

REAL-SCENE CONTEXTUAL CUEING:
WHY TREES ARE BETTER THAN CATS

by

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ABSTRACT

This dissertation was designed to study the impact of stable and unstable landmarks on repeated visual search tasks involving real-scene displays relative to no background displays in a contextual cueing procedure. Contextual cueing, a repeated visual search task, involves implicit learning through associative relationships between a set of distractors and a target location (Chun and Jiang, 1998). Stable landmarks, defined as unmoving, reliable landmarks were items like benches, road signs, and a large fountain. Unstable items, defined as capable of movement and therefore unreliable landmarks, consisted of a cat, people, and other animals. Typically contextual cueing tasks involve repeated exposures to a set of displays over several blocks in the learning phase. In a test phase, participants encounter unseen displays with random target locations.

The current study involved two experiments. Experiment 1 contained real-scene displays where participants searched similar park scenes for a predetermined target amongst stable and unstable distractors. In the test phase, the stable distractors were removed in one condition, and in another, only the unstable distractors were removed. Experiment 2 was identical, although there were no real-scene backgrounds. It was predicted that participants would respond faster to the stable condition, where stable landmarks would help to predict the location of the target. The general hypothesis was that inherent stable objects such as water fountains, benches, and road signs would be more informative about the location of other objects in a scene than would relative unstable objects that could move to different locations or completely out of the scene on their

own such as animals or people. Overall, there was a difference in the degree to which stable and unstable objects influence performance to repeated relative to novel displays. In fact, this difference was observed for stable vs unstable objects encountered in real world scenes and those presented against a solid background. As such, the difference in the processing of stable vs unstable objects in real world scenes was reflected in a greater cost when unstable objects were removed during the test phase relative to when stable objects were removed. Overall the results indicate that participants struggle with repeated search tasks within real scenes.

Keywords: response cost, repeated visual search, contextual cueing, implicit learning, landmarks, real scenes

DEDICATION

This dissertation is dedicated to everyone who helped me and guided me. In particular, God who helped me survive, my wonderful mentor Dr. Edward Merrill who always tells it like it is, Jennifer Young who answered my most random questions and critiqued my work, my parents Jeff and Judy for lending their computers for data collection, my number one pilot data subject and husband Joe Limbaugh, all my many undergraduate research assistants who were incredible data collectors, Amanda, Snyder, my committee, Nick Saban, and everyone else who helped keep me sane! And Cat Effects, your app rocks!

LIST OF ABBREVIATIONS AND SYMBOLS

- df* Degrees of freedom: number of values free to vary after certain restrictions have been placed on the data
- F* Fisher's *F* ratio: A ration of two variances
- M* Mean: the sum of a set of measurements divided by the number of measurements in the set
- p* Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
- t* Computed value of *t* test

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CHAPTER 1

INTRODUCTION

Implicit learning is a type of learning that occurs without conscious awareness of what is being learned or how. It is typically contrasted with explicit learning in which an individual is assumed to be both aware of what is being learned and able to engage in specific efforts to acquire the desired information (Litman & Reber, 2005). It is generally accepted that some forms of information are continuously being picked up from the environment without awareness. Our brains appear to be well suited to selectively attend to important regularities in our environment. Implicit learning seems to be heavily involved in the learning of language (Lichtman, 2013; Swisher, Restrepo, Plante, & Lowell, 1995). For example, infants learn grammar without being explicitly taught the rules of sentence structure (Vokey & Brooks, 1992; Saffran and Wilson, 2003). They may leave out articles, but structurally the sentence is in the correct order. Empirically, Reber (1967) found that participants were able to distinguish between randomly created nonsensical sentences and those that were constructed following a set of probabilistic rules using an artificial grammar although they had no knowledge of the rules that were used to construct them. Implicit contextual maps of our environment help us to navigate through our environments without consciously being aware of the details of the map that we are following. For example, an individual may know how to return home after work, but they may have difficulty explicitly describing the steps that allowed them to do so. Although explicit and

implicit learning are considered to be very different in process and product, usually most learning will include some of each (see Sun, Zhang, Slusarz, & Mathews, 2007).

This dissertation focuses on the constraints of learning associated with one form of implicit learning: contextual cueing. More specifically, I ask whether certain categories of stimuli are more easily associated with learning in this domain than are others. In the review that follows, I begin with an overview of contextual cueing. This is followed by a brief description of categorization processes and the role they can play in contextual cueing. I focus specifically on the possibility that some categories of objects are better suited to be landmarks for navigation than are other categories of objects. Finally, I will discuss several instances in which contextual cueing effects can influence behavior within a natural environment.

Contextual Cueing

Contextual cueing is a form of implicit spatial associative learning that seems to operate on an unconscious level. Contextual cueing occurs when environmental regularities can guide an individual to the location of a predetermined target even when knowledge of these specific regularities and their relation to the target location is not explicitly available (Chun & Jiang, 1998). A typical contextual cueing task involves searching through a display of off-center and rotated Ls serving as distracters and for a rotated target T. Participants searched through several of the displays to find the target. During the study, they viewed both predictable (repeated) and unpredictable (new) displays. The predictable displays were slides that were viewed several times and as a result the locations of the distracters were predictive of the location of the target. Predictable displays included distractors whose location indicated where the target would be located. As participants continually viewed the same set of slides, they became faster at finding

the target relative to the unpredictable displays. The unpredictable displays were slides that participants had not previously seen where the target locations were random and distracter locations could not be used to predict the target location. The observation of faster response times to the predictable displays, relative to unpredictable displays that participants had not seen before, was taken to be indicative of learning. Throughout, participants were not aware of the relationship between the distracter Ls and the location of the target T; in fact, when participants actively attempt to memorize the layouts of the displays no learning occurs (Chun & Jiang, 2003; Jimenez & Vaquez, 2011; Yang, 2012), whereas a more passive search allows for a greater contextual cueing effect (Lleras & Von Muhlenen, 2004; Chun & Jiang, 2003). Participants are also unable to determine which slides they have previously seen (Chun & Jiang, 1998; Chun & Phelps, 1999). Although not explicitly aware of the interaction between target and distractors, participants implicitly knew the layout of the slides and therefore were drawn to the location of the target. This basic result has been replicated across a variety of materials and conditions over the years (Chun and Jiang, 1998; Jiang and Chun, 2001; Chun and Nakayama, 2000; Goujon, Didierjean, & Marmèche, 2007).

Contextual cueing can reflect an important mechanism of learning in everyday situations. It allows individuals to pick up on environmental regularities that help to guide them to important aspects of the environment while ignoring the items of little importance (Goujon, Didierjean, & Marmèche, 2007). In typical contextual cueing designs participants learn the layout and therefore become faster at finding the important aspect of that scene: the target. Some of these processes seem to happen preattentively, with participants able to easily ignore what is not relevant at the time. In a study by Thomas and Merrill (2012) participants searched for either a red or a blue target with red and blue distractor items. Rotated Ts and off-center Ls were used,

similar to studies by Jiang and Chun (2001). Like Jiang and Chun, predictable displays contained distractors that predicted the location of the target while unpredictable displays contained random target locations. Contextual cueing was found for both color targets with a magnitude similar to participants who only searched for one target. Although all distractors predicted the location of both targets, it is believed that participants separated displays by color. Thus, red distractors predicted the location of the red target and blue distractors predicted the location of the blue target. Due to the difference in color, participants were able to preattentively ignore the irrelevant color when prompted to search for the other target.

Although contextual cueing seems to be relatively flexible, the magnitude of contextual cueing seems to significantly decrease when there are multiple targets within a display that cannot be easily distinguished by perceptual features alone (Zellin, Conci, van Mühlengen, & Müller, 2011b). More specifically, while search becomes easier when there are distinct categories (like color) of targets, it is difficult for participants to distinguish between more similar targets where no preattentive identification of target search categories is possible. Thomas and Merrill (2013) found that participants did show contextual cueing effects when presented with two targets (a T and L) within a set of distractors that were also letters of the alphabet; however, the magnitude of contextual cueing was drastically reduced when compared with those participants who only searched for one target. Apparently, having multiple target decreases the overall predictability of the distractors (they predict two locations instead of one) and therefore decreases the magnitude of contextual cueing. In fact, contextual cueing effects can be completely eliminated by reducing the distractors that predict the location of a target from 75% to 50% (Couperus, Hunt, Nelson, & Thomas, 2011; Merrill & Yang, 2011).

