

**A Dual Process Account: The Effect of Context Congruency on Identification
and Detection Processes in a Change Detection Task**

BY

Sydney Woodin

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Abstract

The goal of this study was to investigate the underlying processes involved in complex scene perception and, more specifically, the influence of context congruency on change detection performance. In two separate experiments, participants were asked to detect changing objects embedded in contextually congruent and incongruent scenes. In the first experiment, participants were faster and made fewer errors detecting incongruent objects than congruent objects. In the second experiment, participants were given valid and invalid cues for the target objects. In this case, participants were faster and made fewer errors detecting incongruent objects when the cue did not accurately describe the target object. This incongruency benefit, however, was eliminated when the cue accurately described the target object. These findings support a dual process account of complex scene perception, wherein task constraints can lead to incongruency benefits in some cases, but not others.

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A Dual Process Account: The Effect of Context Congruency on Identification and Detection Processes in a Change Detection Task

Accurately finding and identifying objects is an important part of our everyday lives. As we move through our day, we are constantly confronted with complex visual scenes that require our attention to focus on what is important and inhibit distraction. Prioritizing information for the focus of attention is said to occur in at least two different ways: endogenously and exogenously (Posner, 1980). Endogenous orienting of attention occurs in a top-down manner, it is resource demanding, goal-driven, and requires conscious effort. For example, imagine you are riding your bicycle on an unfamiliar trail. While you are riding your attention is focused on the trail and your surroundings to keep you safe. On the other hand, exogenous orienting of attention occurs in a bottom-up manner, it requires few resources, is driven by physical features of the environment, and does not require conscious effort (Ruz & Lupianez, 2002). In this case, while you are riding your bicycle through the trails you hear the growl of a bear up ahead. Here, instead of focusing your attention on the safe operation of your bicycle your attention is effortlessly directed to the bear.

In addition to salient features of the environment (e.g., bright lights and loud noises) capturing attention exogenously, some researchers have suggested that points of semantic conflict in a visual scene also quickly and effortlessly attract our attention (LaPointe & Milliken, 2016; Ortíz-Tudela et al., 2017; Smilek et al., 2006), although this claim has been controversial (Henderson et al., 1999). For instance, spotting a dolphin swimming in a backyard pool would catch our attention much faster than seeing a dolphin at a local aquarium because in the former case, the object is contextually

incongruent with the surrounding scene. Seeing a dolphin in a backyard pool does not fit with our previous semantic knowledge and our expectations of backyard pools, therefore our attention is drawn to the object for further processing. Some researchers have described the orienting of attention to semantically incongruent objects as attention being drawn to areas of the scene that are particularly informative and require further investigation (Hollingworth & Henderson, 2000).

The Role of Congruent Contexts in Attention Allocation

For the most part, the visual scenes we encounter, and the objects embedded within them, are contextually congruent. Our past experience with similar scenes can help us navigate new scenes effortlessly by guiding our attention to areas of the scene that are in line with our current goals (Vo & Schneider, 2010). For example, imagine driving along an unfamiliar highway. Despite having never driven on that highway before, your attention does not wander aimlessly. You know where your attention is needed for the safe operation of the vehicle, based on your previous experience with similar scenes. In this way, the context guides attention to relevant areas of the scene (Neider & Zelinsky, 2006).

A classic example of past experience guiding attention comes from the contextual cueing literature. Chun and Jiang (1998) conducted several experiments exploring different target and scene configurations. In a typical experiment, participants were asked to search for a specific targets (T shapes) among distractor stimuli (L shapes) and asked to respond based on the rotation of the letter by pressing the corresponding key as fast as possible. The configurations were divided into two categories: old and new. The experiment consisted of 720 trials split into 6 blocks in which the “old” configurations

were repeated numerous times. In each block however, 12 “new” configurations specific to that block were added. Location probability effects were eliminated by ensuring that the target objects were placed in one of the 24 locations equally as often. This suggests that any differences among trials as participants proceed through the experiment can be attributed to implicit learning of the configurations. Chun and Jiang discovered a contextual cueing effect which suggests that participants unintentionally learned the configurations after repetition, thereby completing faster and more accurate trials. This study demonstrates that prior experience with a context can guide attention implicitly and be easily applied to subsequent search tasks producing faster and more accurate trials (Chun & Jiang, 1998).

Davenport and Potter (2004) conducted another study in which a context congruency advantage was present. In this series of experiments, participants were shown various images containing target objects that were either semantically consistent or inconsistent with the background. In each experiment participants were asked to describe a different part of the scene—either the background, the target object, or in one case both. Overall, Davenport and Potter found that participants were faster and more accurate at reporting objects and backgrounds when they were semantically congruent than when they were semantically incongruent.

These studies demonstrate that a congruent context is exploited for both the efficient and effortless navigation of a scene, but also for the identification of the objects that make up the scene. Relying on previous semantic knowledge allows us to process visual scenes we have not yet encountered, but are similar to past experiences, and thus interpret them faster and more accurately.

The Role of Incongruent Contexts in Attention Allocation

The studies mentioned above provide evidence that a congruent context and its similarity to past experiences is exploited for efficient and effortless attention processing. Yet, there are several studies that demonstrate encountering an object out-of-context produces efficient attentional processing as well (Loftus & Mackworth, 1978; Hollingworth & Henderson, 2000; LaPointe et al, 2013; Ortiz-Tudela et al., 2017). Loftus and Mackworth's study was one of the first to demonstrate a context incongruency benefit.

Loftus and Mackworth (1978) presented participants with complex line drawings that incorporated a target object that was either contextually congruent or incongruent. Participants were asked to examine the scenes in preparation for a later recognition test. As participants studied the scenes their eye movements were recorded. Loftus and Mackworth suggested that eye fixation is closely related to the focus of attention. The researchers found that participants fixated the incongruent targets significantly faster than the congruent targets. They, therefore, concluded that attention was drawn to incongruent objects (Loftus & Mackworth, 1978).

Attempts to replicate the findings of Loftus and Mackworth (1978) have produced mixed results. Some researchers have argued that the simplistic stimuli used by Loftus and Mackworth may have contributed to the incongruency benefit they reported (Henderson & Hollingworth, 1999). However, others have replicated the incongruency benefit using more naturalistic and complex stimuli, although using different tasks (Gordon, 2004; LaPointe et al., 2013; LaPointe & Milliken, 2016, 2017; Ortiz-Tudela et al., 2017, 2018).

In one study, LaPointe and Milliken (2016) used a flicker task to present participants with photographs that switched between scenes that contained and did not contain a target object. The target objects were either congruent or incongruent with the semantic context of the scene. The participants were asked to detect the object that was changing as quickly and accurately as possible and then identify the object. LaPointe and Milliken reported faster performance for the incongruent than congruent targets and that eye movements were directed preferentially toward the incongruent objects early in scene processing. These results are in line with the previous research by Loftus and Mackworth (1978) and were taken as evidence that semantically incongruent objects attract attention. Although in this case, the images were presented in a brief and repetitive manner, as opposed to the sustained viewing task used by Loftus and Mackworth.

A Dual Process Account

The research reviewed to this point reports conflicting effects of context congruency on attention allocation during scene perception. In some cases, a congruent context helps the viewer navigate a scene and identify the objects that make up the scene. In other cases, an incongruent object draws attention, leading to fast detection and identification. Recently researchers have proposed a dual process account of these conflicting results (LaPointe et al., 2013; LaPointe & Milliken, 2016, 2017; Ortiz-Tudela et al., 2017, 2018). According to this account, a process involved in identifying objects in a scene benefits from context congruity. Based on past experience, a congruent context drives expectations about what should be present in a scene, it helps effortlessly guide attention to important areas of the scene, and it helps to easily identify objects that make up the

scene. At the same time, a process involved in the detection of novelty benefits from context incongruity. As expectations are driven by the context of a scene, attention is drawn to areas that violate those prior expectations (e.g., semantically incongruent objects). Researchers have argued that these two processes, detection and identification are at play during most situations of scene perception. However, the weighting of the two processes will be determined by task constraints and will lead to differences in performance. In an attempt to shift the relative weighing of these two processes with a single task LaPointe et al. (2013) used a change detection task.

