketball to players on their same team (e.g., white shirt team member passes ball to white shirt team member). The primary task was to either count the total number of passes made by the white shirt team or the black shirt team (easy condition) or keep a separate count of aerial and bounce passes for the attended team (hard condition). At one point during the video either a woman holding an umbrella or a person wearing a full-body gorilla suit walked through the middle of the game. The unexpected event of either the umbrella woman, wearing pale colors different from either team, or gorilla, wearing black, lasted for five seconds. Overall, 35% of participants were inattentionally blind to the umbrella woman and 56% were inattentionally blind to the gorilla. The results of this study revealed that more participants were blind to the UEO in the hard condition (55%) then the easy condition (46%). This result suggests that the greater the WM load of the task, the greater likelihood that a participant will be blind to the UEO. This result provides support for the general capacity theory in that, compared to the easy condition, an increased WM load (hard condition) led to a greater rate of IB. The current study attempted to replicate this finding by manipulating WM load.

In contrast to general capacity theory, load theory was proposed by Lavie (1995; Lavie, Hirst, de Fockert, & Viding, 2004). Proponents of load theory asserted that the processing of task-irrelevant stimuli is contingent on perceptual and WM task demands. Proponents of this theory suggest that there exist two selective attention mechanisms: perceptual and cognitive. The perceptual selection mechanism (see Lavie, 1995; Lavie & Tsal, 1994) has been described as a passive system, while cognitive selection has been described as more active in terms of mechanisms of attentional control (Lavie et al., 2004). An increase in perceptual load can be accomplished by increasing the number of to-be-perceived task-relevant items or by increasing the difficulty of identifying the same number of items (Lavie, 2006). WM load can be manipulated, among other methods, by varying the amount of information one is required to update and store in memory. Manipulations in the current study were aimed at loading WM load and holding perceptual load constant.

Based on load theory, it is expected that under high perceptual load, irrelevant stimuli in the visual system will go unnoticed (i.e., there will be less interference from distractors). When perceptual load is low, leftover attentional resources should automatically be allocated to perceive task-irrelevant stimuli (e.g., distractors and the UEO) (Lavie, 2006; Rees & Lavie, 2001). According to load theory, a major role of WM is preserving a distinction between relevant and irrelevant information by maintaining processing priorities. Thus, it would be predicted that as WM load increases, WM will be less able to separate targets and distractors, and thus more attention is biased towards distractors (i.e., higher rate of noticing the UEO).

Separate predictions, based on load theory, are proposed for processing when under high perceptual load and for processing when under high WM load. When perceptual load is high, IB rates are high because demands from processing the task-relevant stimuli prevent task-irrelevant (UEO) stimuli processing (e.g., results from Cartwright-Finch and Lavie, 2007). However, when under high WM load, load theory predicts that IB rates should diminish and detection of the UEO should improve. This prediction indicates that WM is needed in order for selective attention to prevent processing of task-irrelevant information.

The relationship between WM and selective attention was investigated by de Fockert and Bremner (2011) in a static IB paradigm. The authors aimed to investigate whether an increase in WM load can reduce IB. A line task was employed where participants were asked to press one of two keys to indicate which of two lines was longer. In addition the authors presented participants with either 1 (low WM load) or 6 (high WM load) digits to keep in memory while completing the line task. After the line task sequence the participants were probed with a single digit and asked if that digit had been presented previously. As is standard in IB paradigms, a critical stimulus was presented and participants were subsequently questioned if they had seen anything other than the lines or mask and if they answered yes, then they were probed with four shapes and asked if they had seen any of them previously. The results of this study revealed that a greater number of participants detected and identified the UEO in the high WM conditions compared with low WM load conditions. Conclusions proposed by de Fockert and Bremner (2011) include that processing of the UEO is enhanced when WM is unavailable because selective attention requires available WM resources to maintain target processing when distractors are present. The results found in this study support predictions based on load theory because, contrary to the results reported by Simons and Chabris (1999), greater WM load led to a decrease in IB rate. The current study design allowed for testing of support or nonsupport for the two competing theories.

Factors Related to Current Study that Affect IB Rate

Research has found that difficult tasks elicit higher rates of IB than relatively easier primary tasks (Cartwright-Finch & Lavie, 2007; Simons & Chabris, 1999; Simons & Jensen, 2009). In addition, it has been found that when the UEO is similar (categorically or featurally) to attended objects (e.g., attending to black team while ignoring white team with a black UEO), observers are more likely to notice the UEO (Simons & Chabris, 1999; Most et al. 2001). In contrast, when the UEO is similar to the ignored (or unattended) distractors (e.g., attending to white team and ignoring black team with a black UEO), participants are less likely to notice the UEO (Koivisto & Revonsuo, 2007; Most, et al., 2005; Most et al., 2001). The study conducted by Simons and Chabris (1999) is an example of how task difficulty and similarity of the UEO to targets or distractors affects IB rate.

In the study previously discussed by Simons and Chabris (1999), the similarity of the UEO to the targets was shown to also affect the rate of IB. Participants had similar rates of IB for the umbrella woman when attending to the white (31%) or black (38%) teams. On the other hand, when participants were presented the gorilla UEO, those attending to the white team had a much higher IB rate (73%) than those attending to the to the black team (42%). These results suggest that the likelihood of being inattentionally blind was related to the similarity of the UEO to other objects. Because the umbrella woman, wearing pale colors different from either team, elicited fewer “non-noticers” (participants that reported not seeing the UEO) than the gorilla, wearing the same color as the task-irrelevant team, the authors concluded that observers are less likely to be inattentionally blind when the UEO is similar to attended events or more inattentionally blind when the UEO is similar to the distractors.

Another example of how UEO similarity affects IB rate is illustrated in the results reported by Most et al. (2001). These authors found that when participants were asked to attend to white items and ignore black items the percentage of participants who noticed a white UEO was s significantly greater (94%) compared to when the UEO was black (6%). Similar results were found when participants were asked to attend to black items and ignore white items such that when the UEO was white more participants noticed the UEO when it was black (94%) compared to when it was white (0%). These results suggest that the more similar the UEO is to attended items, the less likely the observer will be inattentionally blind. Stimulus characteristics of color (Most et al., 2005; Simons & Chabris, 1999) and shape (Most et al., 2005) have elicited similar results. In addition to investigating the influence of similarity, an examination of how the need for selective attention affects IB rate may be achieved by introducing distractors alongside targets in an IB task.

Manipulating the presence and amount of distractors in a display, Koivisto and Revonsuo (2008) required observers to set their attention for three black circles when, at one point, a white cross (the UEO) moved randomly on the display. The researchers found, in one of their five experiments, that despite no distractors in the display, and the UEO moving in the same manner as the targets, nearly half (40%) of participants failed to report they saw the UEO. These results suggested that simply ignoring distractor items is does not abolish IB. Koivisto and Revonsuo (2008) also showed, in a separate experiment, that the number of distractors presented in a display (one or five) does not influence the rate of IB observed. The percentage of participants exhibiting IB was significantly higher when one or five distractors were present (53.8% and 52% respectively) compared to when there were no distractors in the display (21.7%), but there was no significant difference in IB rate between the one and five distractors conditions. The results from this study suggested that the number of to-be-ignored stimuli the researchers presented was irrelevant, but the crucial element was that participants had *something* to ignore. Additionally, this study demonstrated not only that the presence of distractors (and the need for selective attention) are not necessary for IB to occur, but also that the presence of distractors increased IB rate compared to when distractors are absent from the experiment. Many of the IB tasks discussed have only manipulated stimuli in the visual modality, but the current study aimed at investigating the role of task relevant or irrelevant audio stimuli on IB rate.

Auditory Load and IB

In most everyday occurrences, outside of the lab, an individual is bombarded with both visual and auditory stimuli and attempting to attend to too much stimuli may negatively influence performance. Simulated driving experiments have shown that driving while carrying out a phone conversation is associated with impaired reaction time and memory (Strayer, Drews, & Johnston, 2003). In addition, Strayer et al. (2003) found that simply listening to audio stimuli had no influence on the rate of IB. These findings suggest that awareness deficits are more readily apparent in dual-tasks situations.

Because most situations in the real-world present individuals with visual and auditory input, it is important to understand exactly how these two modalities influence attention and awareness. However, recent reports have presented conflicting findings regarding the effect of audio stimuli on IB task performance. Pizzighello and Bressan (2008) claimed that attending to a verbal stream is enough to decrease detection of unexpected stimuli. However, contrasting evidence is provided by results reported by Beanland, et al. (2011), which showed evidence suggesting that IB is reduced with increased auditory load.

In a cross-modal dynamic IB study Pizzighello and Bressan (2008) used two types of auditory attention tasks. The first audio task required participants to listen to sentences while the second required participants to listen to a list of words and recall was tested. A bounce tracking task was implemented for the visual component, and participants performed the auditory and visual tasks simultaneously or separately. The results of this study revealed that observers had a greater IB rate when performing the dual-task compared to when only completing the visual task. Findings also indicated that there was no difference in IB rates when performing the dual-task compared to only performing the auditory task. This result suggested that even in the absence of a primary visual task, auditory stimuli increased IB rates the same as when performing a dual-task. Based on these results the authors' real-world generalization was that listening to the radio while driving will increase the probability of an accident. These results are consistent with the general capacity hypothesis discussed above.

Later, research conducted by Beanland et al. (2011) found that attending to audio stimuli decreased IB rate compared to when audio stimuli was irrelevant. The authors examined the effect of concurrent auditory stimuli on IB by dividing participants into four load conditions: two visual (low and high) and two auditory (low and high). In the low visual load condition participants were required to perform a bounce tracking task and in the high visual load condition the same task was required although the speed of the stimuli was increased (31-36 bounces per trial and 55-62 bounces per trial respectively). The auditory load conditions were dual-tasks where the slow bounce tracking task was performed either while participants simply listened to a song ("Mamma Mia" by ABBA) without tones (low load) or listened and verbally responded to embedded tones (high load). Results revealed that IB rates were significantly greater in the high visual load condition compared to the low visual load condition and both audio conditions. In addition, while no difference was found between the low visual load and low auditory load conditions, high auditory load elicited significantly lower IB rate than low visual load. These results suggested that attending to audio decreased IB rate. This finding is consistent with previous IB research (Beanland & Pammer, 2010) and attentional blink research (Olivers & Nieuwenhuis, 2005). The authors posed that based on the results, listening to the radio while driving, “may not be as hazardous as was once thought,” (Beanland, et al., 2011; p.1291). Beanland et al. (2011) suggested that when encoding or recalling stimulus details is not necessary, extra task demands levied by attending to auditory stimuli are relatively low compared to when the stimulus must be recalled (as in Pizzighello & Bressan, 2008). A follow up study conducted in the same report (wherein irrelevant tones were added to the low visual load condition) suggested that the reduction of IB rate in the high auditory load condition was due to the audio task being distracting. The authors proposed that the noticing of unexpected objects may be enabled by distracting, but not demanding, concurrent audio stimuli.

The conflicting results presented by Pizzighello and Bressan (2008) and Beanland et al. (2011) may be due to the difference in audio used in the two studies and task demands. Participants in the study conducted by Pizzighello & Bressan (2008) were exposed to sentences and word lists. Conversely, participants in Beanland et al. (2011) were exposed to music and asked to report tones. A limitation of the Pizzighello and Bressan (2008) design is that the audio condition demanded either superficial or no attention to the visual display and thus it is possible that participants were inattentionally blind because they were not engaged in the task rather than not perceiving the UEO. In addition, Beanland et al., (2011) argued that task demands increase substantially when unfamiliar audio is presented (as in Pizzighello & Bressan, 2008) and thus IB rates should increase.

Current Study Manipulations

The current study design was implemented to clarify inconsistencies in the literature concerning the influence of auditory stimuli on IB rates and to provide a new test for load theory (Lavie et al., 2004) and general capacity theory (Engle, Cantor, & Carullo, 1992). In the current study, cognitive load was qualitatively manipulated in three auditory load conditions, and the presence of distractors was manipulated and thus so was the need for selective attention. These manipulations allowed for an examination of how cognitive load and selective attention influence IB rate.