Overall, contextual cueing has been found to be a robust phenomenon indicative of implicit spatial associative learning. Although some evidence suggests it is not a very flexible form of learning, research has demonstrated that current goals can help preattentively guide contextual cueing. For instance, having more than one goal, like finding two separate targets within the same display, can modify contextual cueing effects. If these specific goal related processes can help shape contextual cueing, then it is possible that other goals can also guide implicit search. In this research, I focus on categorical features of environmental objects that may be relevant to their utility as landmarks. More specifically, landmarks are most useful if they can consistently predict when and when not to turn along a route. Hence, I am researching whether or not individuals can create and use categories reflecting landmark relevant and landmark irrelevant objects when processing real-world scenes. Further, I am testing whether or not these categories also operate in non-scene presentations.

Categorization Processes and Their Relevance to Contextual cueing

The ability to categorize the objects that we encounter every day in our environment represents a fundamental and important ability. Any single object can be categorized in many different ways and on many different levels. For example, a dog can be a pet or a problem (if you are a mailman). In addition, your pet could be a beagle, a dog, an animal, and an animate object. The way that we classify objects provides useful information about how to interact with them. For example, if you categorize an object as a pet, you know that you can approach it. If you categorize an object as an animal, you know that it probably needs food and water. If you categorize an object as animate, this label can help you to decide if it will likely be in the same location the next time you encounter it, as animate objects are likely to move.

Categorization is a cognitive activity that can often happen without conscious awareness. Category learning seems to be a mostly implicit process and categories can be acquired without the use of declarative memory. Knowlton and Squire (1993) found that participants with amnesia performed similarly to controls in categorizing patterns although the amnesic participants could not indicate if they had previously seen the pattern. Similarly, amnesic participants categorized animals as successfully as control participants although amnesic participants could not indicate if an animal had been previously displayed (Reed, Squire, Patalano, Smith, & Jonides, 1999). We attempt to group items based on similarities; this is one of the things that makes our thought processes efficient.

Semantic priming helps to illustrate this. In semantic priming when someone is primed with a certain word (an animal), it becomes easier for them then to name other animals while it would be much harder for them to name types of cars. Mentioning one word can then activate several other similar words, or frequently paired words. Semantic priming has many benefits. It helps facilitate language comprehension as well as maintains focus on context-appropriate aspects of an individual's current surroundings. Priming effects are greater when words are more similar in meaning. For example, Ratliff and McKoon (1976) found that participants responded faster to target words when primed beforehand with a similar noun. Brady and Olivia (2008) found that statistical learning, learning in which data and other regularities are found in the environment, also operates in regards to semantic categories. Brady and Olivia posit that in a complex world categories serve to group redundant items into a single area so that those items can then be analyzed as a whole instead of individually.

There is considerable evidence to indicate that people can learn and use a variety of highly abstract categories. For example, living and nonliving are labels that can classify common

objects into unique categories. One study found that when asked to categorize words into living or nonliving, participants performed this task easier when the semantic prime before the word was similarly classified as living or nonliving (Dellantonio, Innamorati, & Pastore, 2012). In other words, participants were able to implicitly make use of association between items based on the category distinction of living vs nonliving things. When the prime was living and the following word was also living, participants grouped the items more efficiently.

Categories can influence contextual cueing by allowing people to focus on categories of distracters that may be relevant to their current goals. This helps us to focus on those things in our environment that are important and requires us to spend much less time dealing with objects that are in an unimportant category. Instead of concentrating on things in the environment that are of little importance, we can concentrate on more important things like those things needed for survival. In a study conducted using categories of letters and numbers, participants were able to selectively attend to the category of importance, while ignoring the irrelevant category in a contextual cueing task involving two targets (Thomas & Merrill, 2013). The ability to preattentively separate categories aided in locating the target in these displays. Likewise, as participants searched through a display of red and blue rotated L's and T's (target item) participants easily separated the two colors into relevant and irrelevant categories, depending on the relevant target color (Thomas & Merrill, 2012). Participants were simply able to block out the category that was not important at the time.

In the contextual cueing study by Thomas and Merrill (2012), participants were able to preattentively ignore the target color that was not relevant at the time. Participants were able to do this through categorization. Since the two separate targets were two separate colors, participants grouped the distractor of the same color with its respective distractors. Participants

likely viewed the same display as two separate layouts, depending on the color for which they were currently searching. In research by other investigators, infants were shown several wavelengths of the same basic color in a habituation test to determine whether or not they could categorize color. The infants were able to categorize the hues into basic color groups based on infant looking-time and were habituated equal to several different hues of the same color (Bornstein, Kessen, and Weiskopf, 1976). It appears the categorization of color is something that is simple enough that it occurs without much effort or awareness. To what extent can other categories aid in search based on easily grouped conceptual properties?

Goujon (2011) found the categorization of a scene can assist visual search for targets within that scene. Goujon investigated whether categories had any influence on participants' visual search. Participants were asked to semantically categorize the real-environment scenes (photographs of a kitchen, bedroom) and then locate a target (a T or L). Several scenes were predictive in that targets were always located in the same position in different exemplars. Other scenes were not predictive in that they had randomly placed targets. Participants were first asked to explicitly identify the category to which the photographed room belonged and then were asked simply to view a photograph of a room within the same category, a more implicit categorization process. Afterwards, participants located the target. When participants were 'primed' with the photograph of a room within the same category, participants found the target faster. Hence, Goujon found that categorization processes can facilitate visual search. However, it is not clear if the same pattern would be found by implicitly activated category information.

In my dissertation, I will be focusing on implicitly activated categorical properties of objects with a scene. Of particular interest is examining the properties of objects and how those objects serve as landmarks during wayfinding activities. Wayfinding includes developing and

then being able to recall a route through an environment. This skill develops early and landmarks provide important information conducive to route learning, especially in young children (Lingwood, Blades, Farran, Courbois, And Matthews, 2015). Although it is possible to learn a route without landmarks, adding landmarks can improve the navigation of young children and even adults tremendously (Lingwood et al., 2015). Landmarks provide crucial information about when and where to turn. It would make sense that the best landmarks would be those that are consistent and stable, instead of ever changing. I am interested in whether these properties of objects can implicitly guide learning as people view and search of objects in pictures of real world scenes.

Category features that may be consistent with landmark relevant and landmark irrelevant categorization processes include such things as animate vs inanimate and living vs nonliving. Research has indicated that people can implicitly categorize objects on the basis of these features. Even babies can classify objects based on living qualities. Research has shown that infants as young as 18 months could classify small plastic objects (a cow, a desk) as either animate or inanimate even when inanimate objects had legs (Rostad, Yott, & Poulin-Dubois, 2012). This suggests that some knowledge categories, especially those of living versus nonliving objects, are available at even a very young age and shows that even infants have an understanding of what living and nonliving categories really mean (that a living item has more than just legs). Other studies found the differences in categorization in even younger babies. Seven and eight month-olds infants were shown pictures of furniture and of animals. Event related potentials that were measured as infants saw the pictures of the two different categories indicated that infants respond differently to the different categories (Elsner, Jeschonek, & Pauen, 2013; Jeschonek, Marinovic, Hoehl, Elsner, & Pauen, 2010). Dellantonio, Innamorati, and

Pastore (2012) suggest that all categories about objects in an environment are built off of the two basic categories; animate and inanimate. Dogs may be placed in the “dog category” but they are still a member of the even bigger category of animate. This suggests an unconscious categorization process in which all things are first gauged at a basic level (dog) and then categorization can proceed outward in both directions of either classification into the category inanimate and animate or a more subordinate category (beagle).

In support of the proposition that “living things” also operates as a functional category for adults, researchers have demonstrated that the ability to recognize living things can be impaired by specific brain injury. People affected by living things agnosia can become completely incapable of recognizing all living things suggesting that recognizing living things is something very basic and vital in the brain (Farah, McMullen, & Meyer, 1991). Participants with living things agnosia were required to view photographs or drawings of both nonliving and living things. Participants were then required to name the object. In the study by Farah and colleagues (1991) the first participant named 52% of the living items correctly and 84.1% of nonliving things correctly. The second participant named 33.4% of the living things correctly while naming 76.7% of the nonliving items. Gaffan and Heywood (1993) concluded living things agnosia results from a “a modality-specific but not category-specific impairment in visual representation, since living things are more similar to each other visually than nonliving things are.” Basically, living things are more similar to one another than nonliving things and therefore are harder to distinguish. Not only do people utilize the categories of animate and inanimate, in semantic and lexical tasks it was also observed that participants made a clear distinction between domestic and wild animals, with the categories existing in separate clusters in the brain (Schwartz, Baldo, Graves, & Brugger, 2003). Obviously people recognize animate and inanimate objects separately

and it would make sense that they would also *treat* them differently. For example, people would expect animate objects to be able to change positions and inanimate objects as much less likely to change, especially on their own. When an object is categorized as either animate or inanimate, it seems likely that some immediate properties are activated about that object. Could it be dangerous? Is it friendly? Should I run?