In a typical change detection task participants are shown scenes or photographs with a target object (Rensink et al., 1997). The scene changes rapidly between a picture containing the target object and a scene where the object is absent, usually with a white or grey screen interleaved between picture presentations. The participants are asked to detect the change as quickly as possible by identifying the object that is absent from one scene (Rensink et al, 1997). Change detection tasks have been shown to reliably produce incongruency benefits, such that incongruent objects are detected faster and more accurately than congruent objects (Gordon, 2004; Hollingworth & Henderson, 2000, LaPointe & Milliken, 2016).

Over the course of three experiments, LaPointe et al. (2013) investigated whether subtle manipulations to a change detection task could shift the weighting of identification and detection processes in such a way as to produce congruency benefits. In the first experiment, participants viewed images that contained either semantically congruent or incongruent target objects. On each trial the images rotated between three screens: an image containing the target object, a blank screen, and an image of the same

scene but without the target object. Participants were required to detect the changing object as quickly and accurately as possible and then to report the identity of the object. The researchers replicated previous findings, showing more efficient performance for incongruent objects than congruent objects.

LaPointe et al. (2013) argued that if the detection portion of the task was made trivial, performance should shift from an incongruency benefit to a congruency benefit. To do so, in the second experiment the researchers removed the blank screen typically presented between images in change detection tasks. In this case, the usual incongruency benefit was reversed and participants were now more efficient at detecting congruent target objects than incongruent target objects. In a final experiment, LaPointe et al. attempted to shift the relative weighting of the two processes disproportionately in favour of the detection process. To achieve this, the researchers had participants complete an experiment similar to their first experiment, but instead of a requirement to identify the changing objects, the participants were asked to locate the objects. The results for this experiment yielded a significantly large incongruency benefit. LaPointe et al. took these findings as evidence that there are two processes that underlie scene perception: identification and detection. Further the relative weighting of these two processes favours detection in a typical change detection task, producing performance benefits for incongruent objects in this task.

LaPointe and Milliken (2017) took a different approach in an attempt to provide more evidence in support of the two processes that underlie scene perception. The strategy here was to compare scene perception performance across tasks. In particular, the researchers compared scene perception in a visual search and change detection task

while keeping the stimulus set constant. LaPointe and Milliken reported the typical incongruency benefit in change detection performance; that is, target objects that were semantically incongruent with the context of the scene were detected more efficiently than target objects that were semantically congruent. Conversely, performance in the visual search task favoured congruent target objects. LaPointe and Milliken argued that there are features of the visual search task that favour the use and exploitation of congruent contexts. One such characteristic is the sustained scene viewing in a visual search task. In contrast to the brief and abrupt scene presentations used in change detection tasks, in visual search tasks participants usually have long and uninterrupted views of the scenes.

Another task feature that differs across visual search and change detection tasks is that in visual search tasks participants are usually given information about the target object at the beginning of each trial. That is, they have prior knowledge of what to look for in the upcoming visual scene. In change detection tasks, however, no such information is given prior to the trial. LaPointe and Milliken (2017) argue that this prior knowledge of the target object might encourage participants to use the context to guide their search, producing a performance advantage for target objects embedded in contextually congruent scenes. Similarly, Chun and Jiang (1998) found that individuals were faster to identify targets in a scene if they had been cued with a picture or word. The literature surrounding attention cueing before viewing visual scenes suggest that a cue produces a context congruency benefit. However, a gap in the literature indicates that there is no evidence that a cue benefits perception of more complex scenes. Past research has only explored this phenomenon with geometric configurations and line

drawings that can be implicitly learned. Researchers propose that restrictions within a specific scene are guided by our semantic knowledge (e.g., we would not expect to see a dolphin in a backyard swimming pool) and because of that, we use different processes to evaluate more complex scenes than we do simpler ones in which we do not possess previous semantic information about (Hollingworth & Henderson, 2000).

Neider and Zelinsky (2006) also conducted a study exploring the effects of contextual cues. They focused on the influence a cue has on response times to incongruent and congruent target objects in a scene (Neider & Zelinsky, 2006). In this experiment, only three target objects were used: a helicopter, a blimp, and a jeep. Instead of the typical change detection task Neider and Zelinsky included multiple objects in each scene. Some objects were placed in areas of the scene that fit their context (e.g., a helicopter in the air) whereas, others were placed in more unexpected locations (e.g., a jeep in the air). The motive here was to determine which objects participants fixated on most, incongruent or congruent objects. Before participants were shown the scene, they were given cue words to guide them in their search for the target object. Here, Neider and Zelinsky discovered a congruency benefit. That is, participants were faster and fixated more often on objects that were congruent with their placement in the scene. The authors speculated that this occurred because participants used the cue word to guide their attention to appropriate areas in the scene, therefore they were more likely to find congruent objects over incongruent (Neider & Zelinsky, 2006).

The studies discussed above suggest having prior knowledge of the target object encourages participants to use a congruent context to guide their attention when exploring a visual scene. LaPointe and Milliken (2017) argue that having this prior

knowledge acts as a cue to lean more heavily on the identification process and a congruent context, than the detection process and an incongruent context. To explore this idea further LaPointe and Milliken attempted to shift the relative weightings of the two processes in a change detection task by giving participants information about the target object prior to completing a change detection trial. Participants were presented with an image or word describing the target object prior to the presentation of the scenes in the change detection task. Adding the prior knowledge element of a visual search task to the change detection task created a shift towards using the object identification process. LaPointe and Milliken found that introducing information about the target object prior to the change detection task reduced the size of the incongruity benefit but did not eliminate it and it did not produce a congruency benefit as predicted. Nonetheless, LaPointe and Milliken speculated that having knowledge of the upcoming target object encouraged participants to use the structure of the scene to guide attention on congruent trials. The researchers took the reduction in the size of the incongruity benefit in this case as further evidence that two processes underlie scene perception and the relative weightings of these two processes are contingent on task constraints (LaPointe & Milliken, 2017).

This research suggests that methods that guide attention in change detection tasks are very different from those that guide attention in visual search tasks. It also implies that the processes involved in perception of visual scenes are complicated and the results reported in the literature have been conflicting. Although the manipulation of many of these variables have provided more clarity on how internal attention processes work, further investigation into these topics is necessary.

Conducting Cognitive Psychology Experiments Online

In recent years, conducting psychological research online has become much more prominent (Semmelmann & Weigelt, 2017). Online studies are no longer limited to surveys and questionnaires. Psychologists are using online platforms to conduct research in most sectors of psychology including cognitive research. Many researchers are wary of the of the possible environmental differences when using an online platform and how that will impact the results of their studies. Researchers have expressed concerns surrounding the differences in operating systems, connection speeds and actual hardware (Semmelmann & Weigelt, 2017). Despite these concerns, recent research has demonstrated that studies in cognitive psychology conducted online have largely replicated those conducted in the laboratory.

