CONTEXTUAL CUEING IN MOVING
SCENES

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A THESIS

Submitted in partial fulfilment of the requirements for
the degree of Master of Arts in
the Department of Psychology
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2017

ABSTRACT

There are a number of different processes involved while performing a visual search task. One likely process involves learning spatial regularities in our surroundings. Contextual cueing reflects a form of associative learning between a target location and its surrounding environmental context through repeated exposure to consistent spatial orientation. Research on the phenomenon as it applies to a real world search has been limited by several choices in research methodology. The current study addresses this problem by incorporating dynamic, multicolored, and complex videos that allow for more accurate conclusions about the realistic applications of contextual cueing effects to be drawn. Participants (N =62) completed a search task while viewing videos taken from a virtual environment. Videos were either experienced once or multiple times throughout the experiment. Results showed that participants were able to locate a target object within the repeated videos faster than in novel videos. It appears that target-context associations can be formed under dynamic conditions using realistic stimuli. Implications for wayfinding, along with underlying cognitive processes, are discussed.

LIST OF ABBREVIATIONS AND SYMBOLS

df	Degrees of freedom: number of values free to vary without violating any constraints placed on the data.
F	Fisher's ratio: A relation of two variances
p	Probability of finding observed, or more extreme, results when the null hypothesis is true.
$<$	Less than
$=$	Equal to
N	Sample size
ANOVA	Analysis of variance
LSD	Least Significant Difference
M	Mean
SD	Standard Deviation

ACKNOWLEDGEMENTS

I would like to thank Dr. Ed Merrill, my mentor and committee chair, for his encouragement and guidance. Ed has been a boundless source of wisdom and his sincere interest in my progress and research has made completing this project a wonderful experience. I would also like to thank my research assistant, Jacqueline Mann-Luby, for helping me gather data for this study.

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INTRODUCTION

Conducting a visual search is a common activity of daily life, whether it is searching for a car in a mall parking lot or simply looking for the lost remote control in the living room. The influence of context when performing these everyday tasks often goes under looked. For example, when going to the grocery store, we may learn the location of the meat section based on its spatial relation to the candy aisle. If the store were to change the orientation of the aisles while leaving the meat section in the same location, we may lose our ability to efficiently navigate to the meat section of the store. Contextual cueing reflects a phenomenon that emphasizes the importance of the surrounding environment when performing a search task. It is a form of associative learning that occurs through continued and consistent exposure to a target location and its surrounding context (Chun & Jiang 1998).

Contextual Cueing

The standard paradigm used to demonstrate contextual associative learning was developed by Chun and Jiang (1998). The procedure involved a search task within an array of L's rotated at various degrees. Imbedded in each array was a target letter, T. The target object was rotated such that the tail faced left or right. The participants were asked to find the target and indicate the direction the tail end of the letter was facing. Specific displays were repeated throughout the experiment (repeated displays). Other arrays (new displays) were experienced only once. After exposure to the different arrays, response times to the repeated displays became relatively faster compared to the new displays.

Of additional importance, this form of associative learning tends to be implicit rather than explicit in nature. The use of explicit memory requires our conscious effort and awareness. Alternatively, implicit learning and memory does not involve conscious awareness. Encoding, retrieval and recall are all achieved without our deliberate effort. Implicit memory, compared to forms of declarative memory, allows for more information to be obtained (Chun & Jiang, 1998; Chun & Nakayama, 2000). Chun and Jiang (1998) found that at the end of the procedure participants could not recognize the repeated displays, indicating the use of implicit memory.

Contextual associative learning can be demonstrated under a range of conditions. For example, the influence of distractor quantity on contextual cueing effects has been evaluated. Yang and Merrill (2015) provided evidence that the quantity of distracting stimuli does not have a direct effect on adults and older children's ability to form meaningful associations. They showed respondents were able to attain some form of contextual learning with low levels of relevant versus irrelevant distracting stimuli. Age effects have also been examined. For example, Merrill et al. (2013) found that children (mean age = 6.30 years), young adults (mean age = 19.80 years) and adults (mean age = 72.17 years), can exhibit a contextual cueing effect. Additionally, persons with intellectual disabilities (ID) are able to demonstrate a facilitation effect in a contextual cueing task (Merrill et al., 2014). Further, persons with ID showed an improvement in target locating when only half of the distractors in displays were predictive of the targets location (Merrill et al., 2014).

Commonalities in our environment allow for the more efficient processing attributed to implicit associative learning. For example, our ability to recognize the similar characteristics of an environment could lead to faster target locating within that environment. Feldmann-Wustefeld and Schubo (2014) conducted three experiments varying the homogeneity of the distractors in a contextual cueing paradigm. In experiment 1 Participants were asked to report the location of a target object (T) located in a display of one of three conditions of varying distractor homogeneity: orientation 1, orientation 2, and orientation 4. Participants were asked to complete the same procedure as experiment 1 in the latter two experiments. However, in experiment 2 distracters were always in the 4 orientation condition with varying colors of distractors. In experiment 3 the context L's were always in the 1 orientation with varying levels or distractor color. Results showed a decreased reaction time for more homogenous displays in addition to lower reaction times for repeated displays. The homogeneity of the environment leads to a grouping of contextual characteristics and allows for more efficient searching (Feldmann-Wustefeld & Schubo, 2014). It seems the similarity among stimuli in an environment can lend an advantage to contextual learning.