It is proposed here that people implicitly assign properties to an object based on the category to which it belongs (e.g., animate or inanimate). I am suggesting that one outcome of this process is determining how beneficial the item would be as a landmark in an environment for purposes of wayfinding. Landmark relevant properties would include determining the likelihood of an object to be moved or to move on its own. Smaller, more portable objects in an environment are more likely to change locations and be less permanent in an environment. One functional utility for categorizing objects as stable or unstable, is that items categorized as stable make much better landmarks. Stable objects are likely to remain in the same location and therefore would be much better predictors of the location of a particular target during future search. Due to the fact that individuals classify animate and inanimate categories so readily, when attempting to acquire landmarks in an environment, especially permanently, individuals should rely more on the objects that will remain stable in an environment. And we would likely benefit from being able to implicitly access that information as our explicit system is otherwise engaged in the effortful aspects of navigation (e.g., looking for street signs).

As stated before, in this research I am interested in determining if object features like living versus nonliving or stable versus movable make some objects more easily learned as predictors in the spatial environment than others? In other words, would belonging to these abstract categories impact what items individuals attend to in their environment when looking for

a reliable landmark. In the experiments proposed for my dissertation I will examine whether or not these categorical features can influence visual search in a repeated search task. In a typical repeated search paradigm, individuals exhibit facilitation, or contextual cueing, when objects in the search display reliably predict the location of the target. The basic rationale for these studies is that certain object properties make some things more useful as predictors of future visual search than do others. In Experiment 1, I will examine how stable and unstable items work as landmarks within real-scene displays. Backgrounds will consist of typical park backgrounds. In Experiment 2, the procedure will be identical with the exception that display backgrounds will be a blank light gray scene. Stable distractors will be those that cannot or are unlikely to move, such as road signs and unstable distractors will be those things that can move on their own; animate objects like a cat, a dog, and people.

Contextual Cueing in the Natural Environment

In the environment it is likely that people typically use some sort of contextual cueing as they perform everyday activities. Contextual cueing may allow us to have an implicit contextual map for dealing with the environment without using huge amounts of explicit memory. It guides our attention towards the important aspects of our environment and away from the less important things (Goujon, Didierjean, & Marmèche, 2007). In that way, contextual cueing, or memory guided selective attention, can help guide a person towards relevant aspects of the environment. What kind of important things can be learned through contextual cueing? Can we make some suggestions? In a supermarket, when we see the eggs we are very often led to thinking about our need for purchasing milk that is typically nearby. When driving along the highway, important street signs are typically located in similar places along the road to prevent us from missing them

and causing potential accidents even though we are not specifically trying to locate them.

Because attention is directed to the relevant information, we can do what is necessary without using a great deal of explicit memory and attention.

In everyday navigation, it would be reasonable to think that implicit spatial learning may also influence behavior. There are at least two ways that implicit learning can assist with environmental learning in support of navigation. First, implicit spatial associative learning can facilitate learning about individual landmarks that are important along individual routes. Individuals may learn the good and bad predictors of where to turn for each environment they encounter. Second, learning about what kinds of objects make good landmarks versus those that do not may be a general form of learning that can occur in a relatively implicit manner. Individuals may assign properties to objects that identify them as good or bad predictors. Individuals would then ignore the bad predictors whenever they are encountered in a new environment. In a real environment some objects can move on their own and some objects cannot. Some objects are easily moved by an agent and others are not. The objects that consistently guide individuals to the target location would be landmarks that an individual would be more likely to use in the future. The question becomes, how do we process information concerning good and bad predictors of location in a natural environment?

While the laboratory environment is full of examples that demonstrate that relations between targets and distracters can be arbitrary, it is reasonable to consider the likelihood that a real-world context may impose some constraints on which distracters can serve as good predictors of a target's location. For example, in real-world environmental learning it would make sense that individuals would pay more attention to objects in the environment that would be unlikely to move when searching for a specific stationary target. While most contextual cueing

studies have included randomly scattered letters or other arbitrary items, it is more likely that contextual cueing that operates in real environments takes into account important features of objects and selects those that would be more beneficial for finding a target location. Few studies have attempted to investigate contextual cueing in real world scenes. Furthermore, those that have used real world scenes typically do not actually investigate real-world landmarks and real-world targets (see Brockmole, Castelhana, & Henderson 2006). For example, although Brockmole was interested in the role of real world context in predicting a target location, he used letters (T or L) embedded in naturalistic scenes as his targets. Hence the applicability of results such as these to the role of contextual cueing to real environments is rather limited.

We know that participants are able to implicitly learn the relationship between the environmental context and a target. However, we do not know how this process operates in real world contexts where both the target and the contexts are plausible objects in the environment. Logically, there are several important differences between the arbitrary contexts used in laboratory tasks and real world objects typically found in the natural environment. How and why do individuals select the predictors (commonly thought of as landmarks) that enable them to find a specific goal location when navigating through their environments? Does the real world environment constrain search to plausible landmarks and can that information be implicitly acquired? Is there a difference between certain landmarks at an implicit level? When trying to find your way around a grocery store, for instance, one would not use a person as a landmark. People can move. However, one might use the location of a freezer or a cash register as a landmark, because it is less likely to move. Using roads signs, buildings, and trees would lead to a much more successful search because items such as those are much more predictable in real environments. Using a cat that may be by a target, a bird, or a yard-sale sign would obviously

lead to a much less successful search next time. Those items may have moved. It would make more sense for these unconscious contextual guides to exclude items that are unstable in an environment and only include those objects that are stable over time in order for contextual cueing in real environments to be most efficient.

Therefore, it would be beneficial for these contextual maps to account for animate and inanimate objects. When searching a real-life scene it would be more beneficial to learn a target item relative to an inanimate object, simply because it is less likely to move than an animate object. Obviously some inanimate objects are capable of *being* moved but we know that animate objects are capable of moving on their own. Therefore it would be more likely that using a lamp, a chair, or a computer as a basis for the location of a target would lead to a more successful real-life search than using a cat, a bird, or a person. The categories of animate and inanimate objects are deeply ingrained within the human brain; therefore these categories should allow individuals to preattentively select for the more appropriate distractors, much like categories of color would. In contextual cueing paradigms, it would be more beneficial for participants to selectively attend to the category of distractor items (landmarks) that will provide them with the best option for locating the target item. Participants should be able to preattentively ignore the less useful category (the objects that move or the objects that are likely to move on their own) and selectively attend to the objects that can serve as landmarks and are more useful in search (objects that do not move and inanimate objects). For contextual cueing to be beneficial in a person's real environment, landmarks cannot be selected randomly without some discrimination as to which items would be better at identifying where to turn than others.

The Current Study

In this research I am interested in the distinction between stable and unstable distractors. The general hypothesis is that participants will base the location of the target off the distractors that make better sense to use in a real environment scene. More specifically, in the stable/unstable distractor condition participants should preattentively ignore the unstable distractors. Therefore, when the stable distractors are removed and the unstable distractors remain, participants should show an increase in time to locate the target. In a real-life environment it is unlikely that objects that can be moved will always remain in the same location. Individuals should base target search on more stable objects that are less likely to move. When choosing between which objects to use to locate a target it would be much more adaptive to use the item that is less likely to move (inanimate) because it has to be moved. Animate objects are much more likely to move because they are capable of walking, therefore they are categorized as unstable. Here categorization processes should allow individuals to preattentively ignore the less valuable distractors and focus more on the more valuable distractors. Unlike most contextual cueing studies, distractors will be real items and participants will be more likely to employ contextual cueing strategies that are more similar to those that they use in a real environment. Therefore they will be able to select landmark locations that in a real environment would better predict the location of a target.