Semmelman and Weigelt (2017) used 5 classic paradigms in cognitive psychology and attempted to replicate them using an online platform. The researchers explored the Stroop task, the Flanker task, a visual search task, a masked priming task, and an attentional blink task. They divided participants into three conditions: a classical laboratory setting, web based in a laboratory setting and a web setting. These conditions were chosen so that the researchers could investigate environmental, hardware, and technology differences across the three settings (Semmelman & Weigelt, 2017). After conducting two experiments to establish a baseline, researchers went on to conduct 5 more experiments, one for each task. The results revealed that despite the significant differences in response times between conditions they were able to replicate four of the five tasks in an online setting. The priming task was not replicated, however Semmelman and Weigelt (2017) argue this was due to the time sensitive nature of the

task. These results demonstrate the robustness of several cognitive psychology effects, with similarity in results between online and laboratory experiments.

Published research on complex scene perception using online tools is sparse. One example comes from Spaak et al. (2020) who used an online platform to investigate the influence of context congruity on change detection performance. By addressing many of the problems found in previous research Spaak et al. believed that this online study would provide more insight into the processes underlying scene perception. The researchers used a flicker task with a localization component to assess accuracy, in addition to a response time measure. The localization component is particularly important in an online study because it ensures task compliance when a researcher is not present. Using the online approach for data collection, Spaak et al. were successful in replicating the previous laboratory-based studies—demonstrating faster and more accurate change detection for incongruent objects than congruent objects. These results indicate that despite using an online platform, participants are still faster at detecting changes to incongruent objects than congruent objects in a complex visual scene.

Current Study

The current study was designed to further investigate the processes involved in scene perception, with a particular focus on the influence of context congruency. To this point, there have been conflicting reports of performance benefits when a target object is semantically congruent or incongruent with the context of a scene. Researchers have proposed two independent processes that drive scene perception: identification and detection. Further, the relative weighting of these two processes in any given task will determine the efficiency with which semantically congruent and incongruent scenes will

be perceived. The intention of the current study is to further illustrate the processes of identification and detection and to demonstrate that the weighting of these processes can be directly manipulated using a change detection task.

Experiment 1

The purpose of the first experiment was to replicate the common finding of an incongruency benefit in a change detection task and to do so using an online platform for data collection. Participants were asked to detect a changing object across brief and repeated scenes as quickly and accurately as possible and to then indicate where that object was located in the scene. Previous research has shown that performance in this task relies more heavily on the process of detection than the process of identification. Therefore, it is expected that participants will show faster and more accurate change detection performance on incongruent trials than congruent trials.

Method

Participants

Twenty-four undergraduate students (6 male) enrolled in an introductory psychology course at Mount Allison University, ranging in age from 18 to 24 years ($M = 19.43$, $SD = 1.98$) volunteered to participate in this experiment in exchange for partial course credit. All participants reported normal or corrected-to-normal vision.

Materials

One hundred and forty pairs of images that were taken in Brisbane, Australia were used in Experiment 1. These images were taken from a previous study conducted

by LaPointe et al. (2013). The pairs consisted of a background only photo (A') and a photograph with the same background containing a target object (A). The background photographs were taken in various conditions and settings. They varied in their lighting, complexity, and location (i.e., both indoors and outdoors). The photographs containing a background and target object were created digitally by inserting target objects into the previous existing background photographs. The target objects consisted of animate objects (e.g., humans and non-human animals) and inanimate objects (e.g., plants, lamp posts, and cars).

Half of the image pairs included target objects that are semantically congruent with the background scene, and the other half included target objects that were semantically incongruent with the background scene. For the contextually congruent background and object pairing a target object that would naturally be found in the scene was selected and placed in a naturally fitting position within the photo (e.g., a toaster on a kitchen counter). In the contextually incongruent images, the target objects were placed in a background where they would not naturally be found but were still placed in a naturally fitting location (e.g., an emu on the living room floor). The object categories differed from photograph to photograph on what was regarded as contextually congruent and incongruent. For example, a forest background would be considered contextually congruent for a bear, but it would be contextually incongruent for a boat. Although target objects were embedded in various backgrounds for both contextually congruent and incongruent conditions, the objects were always placed in similar locations between conditions. For instance, if in the contextually congruent condition (e.g., forest floor) a target object (e.g., a bear) was placed in the middle of the photograph, in the

contextually incongruent condition (e.g., bedroom floor) the target object (i.e., the bear was also located in the centre of the image.

The experiment was programmed and conducted online using gorilla.sc, a website designed by cognitive psychologists for cognitive psychology experiments. Because the experiment was conducted online, the computers and keyboards used by the participants necessarily varied.

Procedure

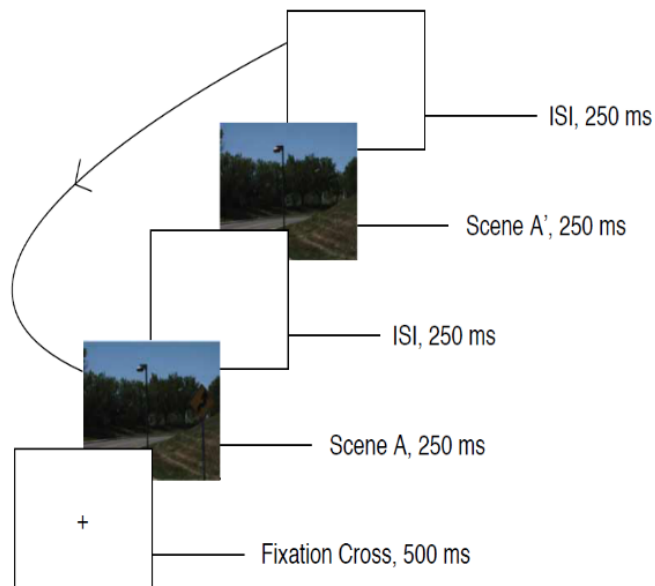
Before beginning the experiment, participants were provided with a consent form that detailed the potential risks and benefits of participating in the study. The consent form also informed participants that they were free to end the experiment at any time at no penalty. Once the participants had read and agreed to the terms of the consent form, they were given written instructions detailing the nature of the task.

Each trial began with the presentation of a fixation cross, centred on the screen for 500 ms. Following the fixation cross, the first image (*A*) was presented for 250 ms. The first image contained both the background and target object. This image was replaced with a blank white screen or interstimulus interval (ISI) for 250 ms., followed by the second image (*A'*) containing only the background for 250 ms. Finally, another ISI appeared for 250 ms. This sequence, from the first image to the final ISI, continued to cycle until the participant had made a manual response, presumably detecting the changing object. Figure 1 displays the flicker task used in Experiment 1. Upon detecting the change, the participant was asked to press a button, ending the trial. Upon pressing the button, a white screen appeared with a vertical line in the centre. Participant were

prompted to indicate whether the changing object had been located on the left or right side of the screen. All 140 image pairs (i.e., 70 congruent and 70 incongruent) were presented to the participant in a random order.

Figure 1

Flicker Task used in Experiment 1



Note. Each trial began with a fixation cross, which remained on the screen for 500 ms. Next, the first image (*A*) was presented for 250 ms. This image included both the background and the target object. The first image was followed immediately by an interstimulus interval (ISI) for 250 ms. Then the second image (*A'*) appeared for 250 ms. The second image contained the background only. Finally, another ISI appeared at the end of the sequence for 250 ms. This sequence, from the first image to the final ISI continued until a manual response was made.