The current study replicated and extended facets of load conditions present in previous studies (e.g., low visual load in Experiment 2B and high auditory load in Experiment 1from Beanland et al., 2011). The high load condition in the current study extended the high auditory load condition in Beanland et al. (2011) because participants were required to maintain and update information in WM (similar to the dual-task condition in Pizzighello & Bressan, 2008). The inclusion of this high load condition was intended to extend current knowledge about how auditory load affects IB rates. Similar to the low visual load condition in Beanland et al. (2011, Experiment 2B, p. 1289), participants in the current low load condition were be required to press a button each time a white letter touched a midline, but were not required to respond to audio stimuli. In addition, similar to the high auditory load in Beanland et al. (2011) the current medium load condition required participants, in addition to tracking white letters, to press a button each time they heard a tone while a song played.

The high load condition in the current study extended the high auditory load condition conducted in Beanland et al. (2011). The high load condition in the current study required participants to update and maintain the number of tones heard during each trial in addition to responding to visual and auditory stimuli as in the medium load condition. This condition provided the crucial test of whether updating and maintaining information, and thus loading WM, increased IB rate in a multimodal task.

In addition to manipulating auditory load, the presence of distractors was manipulated to examine the influence of selective attention on IB rate for the qualitatively different cognitive load conditions. Thus, the current study provided an investigation of the proportion of “noticers” (those who reported seeing the UEO) at each level of load when active ignoring of distractors was needed and when distractors were absent from the display (active ignoring of distractors not necessary). According to results reported by Koivisto and Revonsuo (2008) the inclusion of distractors to ignore significantly increased the likelihood a person was inattentionally blind to the UEO. This result supported the idea that strengthening an attentional set (adding something to ignore) increased IB rates (Most et al., 2005).

Several methodological points are important based on previous literature. The current study investigated central inattentional blindness by presenting the UEO, among other dynamic stimuli, in an area where the participant was instructed to attend. The current study was unlike the visual task used in Beanland et al. (2011) where bounces were counted on the edges of the display. The current study presented a display where, similar to the procedure conducted by Most et al., (2001), a midline horizontally dissected the center of the experimental display where the participants were instructed to maintain gaze. Based on previous results on similarity of the UEO to targets or distractors, the current study utilized a UEO different in color than either the targets or the distractors (Simons & Chabris, 1999). Finally, based on attentional set literature (Most et al., 2005) all stimuli presented in the current study consisted of letters in order to maintain consistent similarity.

IB Predictions

Proponents of load theory (Lavie et al., 2004) stated that the processing of distractors (e.g., the UEO) is contingent on perceptual and WM task demands. Based on load theory, it would be expected that when perceptual load is high, IB would be high. In the current study, perceptual load was held constant by maintaining the speed and similarity of the figures across conditions. In addition, based on load theory, it is expected that when WM load is high, IB should be inversely affected, that is IB rates should decrease.

Research has shown, in a static IB paradigm, when WM load was high fewer non-noticers were found than when WM load was low (de Fockert & Bremner, 2011). The authors argued that result was found because, when WM was unavailable, attention to the primary task worsened, or in other words the attentional set weakened, and thus detection improved. Thus, requiring participants to update and recall the number of tones, as in the high load condition, was expected increase WM load demands and thus fewer non-noticers when distractors were present. Consequently, based on load theory (Lavie et al., 2004) it was expected that, when distractors were present, fewer non-noticers would be found in the high load condition compared to the low and medium load conditions. In addition, it was expected that in the medium load condition fewer non-noticers would be found than in the low load condition. This prediction was based on the idea that as cognitive load was increased, attentional set was weakened and this would allow for more irrelevant-distractor processing (Most et al., 2005). However, based on load theory, when distractors were absent, no differences were expected between the load conditions because cognitive load should have no effect on performance when selective attention was not required.

Koivisto and Revonsuo (2008) showed that the presence or absence of distractors influenced IB rate. Results from that study showed that, in the absence of distractors, fewer non-noticers were found compared to when one or five distractors were present. However, the influence of cognitive load on IB rate when selective attention is manipulated (distractors present/absent) has not been examined. Load and general capacity theories differ on predictions about the specific influence cognitive load has on the rate of IB when distractors are present or absent.

Considering the current study design, it was expected that, based on load theory, IB rates would steadily decline when distractors were present, but remain constant when distractors were absent. This pattern of results was expected due to the need for selective attention when distractors were present whereas selective attention was not necessary when distractors were absent. According to proponents of load theory, greater cognitive load should hinder an individual's ability to maintain selective attention on the target and away from distractors (Lavie et al., 2004). Thus, increasing cognitive load was expected to decrease IB rate when there were distractors. However, when selective attention was not needed to perform the visual task (such as when distractors were absent) cognitive load was expected to have no effect on performance. See Figure 1 for Expected IB results for each load condition in the presence and absence of distractors as predicted by load theory.

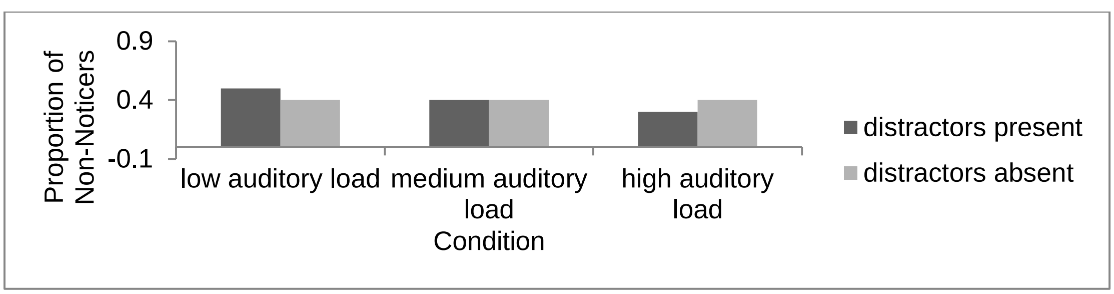

Figure 1. Expected IB results for each load condition in the presence and absence of distractors as predicted by load theory.

Alternatively, based on general capacity theory, it was expected that IB rates would increase as cognitive load increased. Increasing load was expected to decrease performance such that there would be fewer non-noticers in the low load condition compared to medium and high load conditions. Furthermore, it was expected that fewer non-noticers would be found in the medium load condition than in the high load condition. This was expected to occur, based on general capacity theory, because attending to auditory information depletes attentional resources from being allocated to visual information which has shown to increase IB rates (e.g., Pizzighello & Bressan, 2008). In addition, it was expected that the presence of distractors would increase IB rates across load conditions compared to when distractors were absent. See Figure 2 for Expected IB results for each condition in the presence and absence of distractors predicted by general capacity theory.

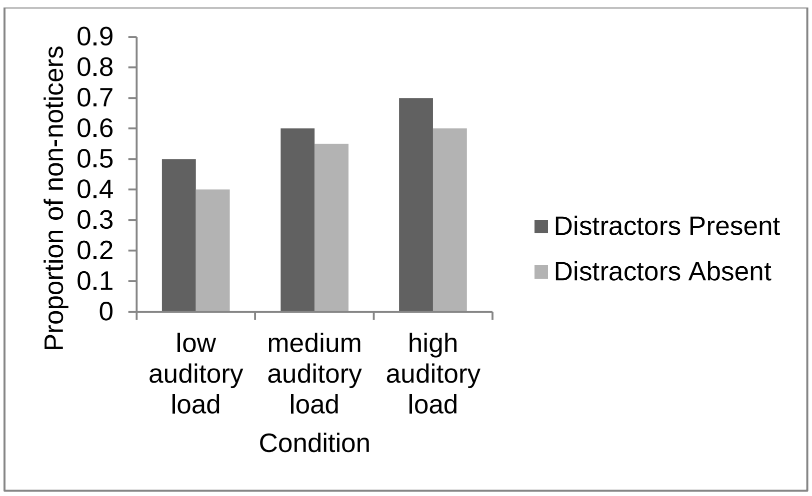

Figure 2. Expected IB results for each condition in the presence and absence of distractors predicted by general capacity theory.

Accuracy Predictions

Participant task accuracy in the current study was be examined for letter tracking, tone counting, and tone recall. In addition, the presence of a practice effect was determined. Regarding letter tracking, three predictions were made. Based on load hypothesis, letter tracking mean error scores were not expected to be significantly different across load conditions for noticers or non-noticers. Thus, for the current study, it was expected that there would be no significant differences in mean error rate between the load conditions regardless of whether distractors were present or absent. A recent study showed support for load theory such that no difference in letter tracking mean error was found for conditions similar to the current low and medium load distractors present conditions (Beanland et al., 2011). Additionally, previous research showed no difference in letter tracking accuracy for noticers compared to non-noticers (Beanland & Pammer, 2012). However, if selective attention was weakened then targets and distractors may be more likely to be confused and miscounted (Most et al., 2005). Thus, a primary hypothesis was proposed such that it was expected that there would be no differences in letter tracking accuracy when distractors were absent, but a decline in performance was expected when distractors were present. Conversely, results from a study supporting general capacity theory showed performance was worse for a dual-task condition compared to a visual-only task condition and non-noticers more errors than noticers (Pizzighello & Bressan, 2008). Thus, based on general capacity theory, it was expected that there would be differences in mean error based on load and whether the UEO was noticed. Specifically, it was predicted that performance would decline as load increased and noticers would make significantly fewer errors than non-noticers regardless of whether there were distractors or not.

Regarding tone counting predictions, in a study that supported load theory and featuring a similar condition to the current medium load (high auditory load in Beanland et al., 2011); all participants accurately reported the number tones during the visual task. Based on load theory it was expected that the results would show no significant differences between medium and high load in tone counting mean error. However, based on general capacity theory, performance was predicted to decline as load increased, including accuracy on the primary task. Support for this prediction was provided by the results reported by Pizzighello and Bressan (2008) where participants' performance was worse for a dual-task compared to a visual-only task.

In a study similar to the current one, when information was to be recalled, results showed that recall performance (number of words correctly recalled) was worse when the UEO was presented compared to when the UEO was not (critical trial compared to pre-critical trial) (Pizzighello & Bressan, 2008). In addition, those who noticed the UEO in the critical trial recalled fewer words compared to the pre-critical trial (Pizzighello & Bressan, 2008). Therefore, for the current design, the anticipated results were that weighted error scores for the number of tones recalled would be significantly greater when the UEO was presented compared to when it was absent from the display. In addition, it was expected that noticers, during the critical trial, would have significantly more errors than non-noticers. No significant interactions were expected for tone recall accuracy. Based on results found by Beanland et al. (2011), a practice effect was expected such that earlier trials (Trial 2 & Trial 3) were expected to have more errors than later trials (Trial 4 & Trial 5).

CHAPTER 3 METHODS

Participants

The participants included in the analysis consisted of undergraduate students recruited from Louisiana State University via the human research subject pool. All participants were awarded course credit for participation. In order to participate in the study participants were required to report having normal or corrected-to-normal vision. Data from a total of 289 participants were collected. In order to ensure that data included in the analysis is the highest quality several exclusion criteria were applied. Participants' data was included in the analysis only if they reported noticing the UEO in the full-attention condition. In addition, participants' data were excluded from the analysis if they reported extensive knowledge about the inattentional blindness paradigm and if she/he was expecting something to happen before the UEO appeared (e.g., a gorilla to walk through the scene). Participants were recorded as a noticer only if they were able to report both the color and shape of the UEO, and if a participant answered one or either questions wrong they were recorded as a non-noticer.

Based on the exclusion criteria of this study, data from a total of 88 participants were excluded. Fifteen participants reported they were knowledgeable about inattentional blindness paradigms and were expecting something to happen. Data from 71 participants were excluded from the analysis because the participants reported not noticing the UEO in the full-attention trial. Fifteen of these participants, however, answered all questions about the UEO correctly, but still reported they did not notice the UEO in the full-attention condition. Following these exclusion criteria, data from 201 participants were available to analyze. In order to retain consistency across conditions, data from 30 participants were analyzed for each condition.