There were two contextual cueing tasks. In the first experiment participants searched for and indicated the location of a small flag within a typical park scene. The distractors in the scene consisted of stable (a bench, a fountain, a crosswalk sign, a stop sign, and a lamp post) and unstable (a man on a bicycle, a woman jogging, a bird, a cat, and a dog) distractors. During an acquisition phase, participants viewed 10 scenes repeatedly. These 10 predictable displays

contained both the stable and unstable objects and all predicted the target location. After several blocks in the learning phase, participants then completed two blocks of a test phase. Testing contained the predictable displays encountered in the learning phase in addition to new unpredictable displays where distractors did not predict target location. Testing consisted of two conditions for each experiment. In one condition the stable objects were removed from the scenes and only the unstable objects were left to predict the target location. In the second condition the unstable objects were removed and only the stable objects were left to predict the location of the target. It was predicted that participants would respond faster to the predictable displays within each of the two conditions, as participants had previously experienced these displays in the learning phase. It was predicted that if participants identified stable objects as better landmarks, then they would have exhibited a larger difference between the predictable and unpredictable when the stable objects are present. To test if these landmarks (distractors) maintained their properties of a good or bad landmark when not in a scene context, a second experiment was designed. In Experiment 2 participants searched for a single small flag (target). The distractors consisted of the same distractors presented in Experiment 1. The difference in the two experiments was the background. While Experiment 1 had a real-scene background consisting of a wooded park scene located by a road, Experiment 2 had a simple light grey background. If the properties that make an object a good landmark are inherent in the object, then contextual cueing differences for stable vs unstable objects should be the same whether the object is embedded in a scene (Experiment 1) or presented in isolation (Experiment 2). If the properties that make an object a good landmark are produced by the object appearing in context, then contextual cueing differences for stable vs unstable objects should be greater in Experiment 1 (in favor of stable objects) than in Experiment 2. Overall, the hypothesis was that participants

would exhibit contextual cueing and respond faster to the targets located in predictable slides than in unpredictable slides due to the implicit learning of distractor locations. Specifically, in Experiment 1 and 2 it was expected that participants would locate the target faster during the test phase condition in which stable objects remain in the predictable displays than in the slides where only unstable items are present in the predictable displays. It was predicted that participants would place more importance on the distractors that are better landmarks, the stable items.

CHAPTER 2

METHOD

Experiment 1

Participants

Participants were recruited through the introductory psychology subject pool at the University of Alabama. A total of 68 participants completed Experiment 1. Participants received course credit for completing the study. The mean age of participants was approximately 19 years old.

Stimulus Materials

Stimulus displays of real-world scenes were presented on a computer monitor. In the first experiment displays consisted of outdoor park scenes with a road and trees (see Figure 1). In the experiment there were 10 predictable displays and 40 unpredictable displays. Predictable displays consisted of an outdoor scene with a target item to be located by participants. The target was a small, white flag containing the University of Alabama seal. Distractor items were grouped into two categories: stable and unstable. Stable items are those that typically remain in the same location in a real world scene (e.g., a bench and road signs) and unstable items are those items that are likely to be moved by an agent (a man on a bicycle) or move on their own (cat). There were 5 different distractors of each type. Stable items consisted of a large water fountain, a concrete bench, a crosswalk sign, a stop sign, and a lamp post. Unstable items consisted of cat, a

man on a bicycle, a woman jogging, a bird, and a dog. In each of the predictable displays, the locations of both categories of the distractors predicted the location of the target in the display during an acquisition phase. Each time the scene was presented, all the distractors and the target were in the same location. Across all displays the background scene was similar (i.e., no unique large buildings) to prevent any specific background information from predicting the target location. Further, the location of the target and distractors changed in each background.

Predictable displays in the test phase were the same 10 predictable displays used during acquisition except they included only have half of the distractors. Half of the predictable displays during the test phase only included the stable distractors (street sign, lamp post) and the other half only included the unstable distractors (cat, bicycle). Unpredictable displays were only presented during the test phase. Distractors were presented in random locations and hence did not predict the target when the unpredictable displays were presented.



Figure 1. Experiment 1 Example Stimuli

Design

The independent variables were Predictability (predictable or unpredictable display) and the type of distractors (stable or unstable). The primary dependent variable was the reaction times (RT) to locating the target item in the slides during the test phase. Of primary interest was the degree to which reaction times in the predictable condition were faster than those in the unpredictable condition during the test phase.

Procedure

Experiment 1 was presented using Superlab experimental lab software with automatic recording of reaction times to the nearest millisecond. Participants were presented a series of displays on a computer screen. Participants were asked to find the target flag and to indicate the side of the flag that displayed the University of Alabama Seal (right or left) in each display as fast as possible without making errors. Participants identified the location of the seal on the flag by pressing either the A (left) or L key (right) on the computer keyboard. In each condition there were 4 acquisition blocks consisting of only predictable displays (where all the distractors predicted the location of the target). In each learning block the 10 predictable displays were repeated 4 times each. In the learning phase, participants were shown 10 real-life scenes consisting of typical wooded street views. In the learning phase all distractors appeared in each of the scenes.

After the learning phase there were 2 blocks in the test phase consisting of a total of 60 trials. Predictable displays within the test phase were categorized into two types: Stable (block A) and unstable (block B). There were 10 displays in each category, repeated two times each. In

the stable category the unstable items were removed so that these slides only consisted of the stable distractors. The background scene remained in every display. In block two, predictable slides had the stable distractors removed so that the only distractors within the scene were the unstable items (cat, bird). The two types of predictable displays were randomized within the test block. There were 40 unpredictable displays for each condition. Like the predictable displays, half of the unpredictable displays only included stable distractors items while the remaining half only included unstable distractor items.

Experiment 2

Participants

Participants were recruited through the introductory psychology subject pool at the University of Alabama. A total of 63 participants completed Experiment 2. Participants received course credit for completing the study. The mean age for participants was approximately 19 years old.

Stimulus Materials

The same stimulus items were used in Experiment 2 as were used in Experiment 1 with the exception that the background scene was replaced with a solid light grey background (see Figure 2).

In the experiment there were 10 predictable displays and 40 unpredictable displays. Predictable displays consisted of displays with a target item being a single, small flag. Targets were located equally in each quadrant of the displays. Distractor items were grouped into two categories: stable and unstable. Stable items are those that typically remain in the same location

in a real world scene (e.g., benches and road signs) and unstable items are those items that are likely to be moved by an agent (bicycle) or move on their own (cat). There were 5 different distractors of each type. Stable items consisted of a large water fountain, a concrete bench, a crosswalk sign, a stop sign, and a lamppost. Unstable items consisted of cat, a man riding a bicycle, a bird, a woman jogging, and a dog. In each of the predictable displays, the locations of both categories of the distractors predicted the location of the target in the display during an acquisition phase. Distractors in Experiment 2 were sized according to usual size in Experiment 1 as if they were located within a scene, as to not add a variable of size into Experiment 2 that was not in Experiment 1.

Predictable displays in the test phase were the same predictable displays used during acquisition except they included only have half of the distractors. Unpredictable displays were only presented during the test phase. In the half of the unpredictable displays, the five stable distractors were used and in the other half the five unstable distractors were used. However, these distractors were presented in random locations and hence did not predict the target when the unpredictable display is presented. The relative size of individual objects was approximately the same in the two experiments.



Figure 2. Experiment 2 Example Stimuli.

Design and Procedure

The basic design and procedure was identical to Experiment 1.

CHAPTER 3

RESULTS

Experiment 1

Preliminary Treatment of Data

Mean response times were calculated for the four blocks of the learning phase and for the four conditions of the test phase. Errors for participants included in data analysis were less than 1% overall. Hence, error rates were not analyzed. Improvements in performance during the learning phase would reflect both general task learning and changes associated with stimulus repetition. Contextual cueing effects would be indicated by faster response times to predictable than to unpredictable displays in the test phase. If participants exhibit the selective implicit learning of context as a function of landmark stability, then contextual cueing effects in the stable landmark conditions should also be greater than those in the unstable landmark conditions. This would be evidenced by a stability x predictability interaction.

Analysis of Learning Phase

These data were analyzed using a One-Way ANOVA with reaction times (dependent variable) being measured across all four blocks (independent variable). There was a significant difference in reaction times across blocks, $F(3, 43) = 85.750$, $p = .000$, $\eta_p^2 = 1.00$. A Tukey HSD post hoc analysis revealed that the mean for block 1 was significantly greater than the other three blocks at $p < .01$, see Figure 3. Participants became faster at locating the target with increased

practice. This response time decrease could be due to a variety of factors including learning the procedure, becoming better at recognizing the target, and learning of the scene displays.

