The Effect of Task Interruptions and Reliable Cues on Detection Changes Within Dynamic Scenes

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THE EFFECT OF TASK INTERRUPTIONS AND RELIABLE CUES ON DETECTING CHANGES WITHIN DYNAMIC SCENES

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ABSTRACT

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Interruptions are a common problem for attention and pose a threat to visual task performance. The Memory for Goals (MFG) theory suggests that strongly and accurately encoded cues can assist the ability to resume a primary task after an interruption (Altmann & Trafton, 2002). Encoded cues can undergo an activation decay during an interruption and become forgotten. Currently, there has been limited research on how visual interruptions affect cued recall within a dynamic environment. Thus, the goal of the present study was to examine the effect of cuing and task interruptions on change detection within dynamic scenes. Undergraduate students watched 24 videos (12 with interruptions and 12 without) and answered general questions about the scene. Of the 24 videos, 8 contained a single object that underwent a perceptual feature change in color, brightness, appearance, or disappearance. Participants were assigned to one of three cueing conditions (reliable, unreliable, or no cue). It was predicted that the reliable cue group would report more changes than the unreliable and no cue groups. It was also predicted that more changes would be detected within uninterrupted than interrupted trials. Findings from the present study supported most of these predictions. Participants correctly detected more object changes during uninterrupted trials. Additionally, the reliable cue group correctly detected more object changes during uninterrupted trials. However, providing reliable cues had no effect when interruptions were present. Overall, these results support the MFG theory suggesting that visual interruptions may have allowed the encoded cues to decay resulting

in poorer change detection performance compared to uninterrupted viewing conditions.

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CHAPTER 1

INTRODUCTION

Interruptions are an unavoidable part of daily life. Some interruptions can be a minor nuisance (i.e., text notifications), while others can negatively impact performance on a task (i.e., lengthy conversations with a coworker). In high-risk circumstances (e.g., aviation, healthcare, surveillance), interruptions can potentially lead to serious errors. For example, if a surveillance operator stops monitoring a screen to address a question from a colleague, he may miss a critical change within the environment. When the operator returns to the monitoring task, he may be unaware that anything changed. Research using a surveillance task has shown that visual interruptions decreased the number of threats detected by 20% compared to no interruption conditions (Miller, Boehm-Davis, & Stanard, 2014).

An interruption occurs when attentional resources shift from one (primary) task to attend to a separate (secondary) task (Trafton & Monk, 2007). After completing the secondary task, the primary task is resumed. During an interruption, attention is entirely directed to the secondary task. In contrast, a distraction is said to occur when attention is only partially diverted to the secondary task while completing a primary task (Clapp, Rubens, & Gazzaley, 2009). An example of a distraction would be a student talking on the phone while responding to an email. While the student is still writing the email, some of the attentional resources are being used to respond to the phone call. Although the effects of distractions and interruptions are each worthy of further research, this study focused on interruptions.

A particular class of interruptions are visual and pose a significant threat to performance because most people are unaware of how frequently they occur and their effects. In general, people overestimate their ability to remember detailed visual information when looking around their environment. People are unaware that recalling objects and their locations in a visual scene requires (1) visually focusing one's attention to the object and (2) storing the object within memory. A visual interruption that occurs while an individual is focusing on an object may result in the object being temporarily unattended to or forgotten. Visual interruptions are particularly problematic for focused attention in environments involving many objects, especially when they are in motion (Hunter & Parush, 2010). In highly active, dynamic environments with many objects in motion, some objects occlude others from view. If an object changes while occluded, the change may not be noticed once it returns to the individual's view. An example would be a lifeguard monitoring a busy pool for swimmers in distress. The lifeguard must monitor multiple individuals while they are swimming, who can be occluded by other individuals. The inability to notice objects changing within dynamic scenes can be dangerous for critical tasks requiring visual monitoring, especially if the individual is overconfident in his or her ability to recall objects and environments. Thus, the purpose of this study was to examine how interruptions could negatively impact change detection performance.

The Theory of Interruptions

Historical background. The earliest study conducted on interruptions was by Ziegarnik (1927). Her focus was on memory and whether tasks could be recalled easier in uninterrupted or interrupted conditions. Ziegarnik had her participants complete a series of 18 to 22 total tasks requiring manual (i.e., constructing a cardboard box) or mental skill (i.e., completing a puzzle) as quickly as possible. While participants were encouraged to complete the study quickly, no time limit was given to complete each task. During half of the tasks, she would interrupt participants by presenting them with an additional task that needed completion. The additional task was like the other tasks used in the study. Participants were then asked to resume their previous task.

After the experiment, she asked participants to state which tasks were the most interesting or pleasant. She also took notes for trials where participants commented on any aspect of the task. Her findings showed that participants recalled interrupted tasks more frequently than uninterrupted tasks. She suggested that being interrupted during a task could have surprised participants. This surprise was thought to emphasize the task to participants, making the interrupted tasks more memorable. Ziegarnik's interruption research was the first to view interruptions experimentally.

Fitts and Jones (1947) rekindled interruption research in their technical review of pilot errors and aviation accidents. Their report cited multiple attentional and design errors that contributed to accidents and near misses reported by pilots; however, only one section of the report addressed interruptions. Their evaluation showed that most interruptions occurred during a pilot's normal routine. Fitts and Jones viewed the interruptions as the causal factor for forgetting errors, or failure to carry out a task that they had been doing before the interruption. They suggested that pilots could reduce these errors by incorporating routine checklists and self-assessments into their current routine. Importantly, Fitts and Jones stated that using both checklists and self-checks should reduce the amount of error, but not eliminate errors. Their report was among the first to address interruptions as a performance factor in an applied environment.

While researchers continued to explore interruptions in other applied settings (Bainbridge, 1982; Field, 1987; Kreifeldt & McCarthy, 1981), there was not much research on variables contributing to the disruptiveness of an interruption. Gillie and Broadbent (1989) investigated this problem in their study of the impact of interruptions on attention and memory. Specifically, they were interested in whether the duration of an interrupting secondary task, its similarity to other tasks, and its difficulty affected performance on a primary memory task. The primary task used a computer game that required participants to recall items from a list. Item locations varied and participants were required to find and put the items into their inventory. During some sections of the primary task, participants completed a secondary task that required them to read and say words as they appeared on the computer screen. The secondary task appeared on the same screen as the primary task, thus occluding the screen. Gillie and Broadbent found that none of the variables they manipulated accounted for the effects of interruptions on memory recall performance in and of themselves. The results demonstrated, however, that the combination of similarity and complexity affected task performance. Specifically, primary task performance was significantly affected when (1) the secondary task demanded a high degree of attention (complexity) and (2) was like the primary task.

Memory for goals. The initial work of Gillie and Broadbent (1989) led researchers to start studying interruptions with respect to primary and secondary tasks (e.g., Altmann & Trafton, 2002; Brixey et al., 2004; Latorella, 1996, 1998). While researchers differed in how they conceptualized and implemented interruptions, there was a consensus that interruptions impacted primary task performance. One prominent view of interruptions is the Memory for Goals (MFG) theory proposed by Altmann and Trafton (2002). The MFG theory describes the relationship between a primary goal and a second, interrupting goal. A goal is defined as a user's intention to accomplish a task. According to this theory, completion of the primary goal requires encoding cues strongly associated with the goal for later recall. Goal competition is dependent on cues to guide attention toward completion of the goal. According to Altmann and Trafton, suspended primary goals can only be recalled when an associative cue is retrieved from memory and is distinct from the secondary goal. This cue must be available prior to the interruption and after the interruption is completed (Altmann & Trafton, 2004; Trafton, Altmann, Brock, & Mintz, 2003). Cues that are not attributed to the primary goal may result in errors, unnecessary repetition of steps for the primary task, and inefficiency in time.

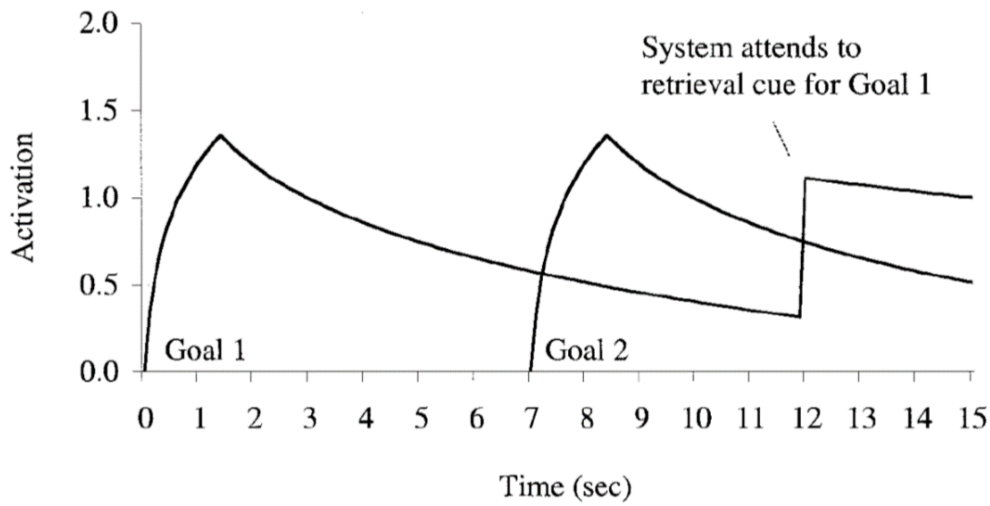

Figure 1. A graph depicting the decay of goal activation over time for a primary task (Goal 1) and a secondary task (Goal 2). Adapted from Altmann and Trafton (2002).

A critical component for the MFG theory is the priming constraint. The priming constraint refers to when a primary task goal is in a state of suspension or incompletion and requires an associated cue to progress forward (Altmann & Trafton, 2004). If cues from the primary goal are like those of the secondary task, then primary task performance can suffer (Altmann & Trafton, 2002). This is due to the primary task goal cues overlapping with those of the secondary goal (see Figure 1). If the overlap is significant, then cues from the primary goal should be more difficult to recall and cause errors in primary goal performance. On the other hand, when the cues for the primary goal are independent from those of the secondary goal, it should produce a high level of activation within working memory resulting in minimal or no effect on recall and subsequent performance (as shown by the retrieval cue pointer in Figure 1). Thus, when a primary goal is interrupted, a cue that is highly active will lead to faster primary goal recall. Cues that generate a high level of activation are important for tasks that require continual attention to achieve good performance. If a task has a lower level of activation, the cues may be misattributed to other tasks: resulting in the primary goal errors. Further, this effect is greater when cues for the primary task are not strongly encoded or uniquely different from the secondary task. Also, to keep goal activation high, a cue needs to be encoded prior to the interruption and be available within the viewing environment after the interruption. If there is minimal activation for cues within the environment, then the goals are susceptible to being forgotten and lost from working memory.