Implicit associative learning of the context utilizes information in the environment, thereby aiding the processing of visual information. Wayfinding is a skill that also requires the use of environmental information. Wayfinding reflects a person's ability to identify their location in an environment in addition to selecting and successfully navigating to other positions in that environment (Vilar, Rebelo, & Noriega, 2014).

Many different processes are involved in successful wayfinding. As we navigate through our environment we begin to develop spatial knowledge of our surroundings. Route knowledge reflects the association of a landmark or object with a turn or direction (Munzer, Zimmer, & Baus, 2012). Route knowledge includes taking an egocentric frame of reference and individuals use a sequence of events or objects to help them find their way from one location to another (Kelly, Carpenter, & Sjolund, 2015; Walkowiak, Foulsham, & Eardley, 2015). More sophisticated forms of spatial learning consider the entire context of an environment. This is referred to as survey or configural knowledge. This learning reflects the ability to adopt an allocentric frame of reference and identify one's location in relation to other locations or objects in an environment (Rizzardo et al., 2013). Additionally, persons who have acquired some form of configural knowledge are able to plan and identify shortcuts through untraveled paths from one destination to another. The standard paradigm used to study contextual cueing could be seen as analogous to encountering visual information in our environment while performing a search task or wayfinding. The L's in each array comprise a context, just as buildings, trees, and other common objects form the context for real world visual searches.

Additionally, both wayfinding and implicit associative learning involve activity of the hippocampal regions during learning. For example, wayfinding activates portions of the hippocampus. Ledoux et al. (2014) had participants with and without schizophrenia complete a wayfinding task while being scanned with a magnetic resonance imaging (MRI) device. Individuals diagnosed with schizophrenia show a decrease in abilities related to the hippocampus. The results showed that the control group performed better on the wayfinding task than those with schizophrenia. Further, better wayfinding performance was associated with increased hippocampal function whereas poor performance was associated with a decrease in hippocampal function.

With respect to implicit associative learning, Negash et al. (2015) demonstrated, through the use of MRI and the standard contextual cueing paradigm, that higher hippocampal volume was associated with greater contextual learning. Because both wayfinding and contextual associative learning are related to hippocampal function it is reasonable to speculate that investigating the learning of implicit target-context associations may be relevant to our day to day navigation and searches. Consequently, common, realistic objects should be integrated into contextual cueing methods.

Contextual Cueing using Real World Pictures

Recently, studies have been conducted to better understand some aspects of contextual associative learning in a real world search. Researchers have attempted to take a more realistic approach by using real world pictures in the standard contextual cueing paradigm. Brockmole and Henderson (2006) used photographs of real world scenes with a target T and L imbedded within each picture. The experiment contained pictures that participants had not previously encountered (new display) and repeated pictures which participants had been previously exposed (repeated display). Consistent with previous contextual cueing results, the study showed a decrease in reaction time for the repeated displays as opposed to the novel displays; indicating the acquisition of contextual learning. With research on target-context associative learning moving towards experimentation with real world stimuli, the nature of memory involved merits examination. Using a real world image as opposed to an array of objects allows for context recognition and the use of explicit memory (Huang & Grossberg, 2010). Brockmole and Henderson (2006) found that when participants were shown the repeated displays, they were able to reliably recognize and place the target object in its correct contextual location. The use of a real world scene may provide for recognition and use of information stored in long term memory (Gourjon, Didierjean, & marmeche, 2007). The information that becomes available through explicit recognition of a scene can guide attentional search to specific areas of the visual field (Huang & Grossberg, 2010). In a follow up experiment, Brockmole and Henderson (2006) examined the role of semantic meaning in contextual cueing. In this investigation, participants completed a search task in a set of inverted real world scenes. When compared to results from normal scene depictions, twice the number of scene repetitions were required to achieve maximal learning. Thus, contextual cueing effects may be facilitated by semantic memory (Brockmole & Henderson, 2006).

The role of contextual cueing in real world applications may involve semantic associations (Gourjon, Didierjean, & Marmeche, 2007). For example, if a person were searching for a target location on a beach, semantic knowledge of the spatial orientation of a beach will guide attention to specific, relevant areas of the visual field; one would not search for a beach bag or chair off into the distance of the ocean. Knowledge that certain objects will typically be located in terrestrial space could potentially cut a search area in half (Huang & Grossberg, 2010; Chun, 2000; Eckstein, Drescher, & Shimozaki, 2006).