Results

The two dependent measures used in this experiment were mean response times (RTs) and proportion of errors. Mean RTs were calculated by averaging the time it took participants to detect the changing target object, from the onset of the first image to the

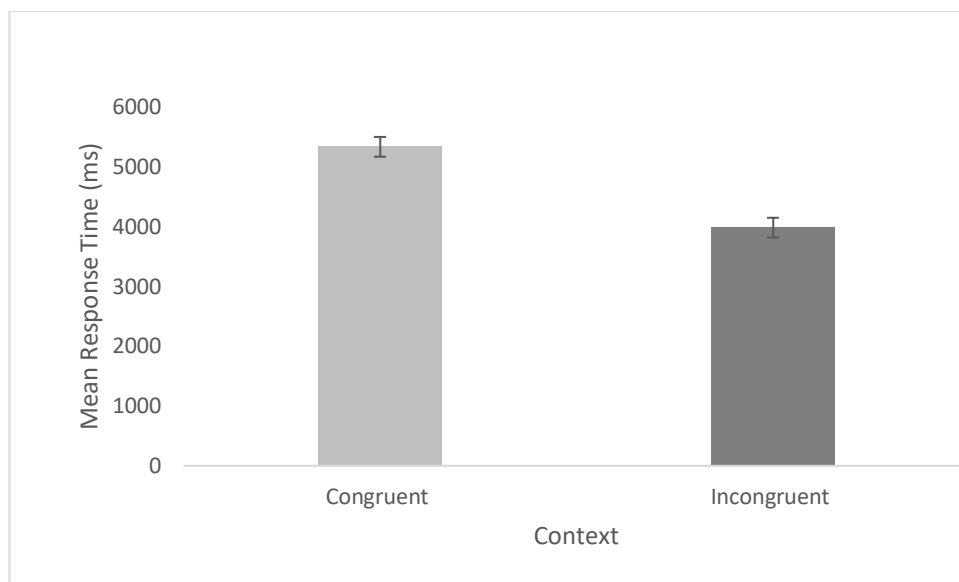
button response, for each context condition (i.e., congruent and incongruent), for each participant. Mean RTs were only calculated for trials in which a correct location was reported. Errors were calculated from those trials in which a button response was given, but the incorrect location was reported. Errors were calculated as a mean for each participant for both context conditions. Each of these dependent measures were separately analyzed by comparing performance in the congruent and incongruent contexts using paired sample *t*-tests.

Response Times

Mean response times for the congruent and incongruent conditions were submitted to a paired-sample *t*-test. Participants were significantly faster to detect the changing object on incongruent trials ($M = 3984.46$ ms) than congruent trials ($M = 4660.37$ ms), $t(23) = 5.79$, $p < .001$. Figure 2 displays the mean response times for the congruent and incongruent conditions.

Figure 2

Mean Response Times for the Detection of Change in both Context Conditions



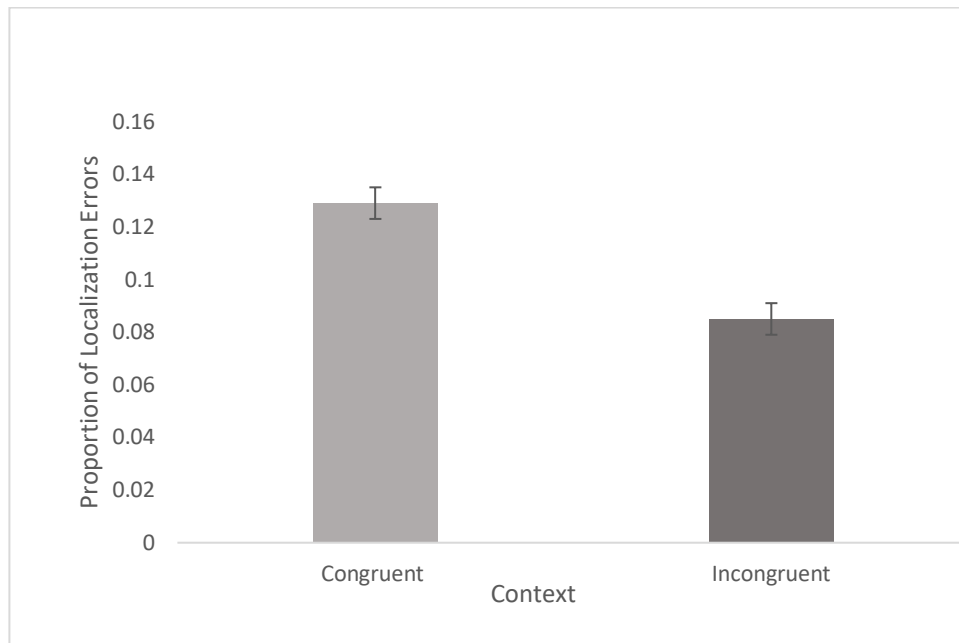
Note. The error bars in this figure and those that follow represent standard error of the mean corrected to remove between-participants variation (Morey, 2008).

Errors

Error rates for context conditions were submitted to a paired samples *t*-test. Participants made significantly more errors in the congruent condition ($M = .13$) than in the incongruent condition ($M = .09$), $t(23) = 5.18, p < .001$. Figure 3 displays the mean error rates for both context conditions.

Figure 3

Proportion of Localization Errors for both Context Conditions



Discussion

The purpose of the first experiment was to replicate the common findings in the literature by establishing an incongruency benefit in a change detection task (e.g., Hollingworth & Henderson, 2000; LaPointe et al, 2013; Loftus & Mackworth, 1978; Ortiz-Tudela et al., 2017; Spaak et al., 2020). As expected, participants were significantly faster at detecting changing objects when they were situated in an

incongruent context. This experiment is an important contribution because it not only replicates several previous studies that have demonstrated an incongruency benefit using a change detection task, but it also replicates the one previous demonstration of such an effect using an online data collection method. This finding further establishes the robustness of the incongruency benefit when participants are asked to monitor complex visual scenes for change. This experiment is also important for the current study because it forms the basis for the manipulations introduced in Experiment 2.

Experiment 2

The purpose of Experiment 2 was to determine whether performance in a change detection task can be altered in such a way as to produce more efficient performance on congruent trials than incongruent trials, within participants. Previous research has been successful in demonstrating congruency and incongruency benefits across tasks using the same stimuli and in eliminating an incongruency benefit across participants (LaPointe & Milliken, 2017). However, to this point there are no reports of both congruency and incongruency benefits within the same task and within the same participants. The strategy here was to shift the process weightings from detection to identification by giving participants a cue to the identity of the target object at the beginning of each trial. In one block of trials, the cue accurately described the target object; here it was expected participants would detect changes to congruent objects more efficiently than incongruent objects. In another block of trials, the cue did not accurately describe the target object; in this case it was expected participants would detect changes to incongruent objects more efficiently than congruent objects.

Method

Participants

Twenty-four undergraduate students (7 males) from the Psychology Department at Mount Allison University, ranging in age from 18 to 25 years ($M = 19.21$, $SD = 1.77$) participated in this experiment in exchange for partial course credit. Participants reported normal or corrected-to-normal vision.

Materials

The materials used in the present experiment were similar to those used in Experiment 1, with the addition of written cues. At the beginning of each trial, a written one-word cue was presented that either accurately (i.e., valid cues) or inaccurately (i.e., invalid cues) described the target object for that trial.

Procedure

The basic procedure used in Experiment 1 was used in the current experiment. However, in this case a written one-word cue for the target object was presented at the beginning of each trial and the 140 pairs of images were presented over the course of two blocks of trials. In one block, all the cues were valid. That is, the cue matched the target object. In another block, all of the cues were invalid. That is, the cue did not match the target object, neither did it match any other objects in the image. The order of the blocks was counterbalanced across participants.