Apparatus and Stimuli

The current study was programmed in MATLAB and was presented on computer screens. The experimental display consisted of a white outlined rectangle (28.74° x 21.65° visual angle in size) presented on a light gray background. The experimental display presented a small blue fixation box in the center that was bisected by a horizontal blue line. Contained in the experimental display were four white and four black "L" and "T" shapes, each subtending approximately 1° x 1°. The "L" and "T" shapes were employed as stimuli for the letter tracking task. These stimuli were programmed to move independently and randomly from each other. In addition, the movement of the "L" and "T" shapes was constrained to linear trajectories. Letter stimuli bounced off the experimental display borders, but passed through the blue horizontal midline. Considering all trials, letter stimuli passed through the horizontal line an average of 32.78 times. The unexpected stimulus consisted of a dark gray "A" shape, subtending 1° x 1°. The UEO appeared 35s after the start of Trial 5 (critical trial) and Trial 6 (full-attention trial). The UEO moved horizontally from right to left occluding the blue midline and fixation box. The UEO was displayed onscreen for 5s. All stimuli traveled at a pace of 6cm/s. Figure 3 displays the Order of events in current study for low and medium load distractors present conditions. See Figure 4 for the Order of events in current study for the high load distractors present condition.

Audio stimuli were presented through headphones using an MP3 player. Auditory stimuli consisted of a familiar popular song ("My Girl" by The Temptations), and was looped and edited so no gap between plays was heard. In addition, sine wave tones (at 700Hz; duration 200ms) were incorporated into the audio loop of the song in all conditions. Between 4-8 tones played for each trial (M = 5.74, SD = 1.4). The current experiment consisted of six 45 second trials.

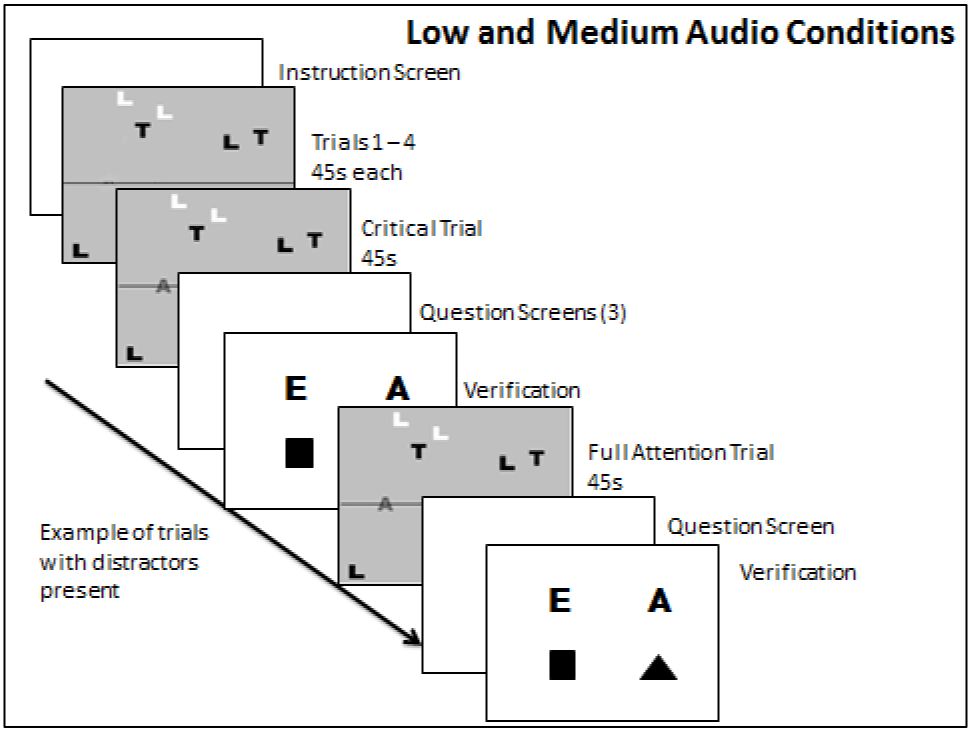

Figure 3. Order of events in current study for low and medium load distractors present conditions.

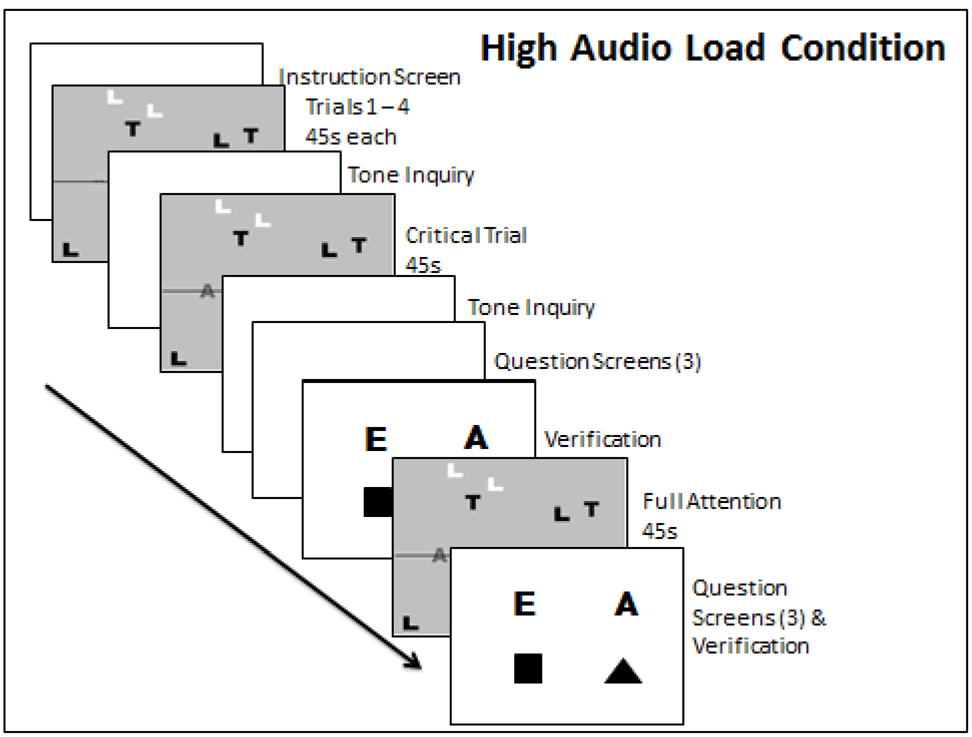

Figure 4. Order of events in current study for the high load distractors present condition.

Design and Procedure

A between-subjects visual condition was employed; distractors (present, absent). Participants were required to attend to white letters and ignore black letters (when present). Three between-subjects load conditions were employed. The low load condition presented the song and tonal frequencies to participants, and the participants were informed of the tones and that they were not required to respond to them. The medium load condition consisted of the same song, but participants were required to press a button each time they heard a tone. The high load condition presented the same stimuli as the medium load condition, but participants were asked report how many tones were heard after each trial. While the UEO was displayed (during Trial 5 and Trial 6) there were no tones presented to participants. The measured variable for IB results was the proportion of non-noticers (those who failed to report seeing the UEO).

Upon arrival to the experiment participants were informed that the goal of the experiment was to assess their object-tracking capability. Prior to the experiment, participants were informed that they would see both white and black “L” and “T” shapes (in the distractors present condition) or only white “L” and “T” shapes (in the distractors absent condition). All participants were instructed to press a keyboard button if a white letter touched the midline. In the low load condition participants were instructed to perform the letter tracking task and that they were not required respond to the embedded tones in the song. In the medium load condition participants were instructed to perform the letter tracking task and press a button each time a tone was heard (tone counting task). In the high load condition the participants were instructed to perform in the same manner as in the medium load condition, but they were also told that after each trial they would be prompted (from 0 to 9) to report how many tones were presented in the previous trial.

Immediately following Trial 5 (critical trial), similar to the procedure conducted by Most et al. (2001), participants were asked if they had seen anything other than the white and black "L" and "T" shapes. Participants were classified as noticers only if they were able to report the shape and color of the unexpected stimulus. Following questioning, the full-attention trial (Trial 6) was administered wherein the participants were instructed to watch the display and not track the letters (see Appendix for list of awareness assessment questions and full-attention instructions). Those who were unable to correctly answer questions about the color and shape of the UEO after the full-attention trial were excluded from further analysis. During debriefing participants were asked about their knowledge of IB research paradigms and whether they were expecting anything to happen before the UEO appeared.

CHAPTER 4 RESULTS

Inattentional Blindness

See Table 1 for the Contingency Table for IB Analysis. See Figure 5 for a Proportion of non-noticers for load and distractors conditions.

Table 1. Contingency Table for IB Analyses

Distractors Present	Load			Distractors Absent	Load		
	Low	Medium	High		Low	Medium	High
Noticers	19	17	22	Noticers	26	24	26
Non-Noticers	11	13	8	Non-Noticers	4	6	4

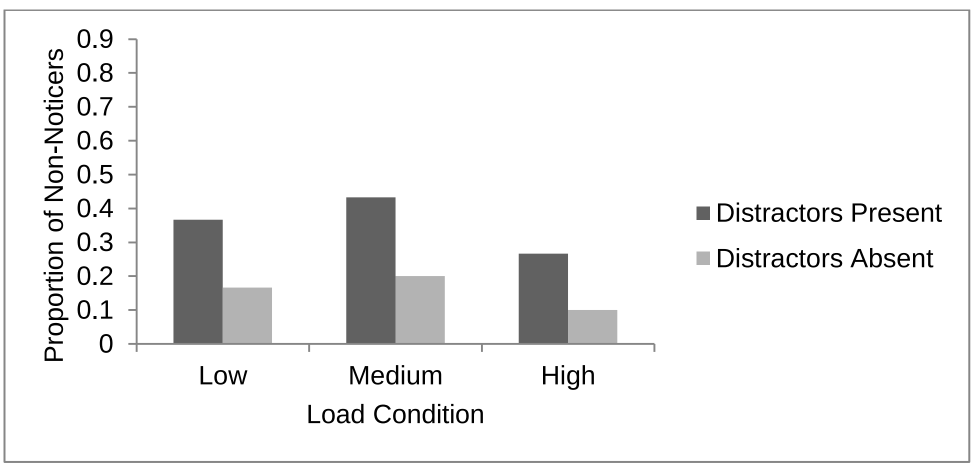

Figure 5. Proportion of non-noticers for load and distractors conditions.

Phi (φ) is a common measure of association for 2x2 contingency tables and is reported for each chi-square analysis. To determine whether distractor presence or absence influenced the rate of IB in participants 2x2 chi-square analyses were performed for each level of load. There was a significant association between distractor presence and whether or not participants noticed the

UEO in the low load condition, X^2 (1) = 4.36, p =.037, φ = .27. This result indicates that fewer participants than expected noticed the UEO when distractors were present whereas more participants than expected noticed the UEO when distractors were absent. After calculating an odds ratio, it was revealed that the odds of a participant noticing the UEO were 3.76 times higher if distractors were absent from the display compared to when they were present in the low load condition. The association between distractor presence and whether or not participants noticed for the medium load condition approached significance, X^2 (1) =3.77, p =.052, φ = .25. After calculating an odds ratio, it was revealed that the odds of a participant noticing the UEO were 3.05 times higher if distractors were absent from the display compared to when they were present in the Medium Load condition. However, there was not a significant association between distractor presence and whether or not participants noticed in the high load condition, X^2 (1) =1.67, p =.197, φ = .17. See Table 2 for the Results of Power Analysis from Comparisons Between Distractors Present and Absent for Each Level of Load. See Table 3 for Support for Load or General Capacity Theories Based on IB Results Comparing Distractor Presence for Each Level of Load.

Table 2. Results of Power Analysis from Comparisons Between Distractors Present and Absent for Each Level of Load

	Low Load	Medium Load	High Load
Observed Power	.63	.54	.27
Effect Size “w”	.30	.27	.18
Noncentrality parameter (λ)	5.29	4.21	1.84

Table 3. Support for Load or General Capacity Theories Based on IB Results Comparing Distractor Presence for Each Level of Load.