Researchers have examined the impact of semantics in contextual cueing with real world scenes. The information about the identity of a scene or object can provide additional information that will guide attention in search tasks. A study conducted by Gourjon (2011) examined the effect of semantic category on contextual cueing. This experiment used the standard research paradigm tasking participants to locate a target T or L in a display of real indoor photographs. The results showed that when the semantic category (i.e. kitchen, bedroom) of each scene was the only predictor of the target location, contextual cueing effects were observed. However, these results were found only when the search task was preceded by a categorical decision about the indoor photographs. It is also important to note that the outcome of the study was due to implicit processes. This finding contradicts the earlier results of Brockmole & Henderson's (2006) demonstration of explicit memory use. Another study conducted by Gourjon, Didierjean, and Marmeche (2007) examined the influence of semantic information in learning contextual associations. The first experiment consisted of an array of numbers in a plain background that were consistently paired with a target number's location. Contextual cueing effects were observed. In a follow up experiment, the researchers used the same procedure with one exception: the category of numerical context (even vs. odd) was the only predictor of target location, not spatial orientation. Contextual cueing was also observed under these conditions. The results suggest that the category of contextual information can have an impact on acquiring spatial knowledge (Gourjon, Didierjean, Marmeche, 2007).

Another study conducted by Brockmole and Henderson (2006) examined the advantage in search time afforded by underlying memory and executive functioning processes. When performing a search task, there are two systems at play: recognition and attentional guidance (Brockmole & Henderson, 2006). Recognition occurs first and guides attention to relevant spatial locations. The authors wanted to further examine the role of recognition and attention allocation in a contextual cueing task using real world scenes. Participants searched for a target letter embedded in a real world photograph. Using eye tracking technology, their results showed that using real world scenes allows for more efficient recognition and attentional guidance effects, beyond those typically observed using nonsense displays. In order to assess whether these processes occur at relatively the same time, the authors mirror reversed the scenes that were repeated in previous phases of the experiment. The authors found that scene identity initially directed recognition and recognition of later visual information subsequently guides attention.

The research on implicit associative learning in a real world search has shown that semantic category and identity of the context can facilitate contextual learning (Gourjon, Didierjean, Marmeche, 2007). Additionally, a contextual cueing effect can in fact be detected using real world scenes (Brockmole & Henderson, 2006). Implicit associative learning between an environment and target enables faster searches. This could prove useful when performing everyday tasks. However, whether this form of contextual learning takes place in a dynamic search environment with a realistic target, is not known.

The Current Study

The present status of research on real world contextual cueing does not provide a comprehensive understanding of the mechanisms and processes involved in a real world search. The research available on realistic search tasks are all conducted using a static display where the participant searches for a target that would not be a typical feature of the real world scene (imbedding a T or L in a kitchen or street background). Hence, it is not clear that these results would apply to how individuals commonly interact with their environment. Can we find a contextual cueing effect using a mobile, interactive search taken outside the paradigm of using static displays? The current study incorporates unique, complex stimuli in order to address this question. In accordance with previous investigations, the mean search time for repeated and new videos was the dependent variable (Brockmole & Henderson, 2006; Chun & Jiang, 1998).

This research evaluates the following hypothesis: Implicit associative learning in videos will facilitate faster search times for repeated versus new videos. Essentially, the study will be examining associative learning in moving scenes. To understand if existing findings from contextual cueing paradigms are relevant and applicable to real world scenarios, associative learning needs to be demonstrated using ecologically appropriate materials. The current study accomplishes this by using a video based search through a virtual environment made up of realistic objects.

METHODS

Design

Consistent with previous research, the current research employed the use of a repeated measures design (Brockmole & Henderson, 2006; Gourjon, 2011). The study consisted of two independent variables, each with two levels (Video: repeated & new; Exposure: first & second). Videos were used to convey the environment in which the search task took place. Repeated videos were those that were experienced more than once throughout the experiment. A new video was one that was only experienced once. Participants were exposed to repeated videos and sets of new videos twice. In the first exposure, repeated and new videos were shown in separate blocks. In the second exposure, the repeated videos along with a unique set of new videos was shown, again in separate blocks. The dependent variable was the mean search time for locating a target object within each video. The experiment followed an ABAB design. In the first block, participants were repeatedly exposed to six videos, six time each for a total of 36 trials. (A: Repeated Block 1 & Repeated Block 2). In the second block (B: New Block 1) participants were shown 12 new videos for a total of 12 trials. In the third block (A: Repeated Block 3), the previous six repeated videos were shown twice for a total of 12 trials. Finally, in the last block (B: New Block 2), six videos from New Block 1 were intermixed with six novel videos for a total of 12 trials.

Participants

A total of 62 students were recruited through the University of Alabama Subject Pool. Each student was given 1.5 course credits towards their psychology 101 class for their participation in the study. Participant age fell between 18 and 25 years, with an average age of 18.5 years. The sample included 45 females and 17 males.

Materials

A virtual environment was created using the HAMMER editor software and designed to reflect a city or town. Videos were taken from 24 different locations within this environment. The videos portray a progression from the first person point of view along a straight path. All of the videos included several complex objects of various sizes, shapes, and colors. For instance, some of the videos included benches, trees, buildings, skyscrapers, fences, and cars (see Figure 1 for a screenshot from one of the videos). Only outdoor environments were depicted and all of the objects in each video were located on either the left or right side of the path being traveled. Although each of videos were similar in that the environment was always a city block, they were distinct from one another in that they contained unique spatial orientations and qualitatively different objects. Each video took approximately 18 seconds to complete. By the end of the video, the progression through the bulk of the environment was complete and all that remained in view were distant buildings and faint objects not in clear sight. The only object that appeared in all of the videos was the target object, a satellite dish. The target object needed to be located in a variety of random locations while still accurately representing its use in the real world. Using a satellite dish allowed the target to be placed in a wider variety of locations such as on the side, top, bottom, or on the ground near, buildings and other objects.