Altmann and Trafton (2002) also discuss the importance of time with respect to cues. The interaction of goal directed behaviors and the stages of an interruption are also tied to the time course of goal activation in memory. If the activation of a goal is delayed for an extended time period, then the primary task goals will begin to decay within memory. Goal activation will continue to decay the longer a primary goal goes without being re-activated. Thus, MFG suggests that as the duration of a secondary task increases, it decreases the likelihood that the primary task will be reactivated. For the purposes of this paper, overall goals are referred to as tasks and interest lies in the effect of interruptions on overall task performance.

Change Detection and Interruptions

Naïve realism. A common task that tests the effect of goal decay is detecting a change within an environment. According to Rensink (2002), change detection is the ability to notice when an object changes. This may sound like a simple task. However, people greatly overestimate their ability to detect change, particularly in dynamic environments (St. John, Smallman, & Hanes, 2005). This mismatch between confidence and ability has been described as naïve realism (St. John, Smallman, & Manes, 2005; Smallman & St. John, 2005). Smallman and St. John (2005) discuss the susceptibility of individuals to change blindness, regardless of whether they have prior knowledge of the change or no knowledge at all. They claim that this overconfidence is due to a misconception that visual perception is equivalent to a video feed. People incorrectly assume that vision is continuous and resilient. What seems like a seamless visual interpretation of the environment is a simplification. Instead, individuals rely on heuristics to make general assessments of the environment. These heuristics act as perceptual shortcuts through which to understand the environment. Heuristics utilize environmental cues such as location, brightness, size, color, and shape to help perceptually guide individuals to make quick and accurate scans. Usually, these heuristics will lead to a correct assessment of the environment, but they are not immune from error.

The coherence theory of attention. Beyond naïve realism, people also underestimate how much attention is required to encode an object within a real-world environment. One theory proposed by Rensink (2000), suggests that encoding and recalling a target is dependent on the amount of attention directed to the target. Rensink's Coherence Theory of Attention states that people do not accurately encode and store the details of every object into working memory. Instead, when people scan an environment, the details of an object are updated continuously as new stimuli come into attentional focus. These objects are stored within working memory, initially as a basic prototype, and undergo change as more information about the object becomes available (Rensink, 2000). The prototypical object continues to be updated within working memory as long as attention is directed to the object. Therefore, as long as an object maintains attention, changes should be noticed and encoded within working memory. Introducing interruptions to a dynamic environment, however, reduces the amount of attention available to encode objects. As MFG theory (Altmann & Trafton, 2002) suggests, people must encode cues regarding changing objects and maintain this cue activation until the end of the interruption. Maintaining encoded cues is incredibly difficult when changes in the environment are unexpected and is even more challenging in the presence of an interruption (Altmann & Trafton, 2002).

Inattentional blindness. In his review, Rensink (2002) discusses the distinction between seeing a change that has already occurred and one that is in the process of changing (dynamic). Change detection that involves a target object to be viewed before, during, and after the change is considered dynamic. If a dynamic change goes unnoticed, the Coherence Theory of Attention would suggest that the visible change was not perceived or updated within memory (Rensink, 2000). Changes without a visual occlusion are referred to as inattentional blindness. A requirement for inattentional blindness research is that the participant must be unaware of the impending change (Jensen, Yao, Street, & Simons, 2011). Importantly, a significant characteristic of inattentional blindness is that after the initial trial, subsequent trials that contain a change are no longer genuinely unexpected. Thus, after the initial trial, participants may shift their attention to search for a change rather than focus on the primary task.

Inattentional blindness has been demonstrated by Simons and Chabris (1999) gorilla study. In the study, participants were asked to watch a video of two teams passing a basketball in a circle. The only instructions given to participants were to count the number of passes that occurred during the clip for a given team. Midway through the clip, a confederate dressed in the gorilla costume would enter the scene, pause in the middle, and then exit the scene. The gorilla was always in full view of the observer. After the clip, the researchers would ask participants how many passes occurred and if they noticed the gorilla that appeared on the screen. Out of the 228 participants, only 58% reported noticing the gorilla. The findings of this study demonstrate that inadequate attention to a changing object can result in the change being missed even when it occurs in direct view.

The Simons and Chabris (1999) study raised an essential question about inattentional blindness: does being aware of a change increase the ability to detect other changes within the same environment? Simons (2010) addressed this idea with another group of participants, some of whom were aware of the gorilla experiment. In this follow-up study, Simons examined whether individuals who were aware of the previous experiment were still susceptible to inattentional blindness. Simons recreated the gorilla study but added two additional changes: a gradual change in the color of the curtain behind the players and the disappearance of one player during the video clip. His findings showed that 72% of participants noticed the gorilla in the scene. However, only 11% of all participants reported seeing the curtain change, and only 16% noticed the absence of a player. This result suggests that participants who expect a specific event to occur are more likely to attend to and notice that event but may still have a limited ability to notice any other changes.

Change blindness. In contrast to inattentional blindness, change blindness occurs when an object change is occluded or overwhelmed sufficiently by additional stimuli thereby masking the change (Jensen, Yao, Street, & Simons, 2011). The individual may be aware of the change, but the object is only perceived before and after the change occurs. Observers experience change blindness when a change in the environment goes unnoticed due to the disruption of the visual flow of events (Jensen, Yao, Street, & Simons, 2011; Rensink, 2002). As an example, suppose an individual at a stop light receives a text message from a friend. The individual glances at the light and notices it is still red and then proceeds to respond to the text. When glancing back up at the intersection, he or she fails to notice that the light has turned green and continues texting on the phone until the driver in the car behind hits the horn. Only then, does the individual look up and notice the light has changed.

The inability to detect a change in the visual field has been shown using various paradigms. Under the saccade-change paradigm (Grimes, 1996; Simons, 2000), a participant's eye movements are recorded when viewing the stimulus. Participants are asked to look at a picture or simple shape. When a saccade occurs, the displayed image is replaced with a similar image where only the target object changed (Rensink, 2002). Change blindness that occurs during saccade-changes is believed to be caused by inefficient encoding of items within the environment (Rensink, 2000). The internal representation is incomplete, and participants are unable to accurately detect a change within the altered environment. The saccade change method typically results in low levels of detected changes and has been historically limited to pictorial stimuli (Grimes, 1996), basic shapes and letters (Simons, 2000).

An alternative method for studying change blindness is the flicker paradigm (Rensink, O'Regan, & Clark, 1997) in which two paired pictures are presented: one of a scene and another identical picture of that scene with a feature change. Participants are shown the images in a rapid oscillating sequence of the original picture (A), a blank screen (mask), and the changed picture (A'). Participants are asked to respond when they detect a change. This oscillating pattern loops for 60 seconds or until a change is indicated. The detection rates in the flicker paradigm are moderate and may be attributed to participants attending to the pre-change and post-change images, rather than an internal representation of the environment. While this paradigm gives insight into how participants search for visual changes, it is experimentally induced and does not occur naturally within the real world.

A more natural investigation of change blindness was performed by Simon and Levin (1997) in their door study. The investigators had confederates approach members of the general public and ask for directions to a location. As the confederate was interacting with the participant, two more confederates disrupted the discussion by carrying a door in between the confederate and participant. While the door occluded the participant's vision, the first confederate switched with a different but similar looking individual. This new individual then continued the initial conversation with the participant. The researchers recorded all interactions and reactions of the participants. Their findings showed that over 50 percent of participants failed to notice the switched confederates. Considering MFG (Altmann & Trafton, 2002), this suggests that participants did not strongly encode features (facial distinctions, attire, hair color, etc.) of the original confederate before the change.

Simons and Levin (1997) did note, however, that some participants claimed that they had noticed the switch during the experiment. These participants did not report what they noticed during their conversation with the confederate but did mention it after the experiment concluded. These individuals were unable to recall specific details of the change suggesting that some of the information was lost or forgotten between the switch and the end of the experiment. This is an important finding. Changes in the environment, even those that are in an individual's direct line of sight, may not be encoded, especially when there is a gap between noticing and reporting the change.

Another study by Levin and Simons (1997) utilized inconsistencies within movie scenes to study change blindness. In their three-part study, participants watched short video clips created by the experimenters. The first study contained videos depicting everyday actions such as two people having a discussion. Each video contained various camera angles of the actors, with abrupt cuts or transitions between scenes. In between camera angle cuts, the actors' appearance or props in the scene would change (e.g., addition or deletion of a prop, changes in appearance, etc.) a total of nine times. Therefore, the cuts in the video acted as occlusions to the changes within the video. Participants were asked to write a brief description of what occurred in the video. Out of ten participants, Levin and Simons found only one who claimed to have noticed a single change (1997). In their follow-up study, the researchers created five videos showing a single actor completing one task (e.g., answering a telephone, walking and sitting in a chair, etc.). Each video only contained one change, which consisted of the original actor swapping with a "similar" looking actor midway through the video. Of the five participants in each video condition, only 33% of participants wrote in their summary that a change occurred. More interesting, of the participants who did not notice the change, most reported an accurate summary of what occurred in the video sans change. This finding shows that while a change may go unnoticed, people are still attending to the general "gist" of a scene.

Cueing

Information about a target must be available prior to and after a change has occurred. According to the Coherence Theory of Attention, an internal representation of a target is volatile when an environment is dynamic (Rensink, 2000). Further, MFG theory suggests that to strengthen an initial representation, a cue needs to be associated with the target before and after a change (Altmann & Trafton, 2002). Having a target associated with a strong cue allows for participants to encode an accurate internal representation and recall targets when the environment changes. Smallman and St. John's (2005) discussion of naïve realism suggests that people rely on heuristics and cues when perceiving objects in an environment. When multiple objects are present, cues may assist in recalling the target within memory and guiding visual search within the environment.

The presence of cues may guide visual search when little information is known about an environment. For example, while most individuals are unaware of the complexities in a cockpit, the average person may have the semantical knowledge that a flashing red light signifies something that requires the pilot's attention. In this case, the flashing red light is guiding the attention to a specific region of the cockpit. Perceptual changes in the color, brightness, and location of a target can help guide attention, when prior knowledge about a situation is not available. Wolfe and Horowitz (2004) reviewed the perceptual feature changes literature and classified them according to how successful they were in guiding attention. In the studies they reviewed, color, brightness, and feature onset were among the most likely characteristics to capture attention during visual search. This suggests that if people are unfamiliar with an environment, changes in the color, brightness, and onset of an object may guide attentional focus.

Wolfe and Horowitz's (2004) review categorized reported differences for successful detection among feature changes. However, they only classified features into broad categories. Features were not ranked individually. Researchers studying feature changes have been inconsistent in suggesting a "best" feature to guide attention. For example, previous research comparing the disappearance and appearance of features has found the appearance of features is easier to detect than disappearance of features (Agostinelli, Sherman, Fazio, & Hearst, 1986; Newman, Wolff, &; Hearst, 1980; Pezdek et al., 1988).

Over two experiments, Agnostinelli et al. (1986), used images depicting two categories of stimuli: meaningful and ambiguous. A meaningful stimulus depicted a familiar form, such as the outline of a car. Ambiguous stimuli rearranged components of a familiar form into an unrecognizable shape, such as scrambling and recombining the pieces of a car. The images were shown once, three, or six times. In the initial experiment, participants were not told that they were performing a feature identification task until after viewing all the images. They then viewed another set of images and indicated if they were identical to the original set. If they believed the images differed, they were asked to indicate if a feature had been added or deleted and provided their responses on physical sheets depicting the original image so that they could compare the presented image with the image on the physical sheet. The results showed that participants detected and identified appearance features more accurately than disappearance features. Regarding stimulus type, changes to meaningful stimuli were identified more frequently than ambiguous stimuli, but only when exposures were limited.