Effect		Support For Load	Contrary to Load	Support For General Capacity	Contrary to General Capacity
Load	Distractors				
Low	Present > Absent	X		X	
Medium	Present = Absent	X			X
High	Present = Absent		X		X

To determine if performance differed across levels of Load, a series of 2x2 chi-square analyses were conducted comparing each level of load when distractors were present in the display. When distractors were present, there was not a significant association between low and medium load, X^2 (1) = 0.28, p =.598, φ = .07. In addition, there was not a significant association between low and high load when distractors were present, X^2 (1) = 0.69, p = .405, φ = .11. Similarly, there was not a significant association between medium and high load when distractors were present, X^2 (1) = 1.83, p = .176, φ = .17. See Table 4 for Results of Power Analysis from Comparisons Between Level of Load When Distractors Were Present. See Table 5 for Support for Load or General Capacity Theories Based on IB Results Comparing Each Level of Load When Distractors Are Present.

Table 4. Results of Power Analysis from Comparisons Between Level of Load When Distractors Were Present

	Low & Medium	Low & High	Medium & High
Observed Power	.08	.13	.90
Effect Size “w”	.07	.11	.42
Noncentrality parameter	0.28	0.71	10.41

Table 5. Support for Load or General Capacity Theories Based on IB Results Comparing Each Level of Load When Distractors Are Present

Effect		Support For Load Theory	Contrary to Load Theory	Support For General Capacity Theory	Contrary to General Capacity Theory
Distractors	Load				
Present	Low = Medium		X		X
	Low = High		X		X
	Medium = High		X		X

A series of 2x2 chi-square analyses were also conducted comparing each level of load when distractors were absent from the display. The results revealed that there was not a significant association between low and medium load, X^2 (1) = 0.48, p = .488, φ = .09. In addition, there was not a significant association between Low and High Load, X^2 (1) = 0.0, p = 1.00, φ = 0. However two cells had expected counts fewer than five. This indicated that the sample size of this 2x2 contingency table may have been too small. Therefore, Fisher's exact test (1-sided) is reported, p = .647. Finally, there was not a significant association between medium and high load, X^2 (1) = 0.48, p = .488, φ = .089. See Table 6 for Results of Power Analysis from Comparisons Between Level of Load When Distractors Were Absent. See Table 7 for Support for Load or General Capacity Theories Based on IB Results Comparing Each Level of Load When Distractors Were Absent.

Table 6 . Results of Power Analysis from Comparisons Between Level of Load When Distractors Were Absent

	Low & Medium	Low & High	Medium & High
Observed Power	.11	.05	.11
Effect Size "w"	.09	0	.09
Noncentrality parameter (λ)	0.50	0	0.50

Table 7. Support for Load or General Capacity Theories Based on IB Results Comparing Each Level of Load When Distractors Were Absent

Effect		Support For Load	Contrary to Load	Support For General Capacity	Contrary to General Capacity
Distractors	Load				
Absent	Low = Medium	X			X
	Low = High	X			X
	Medium = High	X			X

Letter Tracking Accuracy

Weighted error scores were compared in each accuracy analysis. The formula used to calculate weighted error scores was as follows: (Actual - Reported bounces) / Actual bounces * 100. A square root transformation was applied to the weighed error scores for participants' letter tracking accuracy in an attempt to decrease the positive skew of the data and create equal variances between groups. Despite the transformation, Levene's test of equality of error variances was significant, F (11,888) =4.18, p<.001. This indicated the assumption of equal variances across groups had been violated. A 3-way between groups ANOVA was conducted to examine the main effects and interactions of load (low, medium, high; between-groups), distractors (present, absent; between-groups), and noticing (noticer, non-noticer; between-groups) as they related to the square root of weighted error scores for letter tracking. See Table 8 for the Descriptive Statistics of the Dependent Variable for Letter Tracking Accuracy. See Figure 6 for the Mean number of weighted error scores for each of the letter tracking ANOVA conditions.

Table 8. Descriptive Statistics of the Dependent Variable for Letter Tracking Accuracy

	Square Root of Weighted Error Score for Letter Tracking Accuracy	Weighted Error Score for Letter Tracking Accuracy
Mean	3.24	15.88
Standard Error of the Mean	.08	.70
Standard Deviation	.233	20.95
Variance	5.42	438.74
Skewness	.838	2.31

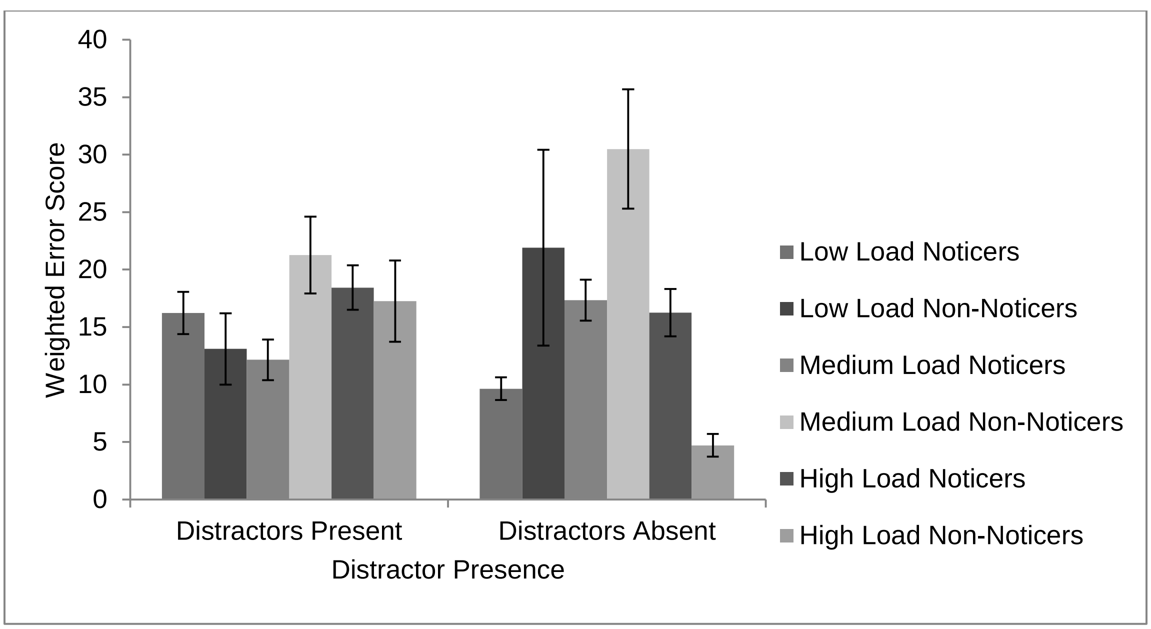

Figure 6. Mean number of weighted error scores for each of the letter tracking ANOVA conditions. Error bars represent standard error of the mean.

A significant 3-way interaction for letter tracking accuracy was revealed, *F* (2,888) = 3.41, *p* = .03, *r* = .08. Minimum mean differences were used to examine cell means (*LSD* minimum mean difference (*mmd*) = 0.73 and *HSDmmd* = 1.22). Examination of cell means revealed that the pattern of this interaction was that, for the low load condition using *LSDmmd,* noticers had greater error scores when distractors were present compared to when distractors were absent. In addition, non-noticers did not differ in error scores when distractors were present compared to when distractors were absent. When distractors were present, however, those who noticed the UEO had greater error scores than non-noticers. Furthermore, when distractors were absent, there was no significant difference found in error scores between those who noticed the UEO and non-noticers. The results when using the *HSDmmd* revealed no significant differences between groups. See Table 9 for Results of Power Analysis for Letter Tracking. See Table 10 for Support for Load or General Capacity Theory Based on Letter Tracking Accuracy LSDmmd Results for 3-way Interaction of Load, Distractors, and Noticing for Low Load.

Table 9. Results of Power Analysis for Letter Tracking

	Effect			
	Load x Distractors x Noticing Interaction	Load x Noticing Interaction	Load x Distractors Interaction	Load Main Effect
Observed Power	.64	.99	.95	.98
Effect Size “f”	.09	.15	.14	.14
Noncentrality Parameter	6.83	20.12	15.86	18.43

Table 10. Support for Load or General Capacity Theory Based on Letter Tracking Accuracy LSDmmd Results for 3-way Interaction of Load, Distractors, and Noticing for Low Load.

Effect		Support for Primary Hypothesis	Contrary to Primary Hypothesis	Support for General Capacity Theory	Contrary to General Capacity Theory
Noticers	Distractors Present > Absent	X		N/A	N/A
Non-Noticers	Distractors Present = Absent		X	N/A	N/A
Distractors Present	Noticers>Non-Noticers	N/A	N/A		X
Distractors Absent	Noticers=Non-Noticers	X			X

Examination of the Medium Load condition cell means, in the significant 3-way interaction, revealed that (using *LSDmmd*), there was no significant difference in error scores for noticers when distractors were present compared to when distractors were absent. However, non-noticers had greater error scores when distractors were absent compared to when they were present. When distractors were present, non-noticers had greater error scores than noticers, and when distractors were absent the same pattern emerged. The results when using the *HSDmmd* revealed no significant differences except, when distractors were absent; non-noticers had greater error scores than noticers. See Table 11 for Support for Load or General Capacity Theory Based on Letter Tracking Accuracy LSDmmd Results for 3-way Interaction of Load, Distractors, and Noticing for Medium Load.

Table 11. Support for Load or General Capacity Theory Based on Letter Tracking Accuracy LSDmmd Results for 3-way Interaction of Load, Distractors, and Noticing for Medium Load.

Effect		Support for Primary Hypothesis	Contrary to Primary Hypothesis	Support For General Capacity Theory	Contrary to General Capacity Theory
Noticers	Distractors Present = Absent		X	N/A	N/A
Non-Noticers	Distractors Present < Absent		X	N/A	N/A
Distractors Present	Noticers < Non-Noticers	N/A	N/A	X	
Distractors Absent	Noticers < Non-Noticers	N/A	N/A	X	

Regarding high load, in the significant 3-way interaction, using *LSDmmd*, it was revealed that there was not a significant difference in error scores for noticers when distractors were present compared to when distractors were absent. Concerning non-noticers, however, error scores were greater when distractors were present compared to when distractors were absent. When distractors were present, there was no significant difference between mean error scores for noticers and non-noticers, but when distractors were absent, noticers had greater mean error scores than non-noticers. When using *HSDmmd*, the same pattern of results emerged. See Table 12 for Support for Load or General Capacity Theories Based on Letter Tracking Accuracy LSDmmd Results for 3-way Interaction of Load, Distractors, and Noticing for High Load.

Table 12. Support for Load or General Capacity Theories Based on Letter Tracking Accuracy LSDmmd Results for 3-way Interaction of Load, Distractors, and Noticing for High Load.

Effect		Support for Primary Hypothesis	Contrary to Primary Hypothesis	Support for General Capacity Theory	Contrary to General Capacity Theory
For Noticers	Distractors Present = Absent		X	N/A	N/A
For Non-Noticers	Distractors Present > Absent	X		N/A	N/A
Distractors Present	Noticers = Non-Noticers	N/A	N/A		X
Distractors Absent	Noticers > Non-Noticers		X		X

Note. N/A = theory does not make prediction about specific relationship. Load theory predicts there will be no differences across load conditions for noticers or non-noticers regardless of distractor presence or absence.

The analysis also revealed a significant 2-way interaction of load and noticing, F (2, 888) = 10.06, $p < .001$, $r = .15$. The pattern of this interaction (using *LSDmmd* = 0.52 and *HSDmmd* = 0.75) was that no difference in mean error scores for noticers compared to non-noticers was found in the low load condition. When comparing groups in the medium load condition, non-noticers had greater mean error scores than noticers. However in the high load condition, noticers had greater mean error scores than non-noticers. When comparing load conditions for noticers, it was revealed that participants in the medium load condition had greater mean error scores than those in the low and high load conditions (low and high were not significantly different from each other). There were no differences found between load conditions when examining non-noticers. This interaction pattern was descriptive when distractors were absent and for non-noticers when distractors were absent, but misleading for all other comparisons. See Figure 7 for the Mean number of weighted error scores for the conditions in the 2-way interaction of noticing and load. See Table 13 for Support for General Capacity Theory Based on Letter Tracking Accuracy LSDmmd Results for the 2-way Interaction of Load and Noticing.