Procedure

Participants were instructed to locate the target object in each of the videos and indicate which side of the path it was on. If the target was located on the left side of the street, participants pressed the S key, second from the left end of the keyboard. If the target object was on the right, participants pressed the L key, fourth from the right end of the keyboard. If a participant failed to locate the target, they were instructed to press the C key. Twelve of the videos had the target located on the left side of the path and the remaining twelve had the target located on the right. The response time to locate the target and press the corresponding key was recorded for each video using the Superlab 4.2 software. Six of these videos were used in repeated video condition and the remaining 18 were used in the new video condition. As in previous research, the mean response time for locating the target object within each video was the dependent measure in the main analyses.

Figure 1. Screenshot of one video from the New videos condition. The target object (satellite dish) is located on the right side of the path, therefore, the correct response would be the S key. In this example, the video has already played approximately 3 seconds.

Participants were tested individually and prior to the start of the experiment they were given a consent form to carefully read over and ask any questions they may have. After giving consent each participant competed all four blocks of the experiment. First, participants were verbally given instructions. Specifically, they were told they were going to see videos taken from a virtual environment and in each video was a target object; a satellite dish. They were then told their task was to locate the satellite dish in each video and indicate which side of the path it was on using the computer key board. After the instructions were given, participants were shown a picture of the target object. Immediately following, the experiment began. In the first block of testing the six videos in the repeated video condition were shown six times each for a total of 36 trials. This first exposure was separated into two blocks of 18 videos for later analysis (repeated Block 1 and repeated Block 2). After completing the search task in the first 36 trials, twelve individual and unique videos from the new video condition were shown. This encompassed New Block 1. Next, participants were shown the six videos in the repeated condition again, twice each for a total of 12 trials (Repeated Block 3). Finally, six of the scenes used in New Block 1 were shown along with six videos not previously seen for a total of 12 trials. This last block comprised New Block 2. After participants made their response, the video ended and the following video automatically began. The total time it took to complete all 72 trials was approximately 15 minutes.

RESULTS

Mean search times to locate the target (excluding errors) were calculated for two blocks of a learning phase (Repeated Block 1 and Repeated Block 2) and three blocks of test phase (New Block 1, Repeated Block 3, and New Block 2). These data are presented in table 1.

Table 1.

Means and Standard Deviations for Locating Target Objects in New and Repeated Videos.

Block	Mean	SD
Repeated 1	4214	1356
Repeated 2	3131	1301
New 1	4396	891
Repeated 3	2704	873
New 2	4154	1180

Note. Repeated Block 1 and Repeated Block 2 are search times for repeated videos in a learning phase. Response times are measured in milliseconds.

Five participants committed greater than 5% errors and their data were not included in the analysis. Error rates for the remaining participants was 2% on average, and was therefore not subjected to analysis. The data was approximately normally distributed, thus, following previous studies, the mean search time for target locating was used as the dependent variable and measure of central tendency. The analysis was conducted in two phases. First I compared search times during the learning phase to assess overall learning during initial exposure to repeated scenes.

Second, search times for repeated and new scenes were compared across exposures. Contextual cueing would be evidenced by significantly faster response times to repeated trials than to new trials.

Repeated Scenes: Block 1 and Block 2

In Repeated Block 1 and Repeated Block 2, participants were shown a total of 36 videos (18 videos in each block). A repeated measures ANOVA was conducted to compare response times in Repeated Block 1 and Repeated Block 2. Results indicated that participants responded significantly faster in Repeated Block 2 compared to Repeated Block 1, F (1, 56) = 51.119, $p < .001$. With more repetition, participants were getting faster at locating the target object. To assess the degree to which facilitation to repeated trials was due to learning where the target was in the individual videos rather than simply getting better at the general task, response times in the last four blocks of trials were compared (Repeated Block 2, New Block 1, Repeated Block 3, and New Block 2).

Main Analysis

To investigate the main hypothesis, a 2 (Video: Repeated vs New) x 2 (Exposure: First vs Second) repeated measures ANOVA was conducted on response times for the Repeated and New videos across exposures. The main effect of video was significant F (1, 56) = 229.653, $p < .001$. Participants were responding faster to the repeated videos compared to new videos collapsing across the first and second exposures. There was also a main effect of exposure, F (1, 56) = 12.346, $p < .05$. There were differences in response times between first and second exposures. There were no significant interactions. Therefore, I did observe a significant effect associated with repetition of trials. Having been exposed to repetitions of the videos did lead to a facilitation in locating the target.