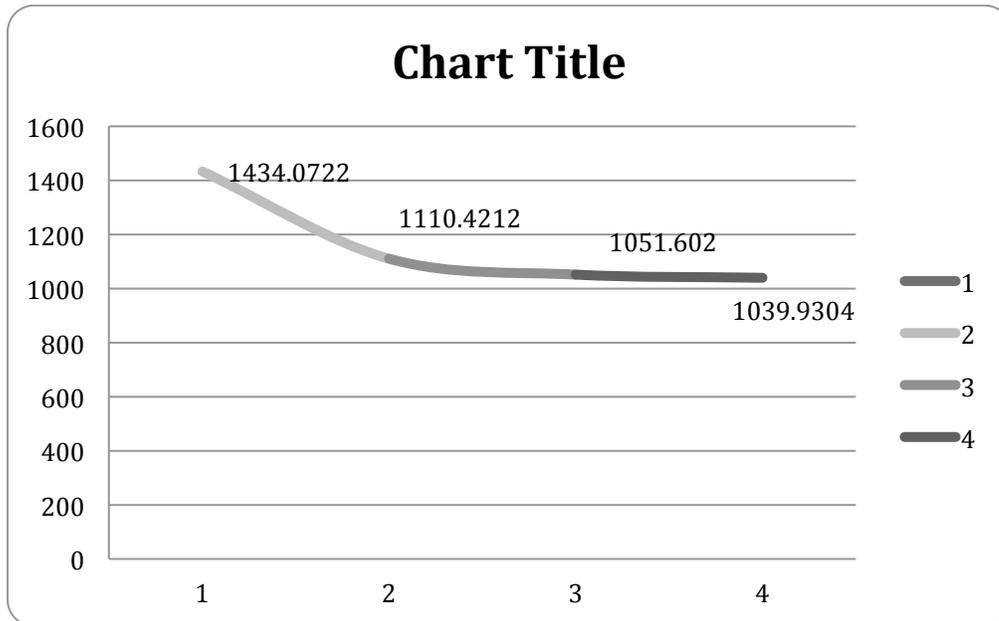


Figure 3. Reaction Time Means in MS Across Learning Phase Blocks

Analysis of Test Phase

Test phase data were analyzed using a 2 (predictability) x 2 (stability) within subjects ANOVA. The analysis revealed a significant main effect of predictability, with the unpredictable condition ($M = 1054$, $SD = 160$) actually being faster than the predictable conditions ($M=1170$, $SD=255$), $F(1,67)=29.364$, $p=.000$, $\eta_p^2=.070$. This was opposite of the predicted direction and indicated that participants responded slower to the repeated displays (See Table 1). Apparently, removing some expected items from the displays actually slowed recognition of the old displays and made the search more difficult. The lack of contextual cueing will be revisited later. There was also a significant effect of stability, $F(1,67)=11.147$, $p=.001$, $\eta_p^2=.143$. Overall, participants

responded faster to the slides in the stable condition ($M=1083.5$) than to those in the unstable condition ($M=1140.5$). There was also a significant interaction between stability and predictability, $F(1,67)=5.054$, $p=.028$, $\eta_p^2=.070$. Participants exhibited a larger effect of predictability in the stable relative to the unstable condition. Again, however, the effect of predictability was opposite my basic predictions in that stability resulted in increased interference or response cost rather than facilitation. Relative to the unpredictable stable displays, the predictable stable displays were 150 ms slower. Relative to the unpredictable unstable displays, the predictable unstable displays were only 80 ms slower. Post hoc analyses revealed that response cost was significant in both conditions (both p 's $< .05$). Hence, participants did exhibit a larger effect to stable relative to unstable distractors. However, the effect was opposite of predictions and resulted in greater response cost rather than greater contextual cueing when stable objects predicted the location of the target.

Although it is unclear from the available data why participants did not exhibit contextual cueing effects to familiar scenes, it is important to note that Experiment 1 is the first study using scenes in which some of the objects in the scene had been removed. As a working hypothesis, I considered that real-scene displays may be viewed more holistically than random displays commonly used in contextual cueing. As a result, moving or removing one or more objects may actually interfere with the processing of the scene in that it looks vaguely familiar, but somehow different. In an attempt to better understand the response cost effect, I evaluated this possibility in a supplemental experiment described later.

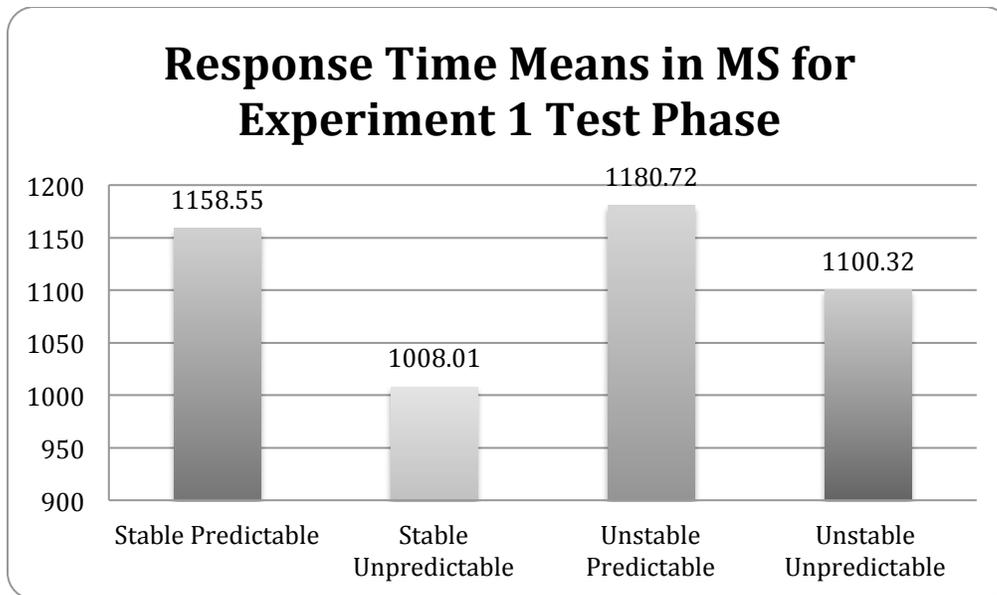


Table 1. Response Time Means in MS for Experiment 1 Test Phase.

Experiment 2

Data preparation for the analysis of Experiment 2 followed the same plan as described for Experiment 1. Errors for Experiment 2 were again less than 1% and errors were not considered further.

Analysis of Learning Phase

These data were analyzed using a One-way ANOVA to determine differences in reaction time across the four learning blocks. There was a significant difference in the reaction times over blocks, $F(3, 55) = 19.945$, $p = .000$, with an observed power of 1.00. A Tukey HSD Posthoc revealed that the mean for block 1 was significantly greater than the other three blocks at $p < .01$, see figure 4. Participants became better at the task as they received increased practice. As in Experiment 1, this general improvement can be due to improvement in a variety of task factors.