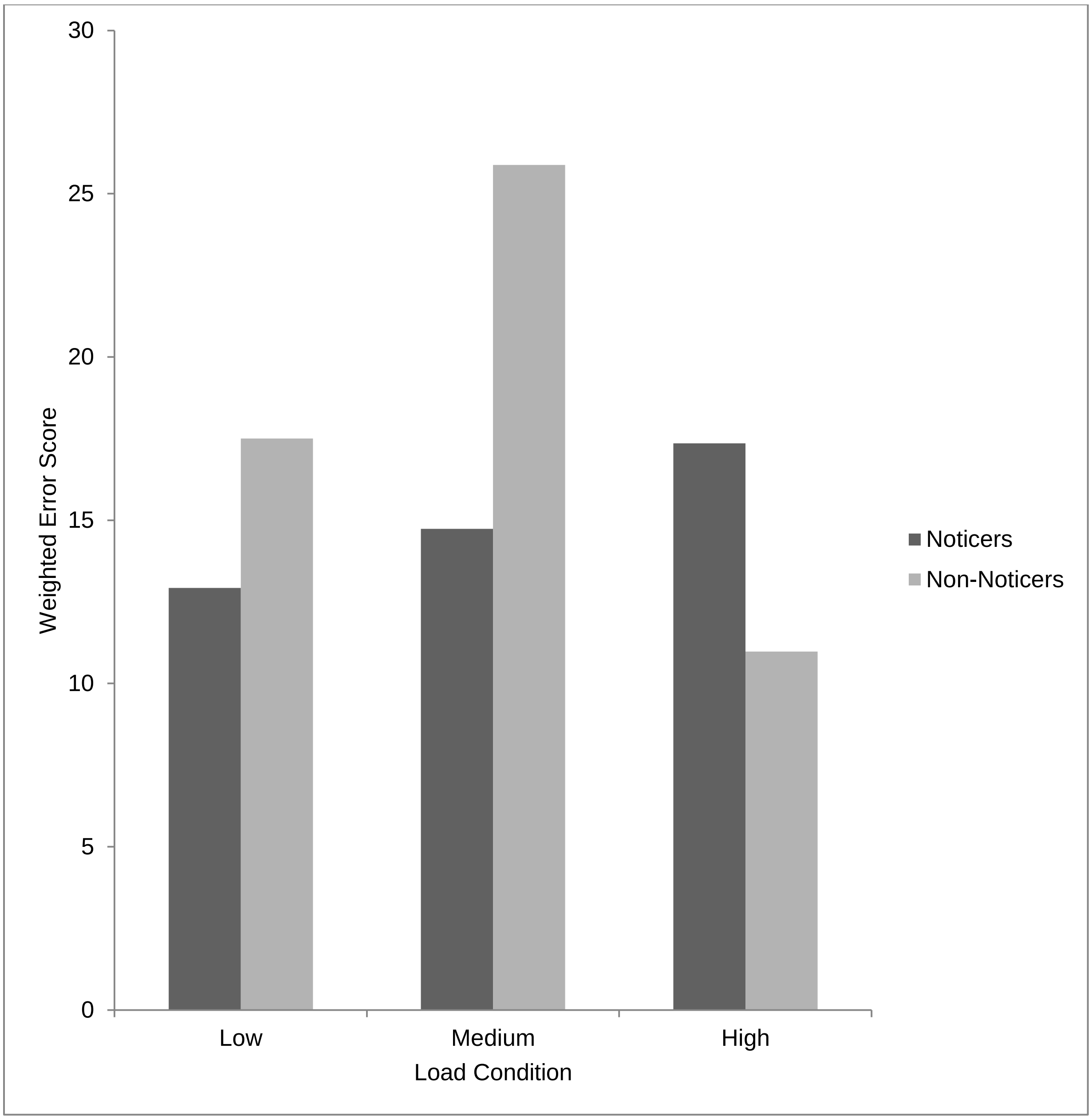

Figure 7. Mean number of weighted error scores for the conditions in the 2-way interaction of noticing and load.

Table 13. Support for General Capacity Theory Based on Letter Tracking Accuracy LSDmmd Results for the 2-way Interaction of Load and Noticing

Effect		Support for Load Theory	Contrary to Load Theory	Support For General Capacity Theory	Contrary to General Capacity Theory
Low Load	Noticers = Non-Noticers	X			X
Medium Load	Noticers < Non-Noticers		X	X	
High Load	Noticers > Non-Noticers		X		X
Noticers	Low < Medium		X	X	
	Low = High	X			X
	Medium > High		X		X
Non-Noticers	Low = Medium	X			X
	Low = High	X			X
	Medium = High	X			X

Note. N/A = theory does not make prediction about specific relationship.

A significant 2-way interaction of load and distractors was also revealed by the analysis, F (2, 888) = 7.93, $p < .001$, $r = .13$. The pattern of this interaction (using *LSDmmd* = 0.52 and *HSDmmd*= 0.75) was that no difference in error scores for the low load condition when distractors were present was found compared to when distractors were absent. However for medium load greater mean error scores were found when distractors were absent, but for high load greater mean error scores were found when distractors were present. When distractors were absent from the display, error scores were greatest in the medium load condition compared to low and high load conditions (low and high did not differ from each other). In addition, when distractors were present in the display no differences in error scores were found comparing the load conditions. This interaction pattern was descriptive for non-noticers and when distractors were present, but potentially misleading for noticers and when distractors were absent. See Figure 8 for the Mean number of weighted error scores for the 2-way interaction of distractors and load. See Table 14 for Support for Load or General Capacity Theory Based on Letter Tracking Accuracy LSDmmd Results for 2-way Interaction of Load and Distractors.

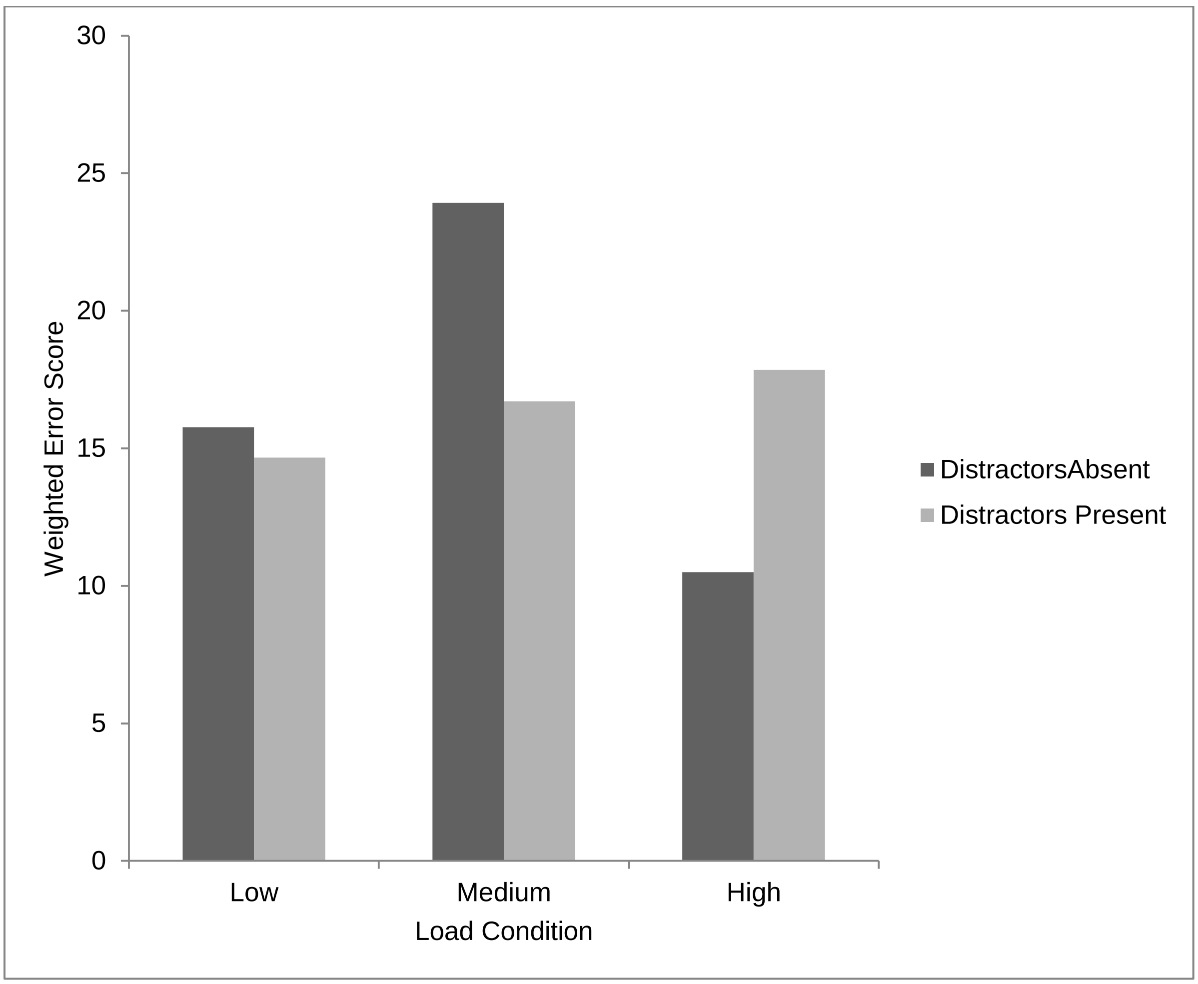

Figure 8. Mean number of weighted error scores for the 2-way interaction of distractors and load.

Table 14. Support for Load or General Capacity Theory Based on Letter Tracking Accuracy LSDmmd Results for 2-way Interaction of Load and Distractors

Effect		Support for Primary Hypothesis	Contrary to Primary Hypothesis	Support For General Capacity Theory	Contrary to General Capacity Theory
Low Load	Distractors Present = Absent		X		X
Medium Load	Distractors Present < Absent		X		X
High Load	Distractors Present > Absent	X		X	
Distractors Present	Low = Medium		X		X
	Low = High		X		X
	Medium = High		X		X
Distractors Absent	Low < Medium		X	X	
	Low = High	X			X
	Medium > High		X		X

A significant main effect of load was found, F (2, 888) = 9.22, $p < .001$, $r = .14$. Participants (using *LSDmmd* = 0.36 and *HSDmmd*= 0.44), in the low load condition had significantly lower weighted error scores than those in the medium load condition. In addition, participants in the medium load condition had significantly greater weighted error scores than those in the high load condition. There was no significant difference in weighted error scores between low and high load. An examination of the simple effect of load for each combination of noticing and distractors revealed that this main effect pattern is descriptive for none of those simple effects. See Figure 9 for the Mean number of weighted error scores for conditions in the main effect of load. See Table 15 for Support for Load or General Capacity Theory Based on Letter Tracking Accuracy LSDmmd Results for Significant Main Effect of Load.

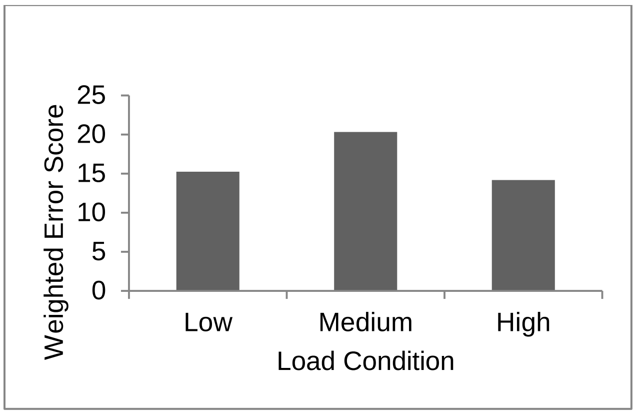

Figure 9. Mean number of weighted error scores for conditions in the main effect of load.