Repeated Scenes: Block 1, Block 2, & Block 3

To further assess learning target locations for the repeated videos, response times for Repeated Blocks 1, 2, and 3 were compared. A one-way (Repeated Video: Block 1, 2, & 3) repeated measures ANOVA was conducted on the three blocks of repeated videos. The results showed a main effect of video F (2, 112) = 57.679, $p < .001$, indicating differences between blocks. Pairwise comparisons using LSD showed response times in Block 2 (M = 3131, SD = 1301) were significantly faster compared to Block 1, $p < .001$ (M = 4214, SD 1356). Additionally, response times for Block 3 (M = 2704, SD = 873) were significantly faster than for Block 1, $p < .001$. Finally, response times in Block 3 were found to be significantly faster than in Block 2, $p < .001$. With more exposure, participants were getting faster at locating targets within the repeated videos. The contextual knowledge acquired over the first two blocks lead to a 1.5 second advantage for target locating in the third block.

Analysis of New videos

Both New Block one and New Block two contained 12 videos. However, six videos in New Block one were also shown in New Block two. Thus, only half of the 12 videos in New Block two were completely novel. Consequently, it is possible that participants were able to locate target objects faster in the six videos that were shown in both new blocks. A 2 (New Block: 1 & 2) x 2 (Videos: novel & repeated) repeated measures ANOVA was conducted to evaluate differences in response times for the six videos shown in both new blocks and the remaining six completely novel videos. There was a main effect of Block, F (1, 56) = 12.951, $p < .05$. Response times were faster in the second block of new videos. There was also a main effect of video, F (1, 56) = 86.905, $p < .001$. Participants are able to locate target objects faster in the six videos shown in both new blocks compared to completely novel videos. There were no significant interactions. It seems that with more exposure, participants are getting faster at target locating. Further, faster response times for the six videos shown in both new blocks may suggest that learning occurred after a single exposure to videos. Despite this, results of the main analysis showed faster response times for videos in the repeated condition.

Supplementary Data and Analysis

The main analysis revealed a main effect of video repetition with response times being faster for repeated versus new videos. Although care was taken to ensure that the videos used in the repeated condition were similar to those in the new condition, it is possible the six videos used in the repeated condition had unique characteristics resulting in faster response times relative to new videos. In order to ensure the significant main effect was due to the manipulation of video repetition (IV), a supplemental experiment was conducted. Procedures for the supplemental experiment were identical to those of the main experiment. However, the videos in repeated and new conditions were exchanged; the six videos used in the repeated condition were replaced with six videos from the novel condition. Consequently, the original six repeated videos were used as novel videos. Mean response times for locating the target object was the dependent variable. If the assignment of videos was not responsible for the significant repetition effect in the primary experiment, the results of the supplemental investigation should be similar to those of the primary experiment.

This analysis was done using data from 14 new participant. Mean search times to locate the target (excluding errors) were calculated for two blocks of a learning phase (Repeated Block 1 and Repeated Block 2) and three blocks of test phase (New Block 1, Repeated Block 3, and New Block 2). These data are presented in table 2.

Table 2.

Means and Standard Deviations for Locating Target Objects in New and Repeated Videos.

Block	Mean	SD
Repeated 1	3774	1226
Repeated 2	3005	1231
New 1	5233	2775
Repeated 3	2616	1176
New 2	4409	1199

Note. Repeated Block 1 and Repeated Block 2 are search times for repeated videos in a learning phase. Response times are measured in milliseconds.

A 2 (video: Repeated vs New) x 2 (exposure: First vs Second) repeated measures ANOVA was conducted to evaluate the effect of video and exposure on response time. Results followed a familiar trend. There was a main effect of video F (1, 13) = 44.626, $p < .001$. Response times were faster for videos in the repeated condition compared to videos in the new condition, regardless of exposure. There was no main effect of exposure, F (1, 13) = 2.859, p = .115. Between the first and second exposures there were no differences in response times. No significant interaction was observed. Based on the supplemental analysis, I was able to rule out that factors intrinsic to the videos used in the repeated condition were responsible for the faster search times. The analysis showed that response times for the supplemental experiment followed that same trend as the main analysis; participants were responding faster to the repeated videos compared to the new videos accounting for both exposures.

DISCUSSION

Contextual cueing reflects a facilitation of visual search through repeated exposure to a search context. It generally involves the incidental and often implicit learning of regularities in the visual environment that predict were the target will be. Traditionally, contextual cueing is studied in static displays and participants scan a search environment for a specific, but arbitrary, object. The goal of this project was to extend previous results on contextual cueing to scenes portrayed as a dynamic progression through an environment that may be more analogous to everyday experience. As hypothesized, participants found that target object significantly faster in the repeated videos compared to new videos. Thus, repeated exposure to particular videos lead to a learned association between the target object and the context in which it was embedded. Further, this occurred without instructions to learn the location of the object. Hence, contextual cueing effects reflecting associative learning between an object and its surrounding context can be observed in dynamic as well as static presentation.

The material of the current study differed from previous investigations in several important ways. First, the context of the learning environment was more complex. More heterogeneous objects made up the context. Second, the context and target were real world objects rather than letters or monochromatic object silhouettes. Hence, they generated a semantic as well as perceptual context. Third because of the dynamic presentation, the context changed over time. Despite these differences, participants learned sufficient information from the context to facilitate their search for the target object. However, it is also likely that the differences in procedure may have resulted in important differences in the cognitive processes that produced contextual cueing in our procedure relative to previous research.