The second experiment was similar to the first but had several important differences. First, participants were informed that the experiment was a feature detection task. Agnostinelli et al. (1986) argued that participant awareness would strengthen the encoding of the images within memory. Second, participants were queried on the presence or absence of a feature after each test image. Thus, participants could not compare the test image to a physical image during the response. Agnostinelli et al. argued that testing participants immediately afterward would require the encoded image to be utilized when comparing the test image. Third, test images were only shown once, so exposure to stimuli was not manipulated. Under these conditions, the researchers found that disappearance changes were detected more than appearance changes. Interestingly, identification performance differed between meaningful and ambiguous stimuli. Agnostinelli et al. found that meaningful stimuli resulted in more identifications of disappearance features than appearance features. However, ambiguous stimuli showed the opposite effect. The authors suggested that appearance identification may require the original and altered images to be available for comparison. Agnostinelli et al. reasoned that for disappearance features, encoding allows for the image to be reconstructed until the missing feature is identified. However, when an image is ambiguous and requires additional encoding, images could not be reconstructed to identify a missing feature. The authors concluded that identification differences between appearance and disappearance might depend on the testing format.

Within change blindness research, investigators have also found that appearance changes are generally detected quicker and more frequently than color, brightness, and disappearance. In their study, Cole, Kentridge, and Heywood (2004) utilized the flicker paradigm to assess how well individuals could detect appearance, disappearance, brightness, and color feature changes. Participants were required to view a fixation cross surrounded by a group of shapes. Each feature type (color, brightness, and disappearance) was compared against appearance. A change consisted of one of the shapes undergoing a feature change during a flicker paradigm. Their results showed that appearance changes were detected more accurately and quickly than all other feature types. However, research with total visual occlusion has shown no differences among color, brightness, appearance, and disappearance (Simons, Franconerri, & Reimer, 2001). Again, the inconsistency in results suggests the way in which feature cues impact change detection depends on the task and environmental conditions. Regarding appearance-disappearance research, Bruce and Tsotsos noted that a feature's appearance often has higher detection rates when compared to a feature's disappearance (Cole, Kentridge, & Heywood, 2004; Pezdek et al., 1988). However, some studies have found no differences (Simons, Franconerri, & Reimer, 2001) or conflicting results (Agnostinelli et al., 1986) for presence and absence feature detection.

The Attention based on Information Maximization (AIM) model by Bruce and Tsotsos (2009) may reconcile inconsistencies regarding the detection of feature changes. The AIM approach to visual attention is dependent on the most prominent object in an environment attracting attention. The prominence of an object could depend on the number, brightness, color, motion, or location of additional objects. The researchers suggest that determining the most prominent feature depends on the context in which objects are present in the environment. A study by Attwood et al. (2018) reported that change blindness relies predominantly on bottom-up processes. In their experiment, participants were asked to identify differences between similar pairs of museum artifacts. The artifacts included pairs of ancient pottery, woodblock prints, and jewelry that had minimal or major differences within each pair. The changes included differences in color, design, and overall wear (e.g., chipping) of the artifacts. The researchers found a significant portion of the reported differences suggested participants utilized bottom-up processing (color, hue, and size differences). However, the difference in some pairs, such as the chip on a bowl, suggested top-down processing during search. The researchers concluded that participants might have utilized semantic knowledge to ascertain that a pottery artifact may have chips and imperfections due to the age of a bowl. The findings of Attwood et al. support the AIM model by suggesting that visual search during change detection may depend on the nature of the changes as well as information known about an environment.

Bruce and Tsotsos (2009) argued that detecting presence requires a new feature to be identified as novel and informative when comparing the target to the environment. Likewise, detecting absence requires the target to lose a feature that produces a response when compared to the environment. The researchers state that all feature changes, including appearance and disappearance, require the feature to be distinguishable from the background. They cited

Rosenholtz's (2004) study on color feature changes as an example of the impact of background on the ability to detect object features. Rosenholtz, Nagy, and Bell (2004) looked at detection differences for a red or pink dot across grey and fuchsia backgrounds. In the grey background condition, participants noticed the red dot amongst pink dots faster than the pink dot among red condition. However, the fuchsia background resulted in the pink dot being identified faster than the red dot condition. Bruce and Tsotsos concluded that Rosenholtz's (2004) findings show the importance of context when looking at feature differences. They argued that most studies utilize a limited experimental design (i.e., white background with stationary stimuli) when looking at feature changes. Utilizing limited experimental designs may only show feature differences in that given environment. Real-world environments contain various objects and backgrounds that may allow one feature to be more salient than another. For instance, a blue object may capture attention within an image of red roses, but not in a video of walking pedestrians. Bruce and Tsotsos (2009) determined that defining which object will capture attention is dependent upon the viewing environment.

Cue reliability. In dynamic environments, there can be multiple objects that capture visual attention. When a task requires attention to a specific object, individuals may be unable to differentiate between the target and irrelevant stimuli. Accurate and reliable cues have been shown to help identify appropriate targets within the environment. Posner, Snyder, and Davidson (1980) showed that cuing significantly impacts where participants look for a target. In their experiments, participants were asked to watch for an "X" that would appear on the left or right side of a display. Prior to target presentation, a warning stimulus would be flashed on the screen. The warning stimulus was either an arrow (experimental conditions) or a plus sign (control condition). In 80 percent of the prewarning arrow trials, the arrow pointed in the direction of the

“X” target; i.e., it correctly cued the appearance of the target. The results showed that participants’ correct responses were significantly faster in accurate arrow trials than neutral prewarning trials. For inaccurate arrow trials, however, participants were slower to respond, and their accuracy was at chance levels. This finding demonstrates that perceptual cues that are reliable can facilitate search performance and unreliable cues can harm search performance.

Memory for goals and cues. The research by Posner et al. (1980) shows that perceptual cues can be used successfully when they are reliable. Their participants were not required to encode the cues and instead relied on their appearance to guide attention to a physical light. Specifically, perceptual cues utilize one object to guide attention to a target object. In contrast, conceptual cues require encoding and must be recalled. Logan (1995) suggested that conceptual cues utilize language to direct attention by communicating a spatial relation to an object. Unlike perceptual cues, conceptual cues require a word or idea to be held within memory until the target object appears in some location in the scene. Conceptual cues must be encoded accurately to facilitate target detection as proposed by the MFG theory (Altmann & Trafton, 2002). For example, Altmann, Trafton, and Brock (2005) tested how cue strength impacts the resumption time of a primary task. In their study, participants were placed into one of three cuing conditions: no cue, subtle cue, and blatant cue. Participants were asked to complete a computer-based resource allocation task. During the task, participants were interrupted with a secondary task for thirty seconds. The secondary task required participants to assess whether icons on the screen were hostile or neutral targets. After the interruption, participants returned to the resource allocation task. For the groups that received cues, a cue relating to the participant’s action prior to the interruption was available on screen. Altmann and colleagues (2005) found that blatant cues significantly decreased the resumption time for the primary task than the no-cue condition.

The finding suggests that providing a cue strongly associated with a primary task can aid in primary task resumption. As suggested by Rensink (2002), successful change detection requires the mental representation of the object to be continually updated as the change occurs. Interruptions, however, disrupt this process and result in the cue being available only prior to and after a change. Memory for Goals (MFG) theory suggests that unless the cue is strongly encoded, the associated level of activation will quickly decay during an interruption (Altmann & Trafton, 2002). Thus, strong cues can keep a target object salient after the occurrence of an interruption.

The Present Study

The purpose of the present study was to examine how task interruptions impact the ability to notice changes in dynamic scenes. In addition, the effects of reliable and unreliable cues were studied. To date, researchers have looked at how interruptions impact the ability of individuals to notice target changes in static pictures (Becker & Rassmussen, 2008; Rensink, O'Regan, & Clark, 1997), radar displays (Hodgetts, Tremblay, Vallières, & Vachon, 2015; St. John, Smallman, & Manes, 2005), driving tasks (Galpin et al., 2009), and letter-oriented feature tasks (Lleras, Rensink, & Enns, 2005; Van Zoest, Lleras, Kingstone, & Enns, 2007). However, there has been limited research showing how interruptions affect attention to more dynamic stimuli. Specifically, most research has not examined the effects of interruptions on the visual flow of information and therefore limits what is known about these effects in a dynamic environment that more closely resembles real world situations.

To examine the effects of interruptions on visual information, participants were asked to watch a set of videos. Each trial consisted of one video that did or did not contain a change in a basic perceptual feature (i.e., color, brightness, or object appearance/disappearance). Changes were present during only 33 percent of trials, which contrasts with previous change detection research containing high rates of target present trials (Attwood et al., 2018; Rensink, O'Regan, & Clark, 1997; Simons, Franconeri, & Reimer, 2000). On some trials, the video was interrupted by visual occlusion for a few seconds. To avoid image rehearsal during the interruption interval, participants were asked to verbally answer a question unrelated to the images. All other trials proceeded without interruption. After the video, the participants were asked a series of questions about stimuli or events that transpired during the scene. The questions were relevant to basic events within the video but did not address any specific feature changes. The final open-ended question asked participants if they noticed anything unusual about the scene. This allowed participants to report a change within the environment without directly asking and priming them for future trials.

To examine the effects of cuing, participants were assigned to one of three groups: reliable cue, no cue (neutral), and unreliable cue. While Posner, Synder, and Davidson (1980) reported that reliable spatial cues resulted in more accurate and faster detection, it is unclear if conceptual cues that relate to a spatial object would have the same effect. Logan (1995) theorized that a conceptual cue could relate to a target within space if a target is identifiable and distinguishable among distractor objects. Therefore, in the present study each group received conceptual cues in the form of a title that related to an object within each video. For the reliable cue group, each video was prefaced by a title that was related to the object of change. The unreliable cue group was also provided a title; however, all titles were unrelated to the change within the video. The titles of the videos for the neutral group were an arbitrary number.

Hypotheses

Hypothesis 1. Overall, it was predicted that participants in the reliable cue group would correctly detect more changes than those in the unreliable and neutral (control) cue groups. The research from Posner and colleagues (1980) showed that reliable perceptual cues result in faster and more accurate responses than neutral or unreliable cues. Additionally, Altmann and Trafton (2002) demonstrated that successful reactivation of the primary task after an interruption requires a cue to be strongly and accurately encoded. However, it is unclear how conceptual cues would improve overall correct detections. Based on the findings of Posner et al. (1980), it was predicted that the group receiving reliable cues would correctly detect the most changes and more than the other two groups; however, it was not clear whether there would be a difference between the unreliable and neutral control cue groups.

Hypothesis 2. A critical component for primary task completion is for the primary task cues to be recalled after an interruption. When a trial is uninterrupted, there is no secondary task interfering with the attentional activation of the primary task (Altmann & Trafton, 2002). Thus, it was predicted that all groups would correctly detect more changes during uninterrupted than interrupted trials.