Results

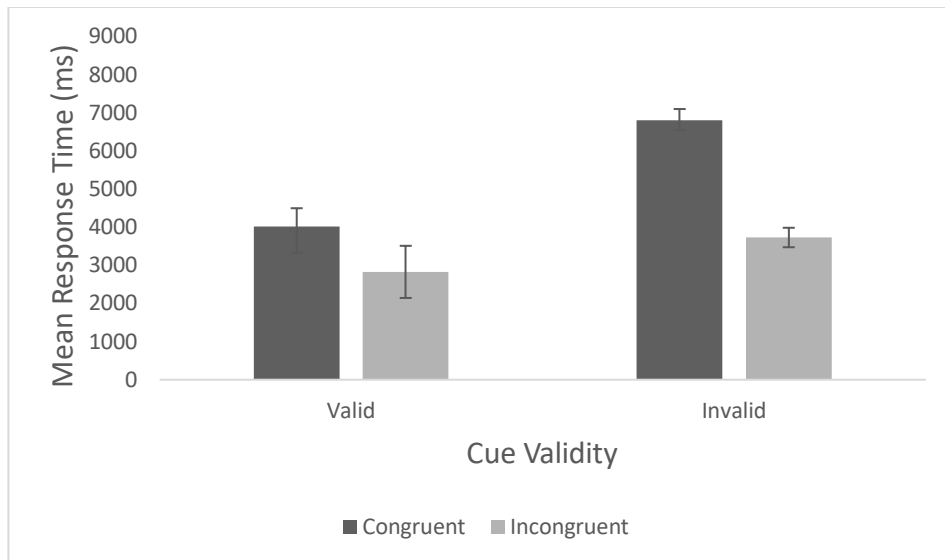
Response Times

Mean RTs for Experiment 2 were submitted to a mixed-factor Analysis of Variance (ANOVA) that treated cue validity (valid vs. invalid) and congruency

(congruent vs. incongruent) as within-participant factors, and cue order (valid first vs. invalid first) as a between-participant factor. The analysis failed to reveal main effects of cue order or congruency (both p 's $> .05$). However, there was a main effect of cue validity, $F(1, 21) = 24.91, p < .001, \eta_p^2 = .54$, with participants faster at detecting target objects on valid trials ($M = 3416.47$ ms) than invalid trials ($M = 5262.19$ ms). The analysis also revealed a two-way interaction between cue order and cue validity, $F(1, 21) = 15.45, p < .001, \eta_p^2 = .42$, as well as a two-way interaction between cue validity and congruency, $F(1, 21) = 9.50, p = .006, \eta_p^2 = .31$. There was also a significant three-way interaction between cue order, cue validity, and congruency, $F(1, 21) = 5.59, p = .03, \eta_p^2 = .21$. Figure 4 represents mean RTs for congruent and incongruent trials when receiving valid or invalid cues, collapsed across all participants regardless of cue order.

Figure 4

Mean Response Times for all Valid and Invalid Trials Collapsed Across Cue Order



To further investigate these differences, mean RTs were analyzed separately for those who received a block of valid cue trials followed by a block of invalid cue trials,

from those who received a block of invalid trials followed by a block of valid trials. For both groups, these means were submitted to a repeated-measures ANOVA, that treated cue validity (valid vs invalid) and congruency (congruent vs incongruent) as within-participant factors.

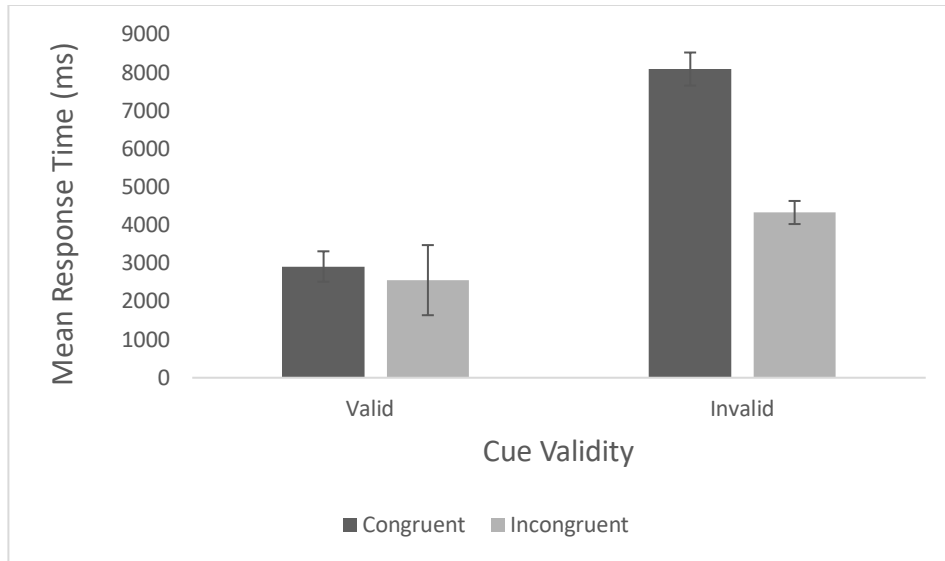
Valid Cues First

For those who received a block of valid cue trials first, the analysis revealed a significant main effect of cue validity, $F(1, 12) = 25.51, p < .001, \eta_p^2 = .68$, with faster responses on valid trials ($M = 2736.36$ ms) than invalid trials ($M = 6210.06$ ms). There was also a main effect of congruency, $F(1, 12) = 14.73, p = .002, \eta_p^2 = .55$, with faster responses on incongruent trials ($M = 3443.92$ ms) than congruent trials ($M = 5502.51$ ms). There was also a significant interaction between cue validity and congruency, $F(1, 12) = 14.40, p = .003, \eta_p^2 = .55$.

To further investigate this interaction, mean RT's for each of these conditions were compared using paired-sample t -tests. There was no difference in the speed at which participants detected congruent ($M = 2915.29$ ms) and incongruent ($M = 2557.43$ ms) targets on valid cues trials, $t(12) = 1.66, p = .12$. However, there was a significant difference in response times between congruent ($M = 8089.72$ ms) and incongruent ($M = 4330.41$ ms) trials for invalid cue trials, $t(12) = 3.90, p = .002$. Figure 5 represents mean RTs for congruent and incongruent trials for valid and invalid cues when the valid cues were presented in block 1.