One feature of a dynamic presentation is that the visual search context is presented in a sequential manner. Therefore, visual information is gathered over time. As each video plays the objects are approached, experienced, and passed. Thus, information that was not processed can be missed with no opportunity to back track and re-experience objects. Therefore, due to this temporal feature and accumulation of information over time, working memory may have a more vital role in the acquisition and maintenance of visual information relative to a static display that can be scanned multiple times. In the present research, it may be that an efficient search involves remembering what items have already been seen while simultaneously attending to approaching objects. Inhibiting irrelevant visual information may be necessary as well. Previous research has shown that higher visual working memory capacity can help direct attention to task relevant areas of a search field (Blacker et al. , 2014) and aid in matching objects to previous memory representation (Manginelli et al., 2012). Additionally, those with higher visual working memory capacity show better maintenance of relevant objects while those with lower capacity tend to maintain irrelevant information (Vogel et al., 2005). In regards to the current study, if participants are better in their ability to remember specific objects while simultaneously attending to incoming information, it may be that they would be able to locate targets faster. In addition, there is a research showing negative impacts of spatial working memory load on visual search. Specifically, Oh and Kim (2004) showed that a higher spatial working memory load can interfere with visual search processes. The materials in the current study may have placed a higher working memory demand on participants. Despite this possibility, a reliable contextual cueing effect was observed in my study. Nevertheless, it is reasonable to think that individual differences in visual working memory may play a greater role in associative learning in dynamic displays.

Another interesting aspect of the study results was that the contextual cueing effects were considerably larger than normally observed. The facilitation effect was a 1.3 second advantage for repeated versus new videos and the reliability of the facilitation effect yielded a level of significance not typically seen in studies that assess contextual cueing. It is quite possible these results may be due to the formation of more complex temporal associations. The objects in each video are presented in a temporal and spatially separate manner. Thus, objects are experienced one at a time and in locations distant from one another and from the target object. Therefore, participants may be learning target locations through a sequence of learned object associations (Molet et al., 2011; Lewicki et al, 1988) rather than simply associating the target with its immediate context. One way this can be accomplished is through participants forming higher order associations with the repeated exposures, as in the case with second order classical conditioning, for example.

Second order conditioning is an extension of Pavlov's first order conditioning where a neutral stimulus (CS1) is paired with a stimulus of motivational significance (US) that produces an unconditioned response (UR). The neutral stimulus thereby comes to elicit the unconditioned response, now called the conditioned response (CR) (Madden et al, 2016). Under the second order conditioning framework, a second stimulus (CS2) is paired with another conditioned stimulus (CS1). Only through being paired with the first conditioned stimulus (CS1), not the unconditioned stimulus (US), does the second conditioned stimulus (CS2) obtain associative properties (Gerwirtz & Davis, 2000). It could be that as participants watch each video associations are learned between objects as they come into clear view. For example, if an association was formed between a bench and the later target object, then the appearance of the bench could come to predict the future location of the target object. Furthermore, the association between the bench and a preceding object (tree) that predicts the bench could be formed. Thus, once the association is learned, the appearance of the tree could predict the location of the target object. In this scenario, the predictive ability of the tree is given by its association with the bench, which was associated with the target object. The further in the distance that the second order stimulus is from the target, the larger the facilitation that can be attributed to contextual cueing.

Contextual Cueing and Wayfinding

Using a fixed array of arbitrary letters or figures to comprise a context does not accurately represent the rich and dynamic environment with which we interact. Hence, producing a contextual cueing effect using standard methods does not clearly show how implicit associative learning relates to many real world scenarios and the real world implications drawn from previous studies may be limited. As suggested earlier, we cannot assume that results from a contextual cueing experiment using random, static objects (i.e. L's), involves the same cognitive processes that are used when we search for bread at the grocery store. The current research was designed to extend previous research by using stimuli more similar to everyday experience.

By producing contextual cueing effects under these conditions, it is not unreasonable to infer that associative learning may be available during daily activities such as wayfinding. When navigating an environment, we rely on objects in immediate proximity to us to help guide us to our destination. Depending on your exact location, those objects will vary. However, regardless of location, your environment typically will not reflect the contexts used in most contextual cueing paradigms.

Incidental associations between objects could be beneficial when wayfinding. Results from this study may suggest that this form of implicit learning may apply to how people find objects in real world searches. In particular it may explain how people alert to the possibility that their destination is about to appear as they attend to multiple objects associated with the details of navigation to a destination. For example, as we travel to slightly new places, we may be primed to locate important upcoming landmarks or locations by the seemingly coincidental recognition of objects that precede them. The initial recognition of specific environmental information can aid in locating important goal oriented objects, such as a particular destination. During a wayfinding situation, it could be that embedded target-context associations at various points along a route serve as a guide, directing us to a series of areas containing relevant navigational information and eventually, to the final destination. In conjunction with other cognitive processes, associative learning may be a sub process involved in how we successfully learn about our environment. Overall, the ability to pick up on spatial regularities can play an important role in learning environments. Particularly when the environment is familiar.