Hypothesis 3. In line with Hypothesis 1 and 2, an interaction was expected between cue reliability and interruptions. As discussed, the uninterrupted trials were expected to result in more correctly detected changes than interrupted trials. Differences in performance among the cue reliability groups were also expected. However, more correctly reported changes were expected for the reliable cue group during uninterrupted trials. According to MFG (Altmann & Trafton, 2002), uninterrupted trials should not require cue recall because the primary task is not suspended. This was only expected for the reliable condition because the neutral and unreliable cue groups have inaccurate cues, which were expected to provide no benefit during uninterrupted trials.

Research Question

Regarding the specific types of target changes, there was evidence to suggest that the type of change would not impact detection (Bruce & Tsotsos, 2009). Simons et al. (2000) found no differences in accuracy when looking at the ability to detect changes in color/brightness or the appearance/disappearance of objects. This finding is inconsistent with previous change blindness and feature detection research that found the appearance of an object is detected faster and more accurately than its disappearance or changes in color and brightness (Agostinelli, Sherman, Fazio, & Hearst, 1986; Cole, Kentridge, & Heywood, 2004; Newman, Wolff, &; Hearst, 1980; Pezdek et al., 1988). Thus, the present study represented the initial investigation into whether the ability to detect the presence or absence of information differs in dynamic scenes and how detecting these changes might be modified by task interruptions and cuing.

CHAPTER 2

METHOD

Sample Estimation

A power analysis was conducted to determine the appropriate sample size for the study. The effect size chosen for this study was .30, as it was considered a medium effect size (Cohen, 1992), with an alpha of .05 and power of .80. A power analysis using the GPower 3.1.9.2 software required a minimum of 84 participants per group for the between-subjects component of the study (see below). This resulted in 28 participants being in each of the 3 experimental groups.

Participants

The sample consisted of undergraduate students from Old Dominion University. The participants completed a questionnaire to determine if they were a native English speaker and if they reported being colorblind (see Appendix A). To help ensure confidentiality, participants were asked only to indicate age and gender (see Appendix B). All participants were asked to sign a consent form (see Appendix C) and this study was approved by the Institutional Review Board at Old Dominion University. Participants were debriefed once the experiment was completed and given two extra credit points in the SONA system for their participation.

Stimuli

Videos. The stimuli consisted of 24 videos either filmed within the local area or downloaded from YouTube. All videos were dynamic, meaning there were multiple objects moving and interacting within the environment. To avoid repetition, no scenes overlapped in location or visual angle. For example, while multiple videos were filmed from a city street, those videos did not contain the same buildings or landmarks.

Feature changes. Eight of the twenty-four videos contained a single perceptual feature change. The specific feature changes addressed: brightness, color, appearance, and disappearance. Each change type was applied to two videos: one involving a high and the other a low amount of motion and objects. An example of a video before and after a feature change is provided in Figure 2. The remaining 16 videos had no feature changes. All changes were created to be salient when static images are compared side by side. Thus, for a color change, a red object changed to blue: for a brightness change, an object within the scene increased or decreased in intensity by a factor of five. The location of the changes was balanced between the center and periphery across the change videos. All changes remained in effect until the end of the video. The feature changes occurred during the final 30 seconds, depending on the length of the video. The change does not always occur at the same time within each video to minimize the opportunity for participants to anticipate the change. Half of the videos contained a six-second interruption (see below). For these videos, the feature changes occurred within this interruption interval. The interruption extended the video times because the scene was paused during the interruption occlusion on screen. This ensured that the designated feature changes were the only features that changed before and after the interruption.

Figure 2. A screenshot of the video before the change (object disappearance) has occurred (top) and after the change has occurred (bottom).

Tasks

Primary task. The primary task for each trial was watching the 24 videos and answering questions about their contents. They were told that some videos might be interrupted (see below). They were also instructed about the possibility of object changes within the videos and to let the experimenter know if they detected a change.

Interruption task. For the trials with interruptions, participants were asked to respond to general questions during a six-second interruption interval. The questions were short and had no relevance to the study (see Appendix E). The goal of the interruption was to minimize the opportunity for participants to maintain the video image in visual memory by engaging them in another cognitive activity. As an additional means to limit visual rehearsal, all of the questions require spatial mental imagery about topics unrelated to the video. An example question is, "What did you wear yesterday?" The question was presented on the screen occluding the video and remained visible for six seconds. The participant responded verbally and resumed watching the video after the interruption was complete. Participants were told that they must respond, even after the video resumed.

Cues. Cues were introduced by the titles given to the videos. There were three cueing groups: reliable, unreliable, and neutral cues. In the reliable cue group, the video titles reflected the change at a conceptual level. An example title would be, “Cars parked on the road” where the change affects a car. The cue did not specify the spatial location of the change. In the unreliable cue group, the titles were unrelated to the change. An example title could be, “Umbrellas blowing on the beach” when the change affects a chair. Finally, the no cue group had neutral titles such as video_1.

Materials and Equipment

Videos. All local videos were filmed using a Canon VIXIA HF R52 Camcorder. The average duration of the 24 videos was 65.50 sec (SD = 10.20 sec). The changes and interruptions were created using Adobe After Effects CC Version 15.1.1. This allowed for all videos to maintain consistency and play at 1080-pixel quality. Videos were displayed on a 54.61 cm x 18.03 cm x 36.32 cm monitor using Windows Media Player.

Response pictures. All change responses reported by participants were marked by the experimenter on response pictures. Each picture was taken from the last frame of the video and was printed on a 21.59 cm x 27.94 cm paper. To indicate where a change occurred, the experimenter placed a 2.54 cm circle sticker on the point that the participant pointed on the screen. This provided a record of where participants pointed to corroborate their verbal descriptions.

Scoring. Participant performance was measured by the correct detection of changes and errors. Correct detections were assessed in two ways: 1) if a change was indicated, and 2) if a "correct change" was reported. A correct change was defined as indicating a change occurred and pointing to the object on the screen within a range of 2 cm. If participants noticed the change and correctly identified the location, they were given one point. If participants only noticed that there was a change but were unable to verbalize the change or correctly identify the location, they were given .5 points. If they indicated no change at all, then no points were given. If participants indicated a change during a no-change trial, an error was recorded. This allowed for all reported changes, correct and incorrect, to be reviewed across all videos.

Procedure

Before the study, participants were asked to answer two short questions regarding English as a first language and colorblindness. Once verified, they were provided a consent form and asked to participate in the study. Participants were randomly assigned to one of the three reliability cue groups. They were then asked to watch the videos. Participants were informed that some of the videos contained an interruption in the form of a question (Appendix E). They were required to verbally respond to the interruption question before they finished watching the video. They were also told that some of the videos contained a change within the scene and that the changes represented anomalies such as a shift in color, brightness, or the appearance or disappearance of an object within the video. If they noticed a change, they were asked to immediately verbalize what they had seen and point to that area of the screen. After each video, participants were asked two multiple-choice questions addressing general items or actions that occurred during the video (Appendix D) by circling the answer on a sheet of paper. The questions did not address any feature changes and focused only on the overall scene. An example of a general item question for a video of a suburban street would be, "Were there more than two cars on the street?" Participants were required to score 70 percent or higher for their data to be used in the study. Once completed, the next trial began, and this process was repeated for all 24 trials. After the final trial, participants were debriefed and thanked for their time. The experiment session took about forty-five minutes.

Experimental Design

This study used a mixed 3 (cueing) x 2 (interruption) factorial design to test the hypotheses. The between-subjects factor was the cueing groups with three levels: reliable, unreliable, and no cues. The within-subjects factor had two levels: interrupted and noninterrupted trials. The dependent measures were the number of correct detections and errors.

CHAPTER 3

RESULTS

Of the 84 undergraduate students who participated, 3 participants did not complete the study or indicated English as a second language. Their data were excluded from the analyses, resulting in 81 participants (12 males; M_{age} = 19.95, SD_{age} = 2.57). All participants met the 70 percent accuracy for the post-video multiple choice questions (*M* = 86.69, *SD* = 0.04, *Mdn* = 42). The Levene's Test of Equality showed no violations with the homogeneity of variance for interrupted $F(2, 78) = 1.291$, $p = 0.281$, and uninterrupted $F(2, 78) = 1.81$, $p = .171$, trials. Descriptive statistics for all reliability groups and within interrupted conditions are provided in Table 1. The descriptive statistics are the number of correct detections based on the eight videos with feature changes.

Table 1

Mean Number of Correctly Reported Changes within Interruption Trials among Reliability Groups

Reliability Groups	Interruption Condition	*n*	*M*	*SD*
Reliable	Interrupted	26	0.57	0.82
	Uninterrupted	26	1.69	1.08
Unreliable	Interrupted	28	0.59	0.68
	Uninterrupted	28	0.88	0.77
Neutral	Interrupted	27	0.54	0.69
	Uninterrupted	27	1.39	1.11

Correct Detections

A 3 Reliability condition (reliable, unreliable, neutral) x 2 Interruption (interrupted, uninterrupted) mixed ANOVA was conducted on correct detections for the 8 change videos (see Table 2). The first hypothesis was that participants in the reliable cue group would detect more changes than those in the unreliable and neutral (control) cue groups. Contrary to expectations, the results showed no significant main effect for differences among the reliability groups, $F(2, 78) = 2.40$, $p = 0.097$, partial $\eta^2 = .058$.

Table 2

Results of the Analysis of Variance for Correct Detections

	SS	df	MS	*F*	*p*	partial η^2
Interruption Condition	22.82	1	22.82	37.76	**.000	.326
Interruption Condition x Reliability Group	4.89	2	2.45	4.05	*.021	.094
Error	47.14	78	0.60			
Reliability Group	4.42	2	2.21	2.40	.097	.058
Error	71.72	78	0.92			

Note. * $p < .05$, ** $p < .001$

The second hypothesis was that all participants would detect more changes during uninterrupted trials than interrupted trials. The results showed a main effect of correct detections for the interruption trials, $F(1, 78) = 37.76$, $p < .001$, partial $\eta^2 = .326$. These results are consistent with hypothesis 2. Specifically, there was a higher number of correct detections for uninterrupted ($M = 1.32$, $SE = 0.11$) than interrupted ($M = 0.57$, $SE = 0.08$) trials.

The third hypothesis predicted a significant interaction between reliability groups and interruptions such that only the reliable group was expected to report more correct changes during uninterrupted than interrupted trials. As predicted, the results showed a significant interaction between the reliability condition and interruptions $F(2, 78) = 4.05$, $p = .021$, partial $\eta^2 = .094$. The mean number of correctly reported changes for groups and interruption conditions is shown in Figure 3. As can be seen, the reliable group had the highest level of correctly reported changes during uninterrupted trials. To determine the source of the interaction, differences between interrupted and uninterrupted trials for each group were assessed with paired t tests and a Bonferroni corrected alpha level of .017. Consistent with hypothesis 3, detections for the reliable-uninterrupted trials were significantly higher than for reliable-interrupted trials (see Table 3). While not hypothesized, the neutral-uninterrupted trials were also significantly higher than neutral-interrupted trials.