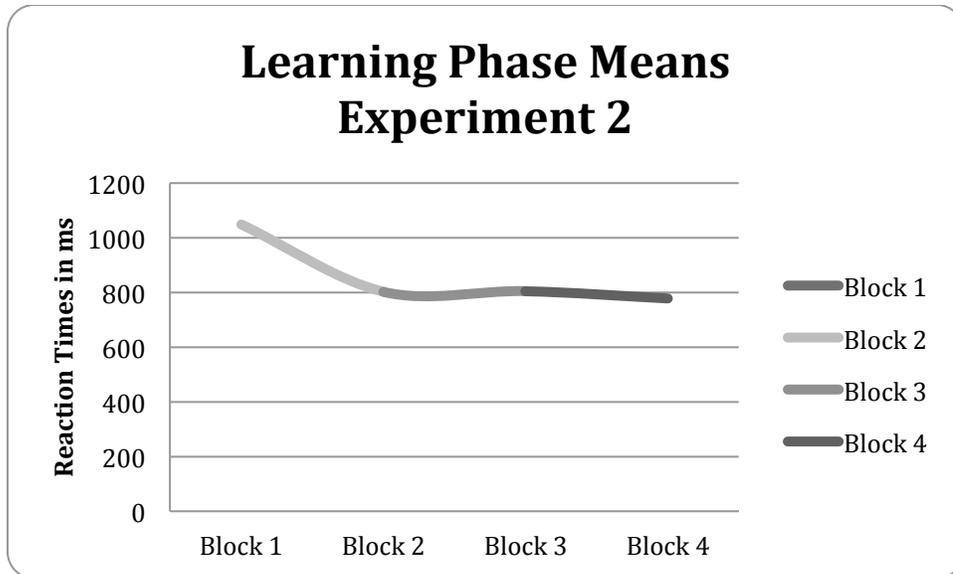


Figure 4. Reaction Time Means in MS Across Learning Phase Blocks

Analysis of Test Phase

Test phase data for Experiment 2 were analyzed using a within subjects 2 (Predictability) x 2 (Stability) ANOVA. Overall there was no significant effect of stability, $F(1, 62) = 1.798, p = .185, \eta_p^2 = .028$ or predictability, $F(1, 62) = .506, p = .480, \eta_p^2 = .008$. Means in the predictable conditions were very similar in both the stable ($M = 825.9, SD = 169.3$) and in the unstable condition ($M = 832.3, SD = 222.8$). Although overall no effects of predictability were observed, there was a significant interaction between predictability and stability, $F(1, 62) = 4.738, p = .033, \eta_p^2 = .071$. The interaction shows a much bigger difference between the predictable and unpredictable displays in the unstable condition than in the stable condition, where reaction times in the predictable and unpredictable displays were more similar. Although neither simple effect was significant, predictability facilitated performance in the stable condition and resulted in response cost in the unstable condition. Interestingly, this pattern was opposite that observed in Experiment 1 where a larger response cost was observed in the stable condition than in the

unstable condition. Hence, the two types of distractors performed differently when presented in scenes than when presented against a gray background.

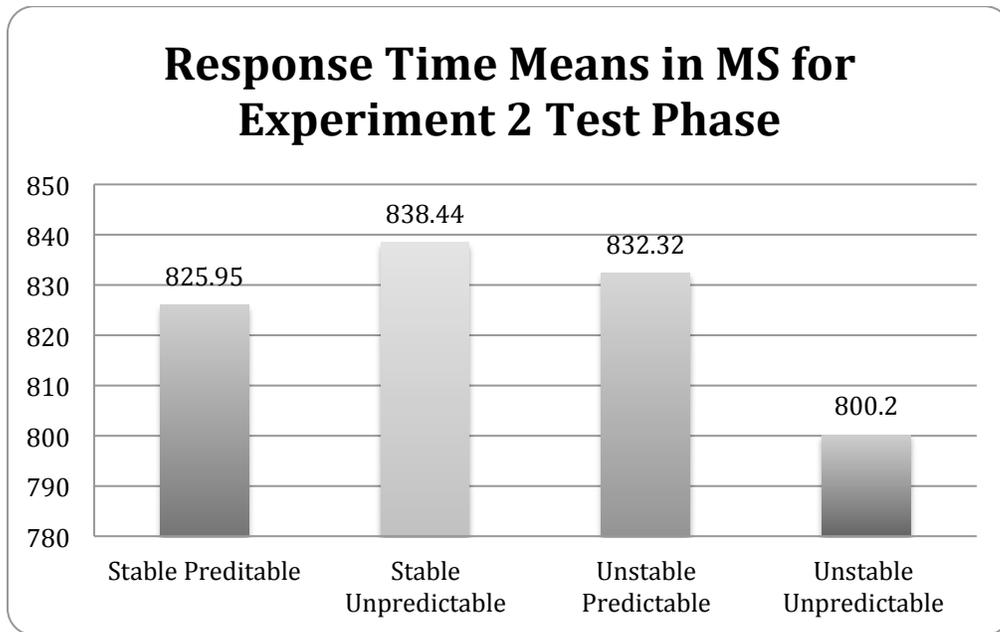


Table 2. Response Time Means in MS for Experiment 2 Test Phase.

Supplemental Analyses

I considered the possibility that the PY 101 participants at the end of the semester were not sufficiently engaged in the experimental procedures to produce reasonable data. In fact, error rates under 1.0% often indicate that participants are not responding as fast as possible. To address this possibility, I decided to repeat the analysis including only the participants who exhibited contextual cueing effects. My rationale was that participants who exhibited contextual cueing effects were very likely performing the task as expected. Including only those participants in the analysis may be more informative about the research questions.

Analysis of Participants with Contextual Cueing

The analyses were repeated with only participants who exhibited contextual cueing in at least one condition. As reported below, the results indicated that the same pattern of performance associated with the stability manipulation was observed for participants who exhibited contextual cueing relative to all of the participants. In Experiment 1, a total of 68 participants completed the study. For the supplemental analysis, 32 participants who exhibited contextual cueing in at least one condition (stable and/or unstable) were included. For Experiment 2, a total of 63 participants complete the study and 49 were included in the supplemental analysis of participants who exhibited contextual cueing.

Experiment 1

A 2x2 repeated measures ANOVA indicated that, like before, there was no significant effect of predictability, $F(1, 31) = .106, p = .747, \eta_p^2 = .003$. There was also no significant effect of stability, $F(1, 31) = 3.554, p = .069, \eta_p^2 = .103$. There was a marginally significant interaction between predictability and stability, $F(1, 31) = 3.523, p = .07, \eta_p^2 = .102$. Overall, the pattern of the data did not change, with participants still responding faster to the unpredictable displays in the stable condition, while responding faster to the predictable displays in the unstable condition (see Table 3). More specifically, the pattern of results associated with the interaction did not change, indicating that participants who did exhibit contextual cueing were affected by the stability manipulation in the same way as was exhibited by all of the participants. Participants exhibited greater response cost in the stable condition relative to the unstable condition. However, because I only included participants who exhibited contextual cueing there was actually facilitation in the unstable condition relative to non-significant response cost in the

stable condition. Of course, it is also important to note that fewer than half of the participants exhibited contextual cueing overall, lending support for the position that my participants did not exhibit any evidence of contextual cueing with repeated exposure to real world scenes.

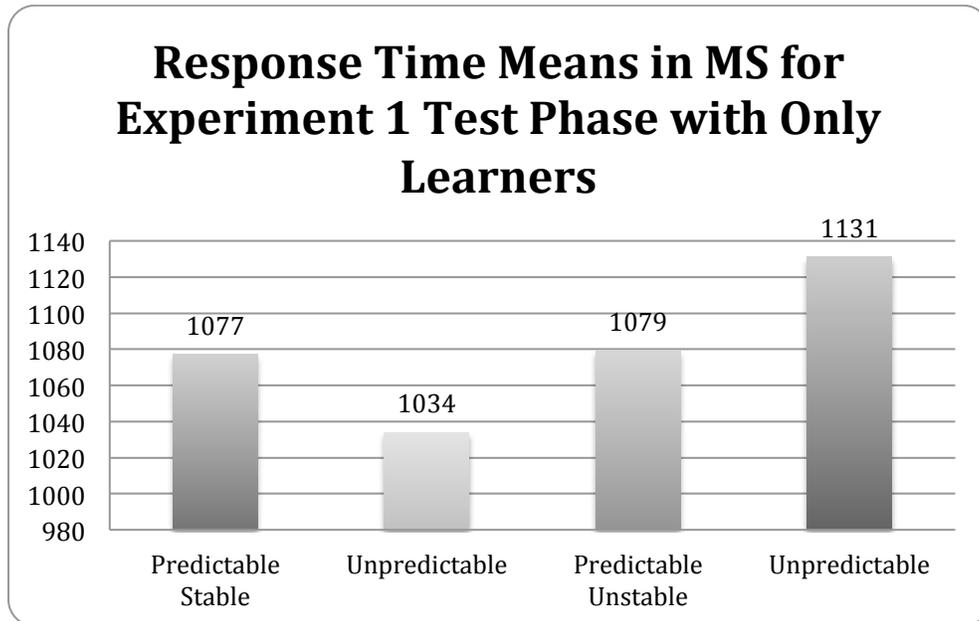


Table 3. Response Time Means in MS for Experiment 1 Test Phase with Only Learners.