Figure 5

Mean Response Times for Participants who Received Valid Trials First

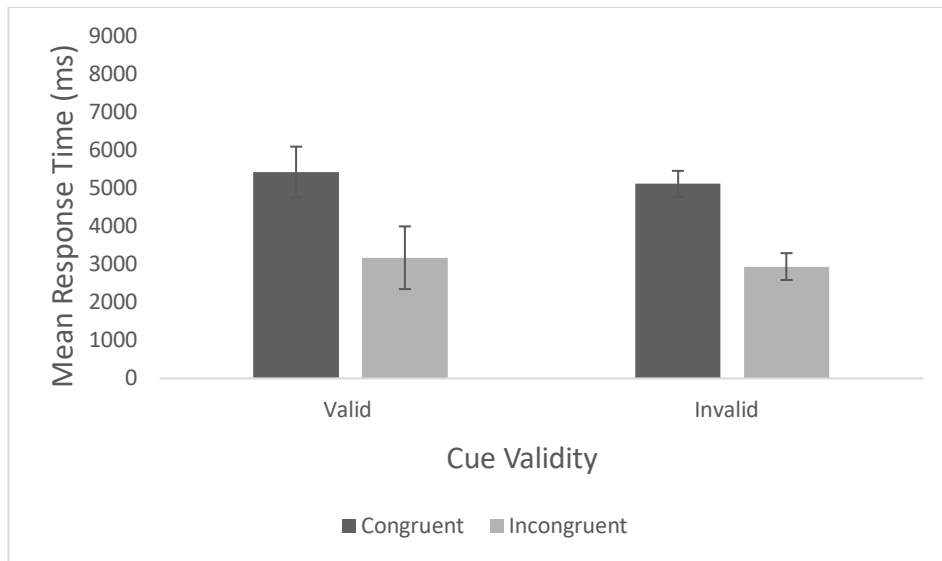


Invalid Cues First

For those who received a block of invalid cue trials first, the analysis revealed a main effect of congruency, $F(1, 9) = 16.99, p = .003, \eta_p^2 = .65$, with participants responding faster on incongruent trials ($M = 3058.40$ ms) than congruent trials ($M = 5272.18$ ms). However, the main effect of validity, $F(1, 9) = .19, p = .67, \eta_p^2 = .02$, as well as the interaction between congruency and validity did not reach significance, $F(1, 9) = .004, p = .95, \eta_p^2 < .001$. Nonetheless, mean RT's for each of these conditions were compared using paired-sample t -tests. For valid cue trials, participants were significantly faster to detect incongruent targets ($M = 3174.82$ ms) than congruent targets ($M = 5426.41$ ms), $t(9) = 3.27, p = .01$. For invalid trials, participants were also faster to detect incongruent targets ($M = 2941.98$ ms) than congruent targets ($M = 5117.95$ ms), $t(9) = 2.39, p = .04$. Figure 6 represents mean RTs for congruent and incongruent trials for valid and invalid cues when invalid cues were presented in block 1.

Figure 6

Mean Response Times for Participants who Received Invalid Trials First

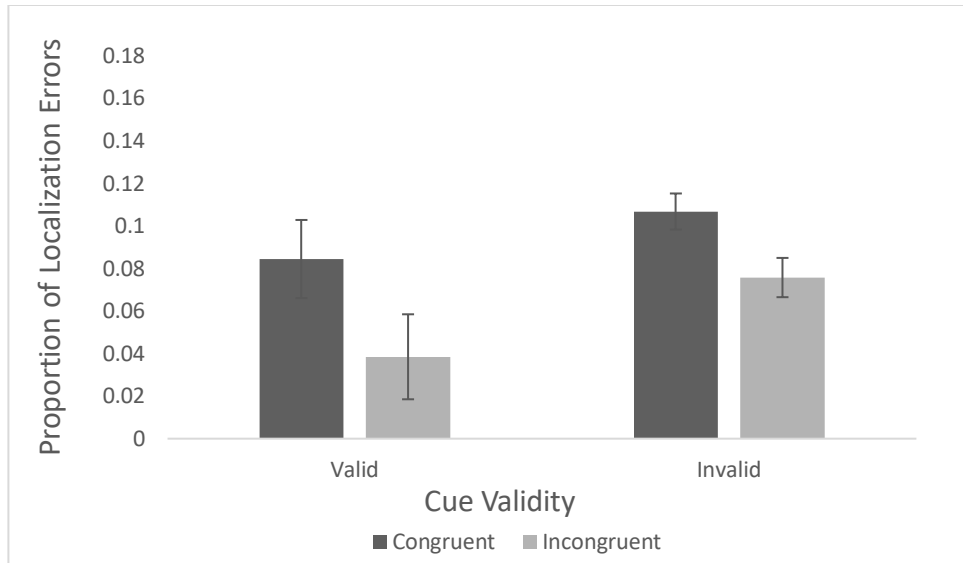


Localization Errors

Mean localization errors were submitted to a mixed-factor ANOVA, that treated cue validity (valid vs invalid) and congruency (congruent vs incongruent) as within-participant factors, and cue order (valid first vs invalid first) as a between-participant factor. The analysis revealed a main effect of congruency, $F(1, 21) = 14.38, p = .001, \eta_p^2 = .41$, with fewer errors for incongruent trials ($M = .06$) than congruent trials ($M = .10$). The analysis failed to produce effects of cue order or cue validity (both p 's $> .05$). There was a significant interaction between cue order and cue validity, $F(1, 21) = 14.87, p < .001, \eta_p^2 = .41$. Importantly, the three factors interacted, $F(1, 21) = 20.46, p < .001, \eta_p^2 = .49$.

Figure 7

Proportion of Localization Errors for all Valid and Invalid Trials



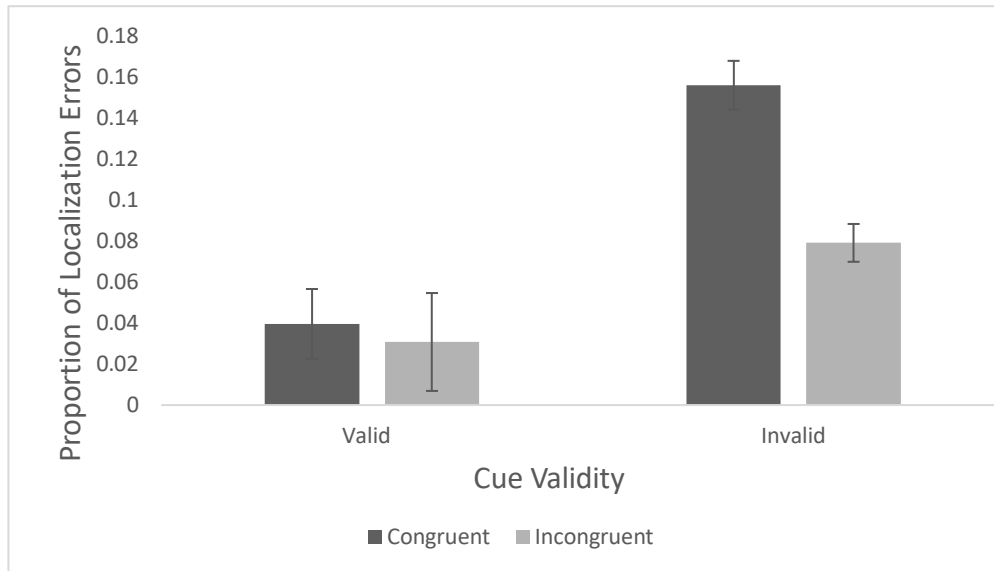
To further investigate this interaction, mean localization errors for those who received the valid block first and mean localization errors for those who received the invalid block first were submitted separately to a repeated-measures ANOVA.

For those who received the valid block first, there was a main effect of cue validity, $F(1, 12) = 14.57, p = .002, \eta_p^2 = .55$, with participants making more errors on invalid trials ($M = .12$) than valid trials ($M = .04$). There was also a main effect of congruency, $F(1, 12) = 10.97, p = .006, \eta_p^2 = .48$, with participants making more errors on congruent trials ($M = .10$) than incongruent trials ($M = .06$). Crucially, there was a significant interaction between cue validity and congruency, $F(1, 12) = 6.38, p = .03, \eta_p^2 = .35$. This interaction was investigated further by comparing mean localization errors for congruent trials and incongruent trials in the valid block and mean localization errors for congruent trials and incongruent trials in the invalid block using paired sample t -tests. For the valid block, there was no difference in the proportion of errors for congruent and incongruent trials, $t(12) = .65, p = .53$. However, for the invalid block, there was a significant difference in errors between congruent and incongruent trials, F

$(1, 12) = 3.38, p = .005, \eta_p^2 = .22$, with participants making fewer errors on incongruent trials ($M = .08$) than congruent trials ($M = .16$).