To assess differences between reliability-interruption condition trials, *t*-tests were conducted comparing group-reliability conditions. A Bonferroni correction resulted in an alpha value of 0.008. The results only showed a significant mean difference between reliable-uninterrupted and unreliable-uninterrupted, $t(25) = 3.27$, $p = .003$. There were no differences among groups for the interrupted trials.

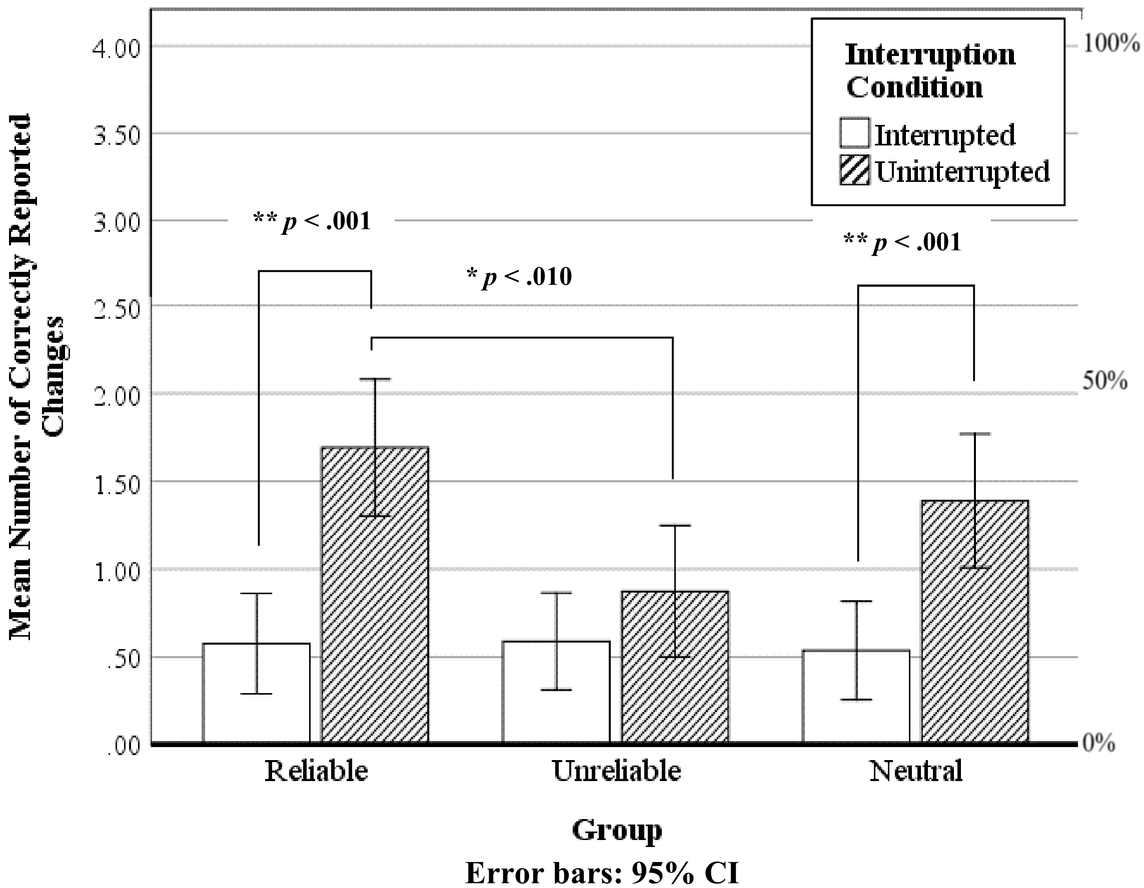

Figure 3. Mean number of correct detections on the left axis and the percentage of correct detections on the right axis across reliability groups and interruption conditions. Each mean is based on four change videos.

Table 3

Pairwise Comparisons of Correct Detections Between Reliability Groups Within Interrupted Conditions

Reliability Group	Group (I)	Group (J)	Mean Difference (I - J)	*SE*	*p*	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Reliable							
	Interrupted	Uninterrupted	-1.12	0.22	*.000	-1.55	-0.69
Unreliable							
	Interrupted	Uninterrupted	-0.29	0.21	.173	-0.69	0.13
Neutral							
	Interrupted	Uninterrupted	-0.85	0.21	*.000	-1.27	-0.43

Note. *$p < .001$

Reported Errors

The data also showed that participants made 64 errors on the 16 videos without feature changes. An analysis of the errors revealed that participants reported 32 errors that were plausible, yet unintended, changes within interrupted (N = 14) and uninterrupted (N = 18) trials. Some examples of unintended errors included a global change in sunlight (brightness), people walking out of frame (disappear), and an object becoming visible after being intermittently occluded by moving objects (appear). In total, 32 errors were reclassified as misinterpretations of the instructions and were removed from the error analyses. The remaining 32 errors were attributed to participants reporting changes that did not occur or were not described as part of the change instructions. More errors occurred within interrupted (N = 25) than uninterrupted (N = 7) trials and included reports of objects moving, stopping, or undergoing a change that was not described in the instructions. Due to the overall low report for remaining errors, no further analyses were conducted.

Correct Detections for Type of Change

Previous research regarding target changes suggested inconclusive evidence for how the type of perceptual change impacts detection. Thus, an exploratory analysis was performed on differences reported for appearance, brightness, color, and disappearance changes. Table 4 shows the frequency breakdown of correctly reported changes according to interruption condition. The frequencies of reported changes show that brightness and disappearance changes were overwhelmingly reported more than other types of changes. The uninterrupted brightness video had the highest level of detection with 45 reported changes. As shown in Table 4, the reported change frequencies were diverse and did not permit a 4 Change Type (appearance, brightness, color, disappearance) x 3 Reliability Group x 2 Interruption (interrupted, uninterrupted) mixed ANOVA. Therefore, reported changes were collapsed across the reliability group and interruption condition.

A one-way repeated measures ANOVA for Change Type (Appearance, Brightness, Color, Disappearance) was conducted on reported changes. The Levene's Test of Equality showed that variances for the different types of changes were not equal, $F(3, 320) = 21.18$, $p < .001$. Due to the violation, nonparametric tests were used. Differences between change types were then tested using the Friedman test. The test showed a significant difference among the types of changes, $\chi^2(3) = 58.471$, $p < 0.001$. The Wilcoxon signed-rank test was used to compare the change type differences using a Bonferroni corrected alpha level of .008. The results showed that the significant differences between Brightness and Appearance ($Z = 4.83$, $p < .001$), Brightness and Color ($Z = 5.69$, $p < .001$), Disappearance and Appearance ($Z = 3.23$, $p = .001$), and Disappearance and Color ($Z = 4.84$, $p < .001$).

Table 4

Frequencies for Correctly Reported Changes by Change Type

Change Type	Interruption Condition	Frequency
Appearance	Interrupted	2
	Uninterrupted	22
	Total	24
Brightness	Interrupted	19
	Uninterrupted	45
	Total	64
Color	Interrupted	4
	Uninterrupted	7
	Total	11
Disappearance	Interrupted	18
	Uninterrupted	30
	Total	48

Note. Each frequency count has a group size of 81

CHAPTER 4

DISCUSSION

The purpose of the present study was to assess how interruptions affect the ability to detect changes within dynamic scenes. Participants were assigned to one of three cue reliability groups: reliable, unreliable, and neutral. Performance was assessed by the number of correctly reported object changes during interrupted and uninterrupted trials.

Overall, the results showed that participants did not detect many changes. On average, they reported only two out of eight possible changes. This finding suggests that participants were incredibly poor at detecting changes, regardless of the reliability condition. When compared to other change detection paradigms, the number of reported detections in the present study was low. For example, Rensink, O'Regan, and Clark's (1997) flicker paradigm study showed a ceiling effect for reported changes. A ceiling effect is common within the flicker paradigm because the original and changed stimuli are presented in an alternating manner until a change is observed. Simons, Franconerri, and Reimer (2000) reported 64 percent of changes were detected in their study when objects changed gradually over a trial. Also, in the study by Simons and Levin (1998) participants interacted with confederates and reported changes that occurred after a visual occlusion, (i.e., the door that temporarily blocked their view), changes were detected 33 to 46 percent of the time. The levels of detection in these studies were lower than the flicker paradigm, but still much higher than what was observed in the present study.

An important consideration for detection in the present study is the low rate of target trials. Only 33 percent of all trials contained targets. Previous change detection research has reported high detection rates while providing a target in most trials (Attwood et al., 2018; Rensink, O'Regan, & Clark, 1997; Simons, Franconeri, & Reimer, 2000; Simons & Levin, 1998). The goal of the present study was to design a method for studying change detection without the expectation of all target-present trials.

Like Simons and Levin (1998), the present study also utilized dynamic stimuli but with a different paradigm. The videos included dynamic stimuli and each change occurred instantaneously and once per video. Also, Simons and Levin had participants unknowingly interact with the target before and after the change. The opportunity for participants to interact directly with the object of change may have led to stronger encoding of the target and resulted in more correctly reported changes. Unlike Simons and Levin, participants in the present study were asked to watch videos, a more passive activity. Thus, they did not interact directly with the change object. Further, although participants were informed about object changes, they were only given cues about the changes. Also, participants in the present study were asked to immediately point to and verbalize any changes seen. Simons and Levin only asked participants if they had additional comments or concerns after the change occurred. Finally, while participants in the present study were informed about the possibility of changes, they were unaware on any given trial if a change would occur, when it would happen, and where. Collectively, these methodological differences may have contributed to weaker encoding of target objects, than in the Simons and Levin study. As Bruce and Tsotsos (2009) argued, the design and context of an experiment can influence how changes are detected and reported.

Although the number of correctly reported changes was low, participants also did not make many errors. On average, there was less than one error per participant. Further analyses resulted in 32 of the 64 reported errors being reclassified because it appeared that participants misinterpreted the change instructions and reported changes that were natural or normal occurrences within the scene. For example, appearance misinterpretations involved an object being temporarily occluded by another object and suddenly becoming visible. In contrast, disappearance misinterpretations occurred when objects became momentarily occluded by another object. Brightness misinterpretations stemmed from scenes involving outdoor lighting, which would gradually brighten or dim, producing a global brightness shift. In some cases, the global brightness change would affect some objects more than others and create a noticeable shift in brightness. Color misinterpretations similarly involved changes, for example in brightness when an object moved from a shadow to an unshaded area. While all participants were given the same information about changes, only some misinterpreted normal occurrences and reported them as changes.

The remaining 32 reported errors involved two different types of inaccuracies. The first were errors attributed to one of the given change types but did not occur within the video. For example, a disappearance error occurred when a participant indicated that a white tent disappeared in the scene. However, the tent was not present during the video and no additional objects or changes in brightness could explain why the participant indicated this change. The second type of error indicated a change that was unrelated to the four types of changes described in the instructions. An example of this type of error was a participant reporting that an individual picked up and moved a water bottle from its initial location. A moving object was not one the changes included in the instructions.