Experiment 2

A 2x2 repeated measures ANOVA was conducted with only participants that indicated contextual cueing in at least one condition. Results were similar to before with a main effect of predictability, $F(1, 48) = 8.884, p = .005, \eta_p^2 = .156$ and a main effect of stability, $F(1, 48) = 2.863, p = .097, \eta_p^2 = .083$. There was also a significant interaction between predictability and stability, $F(1, 48) = 4.373, p = .042$. Again, the pattern of results associated with the interaction did not change, indicating that participants who did exhibit contextual cueing were affected by the stability manipulation in the same way as the entire sample (see Table 4). Not surprisingly, in the analysis of participants who exhibited contextual cueing, there was significant contextual cueing

in the stable condition ($p < .05$), although the effect was not in the unstable condition. Hence, regardless of whether or not contextual cueing was observed, object stability influenced memory for objects (as evidenced by the interaction in both experiments) and does so differently when presented in scenes versus presented against a solid background.

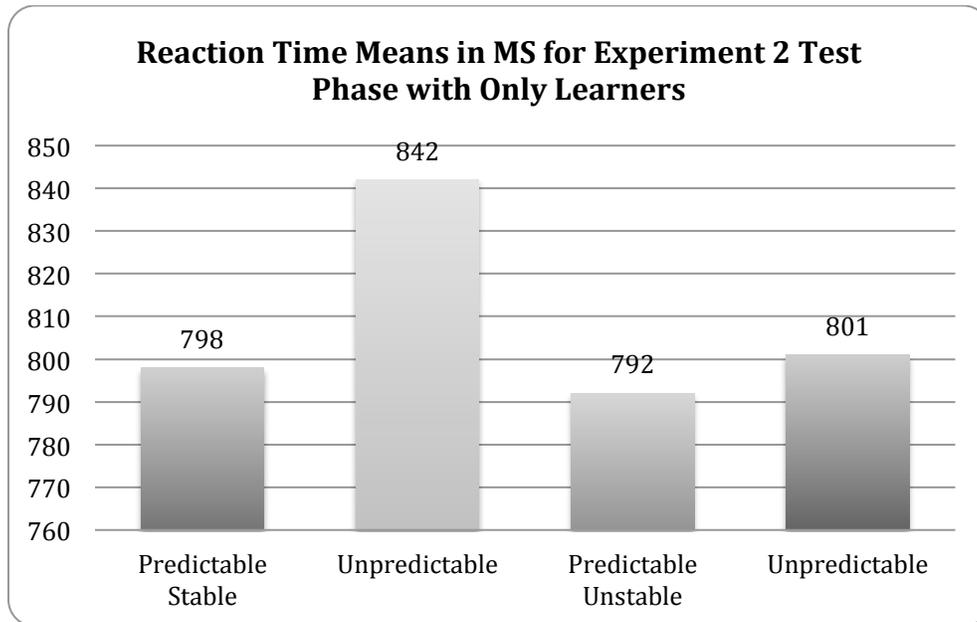


Table 4. Response Time Means in MS for Experiment 2 Test Phase with Only Learners.

Real-Scene Contextual Cueing

Following Experiments 1 and 2, a supplemental study was conducted to determine if participants simply had difficulty with real-scene contextual cueing or if perhaps removing half of the distractors during the test phase was what disrupted contextual cueing. The study was identical to Experiment 1 with the exception that all distractors remained during the test phase. Hence, this was a simple contextual cueing task was using with the same background scenes, distractors, and target. Stability was not of interest, and all items remained during the test phase.

Therefore, the only independent variable considered was predictability. Twenty-five participants recruited from Introductory Psychology classes took part in the supplemental study.

Analysis

A repeated measures ANOVA was conducted to compare predictable and unpredictable displays of the test phase. As in Experiment 1, there was a significant difference between the reaction times to the predictable and the unpredictable displays, $F(1,24) = 7.309$, $p = .012$, $\eta_p^2 = .304$. However, similar to what was seen in Experiment 1 using the real-scene displays, participants actually responded faster to the unpredictable displays ($M = 1090.15$, $SD = 167$) than the predictable displays ($M = 1158.91$, $SD = 220.78$). Again contrary to predictions, participants found the target location faster in the scenes with random distractor locations that they had not previously seen than in the repeated, predictable displays. Therefore, the peculiar lack of contextual cueing and resulting response cost observed in Experiment 1 was not simply because I removed objects from the scenes during the test phase. There must be some other explanation for the failure to observe the expected facilitation effect with repeated displays. This issue will be discussed in the next section.

CHAPTER 4

DISCUSSION

General Discussion of Results

This project was designed to evaluate the effect of repeated exposure on the ability to implicitly learn the location of objects in real world scenes. In particular, it was designed to determine when participants implicitly identified some objects as more informative than other objects that can be encountered in scenes. The general hypothesis was that inherent stable objects such as water fountains, benches, and road signs would be more informative about the location of other objects in a scene than would relatively unstable objects that could move to different locations or completely out of the scene on their own such as animals or people. Overall, there was a difference in the degree to which stable and unstable objects influence performance to repeated relative to novel displays. In fact, this difference was observed for stable vs unstable objects encountered in real world scenes and those presented against a solid background. However, at least when it comes to the processing of scene information, repeated exposure results in a response cost rather than the facilitation that typically reflects a contextual cueing effect. As such, the difference in the processing of stable vs unstable objects in real world scenes was reflected in a greater cost when unstable objects were removed during the test phase relative to when stable objects were removed. Interestingly, the opposite pattern was observed for these same objects when presented against a solid background. Following a more detailed summary of the primary results of these experiments, I will consider why scene processing may lead to

response cost rather than facilitation and how stable and unstable objects may differentially influence memory for real world scenes.

In Experiment 1, it was expected that participants would exhibit contextual cueing. If learning were to occur, contextual cueing effects would be evident through faster reaction times to predictable displays than unpredictable displays. The direction of the response time difference for the predictability manipulation was actually opposite of the prediction. The effect indicated that participants actually responded slower to the slides they viewed multiple times in the learning phase and faster to the displays with distractor locations that they had never encountered. Although unexpected, some possible explanations of what may be happening with predictability will be discussed in further detail below. There was also a main effect of stability for Experiment 1, with participants responding faster to the displays in the test phase that contained stable items, than displays only containing unstable distractors. Of major importance, I observed a significant interaction between stability and predictability, where stability resulted in a much larger response cost between predictable and unpredictable displays in the stable condition relative to the unstable condition. Hence, participants were clearly viewing stable and unstable distractors differently when they were repeated in real world scenes.

In Experiment 2, the main effects for predictability and for stability were not significant. Due to this condition being more similar to traditional contextual cueing tasks (i.e., randomly placed distractors on a solid background) it was predicted that contextual cueing effects would be seen for both conditions. However, in the stable condition of Experiment 2, although response times to the stable predictable displays were faster than those to the stable unpredictable displays, this difference was not significant. There was, however, a significant interaction between predictability and stability in Experiment 2. Opposite of Experiment 1, there was more

response cost in the unstable condition than in the stable condition in Experiment 2. In fact, predictability seemed to facilitate performance slightly in the stable condition, but caused the opposite effect in the unstable condition where response times were faster for unpredictable displays.

Because predictions were based on observing contextual supplemental analyses of both Experiment 1 and Experiment 2 were conducted including only participants who exhibited contextual cueing in the stable and/or unstable condition. Fewer than 50% of the participants in Experiment 1 and approximately 75% of the participants in Experiment 2 did exhibit contextual cueing in at least one condition. Interestingly, the pattern of results between stable and unstable distractors remained the same as when all participants were included in the analysis. Hence, the interaction of predictability and stability did not depend on the observation of contextual cueing in either experiment.

The failure to observe contextual cueing when scenes were presented was a concern for this study. In particular, I wanted to determine if simple methodological differences were the cause of the response cost that participants were exhibiting. Therefore a third study was designed. The particular methodological issue I wanted to test was whether removing half of the distractors (either unstable or stable objects) disrupted the expression of contextual cueing during the test phase. This is not common in contextual cueing studies. Therefore, I repeated Experiment 1 in a supplemental study except the repeated and new displays of the test phase of the supplemental experiment retained all of the distractors. The results were identical to Experiment 1. Participants still responded faster to the unpredictable displays, exhibiting a response cost associated with the repeated displays rather than the expected contextual cueing. Apparently, the lack of contextual cueing for my scenes was not associated with removing half

of the distractors from each scene. Hence, it appears to be a real phenomenon and will be discussed in the next section.

Absence of Contextual Cueing Effects

There was a marked absence of contextual cueing in the two main experiments and also in the supplemental experiment. This was especially unexpected in Experiment 2 when objects were presented against a solid color background. It is reasonable to suggest that removing several of the objects between acquisitions and testing was responsible for the result in Experiment 2. However, Experiment 1 and the supplemental study used real-scene backgrounds, which we suggest may have eliminated contextual cueing effects.