Traditional investigations have shown that target-context associations rely on implicit memory (i.e. Chun & Jiang 2003). However, the present research did not investigate the type of memory involved in contextual learning. There is evidence in support of explicit memory use in a contextual cueing paradigm using real world stimuli (Brockmole &Henderson, 2006). After completion of the current experiment participants reported noticing that some of the videos had been repeated. This may suggest the use of explicit memory. Usually, associative learning under a contextual cueing paradigm occurs without recognition of the repeated stimuli (Chun & Jiang, 1998; Brockmole & Henderson, 2006). The unique characteristics of the videos may have allowed for explicit recognition of specific information that lead to faster target locating. Other research has shown higher recognition for repeated scenes on later memory tasks after completing a contextual cueing task using multi-colored, complex stimuli (Westerberg, et al., 2011).Using explicit processes may be a more efficient and appropriate approach to locating targets within moving, realistic videos. Additionally, explicit memory could help account for the highly reliable effect of video type found in my research. Previous studies have shown that spatial attention may be more effectively guided by explicit compared to implicit, cues (Rosenbaum & Jiang, 2013). It may be that a combination of video recognition and previously learned associations account for the facilitation effect.

Considerations of Implicit vs Explicit Learning

Participants did not report noticing the repetition of particular videos. However, the participants were not specifically asked if they noticed the repetition of the videos or not. A large portion of participants voluntarily mentioned they noticed a few videos were repeated throughout the experiment. Therefore, I cannot conclude that all participants were recognizing that some videos were being repeated. It is possible that participants were completing the experiment while relying completely on implicit processes.

In order to further investigate explicit memory use in the current research, a scene recognition test would need to be administered after the experiment. The test could involve re-exposing participants to the repeated videos with the target object absent. Participants would need to correctly identify where the target object was located during the main experiment. Successful target location identification would indicate that participants explicitly recognized the contents of the videos. On the other hand, a failure to locate a target objects previous location would suggest the use of implicit memory.

CONCLUSION

Interacting with our environment in meaningful ways involves a number of complex processes. Contextual cueing reflects a form of implicit associative learning between an object in an environment and the environment itself. The robustness of this phenomenon has been well established. Attempts to understand how associative learning influences our actions and behaviors in real world settings have been limited. The goal of the current research was to examine contextual cueing effects using items comparable those encountered in the typical environment. Several interesting findings emerged. It appears that learning associations between objects can occur using realistic materials. Additionally, complex visual information may undergo several phases of higher order cognitive processing not likely present in previous studies. In the end, these processes allow for a form of learning to take place that provides a large advantage in locating targets within environments. These results may also provide further insights into how or if this form of associative learning generates environmental knowledge and how that knowledge is used in everyday activities such as wayfinding.

Future studies may involve creating a similar experiment with a memory test at the end of the procedure. The addition of a video recognition test could help determine the type of memory involved in processing moving videos. The currents study did not incorporate a test of memory and is therefore limited in its ability to draw conclusions. Evaluating implicit versus explicit memory would give a more comprehensive understanding of the mechanisms involved in associative learning using these unique stimuli.

Future research could focus on adapting the videos to make them even more realistic. My study uses videos taken of a virtual environment, however, another approach could be to make videos of real environments. The videos could depict progressions through indoor buildings, outdoor locations, and rooms. This would allow for the best possible simulation of an everyday search task. Using a real world video would allow incorporation of other stimuli that may not be attainable using limited virtual environment software such as moving cars, people, and realistic sounds. These modifications could improve the generalizability of results.

REFERENCES

Blacker, K., Curby, K., Klobusicky, & Chein, J. (2014). Effects of action video game training on visual working memory. *Journal of Experimental Psychology, 40*(5), 1992-2004.

Brockmole, James, R., & Henderson, John, M. (2006). Recognition and attention guidance during contextual cueing in real world scenes: evidence from eye movements. *The Quarterly Journal of Experimental Psychology, 59*(7), 1177-1187.

Brockmole, James, R., & Henderson, John, M. (2006). Using Real-world scenes as contextual cues for search. *Visual Cognition, (13)*1, 99- 108.

Chun, M., & Jiang, Y. (1998). Contextual cueing: implicit learning and memory of visual context guides spatial attention. *Cognitive Psychology, 36*(1), 28-71.

Chun, M., & Jiang Y. (2003). Implicit, long term spatial contextual memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*(2), 224-234.

Chun, M., & Nakayama, K. (2000). On the functional role of implicit memory for the adaptive deployment of attention across scenes. *Visual Cognition, 7*(1-3), 65-81.

Eckstein, M., Drescher, B., & Shimokazi, S. (2006). Attentional cues in real scenes, saccadic targeting , bayesian priors. *Psychological Science, 17*(11), 973-980.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175-191.

Feldmann-Wustefeld, T., & Schubo, A. (2014). Stimulus homogeneity enhances implicit learning: evidence from contextual cueing. *Vision Research, 97*, 108-116.

Gerwirts, J., & Davis, M. (2000) Using pavlovian higher order conditioning paradigms to investigate the neural substrates of emotional learning and memory. *Learning and Memory, 7* (5), 257-266.

Gourjon, A. (2011). Categorical implicit learning in real world scenes: Evidence from contextual Cueing. *The Quarterly Journal of experimental psychology, 64*(5), 920-941.

Gourjon, A., Didierjean, A., & Marmeche, E. (2007). Contextual cueing based on specific and categorical properties of the environment. *Visual Cognition, 15*(3), 257-275.