Reliability. The first objective of the present study was to examine the effects of cue reliability on the ability to detect object changes. Previous research from Posner, Synder, and Davidson (1980) suggested that reliable cues result in more accurate detections and faster response times than unreliable and neutral cues. Also, according to MFG theory (Altmann & Trafton, 2002), accurate and strongly encoded cues aid primary task performance after an interruption. Therefore, it was predicted that the reliable cue group would detect more changes than the unreliable and neutral (control) cue groups. While the data showed a trend toward more correct detections for the reliable group, there was no main effect for cue reliability on correct detections or reported errors. Although the results did not produce a main effect for cue reliability, they did show a significant interaction between cue reliability and interruptions. This finding will be discussed below.

Overall, the findings for reliability do not support the work of Posner, Snyder, and Davidson's (1980). However, there are some important methodological differences between Posner et al.'s (1980) experiment and the present study. Posner and colleagues had a static display and asked participants to respond to letters that appeared to the left or right of a fixation cross. The target was reused and familiar across multiple trials (i.e., always a letter). Also, a detectable letter was present during 100 of the 120 trials resulting in 80 percent of trials containing a target. Additionally, all participants were presented with reliable, unreliable, or neutral cues near the target letter. By contrast, the present study utilized dynamic real-world scenes including multiple objects in motion. A detectable object was only present during 8 of the 24 (33%) of trials and was unique to each video. Additionally, participants were only presented with one level of reliability.

Another important difference concerns the nature of the cues themselves. In the Posner et al. (1980) study, cues were provided by an LED light that indicated the location of the target for all reliability conditions. Participants did not have to recall a cue and could instead rely on the perception of the LED. In the present study, however, the title for each video provided a cue that was conceptual; that is, the title indicated which object in the video ought to be monitored. Participants were required to encode the cue and then search for the object spatially within the scene. Logan (1995) theorized that naming an object, or providing a conceptual cue, should equate to a mental representation of the object. Logan argued that using conceptual cues during visual search should help target identification within physical space by providing spatial location information to distinguish the target object from distractor objects. Targets that are not distinguishable from distractor objects should not be identified.

The low rates of detection reported in the present study suggest that participants did not effectively relate the conceptual cues to the target objects. While efforts were made to provide unique titles for the target objects, there were occasional instances where the title did not distinguish the target from distractors. One example was a video titled “street light” that involved a street light containing an appearance change. While the conceptual cue “street light” identified the target object, the video also had other street lights in the scene that did not change. This video had the lowest level of reported detections, which was potentially due to participants not being able to determine to which street light they needed to focus their attention. Therefore, participants were unable to associate the given conceptual cue to the correct spatial object. In contrast, the “trash can” video had the most correct detections. This change was clearly identifiable because the video had only one trash can. Both examples support Logan’s (1995) theory that conceptual cues can only assist search for spatial objects when the target is identifiable from distractor objects. Taken together, the methodological differences between the use of cues in the present study and by Posner et al. (1980) may have resulted in very different levels of detection, particularly in the reliable condition.

Interruptions. The second objective of the present study was to examine the effects of interruptions on the ability to detect object changes. As theorized by Altmann and Trafton (2002), interruptions require participants to recall cues when resuming the primary task.

However, uninterrupted trials do not require cue recall when completing the primary task and instead may rely on the ability for a target to garner attention. Rensink's (2000) Coherence Theory of Attention proposed that detecting changes requires cue availability before and after a change. Thus, participants in all groups were predicted to report more correct changes during uninterrupted trials rather than interrupted trials and the results were consistent with this prediction. This finding supports previous theories (Altmann & Trafton, 2002; Rensink, 2000) which suggests having object information before, during, and after a change can result in higher levels of detection. Uninterrupted trials may have enabled participants to hold a mental representation of the change object within working memory and effectively update the representation as change information attracted attention (Rensink, 2002). By contrast, the lower level of detections reported during interrupted trials may have resulted from cues decaying during an interruption within working memory (Altmann & Trafton, 2002).

Additionally, participants reported more errors during interrupted trials than uninterrupted trials. This finding supports the main effect of interruptions for correct detections. Rensink (2002) suggested that strong encoding of cues prior to an interruption can assist change detection performance. As argued in MFG theory (Altmann & Trafton, 2002), the interrupted trials may have enabled encoded primary task cues to decay in working memory leading to a greater number of reported errors. However, it is also possible the reported errors indicate that cues were encoded incorrectly at the outset. The current results do not shed light on either of these two possibilities.

Interruptions and reliability. The third objective of the present study was to examine the interaction between the reliability groups and interruptions. Recall that reliable cues were expected to improve performance over unreliable and neutral cues (Posner, Snyder, & Davidson, 1980). Additionally, Altmann and Trafton (2002) proposed that interruptions require participants to recall cues when resuming the primary task. Uninterrupted trials do not require cue recall and should not affect detection performance. Further, because the video titles were related to the objects of change for the reliable cue group it was predicted that the reliable group would report significantly more changes within uninterrupted trials than uninterrupted trials. Therefore, an interaction was predicted between reliability groups and interruption condition. The results supported the third hypothesis. The analyses showed that those in the reliable group reported significantly more correct detections in the uninterrupted vs. interrupted trials. This finding supports interruption-based change detection research (Altmann & Trafton, 2002; Rensink, 2002; Simons, Franconerri, & Reimer, 2000) that proposes interruptions lead to overall decreased detection accuracy when compared to uninterrupted trials. Thus, these participants appeared to receive a significant attentional advantage when given reliable change information. The poor performance during interrupted trials suggests that reliable cueing may not offset the cue's decay when being held within working memory during an interruption.

As expected, the advantage for reliable cues did not extend to the unreliable cue group. This result supports the Coherence Theory of Attention (Rensink, 2000). The unreliable group may have encoded the given cues and directed their attention to objects in the video that did not undergo a change and therefore missed the objects that did change. The results also showed that the neutral cue group made significantly more correct detections in the uninterrupted vs. interrupted trials. This finding supports the availability of change information available before, during, and after a change can aid detection if the target attracts attention.

Research question. Differences in detections among the four types of feature changes were also examined because current empirical evidence is inconclusive as to how different feature types impact the ability to detect changes. In previous research where simple shapes were presented against solid backgrounds, appearance feature changes were detected faster and more accurately than disappearing features, or color and brightness changes (Agostinelli, Sherman, Fazio, & Hearst, 1986; Cole, Kentridge, & Heywood, 2004; Newman, Wolff, &; Hearst, 1980; Pezdek et al., 1988). However, research focusing on interruptions and feature detection found no differences between appearance, brightness, color, and disappearance changes (Simons, Franconerri, & Reimer, 2000). Moreover, as noted above Bruce and Tsotsos (2009) suggest that detecting feature changes is dependent on the environment. They argued that object features may capture attention depending on additional objects, motion, and colors present within an environment. Further, Attwood et al. (2018) theorized that change detection may utilize predominantly bottom-up processing but can be overridden when semantic information about an object is known.

The low level of detections observed in this study prevented the opportunity to fully analyze feature changes by reliability group and interruption condition. Collapsing the data across reliability and interruption conditions showed that reported brightness and disappearance changes were detected more often than appearance and color changes. These findings do not support previous research suggesting that appearance changes should result in higher levels of detection (Agostinelli, Sherman, Fazio, & Hearst, 1986; Cole, Kentridge, & Heywood, 2004; Newman, Wolff, &; Hearst, 1980; Pezdek et al., 1988) or that there should be no differences for reported detections among change types (Simons, Franconerri, & Remier, 2000). However, the previous research utilized either simple objects appearing against a solid background or static images with a feature that changed gradually over time. The present study utilized dynamic stimuli involving various environmental locations, lighting, objects, and viewing perspectives that may not be comparable to those used in previous studies. As suggested in Bruce and Tsotsos (2009), detecting a salient feature is dependent upon localized, contextual factors within a given environment. Unfortunately, the level of correct detections in this study was much lower than expected compared to previous research (Agostinelli, Sherman, Fazio, & Hearst, 1986; Cole, Kentridge, & Heywood, 2004; Simons, Franconerri, & Reimer, 2000) and therefore was insufficient to assess statistical differences among the given change types.

Theoretical Implications

Previous research examining feature detections (Simons, Franconerri, & Reimer, 2000) demonstrated that interruptions negatively affect change detection performance when compared to uninterrupted performance. The MFG theory (Altmann & Trafton, 2002) and the Coherence Theory of Attention (Rensink, 2002) suggest that strong and accurate cues are needed to resume the primary task after an interruption. However, these theories did not address differences between interrupted and uninterrupted performance with different types of cues. The findings of the present study show that cue reliability can affect the ability to detect changes in an uninterrupted primary task.

Although participants who received reliable cues about changes did not differ from those who received neutral cues, they did detect more changes than participants who received unreliable information. Unreliable cues may have put participants at a spatial disadvantage when trying to locate the change object. As stated by Logan (1995), conceptual cues can be associated with spatial information about target objects within an environment. The results of the present study showed that reliable cues had higher reports of correct detections when viewed without interruption. This finding suggests that in this condition participants were better able to associate targets spatially from conceptual cues. Additionally, the present study showed that unreliable cues resulted in fewer reports of correct detections. This finding suggests that inaccurate conceptual cues impeded the ability of participants to detect the target. Overall, the results of the present study support Logan's position that conceptual cues can facilitate the identification of a target object within a dynamic environment if they are reliable.

Interruptions and situation awareness. An additional theoretical consideration concerns situation awareness (SA). According to Endsley (1995) situation awareness refers to an individual's ability to perceive, understand, and make judgments of objects within a given environment. Endsley's SA model addresses attention to objects at three levels: perception, comprehension, and prediction. Of primary concern to this study, the perception stage describes how individuals perceive basic attributes and features about objects to determine relevant elements within the environment (Endsley, 1995).

Successful object encoding is dependent on the accuracy of information obtained during level 1 SA (i.e., perception). To measure the accuracy of encoded information, researchers often question individuals about SA during a task. The most common measurement method of SA is the Situation Awareness Global Assessment Technique (SAGAT; Endsley, 1988). In this method, individuals are interrupted during a task after an important event and asked questions pertaining to their SA. Typically, the task is occluded during questioning to capture the individual's current SA.

In this regard, the SAGAT method is similar to the procedure used in the present study where the video was occluded, and participants were asked to respond to a question before an important event. The results showed that participants' perception was negatively affected during interrupted trials when the video scene was occluded. As noted above, interruptions require the target object to be encoded strongly and accurately within working memory (Altmann & Trafton, 2002). During the interruption, the encoded object's level of activation in working memory can decay. Based on the current results, interruptions may result in an encoded object decaying to the point where perception of the environment is severely compromised.

The findings of the present study suggest that interruptions introduced by the SAGAT method may result in poorer level 1 SA performance. Further, individuals may be unaware of their susceptibility to visual interruptions when being probed for level 1 SA. As noted above, Smallman and St. John's (2005) concept of naïve realism addresses the inaccurate belief that vision is resilient and continuous. They theorized that individuals may naively believe they are retaining information about every object during visual search. The low level of change detections observed after visual interruptions in this study suggests that when individuals are probed during the SAGAT process, they may not realize their SA has been compromised.