Table 15. Support for Load or General Capacity Theory Based on Letter Tracking Accuracy LSDmmd Results for Significant Main Effect of Load

Effect	Support for Load Theory	Contrary to Load Theory	Support For General Capacity Theory	Contrary to General Capacity Theory
Low < Medium		X	X	
Low = High	X			X
Medium > High		X		X

The interaction between distractors and noticing was not significant, F (1, 888) = 0.20, p = .66, r = .02. In addition, the main effects of distractors (F (1, 888) = 0.16, p = .69, r = .01) and noticing (F (1, 888) = 0.03, p = .87, r = .01) were not significant. This result indicates that there were no significant differences in mean weighted error scores for those who viewed distractors compared with those who did not, and for those who noticed the UEO and those who did not averaged across the other variables.

Tone Counting Accuracy

A square root transformation was applied to the weighed error scores for participants' tone counting accuracy in an attempt to decrease the positive skew of the data and create equal variances between groups. A 3-way mixed ANOVA was conducted to examine the main effects and interactions of condition (medium load distractors present, high load distractors present, medium load distractors absent, high load distractors absent; between-groups), noticing (noticer, non-noticer; between groups), and UEO presence (absent or pre-critical trial, present or critical trial; within-groups) as they relate to weighted error scores for tone counting. Despite applying a square root transformation, Levene's test of equality of error variances was significant for when the UEO was absent (F (7, 112) = 3.63, p < .01) and present (F (7, 112) = 2.83, p < .01). This is evidence to suggest that the null hypothesis that the error variances of the dependent variable are equal across groups is rejected. However, Box's test of equality of covariance matrices was not significant, (F (21, 2731.81) = 1.50, p = .07. The non-significant result of Box's test is evidence to suggest that the null hypothesis that the observed covariance matrices of the dependent variable are equal across groups failed to be rejected. Figure 10 displays the Mean number of weighted error scores for each of the tone counting conditions. Table 16 displays the Descriptive Statistics for the Dependent Variable for Tone Counting.

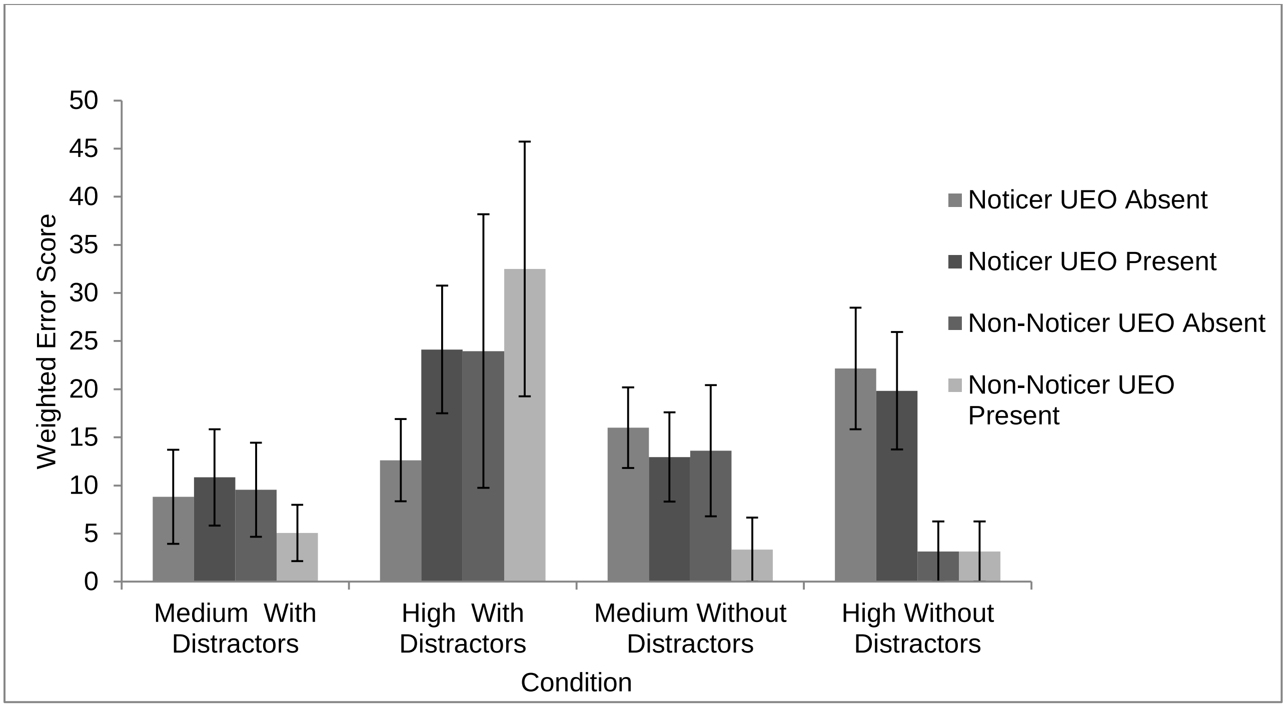

Figure 10. Mean number of weighted error scores for each of the tone counting conditions. Error bars represent standard error of the mean.

Table 16. Descriptive Statistics for the Dependent Variable for Tone Counting

	Square Root of Weighted Error Score for Tone Counting		Weighted Error Score for Tone Counting	
	UEO Present	UEO Absent	UEO Present	UEO Absent
Mean	2.40	2.35	15.83	14.88
Standard Error of the Mean	.29	.28	2.41	2.15
Standard Deviation	3.19	3.07	26.35	23.59
Variance	10.17	9.44	694.21	556.60
Skewness	.96	.86	1.99	1.86

The sole significant effect in the tone counting accuracy analysis was the interaction of UEO presence and condition, F (3, 112) = 3.33, p = .02, r = .29. The pattern of this interaction (using *LSDmmd* = 1.49 and *HSDmmd* = 2.34) was that when the UEO was presented in the display, participants in the medium load distractors present condition had lower scores than those in the high load distractors present condition. In addition participants in the high load distractors present condition had greater scores than those in the medium load distractors absent condition. Using the *LSDmmd* procedure (but not *HSDmmd*) it was revealed that participants in the high load distractors present condition had higher mean error scores than those in the high load distractors absent condition. All other comparisons were not significant when the UEO was present in the display. When the UEO was absent from the display there were no differences between any two conditions in mean number of weighted error scores. Comparing scores between when the UEO was present in a condition and when it was absent revealed no significant differences except for the low load distractors present condition (Using *LSDmmd*) participants were found to have significantly greater error scores when the UEO was present (Trial 5 or critical trial) compared to when the UEO was absent (Trial 4 or pre-critical trial). See Table 17 for the Results of the Power Analysis for Tone Counting. See Table 18 for Support for Load or General Capacity Theory Based on Tone Counting Accuracy LSDmmd Results for 2-way Interaction of UEO Presence and Condition.

Table 17. Results of the Power Analysis for Tone Counting

	UEO Presence x Condition Interaction
Observed Power	.67
Effect Size “f”	.09
Noncentrality Parameter	7.26

Table 18. Support for Load or General Capacity Theory Based on Tone Counting Accuracy LSDmmd Results for 2-way Interaction of UEO Presence and Condition

Effect		Support For Load Theory	Contrary to Load Theory	Support For General Capacity Theory	Contrary to General Capacity Theory
Pre-critical Trial	MD = HD	X			X
	MD = MND	X			X
	MD = HND	X		N/A	N/A
	HD = MND	X		N/A	N/A
	MND = HND	X			X
Critical Trial	MD < HD		X	X	
	MD = MND	X			X
	MD = HND	X		N/A	N/A
	HD > MND		X	N/A	N/A
	HD > HND		X	X	
	MND = HND	X			X

Note. MD = medium load with distractors. HD = high load with distractors. MND = medium load no distractors. HND = high load no distractors. N/A = theory does not make prediction about specific relationship.

Examining the tone counting accuracy analysis it was revealed that the 3-way interaction was not significant, F (3, 112) = 0.261, p = .85, r = .08. In addition, the interactions of UEO presence and noticing, F (1, 112) = 0.50, p = .48, r = .07, and condition and noticing, F (3, 112) = 0.77, p = .516, r = .14, were not significant.

The main effects of UEO Presence, *F* (1, 112) = 0.02, *p* = .88, *r* = .01, Noticing, *F* (1, 112) = 0.86, *p* = .36, r = .09, and Condition, *F* (3, 112) = 1.51, *p* = .22, *r* = .2, were all not significant. Based on the significant interaction between condition and UEO presence the pattern of the main effects of condition and UEO presence are potentially misleading.

Tone Recall Accuracy

A 3-way mixed ANOVA was conducted to examine the main effects and interactions of noticing (noticers, non-noticers; between-groups), distractors (present, absent; between-groups), and UEO presence (present, absent; within-groups) as they relate to the square root of weighted error scores from tone recall. See Figure 11 for the Mean number of weighted error score for each of the Tone Recall conditions. See Table 19 for the Descriptive Statistics for the Dependent Variable for Tone Recall. Covariance matrices of the dependent variable were equal across groups, *F* (9, 863.39) = 1.65, *p* = .10. Levene's test of equality of error variances was not significant for data when the UEO was absent, *F* (3, 56) = 1.56, *p* = .21, but was significant when the UEO was present, *F* (3, 56) = 6.98, *p* < .001. No significant effects were found in the analysis. The 3-way interaction was not significant, *F* (1, 56) = 2.22, *p* = .14, *r* = .2, similarly, the interactions of UEO presence and noticing, *F* (1, 56) = 0.06, *p* = .81, *r* = .03, UEO presence and distractors, *F* (1, 56) = 0.50, *p* = .48, *r* = .09, and noticing and distractors, F (1, 56) = 0.21, p = .65, r = .06 were all not significant. Finally, the main effects of UEO presence, *F* (1, 56) = 0.13, *p* = .72, *r* = .05, distractors, *F* (1, 56) = 0.04, *p* = .84, *r* = .03, and noticing, *F* (1, 56) = 0.43, *p* = .52, *r* = .09, were all not significant.

A 3-way mixed ANOVA was conducted to examine the main effects and interactions of trial (Trial 2, Trial 3, Trial 4, Trial 5; within-groups), load (low, medium, high; between-groups),

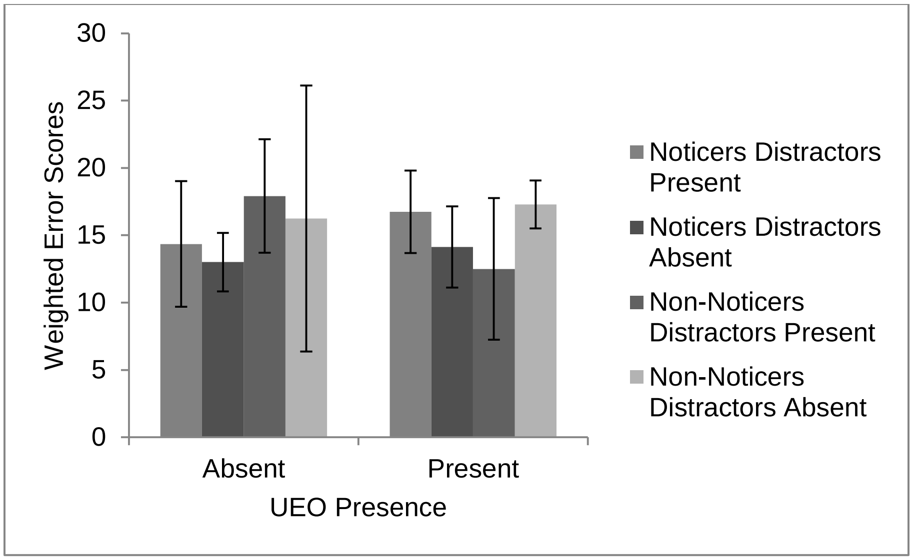

Figure 11. Mean number of weighted error score for each of the Tone Recall conditions.