Figure 8

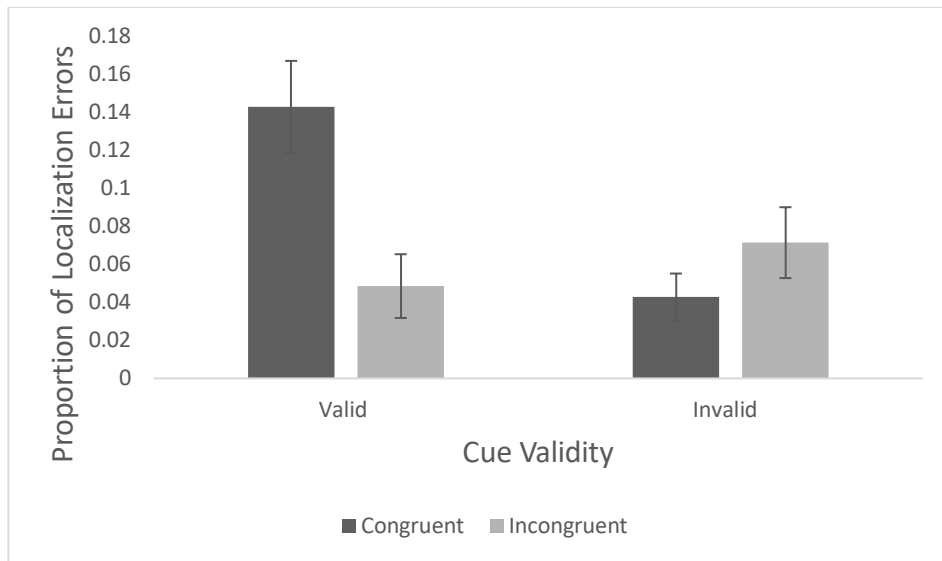
Proportion of Localization Errors for Valid First



For those who received the invalid block of trials first, neither the main effect of cue validity, nor the main effect of congruency reached significance, however, these factors interacted, $F(1, 9) = 13.86, p = .004, \eta_p^2 = .61$. This interaction was further investigated using paired-sample t -tests. For valid trials, participants made significantly fewer errors on incongruent trials ($M = .05$) than congruent trials ($M = .14$), $t(9) = 3.79, p = .004$. for invalid trials, there was no significant difference in errors between congruent ($M = .04$) and incongruent trials ($M = .07$).

Figure 9

Proportion of Localization Errors for Invalid First



Discussion

The purpose of Experiment 2 was to manipulate the underlying processes involved in scene perception in order to produce a congruency benefit on trials with a valid cue and an incongruency benefit on trials with an invalid cue, within participants. Although a congruency benefit was not uncovered, the incongruency benefit, typically found in change detection tasks, was eliminated for those participants who received a block of valid cue trials first. For these participants, the valid cue allowed them to exploit the structure of the congruent context to direct their attention efficiently to the location of the target object, thus eliminating the robust incongruency benefit. After using this strategy in the first block of trials, these participants struggled to adjust their strategy when encountering the second block of trials, which contained invalid cues. For these participants, mean RTs were significantly faster for the first block of trials compared with the second block of trials. In this second block, the robust incongruency benefit emerged.

Those who received the invalid cue block of trials first showed no difference in performance from one block to the next. For both blocks, these participants showed similar overall RTs, and produced an incongruency benefit in both blocks. It may be the case that encountering a block of invalid trials to begin the experiment quickly encouraged participants to adopt a strategy that benefits incongruent objects. Previous research has suggested that the gist information of a scene is extracted prior to local object information (Castelhano & Henderson, 2008; Sampanes, Tseng, & Bridgeman, 2008; Schyns & Oliva, 1994). Relying on the gist information, and any points of disfluency, likely leads to attention being directed to incongruent objects preferentially over congruent objects. It appears as though whatever strategy participants adopted when receiving a block of invalid cues first, it did not change once they received the block of valid trials, as evidence by the similarity in RTs across blocks.

General Discussion

The purpose of this study was to investigate the underlying processes involved in complex scene perception and, more specifically, the influence of context congruency on change detection. In two separate experiments, participants were asked to detect changing objects embedded in contextually congruent and incongruent scenes. In the first experiment, participants were faster and had fewer errors detecting incongruent objects than congruent objects. In the second experiment, participants were given valid and invalid cues for the target objects. In this case, participants were faster and made fewer errors detecting incongruent objects when the cue did not accurately describe the target object, but this incongruency benefit was eliminated when the cue accurately described the target object. These findings support a dual process account of complex

scene perception, wherein task constraints can lead to incongruency benefits in some cases, but not others.

As expected, the results of Experiment 1 showed a significant incongruency benefit. That is, participants were faster and made fewer errors detecting the changing object when the object did not match the context of the scene. This finding is consistent with previous research using change detection tasks (Gordon, 2004; LaPointe et al., 2013; LaPointe & Milliken, 2016; 2017; Ortiz-Tudela et al., 2017; 2018). This finding is particularly important because it replicates the one previous demonstration of this effect using an online data collection method (Spaak et al., 2020). These findings add to the existing evidence that the incongruency benefit in change detection task is a robust effect. Further to this point, despite the challenges of online data collection approaches in cognitive research, the incongruency benefit emerged in the current study.

For Experiment 2, it was hypothesized that on trials that contained a valid cue to the identity of the target objects, there would be a congruency benefit. The rationale here was that with a valid cue, participants could exploit the contextual structure of the scene to efficiently locate the congruent target object. Such a strategy would not work for contextually incongruent targets, regardless of the validity of the cue. Although the results of the second experiment did not confirm this hypothesis, they follow a trend in line with that prediction. The addition of the valid cue prior to the scene caused the incongruency benefit to be eliminated. The addition of the valid cue changed the strategy used by participants to locate the changing congruent target object. It is likely that participants were using the identification process, which relies on previous knowledge to guide attention to areas of the scene where the cued object ought to be

located. Although a congruency benefit did not emerge, to our knowledge this is the first time within a single study that the same participants produced faster and more accurate change detection for incongruent scenes at one point in the experiment, and then no such benefit at another point in the experiment.

It is important to note that the localization error rates in both experiments followed a similar trend to that of the response times. In the first experiment, participants made more errors on congruent trials than they did on incongruent trials. Coupled with the response time data, this demonstrates that participants had more difficulty detecting the changing object on congruent trials than incongruent trials. This can be taken as additional evidence that in a change detection task, our attention is allocated effortlessly to objects that do not fit the context of the scene. Put another way, in change detection tasks that use brief and interrupted scene presentations, our attention system is particularly sensitive to areas of disfluency.

In the second experiment, the overall pattern of localization errors closely matched the pattern of response time data. Similar to Experiment 1, in the second experiment participants made more localization errors on congruent trials than incongruent trials. Participants also made more localization errors on trials with invalid than valid cues. Interestingly, however, the error rates for those who received invalid trials first do not fit this pattern; these participants made more errors on valid trials than invalid trials. Although this finding is not what was expected, it is possible that participants struggled to switch their strategy from a block of invalid trials to a block of valid trials. It is also possible that fatigue could be a contributing factor producing significantly more errors on valid trials than invalid trials for these participants. For

these participants, the valid trials would have been the second block they received. Therefore, by the time they began this block fatigue and less accurate responses could have occurred.

Taken together, the results of these experiments are consistent with the idea that complex scene perception involves two processes—identification and detection (LaPointe et al., 2013; LaPointe & Milliken, 2016; Ortiz-Tudela et al., 2017, 2018). According to this view, task constraints will determine the weighting of these processes, thereby producing congruency benefits in some cases and incongruency benefits in other cases. The current experiments have demonstrated that when participants are not provided with information about the target object or they are provided with incorrect information about the target object prior to viewing a scene they rely more heavily on the detection process, producing an incongruency benefit in performance. However, when provided with accurate information about the target object prior to viewing a scene, reliance on these two processes shifts in weighting towards the identification process and, in this case, eliminates the incongruency benefit in performance.