The present study provides additional considerations for researchers studying SA. Researchers may also be unaware of subjects' vulnerability to visual interruptions when measuring SA. Moreover, if interruptions impact level 1 SA, then SAGAT questions may also undermine attempts at assessing SA at levels 2 and 3.

Although the goals of the present study were not aimed at measuring SA, participants where asked questions about the videos afterward. The results showed that they responded to general questions about each video with over 85 percent accuracy. However, the questions used in this study pertained to general aspects about the video, such as the location of the scene. Typically, SAGAT questions address more specific details of how individuals perceive, comprehend, and predict an object's status within an environment. Therefore, the questions used in this study should not be considered a good measure of SA.

Applied Implications

Visual interruptions are commonly used in change detection research. Investigators have studied interruptions using pictures (Simons, Franconerri, & Reimer, 2000, Rensink, O'Regan, & Clark, 1997), real-world interactions (Simons & Levin, 1997), and movie clips (Levin & Simons, 1997). One of the major contributions of the present study is the use of visual interruptions in real-world dynamic videos. Levin and Simons (1997) used videos that mirrored a movie scene where the camera focused on characters using various camera angles. This resulted in individuals seeing objects from different perspectives and sizes depending on the camera view and field of view. The design of the present study allowed for changes to occur but by maintaining a consistent camera perspective. This method closely mirrors how an individual would view a real-world scene and detect object changes. For example, surveillance operators are often required to watch various camera feeds to identify a target. Typically, surveillance operators monitor multiple screens for incidents that may or may not occur (Hodgetts, Vachon, Chamberland, & Tremblay, 2017). Occasionally, operators are provided with substantial amounts of information about a target that may or may not be reliable. The findings of the present study suggest that providing reliable target information can assist correct detections over unreliable information, provided the operator is not interrupted.

While the results of the present study found no differences between reliable cue and no cue information, all participants were still informed that target changes were possible. Within the context of surveillance, operators are typically given alerts regarding features or the location of a target (Hodgetts, Vachon, Chamberland, & Tremblay, 2017). In these instances, individuals are aware that a target feature may change. As shown in the present study, providing individuals with unreliable information led to fewer correctly reported changes. Surveillance operators may experience a similar situation in their work (Hodgetts, Vachon, Chamberland, & Tremblay, 2017). Operators must judge the reliability of their information and immediately act on it. When information deemed reliable is incorrect, then a target may be missed. The research of Posner, Snyder, and Davidson (1980) supports this notion by showing that unreliable cues resulted in fewer target detections and slower responses when compared to reliable cues.

An additional implication for surveillance is the impact of interruptions. Hodgetts et al. (2017) described the prevalence of interruptions while operators perform monitoring tasks and suggest that interruptions and distractions hinder target detection and lead to misses and false alarms. Once operators return to the task after an interruption, the viewing screen may have changed. The results of the present study showed that detections in the interrupted conditions were significantly lower and provide a cautionary note about the potential effects of interruptions in real-world surveillance tasks. Smallman and St. John (2005) noted that operators may be unaware that the environment has changed, even when reliable cues are available.

By contrast, there are other lower risk situations where interrupting the viewer's visual stream is a fundamental part of the job. For example, magicians intentionally create visual interruptions to occlude an object change with sleight of hand or a misdirection (Macknik et al., 2008). Magicians use a visual interruption in order to perform a change, usually with individuals having some knowledge of the potential for a change. These interruptions are harmless and entertaining, but the observer's experience is similar to the surveillance operator. The individuals' knowledge that they are watching a magic trick does not typically help them detect the changing object. They are unaware of the object change and that they have been fooled until the magician completes the illusion.

Limitations

There were several limitations with this study that bear consideration. One limitation was that the overall number of detected changes was low. The level of correct detections varies among change blindness paradigms (Rensink, 2000; Simons, 2000); however, the level found in the present study is far below other change blindness studies. Participants were informed about the presence of changes in the twenty-four videos but were not aware of the specific videos containing a change. Additionally, participants were told that changes could be related to brightness, color, appearance, or disappearance. This amount of information appeared to be insufficient to help most participants detect the changes.

Another limitation was that the level of detected changes varied across the eight change videos. Several methods were used to minimize the possibility that some changes would be more detectable than others. The magnitude of differences in brightness and color applied to the change objects was matched. The location of the changes was balanced between the center and periphery across the videos. Additionally, the amount of motion and objects within a video were balanced. Each of the eight change videos was created in pairs for the four change types. The two videos were balanced so that one video included many and the other included few moving objects within a scene. Finally, the videos were checked to make sure no events occurred at the same time as the change. For example, a change occurring near a traffic light did not occur if the traffic light was in the process of changing colors. Unfortunately, the results showed that these efforts were insufficient. The dynamic scenes used as stimuli were complex with many objects and different sources of motion that could have diverted a participant’s attention away from the intended sources of change.

A final limitation of the present study concerns the size and saliency of the change objects in the environment. Brightness and color changes were evaluated so the original and changed object were noticeably different when compared side-by-side. In previous research (Rensink, O'Regan, & Clark, 1997; Simons, Franconerri, & Reimer, 2000), there has been limited or no information about the efforts taken to create and equate color or brightness changes. For example, a color shifting from yellow to blue may also shift in brightness. Adjusting the brightness and hue within a color change could make a target more salient than if only the color shifted.

Therefore, in the present study, an attempt was made to match changes in hue and brightness between the changed and non-changed object. Brightness changes were also equated so that the hue and color were similar to the changed object. The actual color and brightness changes were controlled so that they increased or decreased by a factor of five. While brightness changes had the most detections, color changes had the lowest. This finding suggests that color changes were less salient.

Additionally, the size of the appearance or disappearance changes may have been influenced by their known sizes within the real world. While the size of the appearing or disappearing objects in the video image was comparable, the semantic knowledge of the objects differed. For example, a scene involving a boat disappearing may have been more salient than a lightbulb disappearing. More individuals in the present study reported the boat disappearing than the lightbulb. Therefore, the level of detection may have been partly dependent on knowledge about the size of objects within the scene.

Future Research

The present study provided an initial examination into how interruptions impact change detection performance within dynamic scenes. Interrupted videos resulted in lower levels of detection than uninterrupted videos. While a significant effect was found between interruption conditions, it was not possible to determine where participants were looking when the changes occurred. Previous change detection research measured participant interactions through eye gaze data or clicking on locations in the scene (Grimes, 1996; Rensink, O'Regan, & Clark, 1997; Simons, Franconerri, & Reimer, 2000). While the present study provided conceptual cues relating to the target, participants may not have utilized the cues when searching for the change targets. Thus, the opportunity to measure participant gaze and click information would allow researchers to understand where participants directed their gaze and can demonstrate how given cues affect visual search under various reliability conditions.

Another goal for future research should be to evaluate how motion during visual interruptions impacts change detection. The present study utilized a design where the video was paused during the six-second occlusion in order to prevent objects in motion prior to the interruption from changing their position after the interruption. Allowing the video to continue to play while the interruption occurred would have resulted in some objects appearing and disappearing from the screen during the intervening interval. However, in the real world, motion continues during the occluding interval. Therefore, future research should assess how an object's motion or trajectory during a visual interruption impacts the ability to detect changes within a scene.

An additional goal for future research should be to better study how conceptual cues affect change detection. Logan (1996) theorized that conceptual cues can relate to an object within physical space. However, the conceptual cues used in the present study only aided target search during uninterrupted trials. During interrupted trials, the cues were not effective. A potential reason for poorer detection was that cues encoded prior to the interruption decayed within memory. Altmann and Trafton (2002) hypothesized that interruptions require the primary task to be suspended and held within working memory until resumed. Within the context of change detection, objects must be accurately encoded and later recalled after the interruption. Rensink (2002) theorized that objects undergoing change are more readily detectable when visual occlusions are not present. Rensink suggested that object changes must be viewable before, during, and after the change occurs. However, the nature of the cues and the potential for different effects was not considered by Altmann and Trafton or Rensink. Thus, a future goal should be to study more fully how conceptual cues impact working memory in interruption research.

Another goal for future research should be to examine further the effects that interruptions have on SA. The present study showed that interruptions decreased the number of correctly reported changes and suggest that interruptions occurring during level 1 SA may have a negative effect on objects encoded in working memory. Further, because information obtained in level 1 SA influences decisions made during levels 2 and 3 SA (Endsley, 1995), these results have implications for tools used to measure SA such as the SAGAT method. Therefore, future research should address change detection performance utilizing the SAGAT method.

CHAPTER 5

CONCLUSION

The goal of the present study was to examine how visual interruptions affect the ability to detect changes in real-world dynamic videos under different cuing conditions. Previous research regarding interruptions and change detection has primarily utilized simple shapes, letters, pictures, or stimuli that do not represent the real-world environment. Currently, there is limited research on the nature of visual interruptions and cued recall within a dynamic environment. To address this need, the effects of cue reliability and interruptions were examined within dynamic scenes involving various types of feature changes. The results of the present study support previous change detection research suggesting that interruptions can limit the ability to detect changes in real work scenes even when reliable cues are provided.

The findings of the present study provide additional support for MFG theory (Altmann & Trafton, 2005) regarding the impact of visual interruptions and cueing. As theorized in MFG, the observed performance decrement suggests cues decayed during the visual interruption which resulted in fewer detected changes. This finding also has implications for interruption-based research methods, such as the SAGAT approach. The present findings suggest that SA gained during a task may be lost after a visual interruption. In summary, these results show that visual interruptions pose a significant threat to change detection regardless of the reliability of change information available.

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APPENDIX A

SCREENING QUESTIONS

1. Are you a native English speaker?
    a. Yes
    b. No
2. Do you identify as being colorblind or have you been diagnosed as being colorblind? Please answer honestly.
    a. Yes
    b. No
    c. Unsure

APPENDIX B

DEMOGRAPHIC QUESTIONS

1. What is your current age?

    ____

2. What gender do you identify as?

    A. Male

    B. Female

    C. Other

APPENDIX C

INFORMED CONSENT DOCUMENT

PROJECT TITLE: The Effect of Cuing on Task Interruptions in a Dynamic Scene

INTRODUCTION
The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participation in this research, and to record the consent of those who say YES. The title of the study is The Effect of Cuing on Task Interruptions in a Dynamic Scene. This study will be conducted in room 126 in the Mills Godwin Building.

RESEARCHERS
Mark W. Scerbo, Ph. D., Responsible Project Investigator, College of Sciences, Psychology
Kimberly Perry, B.S., Investigator, College of Sciences, Psychology

DESCRIPTION OF RESEARCH STUDY
Several studies have examined the effects of cues and interruptions on recall of information. None of them have studied these factors in dynamic situations.

If you decide to participate, then you will join a study examining the recall of information from a set of twenty-four videos. Some of the videos may be interrupted with a question during the scene, which requires you to respond verbally. After each video ends, you will be asked 3 questions about what occurred. If you say YES, then your participation will last no longer than 75 minutes. Approximately 120 students will be participating in this study.