Table 19. Descriptive Statistics for the Dependent Variable for Tone Recall

	Square Root of Weighted Error Score for Tone Recall		Weighted Error Score for Tone Recall	
	UEO Present	UEO Absent	UEO Present	UEO Absent
Mean	2.99	2.82	15.08	14.38
Standard Error of the Mean	.32	.33	1.84	2.09
Standard Deviation	2.49	2.55	14.27	16.67
Variance	6.22	6.51	203.76	261.53
Skewness	-.20	.10	.53	1.88

and distractors (present, absent; between-groups) as they related to letter tracking accuracy to determine if practice effects were present. Based on the results from Box’s test, the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups failed to be rejected, F (50, 55567.54) = 1.02, p = .44. Based on Mauchly’s test of sphericity, Mauchly's *W* = .95, *p* = .15, sphericity is assumed. Finally, no significant effects were found in Levene's test of Equality of Error Variances, which suggests error variances are equal across groups.

The analysis revealed no significant effects indicating that there was no practice effect. The 3-way interaction, *F* (6, 522) = 1.45, *p* = .20, r = .13, interaction of trial and distractors, *F* (3, 522) = 1.39, *p* = .24, *r* = .09, interaction of trial and load, *F* (6, 522) = 1.11, *p* = .36, *r* = .11, and interaction of load and distractors, *F* (2, 174) = 1.29, *p* = .28, *r* = .12, were all not significant. The main effects of load, *F* (2, 174) = 1.83, *p* = .16, *r* = .14, distractors, *F* (1, 174) = .10, *p* = .75, *r* = .02, and trial, *F* (3, 522) = .74, *p* = .53, *r* = .07, were also not significant. See Figure 12 for the Means of weighted error score for load and distractor conditions by trial. Table 20 displays Descriptive Statistics of the Dependent Variable for Trial.

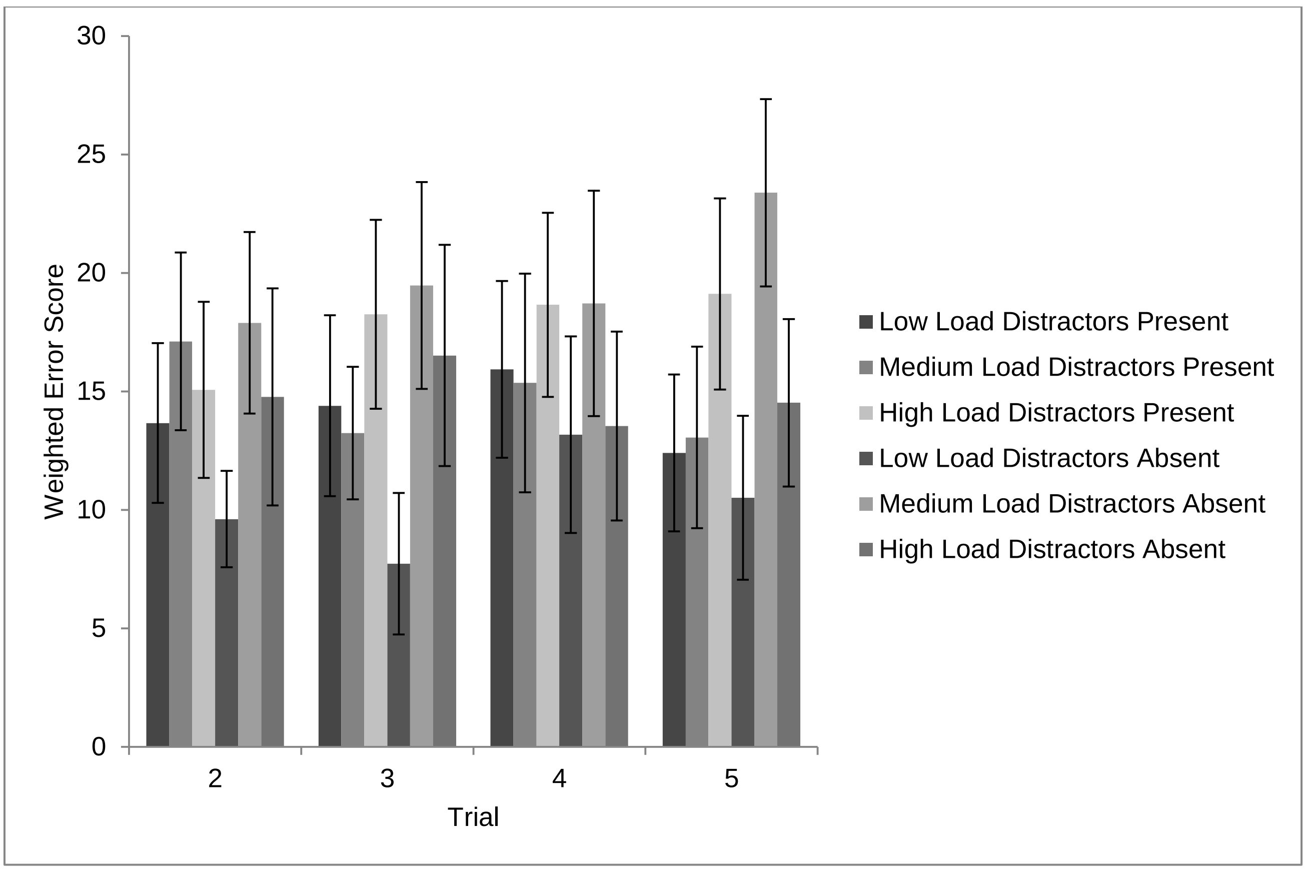

Figure 12. Means of weighted error score for load and distractor conditions by trial.

Table 20. Descriptive Statistics of the Dependent Variable for Trial

	Square Root of Weighted Error Score for Trial				Weighted Error Score for Trial			
	Trial							
	2	3	4	5	2	3	4	5
Mean	3.03	3.08	3.19	3.22	14.68	14.93	15.93	15.50
Standard Error of the Mean	.18	.17	.18	.17	1.47	1.57	1.69	1.52
Standard Deviation	2.35	2.34	2.41	2.27	19.78	21.05	22.69	20.45
Variance	5.54	5.49	5.81	5.13	391.40	443.11	514.64	418.12
Skewness	.77	.97	1.01	.88	2.21	2.38	2.60	2.43

CHAPTER 5 DISCUSSION

Individuals are often unaware of unexpected stimuli presented during an attention demanding task. The literature is not consistent on results regarding the effects of audio stimuli on visual awareness to unexpected stimuli (Pizzighello & Bressan, 2008; Beanland & Pammer, 2011). Research on this topic can help to improve understanding about human awareness during events of high cognitive load (i.e. motor vehicle operation). One of the goals of the current study was to replicate and extend investigations into whether concurrent audio stimuli, either relevant or irrelevant to the primary task, influences the rate of IB. Additionally this study aimed at investigating the role of selective attention in an IB paradigm by manipulating the presence of distractors.

According to load theory (Lavie et al., 2004), and recent findings in a static IB task (de Fockert & Bremner, 2011), IB rates should decrease as cognitive load increases when distractors are present, but not when distractors are absent. An additional study showing support for increased distractor processing when cognitive load is high was conducted by Lavie and de Fockert (2005). These researchers found that under high load of verbal WM results indicated more processing of irrelevant information in a visual search task (requiring non-verbal processing).

Requiring participants to update and recall the number of tones heard (in the high load condition) was expected, based on load theory, to increase WM task demands and thus decrease IB rate when distractors were present. In addition, based on load theory, fewer non-noticers were expected when examining the high load condition compared to low and medium load conditions when distractors were present. Furthermore, fewer non-noticers were expected when examining the medium load condition compared to low load when distractors were present, but no difference in IB rate was expected when comparing these load conditions when distractors were absent. No differences were expected when comparing low and medium load conditions when distractors were absent because, based on load theory, cognitive load should have had no effect on performance when selective attention was not required. Also, based on load theory, IB rates were expected to show a steady decline when distractors were present, but remain constant when distractors were absent. Moreover, increasing cognitive load was predicted to elicit fewer non-noticers when distractors were present in the display. Conversely, when distractors are absent from the display, cognitive load was expected have no effect on noticing the UEO.

Regarding predictions for IB results based on general capacity theory, IB rates were expected to increase as cognitive load increased. Furthermore, increasing load was predicted to decrease performance such that the low load condition would have a significantly fewer non-noticers than medium and high load conditions with medium load showing fewer non-noticers than the high load condition. In addition, the presence of distractors was expected to increase IB rates across load conditions compared to when distractors are absent. Given these predictions, the IB results of the current study provide mixed support for load and general capacity theories.

The results of the current study showed, as was predicted by both load and general capacity theories, when the audio stimulus was irrelevant (low load), the presence of distractors influenced whether participants noticed the UEO. The results also suggested that when distractors were present in the display, less participants than expected noticed the UEO, but when distractors were absent from the display, in the low load condition, more participants than expected noticed the UEO. However, when participants were asked to respond to the audio stimuli (medium and high load conditions) the presence of distractors did not influence the rate of noticing a UEO. This finding replicated research by Koivisto and Revonsuo (2008) that suggested IB rates increased when distractors were present compared to when distractors were are absent from the display. The implication of this result is that when audio stimuli is irrelevant noticing something unexpected is influenced by the need to ignore certain visual stimuli (i.e., visual selective attention). However, contrary to the expectations of the current study, there was no association (medium load approached significance) for IB rate for either medium or high load conditions comparing when distractors were present to when distractors were absent.

When comparing low, medium, and high loads the results show no significant associations between load conditions when distractors were present or when distractors were absent from the display. The finding of no association between load conditions when distractors were present is contrary to predictions based on load and general capacity theories. However, when distractors were absent from the display, the finding of no associations between load conditions is consistent with predictions based on load theory, but is contrary to predictions based on general capacity theory. Contrary to results reported in Pizzighello and Bressan (2008), the results reported here suggest that, compared to a visual-only task (low load) IB rate was no different than when performing a dual-task (responding to both audio and visual stimuli as in the medium load condition). Furthermore, the current results suggest that updating a count in mind (i.e., loading WM) while performing a dual-task does not influence IB rate compared to a visual-only task or a dual-task. These results are consistent with results reported by Beanland et al. (2011) that also showed that, when distractors were present, there was no association between when auditory stimuli was irrelevant and when audio stimuli required responses. However, in their report, the actual rate of IB (proportion of non-noticers) decreased whereas the results reported in this study show that the rate of IB increased (in the medium load compared to low load conditions). The IB results reported here, considered as a whole, indicate that IB rate is influenced by the presence of task irrelevant visual stimuli, but not influenced by audio stimuli – relevant or irrelevant.

Regarding letter tracking accuracy predictions, three predictions were tested: a primary hypothesis and predictions based on load and general capacity theories. According to the primary hypothesis it was expected that there would be no differences in letter tracking accuracy when distractors were absent, but a decline in performance was predicted when distractors were present. The prediction based on load theory was that there would be no significant differences across load conditions for noticers or non-noticers regardless of distractor presence. Finally, the prediction based on general capacity theory was that performance would decline as load increased and noticers would make significantly fewer errors than non-noticers regardless of whether distractors were present or absent.

Letter tracking accuracy results reported here provides mixed support for the three predictions. The results revealed a significant 3-way interaction of load, distractors, and noticing. Consistent with the primary hypothesis, those in the low load condition, who noticed the UEO, showed higher weighted error scores when distractors were present compared to when distractors were absent. However, contrary to the primary hypothesis, low load non-noticers showed no difference in mean weighted error scores between when distractors were present or absent. This finding provides support for the prediction, based on load theory, that there would be no differences across load conditions for noticers or non-noticers regardless of distractor presence or absence. Predictions based on general capacity theory did not apply to differences in scores between distractor presence for noticers or non-noticers at each level of load. This finding suggests that distractor presence does influence primary task accuracy at least for those who were aware of the UEO.

When distractors were present, contrary to what was predicted based on load theory, noticers showed higher mean weighted error scores than non-noticers for letter tracking accuracy. Therefore results reported by Beanland et al. (2011), that showed no differences in letter tracking accuracy, were not replicated. The current findings were also contrary to what was predicted based on general capacity theory. No predictions were made based on the primary hypothesis for this relationship at each level of load. In addition, there was no difference found between noticers and non-noticers when distractors were absent. This finding provides support for the prediction based on load theory and the primary hypothesis, but was contrary to what was predicted based on general capacity theory.