These findings contribute to our understanding of our attention system, as well as a better understanding of how we complete everyday tasks. Throughout our everyday activities there are situations in which we rely more heavily on the identification process—relying on past experience and exploiting the structure and consistency in the environment to guide attention effortlessly. Yet, there are other situations in which we rely more heavily on the detection process—when the environment does not match our expectations, we orient towards novelty for further processing. Driving is one everyday activity that illustrates the contributions of these two processes. When driving on a

highway, much of what we do has become automatized based on past experience, including knowing where to deploy our attention. But we may also encounter situations and objects that demand our attention (e.g., an animal crossing the highway). Both processes—identification and detection—are an important part of functional everyday behaviour.

Despite confirming several of our hypotheses, it is important to mention some possible limitations that may have influenced the results of this study. The main concern with this study is the challenge of conducting cognitive research online. There are several concerns regarding the performance of participants and the individual environmental variables for each participant. A major concern of the online nature of the current study is that the experimenter could not be present during the completion of the experiment. The presence of the researcher in laboratory-based studies can act as a motivator for participants to stay on task. The presence of the researcher can also be helpful to ensure the task is being completed properly and to directly answer any questions participants may have about the task. For the current study, the absence of the researcher could have contributed to participants not trying their best when completing the task. Although the current study replicated previous findings, alleviating some of this concern, response times were somewhat longer and error rates higher than has been reported in some previous laboratory-based studies.

Another possible limitation regarding the online nature of this study is the timing and precision of stimulus presentation and response recording. This study relies on the computer program to automatically display the sequence of images to participants. Each scene is supposed to be available to participants for 250 ms. In an online study it is hard

to control for these specific timing components. Each participant is using a different computer, internet access point, and potentially various internet browsers and software. If internet speeds are slow, researchers are unable to control the speed of stimulus presentation. The timing is important because if participants were able to view the scenes for longer periods of time this could have allowed them to detect changes quicker. In contrast if the scenes were presented too quickly it could have inhibited participants performance. Whether or not these issues were present is unknown. Furthermore, whether or not these issues systematically influenced one experimental condition over another is also unknown. Nonetheless, conducting research online involves less experimental control than in the laboratory.

In conclusion, the results from the present study are evidence that two processes underlie complex scene perception. Both processes are at work in our everyday perceptions of our visual world. In the laboratory, these processes can be systematically manipulated to produce differential performance. The manipulation of target and scene context congruency is one such approach, the manipulation of task constraints in another. The current study adds to our understanding of how these processes operate and under what conditions one process is favoured over the other.

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Appendix A

Consent Form

Mount Allison University, Department of Psychology
LETTER OF INFORMATION / INFORMED CONSENT
Attention and Perception Research

Principal Investigator (P.I.): Dr. Mitchell LaPointe (mlapointe@mta.ca)
P.I. Contact Number: (506) 939-2013
Student Researcher: Sydney Woodin (slwoodin@mta.ca)

Purpose: The general purpose of this research study is to further our understanding of basic processes that contribute to cognitive activities such as perceiving, attending, and remembering.

Description: University students will participate in the study. Each participant will be asked to make simple decisions, as quickly and accurately as possible, upon onset of visual stimuli presented on a computer monitor. Participants' verbal and key press responses will be recorded. For identification purposes, the name of the experiment is *All Along the Watchtower*.

Risks: Although minimal, there is some risk that participants will become bored or irritated by the repetitive procedure. There is also a small risk that participants will feel embarrassed at not performing well in the experimental task.

Benefits: There are no direct benefits to participation in the study. However, this type of research benefits the scientific community by contributing to progressively better understanding of basic cognitive processes that underlie perceiving, attending, and remembering. A practical application for the knowledge gained from these studies includes the designing of optimal human-machine interfaces for tasks with particularly heavy attentional demands.

Confidentiality: Confidentiality will be respected. Data will be kept in a secure office to which only the researchers will have access. No information that discloses your identity will be released or published without your specific consent to the disclosure.

Compensation: Students recruited from an introductory psychology course can receive a portion of their grade (up to 4%) in exchange for serving as a participant. The current experiment will take approximately 60 minutes and volunteers will receive 1% course credit in exchange for their participation.

Participation: Your participation in this study is completely voluntary. If you choose to participate, you have the right to discontinue your participation at any time during or after the experiment, even after signing this form. Should you choose not to participate, or choose to stop once you have begun, there will be no penalties imposed, academic or otherwise. If you choose to withdraw from the study, the data gathered from your participation to that point in the study will be destroyed.

Contact: If you have any questions please ask the experimenter, or you may contact the principal investigator, Mitchell LaPointe (mlapointe@mta.ca). If you have any further questions or concerns, you may contact the Research Ethics Coordinator (Phone: 506-364-2618, email: reb@mta.ca)

Consent: I have read and understand the above information, and agree to participate in this experiment. I understand that I am entitled to a copy of this form to keep.

Signature of Participant

Date

Appendix B

Debrief Form

Mount Allison University, Psychology Department
Debriefing Information Sheet

Attention and Perception Research

Principal Investigator: Dr. Mitchell LaPointe
mlapointe@mta.ca
(506) 939-2013

Researcher: Sydney Woodin
slwoodin@mta.ca
905-525-9140 x24824

SECTION A - Overview

There is a growing list of experiments that have shown that objects encountered in an inappropriate context (e.g., a bear in a kitchen) are easier to detect than objects encountered in an appropriate context (e.g., a bear in a forest). This finding seems at odds with the conventional explanation of how we gather visual information and, more specifically, how we interpret and represent natural scenes. From the conventional perspective, we create a representation of a natural scene by reconstructing it piece-by-piece, beginning with the most basic aspects, such as the horizon line or the contours of buildings, etc.

There has been, however, evidence to suggest that a scene's overall 'style' can be picked up by viewers rather quickly (~ 100 ms), in fact, faster than the individual objects or pieces. It would seem intuitive, then, that gathering a scene's 'style' would help one navigate that scene more efficiently. Knowing the 'style' of a scene (e.g., kitchen) should give reliable information on what objects should be encountered in such a scene, based on our past experiences with similar scenes (e.g., a stove in a kitchen). This 'style' information, along with our past experiences, should also give us information as to where we might find particular objects in such a scene. If a scene's 'style' gives a viewer important information, why then do objects embedded in inappropriate contexts get noticed faster than objects embedded in an appropriate context?

The purpose of the present experiment was to take a closer look at the memorial and attentional processes underlying this inappropriate context 'pop-out' effect. Specifically, we were interested in whether we could promote the use of contextual information by presenting an object name prior to the change detection task. You may have noticed that some of the objects you were shown were part of a contextually inappropriate scene, while others were part of a contextually appropriate scene. We hypothesized that viewers will be faster at detecting the objects presented in the appropriate context when primed with an object or scene that is consistent the change detection image.

Appendix C

Instructions Provided to Participants

Experiment 1

In this experiment, on each trial you will be presented with two pictures. The pictures will be presented one at a time, very briefly. Your job is to determine which object is changing across the two pictures as quickly and accurately as possible. Once you've noticed which object is changing, press the I SEE THE DIFFERENCE! button as quickly as you can. You will then be asked to indicate whether the changing object had been located on the LEFT side of the picture or on the RIGHT side of the picture. Remember, try your best to detect which object is changing as quickly and accurately as possible.

Experiment 2

In this experiment, on each trial you will be presented with two pictures. The pictures will be presented one at a time, very briefly. Your job is to determine which object is changing across the two pictures as quickly and accurately as possible. But before the pictures are displayed you will be given a one word cue to help you find the changing object. Once you've noticed which object is changing, press the I SEE THE DIFFERENCE! button as quickly as you can. You will then be asked to indicate whether the changing object had been located on the LEFT side of the picture or on the RIGHT side of the picture. Remember, try your best to detect which object is changing as quickly and accurately as possible.