Huang, T., & Grossberg, Stephen. (2010). Cortical dynamics of contextually cued attentive visual learning and search: spatial and object evidence accumulation. *Psychological Review, 117*(4), 1080-1112.

Kelly, J., Carpenter, S., & Sjolund, L. (2015). Retrieval enhances route knowledge acquisition but only when movement errors are prevented. *Journal of Experimental Psychology, 41*(5), 1540-1547.

Ledoux, A., Boyer, P., Phillips, J., Labelle, A., Smith, A., & Bohbot, V. (2014). Structural hippocampal anomalies in a schizophrenia population correlate with navigation performance on a wayfinding task. *Frontiers in Behavioral Neuroscience, 8.*

Lewicki , P., Hill, T., & Bizot, E. (1998). Acquisition of procedural knowledge about a pattern of stimuli that cannot be articulated. *Cognitive Psychology, 20*, 24-37.

Madden, V., Bellan, V., Russek, L., Camifferman, D., Vlaeyen, J., & Moseley, G. (2016). Pain by association? Experimental modulation of human pain thresholds using classical conditioning. *The Journal of Pain, 17* (10), 1105-1115.

Manginelli, A., Geringswald, F., & Pollman, S. (2012).Visual search facilitation in repeated displays depends on visuospatial working memory. *Experimental Psychology, 59*, 47-54.

Merrill, Edward, C., Conners, Frances, A., Roskos, B., Klinger, Mark, R., & Klinger, Laura, G. (2013). Contextual cueing effects across the lifespan. *The Journal of Genetic Psychology: Research and Theory on Human Development, 174*(4), 387-402.

Merrill, E., Conners, F., Yingying, Y., & Weathington, D. (2014). The acquisition of contextual cueing effects by persons with and without intellectual disability. *Research in Developmental Disabilities, 35*(10), 2341-2351.

Molet, M., Bugallo, M., & Gambet, B. (2011). Spatial integration using a 3d virtual environment with humans. *Elsevier, 88*(3), 198-201.

Munzer, S., Zimmer, H., & Baus, J. (2012). Navigation assistance: a trade-off between wayfinding and support and configural learning support. *Journal of Experimental Psychology, 18*(1), 18-37.

Negash, S., Kliot, D., Howard, D., Howard, J., Das, S., Yushkevich, P., Pluta, J., Arnold, S., & Wolk, D. (2015). Relationship of contextual cueing and hippocampal volume in amnestic mild cognitive impairment patients and cognitively normal older adults. *Journal of International Neuropsychological Society, 21*(4), 285-296.

Oh, S., & Kim, M. (2004). The role of spatial working memory in visual search efficiency. *Psychonomic Bulletin and Review, 11*(2), 275-281.

Rizzardo, C., Colle, H., McGregor, E., & Wylie, D. (2013). Using a single map display both for navigational planning and for turn-by-turn vehicle guidance: Configural spatial knowledge acquisition. *Journal of Experimental Psychology, 19*(4), 301-319.

Rosenbaum, Gail, M., & Jiang, Y. (2013). Interaction between scene based and array-based contextual cueing. *Attention, Perception, & Psychophysics, 75*(7), 888-899.

Vilar, E., Rebleo, F., & Noriega, P. (2014). Indoor human wayfinding performance using vertical and horizontal signage in virtual reality. *Human Factors and Ergonomics in Manufacturing & Service Industries, 24*(6), 601-615.

Vogel, E., McCollough, A., & Machizawa, M. (2005). Neural measures reveal individual differences in controlling access to working memory. *Nature, 438* (7076), 500-503.

Walkowiak, S., Foulsham, T., & Eardley, A. (2015). Individual differences and personality correlates of navigational performance in the virtual route learning task. *Computers in Human Behavior, 45*, 402-410.

Westerberg, C., Miller, B., Reber, P., Cohen, N., & Paller, K. (2011). Neural correlates of contextual cueing are modulated by explicit learning. *Elsevier, 49,* 3439- 3447.

Yang, Yingying, & Merrill, Edward, C. (2015). The impact of signal-to-noise ratio on contextual cueing in children and adults. *Journal of Experimental Child Psychology, 132,* 65-83.

APPENDIX IRB CERTIFICATION

THE UNIVERSITY OF ALABAMA® | Office of the Vice President for Research & Economic Development
Institutional Review Board for the Protection of Human Subjects

March 9, 2016

Edward Merrill, Ph.D.
Dept of Psychology
College of Arts & Sciences
Box 870348

Re: IRB # 16-OR-109, "Contextual Cueing in Moving Scenes"

Dear Dr. Merrill:

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your application has been given expedited approval according to 45 CFR part 46. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your application will expire on March 7, 2017. If your research will continue beyond this date, please complete the relevant portions of the IRB Renewal Application. If you wish to modify the application, please complete the Modification of an Approved Protocol Form. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants. When the study closes, please complete the Request for Study Closure Form.

Please use reproductions of the IRB approved stamped consent forms to obtain consent from your participants.

Should you need to submit any further correspondence regarding this proposal, please include the above application number.

Good luck with your research.

Sincerely,

[redacted]