EXCLUSIONARY CRITERIA
You will complete a brief background survey to indicate if you are colorblind and whether English is your primary language. To the best of your knowledge, you should not have any color deficiencies and English should be your primary language to participate in this study.

RISKS AND BENEFITS
RISKS: If you decide to participate in this study, then you may face a risk of some fatigue from watching the set of video clips. The researchers have tried to reduce these risks by allowing breaks in between each video. And, as with any research, there is some possibility that you may be subject to risks that have not yet been identified.

BENEFITS: There are no direct benefits for participating in this study.

COSTS AND PAYMENTS
The researchers want your decision about participating in this study to be voluntary. Yet they recognize that your participation may pose as an inconvenience to your time. If you decide to participate in the study, you will receive 2 Psychology department research credits, which may be applied to course requirements or extra credit in certain Psychology courses. Equivalent credits may be obtained in other ways, such as conducting library reports and online surveys. You do not have to participate in this study, or any Psychology Department study, in order to obtain this credit.

NEW INFORMATION
If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

CONFIDENTIALITY
The researchers will take responsible steps to keep private information, such as pre-study, verbal, and written

responses confidential. You will not be asked to provide any personal identifiers. Information will be stored in a locked filing cabinet prior to its processing. The results of this study may be used in reports, presentations, and publications; but the researcher will not identify you. Of course, your records may be subpoenaed by court order or inspected by government bodies with oversight authority.

WITHDRAWAL PRIVILEGE

It is OK for you to say NO. Even if you say YES now, you are free to say NO later, and walk away or withdraw from the study -- at any time. Any data that has already been collected will be destroyed and will not be included in the final analysis. Your decision will not affect your relationship with Old Dominion University, or otherwise cause a loss of benefits to which you might otherwise be entitled.

COMPENSATION FOR ILLNESS AND INJURY

If you say YES, then your consent in this document does not waive any of your legal rights. However, in the event of harm, injury, or illness arising from this study, neither Old Dominion University nor the researchers are able to give you any money, insurance coverage, free medical care, or any other compensation for such injury. In the event that you suffer injury as a result of participation in any research project, you may contact Dr. Mark Scerbo the primary investigator at (757) 683-4217, Dr. Tancy Vandecar-Burdin the current IRB chair at 757-683-3802 at Old Dominion University, or the Old Dominion University Office of Research at 757-683-3460 who will be glad to review the matter with you.

VOLUNTARY CONSENT

By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions later on, then the researchers should be able to answer them:

Dr. Mark W. Scerbo, mscerbo@odu.edu, (757) 683-4217
Kim Perry, email: kperr001@odu.edu.

If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. Tancy Vandecar-Burdin, the current IRB chair, at 757-683-3802, or the Old Dominion University Office of Research, at 757-683-3460.

And importantly, by signing below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

Subject's Printed Name & Signature	**Date**

INVESTIGATOR'S STATEMENT

I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws, and promise compliance. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during the course of this study. I have witnessed the above signature(s) on this consent form.

Investigator's Printed Name & Signature	**Date**

APPENDIX D

POST-VIDEO GENERAL QUESTIONS

1) Traffic sign/manhole cover/ video_1
   a) This video shows a scene of _____.
      i) Bumper-to-bumper standstill traffic
      ii) Pedestrians walking on a city street
      iii) Cars driving in an intersection.
   b) How many FedEx trucks went through the intersection?
      i) 0
      ii) 1
      iii) 3
2) Park/video_2
   a) The ferris wheel stopped _____ time(s).
      i) 1
      ii) 3
      iii) The ferris wheel did not stop.
   b) Which of these items appeared in the video?
      i) A hot air balloon
      ii) A battleship
      iii) A ferris wheel
3) Events/video_3
   a) This scene took place at a:
      i) Museum

ii) City street

iii) Subway

b) The city posted a sign saying:

i) No bicycles

ii) No stopping

iii) No cursing

4) Church podium/Church choir/video_4

a) How many females appeared in the scene?

i) None

ii) 2

iii) 4

b) Approximately, how many people were wearing suit jackets?

i) 1

ii) 3

iii) 5

5) zoo/video_5

a) Approximately how many strollers were in this video?

i) 1

ii) 4

iii) 10

b) The floor of the enclosure was covered in _____.

i) flowers

ii) grass

iii) sand

6) Folders/typing/video_6

a) Most people in the scene were dressed in _____ attire.

i) Professional

ii) Athletic

iii) Uniform

b) The scene appeared to be:

i) A party

ii) A meeting

iii) A lecture

7) Street crossing/video_7

a) This video shows a scene of _____.

i) People watching a parade.

ii) People waiting for a parade.

iii) People marching in a parade.

b) A _____ was in the scene

i) Parade float

ii) bus

iii) Castle

8) Memorial/video_8

a) One of the monuments was a _____.

i) Ship

ii) Person

iii) Anchor

b) How many flags were in the scene?

i) 1

ii) 3

iii) 6

9) Banner/volunteers/video_9

a) People were running on _____.

i) The left side of the road

ii) The right side of the road

iii) Both sides of the road

b) All/most of the runners were _____.

i) Men

ii) Women

iii) Men and women

10) Boardwalk/ video_10

a) Most people in the scene were _____.

i) Swimming

ii) Biking

iii) Walking

b) What time of day was it in the scene?

i) Sunrise/Sunset

ii) Mid-day/Afternoon

iii) Night/Midnight

11) fishing/video_11

a) This video shows a scene of _____.

i) People fishing.

ii) People prepping a boat.

iii) People playing in the water.

b) Which of the following was on the pier?

i) Boats

ii) benches

iii) Bait shack

12) Trashcans/dock/video_12

a) The sailboat had _____ masts.

i) 1

ii) 2

iii) 3

b) What color was the mermaid's hair?

i) Black

ii) Grey

iii) Blond

13) Card players/festival setup/video_13

a) The scene took place at _____.

i) A mall

ii) A park

iii) A house

b) Which of the following **did not** occur in the scene?

i) People were playing a card game

ii) People were doing maintenance on tents

iii) People were mowing the grass

14) Waterside/video_14

a) Most people in the scene were _____.

i) Sitting

ii) Standing still

iii) Leaning over the balcony

b) Which of these was not shown on the television in the video?

i) Commentators

ii) Baseball

iii) Music Videos

15) Downtown Norfolk/video_15

a) There were _____ pedestrians in the scene.

i) zero

ii) around 7

iii) around 15

b) What kind of business were people entering in the scene?

i) A movie theater

ii) A store

iii) A hotel

16) Chess/video_16

a) The people playing were _____.

i) Children (Under 19)

ii) Adults

iii) Elderly (60 +)

b) People were watching from a _____.

i) Roped off area

ii) Window

iii) There were no spectators

17) Webb/video_17

a) People in the scene were _____.

i) Walking

ii) Performing

iii) Buying lunch

b) The message on the sign asked you to:

i) Enjoy your school year

ii) Enjoy your summer

iii) Register for classes

18) Tourism/video_18

a) What were most people looking at in the scene?

i) A statue

ii) A performer

iii) A palm tree

b) How many people wore long pants?

i) 0

ii) 2

iii) 5

19) Graduation/video_19

a) Students in the scene were receiving a _____.

i) Pin

ii) White coat

iii) Medal

b) The scene took place in a(n) _____.

i) Auditorium

ii) Theater

iii) Tent

20) Sailing boats/sunbathing/video_20

a) How many people opened up the cooler?

i) 0

ii) 1

iii) 3

b) How many umbrellas were in the video?

i) There were no umbrellas

ii) Less than 10

iii) More than 10

21) Beach/video_21

a) Where did this scene take place?

i) Sandy beach

ii) Pool

iii) Country club

b) Most people in the scene were _____.

i) Swimming

ii) Playing volleyball

iii) Laying down/sitting

22) North webb/video_22

a) Most people in the scene were _____.

i) Studying

ii) Reading

iii) Getting coffee

b) How many people entered Monarch Market?

i) 0

ii) 1

iii) 3

23) Street light/no alcohol sign/video_23

a) This scene took place at a _____.

i) Park

ii) Suburban street

iii) City street

b) Approximately how many parked cars were in the scene?

i) 1

ii) 4

iii) 7

24) Boat preparation/video_24

a) Approximately how many banner flags were in the scene?

i) 4

ii) 8

iii) 12

b) This video shows a scene of _____.

i) People were finishing a race.

ii) People were watching boats on the water.

iii) People were swimming.

APPENDIX E

THIRTEEN INTERRUPTION QUESTIONS

(12: Experiment; 1: Example Video)

1. Did your 1st grade teacher wear glasses?
2. Approximately, how many chairs were in the last class you attended at ODU?
3. What was the color of your first phone case?
4. What were your High School's school colors?
5. Approximately, how many houses were on the street you grew up on?
6. Does your winter coat have a zipper?
7. What was your first Halloween costume (that you can recall)?
8. What did you wear to your first job?
9. Where did you park your car today?
10. What car did you use for your driving road exam?
11. What row did you sit in the last time you were on a bus?
12. What color was your bedroom in elementary school?
13. Currently, what side of the room is you bed located?

VITA

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EDUCATION

Old Dominion University; Norfolk, VA — **2016 - Present**
PhD, Human Factors (expected May 2021)
MS, Applied Experimental Psychology (August 2019)

Louisiana State University; Baton Rouge, LA — December 2013 - May 2016
Bachelor of Science in Psychology

SELECTED PUBLICATIONS

Hayden, E.M., Wong, A.H., Ackerman, J., Sande, M.K., Lei, C., Kobayashi, L., Cassara, M., Cooper, D. D., **Perry, K**., Lewandowski, W.E., & Scerbo, M.W. (2018). Human factors and simulation in emergency medicine. *Academic Emergency Medicine, 25*, 221-229.

Scerbo M. W., Warvel L, Zybak S., Kennedy R., Ashdown A., **Perry K.**, Newlin-Canzone E., Papelis Y.E., Croll M., & Garcia H. (2017). Analysis of effective speech recognition in a virtual operating room. *Proceedings of the 2017 MODSIM World Conference*.

CONFERENCE POSTER

Perry, K., & Scerbo, M.W. (2019). The impact of interruptions on feature change detection within dynamic scenes. In *Proceedings of the Human Factors and Ergonomics Society 63rd Annual Meeting*, Seattle, WA.

Ashdown, A., Scerbo, M., **Perry, K**., & Davis, S. (2018). Using a Simulated FHR Alert System to Detect Automation-Induced Complacency. Poster session at the *18th Annual International Meeting on Simulation in Healthcare*, Los Angeles, CA.

PROFESSIONAL SERVICE

Judge, Virginia Junior Academy of Science (2018)
Scribe, Society for Academic Emergency Medicine (2017)
Vice President, ODU HFES Student Chapter (2017)
Secretary, ODU HFES Student Chapter (2016)

AWARDS

HFES NEM 2018 Best Action Plan	October 2018
SEES Graduate Student Travel Award	January 2018
HFES First-Year Student Travel Award	October 2017
HFES 2017 Best Action Plan for Student Chapter	October 2017