Examining comparisons for the interaction of load, distractors, and noticing for the medium load condition revealed mixed support for load and general capacity theories and the primary hypothesis. Contrary to predictions based on the primary hypothesis, but supporting predictions based on load theory, the results showed no difference between when distractors were present or absent for those who noticed the UEO. Moreover, conflicting with predictions based on load theory and the primary hypothesis, weighted error scores were greater when distractors were absent compared to present for non-noticers. Consistent with predictions based on general capacity theory, non-noticers showed greater weighted error scores than noticers when distractors were present. Finally, support for both the primary hypothesis and general capacity theory was garnered by the finding that non-noticers had greater error scores than noticers when distractors were absent. Taken together these results indicate that when conducting the dual-task of responding to visual and audio stimuli, accuracy for letter tracking depends on whether the individual noticed the UEO and whether distractors were present or absent.

With regard to comparisons for the interaction of load, distractors, and noticing for the high load condition, mixed support for the three predictions was found. Contrary to the primary hypothesis, but supporting load theory predictions, there was no difference in error scores when distractors were present compared to absent for those who noticed the UEO. However, the primary hypothesis was supported by the finding that, for non-noticers, greater error scores were discovered when distractors were present compared to absent. Furthermore, contrary to predictions based on general capacity theory, but supporting load theory, the results showed that noticers and non-noticers did not differ in accuracy for letter tracking when distractors were present. In addition, the results revealed that, contrary to all predictions, when distractors were absent, noticers had greater error scores than non-noticers.

Letter tracking results also revealed an interaction between load and noticing. Support or nonsupport for the primary hypothesis predictions are not discussed for this interaction because those predictions were based on differences between when distractors were present or absent. However, supporting the prediction based on load theory, there was no difference between noticers and non-noticers for the low load condition. This was contrary to what was predicted by general capacity theory. However support for general capacity theory was provided by the finding that non-noticers had greater error scores than noticers for the medium load group. This finding was contrary to what was predicted by load theory. For high load, it was revealed that noticers had greater error scores than non-noticers. This finding was contrary to predictions based on both load and general capacity theories.

Further examination of the results for the load and noticing interaction revealed mixed support for load and general capacity theories. For those who noticed the UEO, support for general capacity theory was found when it was revealed that those in the medium load group had greater error scores than those in the low load group. This finding was contrary to predictions based on load theory. Supporting predictions based on load theory, it was revealed that, for noticers, there was no difference between error scores comparing the low and high load conditions. This finding was contrary to the prediction based on general capacity theory. In addition, contrary to predictions based on both load and general capacity theories, those who noticed the UEO and were in the medium load condition had greater error scores than those in the high load condition. Support for load theory was obtained from the finding that there were no differences between any load conditions for non-noticers. These findings were contrary to predictions based on general capacity theory.

Letter tracking results also revealed an interaction of load and distractors. For those in low load, there were no differences in error scores when distractors were present compared to absent. This finding provides support for load theory, but is contrary to predictions based on general capacity theory and the primary hypothesis. However, contrary to all predictions, those in the medium load condition had greater error scores when distractors were absent compared to when distractors were present. Results revealed that those in the high load condition had greater error scores when distractors were present compared to absent. This finding provides support for both the primary hypothesis and general capacity theory, but is contrary to what was predicted based on load theory.

Comparisons were also conducted between load conditions when distractors were present and when distractors were absent. There were no significant differences in mean error scores between load conditions when distractors were present. This finding provides support for load theory, but is contrary to predictions based on the general capacity theory and the primary hypothesis. However, when distractors were absent from the display, those in the medium load group had higher mean error scores compared the low load group which supports the prediction based on the general capacity theory. This finding was contrary to the predictions based on load theory and the primary hypothesis. There was no difference found between low and high load conditions when distractors were absent. This finding is consistent with what was predicted based on load theory and the primary hypothesis, but is contrary to the prediction based on general capacity theory. Finally, the results revealed that, when distractors were absent, those in the medium load condition had higher mean error scores than those in the high load condition. This finding is contrary to what was predicted based on the primary hypothesis and both load and general capacity theories.

Letter tracking accuracy results also revealed a significant main effect of load. There were no predictions for main effect of load based on the primary hypothesis. Comparing each load condition, it was found that those in the medium load condition had higher mean error scores than those in the low load group. This finding is contrary to what was predicted based on load theory, but is consistent with predictions based on general capacity theory. Furthermore, there was no difference in error scores comparing low and high load conditions. This finding is consistent with what was predicted based on load theory, but contrary with the prediction based on general capacity theory. Finally, the significant main effect of load revealed that those in the medium load group had higher mean error scores than those in the high load condition. This finding was contrary to what was predicted by both load and general capacity theory.

Regarding predictions for tone counting accuracy, based on load theory, no significant differences between medium and high load conditions were expected. However, predictions based on general capacity theory were that performance was expected to decline as load increased. An interaction of UEO presence and condition was found for tone counting accuracy, and comparisons elicited mixed support for load and general capacity theories.

Comparing conditions of load and distractors for Trial 4 (pre-critical) revealed no differences between conditions. This finding is consistent with the prediction based on load theory, but is contrary to what was predicted by general capacity theory. Examining conditions of load and distractors for Trial 5 (critical) revealed that those in the high load with distractors condition had higher mean error scores than those in the medium load with distractors condition. This finding is consistent with the prediction based on the general capacity hypothesis, but contrary to the prediction based on load theory. Support for load theory was found based on the results that there were no differences in mean error scores when comparing medium load with distractors with medium load without distractors and high load without distractors. Furthermore, the tone counting accuracy results revealed that, contrary to the prediction based on load theory, those in the high load with distractors condition had higher mean error scores than those in the medium load without distractors group. Consistent with general capacity theory, but contrary to load theory predictions, it was revealed that those in the high load group had higher mean error scores when distractors were present compared to absent. Finally there was no difference found comparing medium and high load when distractors were absent. This finding is consistent with the prediction based on load theory, but contrary to the prediction based on general capacity theory. There were no predictions concerning tone counting accuracy comparing pre-critical and critical trials for each condition.

Regarding tone recall predictions, error scores for the number of tones recalled was expected to be significantly greater when the UEO was present compared to absent. Furthermore, during the critical trial more errors were expected for those who noticed the UEO compared to non-noticers. The results of the analysis revealed no significant effects. Furthermore, a practice effect was expected, based on results reported by Beanland et al. (2011), such that a significantly greater number of errors would be found in earlier trials (Trial 2 & Trial 3) compared to later trials (Trial 4 & Trial 5). However no practice effect was found.

Wolfe (1999) offered an alternative hypothesis as to the cause of IB. Wolfe stated that it is entirely possible that a UEO was not seen because attention wasn't directed to it (i.e., the IB hypothesis), but he also argues that it is possible the UEO was not reported as seen because the memory representation of the UEO was forgotten. This latter explanation for the failure of awareness was named the inattentional amnesia hypothesis (Wolfe, 1999). However, as Most et al. (2005) described, the inattentional amnesia hypothesis is a more likely explanation for briefly flashed stimuli (e.g., static IB studies) than for dynamic IB studies wherein the UEO is onscreen for several seconds. Potter (1976) provides evidence supporting the idea that inattentional amnesia is more likely for static IB studies. Conclusions from results shown by Potter (1976) suggest that identification of pictures presented rapidly may take place within 125ms, but creation of a stable memory representation requires approximately 300ms to occur. Therefore, a UEO presented onscreen for 5s (as in the current study) would provide ample opportunity for an individual to create a stable memory representation of the UEO.

Despite the evidence to suggest dynamic IB studies are resistant to inattentional amnesia, the hypothesis is difficult to completely disregard (Most, et al., 2005). Necessarily, the IB paradigm procedures dictate that awareness is assessed after the UEO leaves the display. However, Becklen and Cervone (1983) found that stopping the trial before the UEO left the display did not increase the rate of noticing the UEO. Furthermore, Simons and Chabris (1999) argued against the inattentional amnesia hypothesis as an explanation for their results due to the unexpected nature of their UEO. These authors believed that if their participants did see a person in a gorilla suit that they would be unlikely to forget that event. In the current study, the inattentional amnesia hypothesis is a doubtful explanation for the results because of the dynamic nature of the stimuli, the amount of time the UEO was visible (5s), and (in the low and medium load conditions) participants were questioned about the UEO immediately after the critical trial . However, in the high load condition, participants were questioned about the number of tones they recalled after each trial. Therefore the tone recall inquiry occurred immediately after the critical trial and prior to assessment of awareness of the UEO. Therefore, the inattentional amnesia hypothesis could possibly explain the results for the high load condition. Participants may have seen the UEO in the high load condition but forgot due to the longer time between the appearance of the UEO and awareness inquiry. Another possibly is that because attention was occupied by updating and recalling the number of tones in the trial inattentional amnesia for the UEO could have occurred. However, the inattentional amnesia hypothesis is an unlikely explanation for the high load condition results because there was no association of load on the rate of noticing found when comparing high load to the other load conditions when distractors were present or absent.

In conclusion, the findings reported in the current study suggest that noticing something unexpected depends on whether visual selective attention is required and whether concurrent audio stimuli is relevant. The current results replicate those found by Beanland et al., (2011), but are contrary to those found by Pizzighello and Bressan (2008). Regarding driving behavior, these results suggest that listening or even updating and maintaining information from the radio while driving will have no influence on the likelihood of noticing an unexpected jaywalker. Future studies may better understand these relationships by applying WM capacity assessments. In addition future studies may be able to directly test whether the UEO passed through a participants' gaze by utilizing eyetracking methodology. Taken together the current results are optimistic about the use of the radio while driving.

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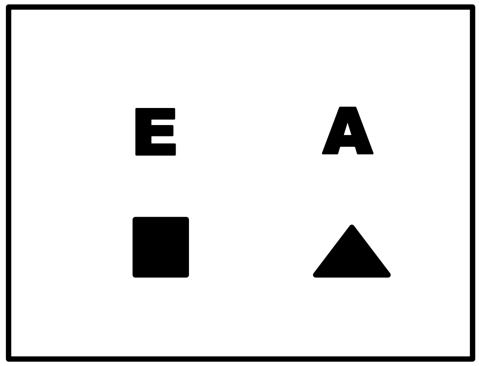
APPENDIX AWARENESS ASSESMENT

The following questions were asked after critical and full-attention trials. Participants answered the questions sequentially and were not allowed to skip a question or return to a previous question.

1. On the last trial did you see anything other than the black and white Ls and Ts (anything that had not been present on the previous trials)? Press the y key for yes. Press the n key for no.
2. If you did see something on the last trial that had not been present during the first two trials, please indicate the color of the object and indicate if you are guessing. Press 1 if it was black. Press 2 if it was white. Press 3 if it was gray. Press 4 if it was blue. Press 5 if it was black and you are guessing. Press 6 if it was white and you are guessing. Press 7 if it was gray and you are guessing. Press 8 if it was blue and you are guessing.
3. If you did see something on the last trial that had not been present during the first two trials, please indicate its direction of movement. If you did not see something please guess (Please indicate whether you did see something or are guessing). Press 1 if it was moving to the right. .Press 2 if it was moving to the left. Press 3 if it was moving up. Press 4 if it was moving down. Press 1 if it was moving to the right. Press 5 if it was moving to the right and you are guessing. Press 6 if it was moving to the left and you are guessing. Press 7 if it was moving up and you are guessing. Press 8 if it was moving down and you are guessing.
4. If you did see something during the last trial that had not been present during the first two trials, please indicate which shape you saw from the four examples below by pressing the corresponding number on the keyboard. If you did not see anything please guess.



In the high load condition participants were asked the following question after each trial.

5. How many tones do you remember hearing? Press 1 if you think there was 1 tone. Press 2 if you think there were 2 tones. Press 3 if you think there were 3 tones. Press 4 if you think there were 4 tones. Press 5 if you think there were 5 tones. Press 6 if you think there were 6 tones. Press 7 if you think there were 7 tones. Press 8 if you think there were 8 tones. Press 9 if you think there were 9 tones.

In the full-attention trial for all load conditions participants were instructed with the following statement.

6. On the next trial you are not required to respond to the white letters or the tones. Simply watch the screen.

VITA

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