Response Cost in Repeated Search Tasks

Repeated visual search through a display typically results in a facilitation effect to locating the target in the display. Participants search for a target location within a handful of displays and respond much faster to the slides they have previously searched (cite typical CC studies). This effect has been found in numerous studies and under numerous conditions. It has been found when a target is embedded in displays when all the distractors are the same (Chun and Jiang, 1998) and when all the distractors are different from each other (Chun, 2000) It has been found when all of the distractors predict the location of the target (Chun and Jiang, 1998) and when as few as 33% of the distractors are predictive (Yang and Merrill, 2015). It has been found when the displays consist of randomly placed objects against a solid background (Chun and Jiang, 1998) and when the objects that predict the target location are logically located within a complex scene (Brockmole and Henderson, 2006). Nevertheless, there have been occasions

when repeated visual search has resulted in response cost rather than facilitation Response cost is indicative of participants actually responding slower to the slides they have previously had to opportunity to learn. Several manipulations during repeated search experiments have been found to result in response cost. In this section, I consider whether previous observations of response cost can help to explain the results I observed in the real world scene condition in Experiment 1 and the supplemental experiment.

Response cost has been observed when participants are required to locate multiple targets in a single display or when a single target has appeared in multiple locations in the display. In other words, response cost can result when the predictive power of the context is reduced. In a study by Thomas and Merrill (2013), participants were instructed to locate either a T or a 5 within a display of 16 letters and numbers. Across blocks a prompt appeared to indicate which target was now the relevant target and the other, still located within the displays, was to be ignored. Although a similar design using targets of different colors yielded contextual cueing (Thomas and Merrill, 2012), the study involving numbers and letters did not. Participants responded significantly slower when searching for two targets located within the same display. This may indicate that participants are sometimes able to preattentively ignore a target when it has very different features (color), but not when the target differences are relatively similar (letters and number). The study by Thomas and Merrill (2013) suggest that there may be limitations to contextual cueing and the flexibility of contextual cueing may be less than previously thought. In the study by Thomas and Merrill, participants were searching amongst distractors for multiple targets and therefore may have been drawn to the other nonrelevant location by the scenes containing two targets. In the current study, due to how similar the backgrounds were, participants may have subjectively treated the targets as moving to multiple

locations. Much like having multiple targets within the same display, participants may have initially been drawn to the location of the other target or the previous location of the target after it has been moved. As observed in the study by Thomas and Merrill (2013), it appears that participants automatically scan an area occupied by a target that was previously relevant. Yang and Merrill (2015) actually changed both target identity *and* location. Previous distractors became targets throughout the study and participants responded more slowly to the predictable displays than to the unpredictable displays. Yang and Merrill found that although changing targets caused an increase in response times, less response cost was observed when new targets were located in a previous target location. When targets changed both identity and location, the most response cost was seen.

Similarly, response cost as been observed when participants attempt to locate multiple targets locations in a single display (Yang & Merrill, 2015). A single target moved to different locations within the same display causes the distractors to become less predictive of specific locations as the target moves. Researchers have shown that moving targets to locations previously occupied by distractors caused reaction times to be slower to displays that had been seen before than to new displays (Ogawa, Takeda, and Kumada, 2007; Makovski and Jiang, 2010). Ogawa and colleagues suggest that participants must attend to the target and simultaneously inhibit attention the location of the distractors as they were learned to be irrelevant. Moving a target to a location previously held by a distractor would cause an interference of inhibition to the previous distractor and a facilitation to the target, resulting in response cost. Although greater interference is found when the target occupies a location previously held by a distractor, Makovski and Jiang (2010) have also shown that response cost increases as the new target location becomes more distant from the old target location.

It is reasonable to assume that participants may have viewed the background scenes in Experiment 1 as fundamentally the same scene with moving targets and distractors. Therefore, they exhibited response cost in Experiment 1. Participants viewed the same 10 displays multiple times throughout the learning phase, and there was no indication that participants were learning across the blocks of the learning phase. Participants may have viewed the target as ever moving within the same display, which caused the target location to be less predictable which resulted in either no contextual cueing or a response cost. If the design caused participants to view the backgrounds as identical and the context became less predictable, response cost may have resulted. Like in Yang and Merrill's study, the same target moving to completely new locations within the display may have caused the response cost seen in Experiment 1.

A different possible explanation for why response cost was evident in the Experiment 1 results is that perhaps there was an integration of individual objects with the background that formed a single, unitary scene. Following integration, isolating individual object locations becomes more difficult. Therefore, target detection times become slower when scenes are repeated relative to the new slides, accounting for response cost. This may explain why no contextual cueing was evident when objects were embedded as part of a larger structure. In a study by Conci, Muller, and Muhlenen (2013) a typical contextual cueing design was conducted using Chun and Jiang's typical Ts and Ls, with the exception that stimuli included a square located within the scene, encompassing some of the distractors and target. Results indicated contextual cueing when the target was presented within the square and significant costs to contextual cueing when the target was located outside of the square. Overall, Conci and colleagues found that grouping objects creates segmented units that affect contextual cueing and creates units. Some groups may or may not attract attention. The binding of features into a single

larger display, like distractors into a real scene, requires more attention to pull out individual features when searching a repeated display. Assuming that repeated exposure to the repeated displays resulted in a stronger binding of the parts, then searching for individual items in the repeated displays may have taken longer than searching for the same, less well integrated items in new displays during the test phase. Contextual cueing is reduced when objects are embedded as part of a larger structure, as individuals tend to view these structures as a whole and not as individuals (Conci, Muller, and Muhlenen, 2013).

Discussion of Stability

A primary focus of this experiment was on how the relative stability of landmarks influenced implicit learning of real world scenes. I had expected to find that stable landmarks would be better learned than unstable landmarks when presented in a scene and that participants would use the stable landmarks to facilitate the search for a target in these scenes. The actual relationship I observed between stability and learning was much more complex. Most importantly, as discussed earlier, repeated exposure to the scenes actually resulted in slower search times relative to new displays. Nevertheless, there was a difference in the magnitude of response cost observed when stable items were removed from the displays relative to when unstable items were removed. In the real world scenes, removing the stable items (in the unstable condition) caused participants to exhibit significantly less response cost than did removing the unstable items. This was very different from participants who viewed the objects out of context and randomly located on a solid color background. In this condition, removing the stable items resulted in a small and nonsignificant response cost whereas removing the unstable items resulted in a small and nonsignificant facilitation, with the difference between conditions being

significant. In other words, presenting the stable items in real world scenes resulted in them affecting visual search very differently than when they were presented out of context. The unstable items were much less affected by being included in a real world scene.

Why should stable items be affected more by being included in real world scenes than are unstable items? One possible explanation is based on an argument similar to one suggested for the observation of response cost in scene perception. I suggested that response cost may have resulted from the integration of landmarks into the scene display with repetition of the scenes. Here I suggest that stable landmarks, because they are commonly more likely to remain in the scenes across real world exposures, may be more easily integrated into the background than are unstable landmarks. As a result, response cost may be more likely to develop faster for stable than for unstable landmarks. Stable items are more likely to be bound to scene context and remain in the scene the next time they are encountered which results in a response cost. Participants took significantly longer to find the target in predictable displays where only stable distractors remained, suggesting that these items became so integrated within the overall scene that participants did not notice them in the learning phase and therefore were unable to utilize them in the test phase. In Experiment 2, no context existed, so participants noticed all items equally and perhaps even depended on the stable items more than the unstable, as indicated by the pattern of the results.

Despite not finding contextual cueing effects in Experiment 1 or 2, participants were clearly processing stable and unstable landmarks differently. Obviously this difference in how participants treated stable and unstable landmarks is not influenced by whether they exhibited contextual cueing or not. Even when participants who did not exhibit contextual cueing were removed in a supplementary analysis, there was no difference in how the participants who

exhibited contextual cueing processed the landmarks. Overall, when unstable items were removed in Experiment 1, there was a large response cost. While in Experiment 2, removing the stable items caused a larger response cost, indicative of the different type of landmark processing occurring in each of the two display scenarios.

Contextual Cueing and Wayfinding

Contextual cueing typically has involved arbitrary distractors that predict the location of an arbitrary target (Chun and Jiang, 1998). Scenes are static, backgrounds are blank, and participants simply click through contextual cueing tasks without too much explicit processing. Introducing real-scenes and realistic distractors may interfere with the way that contextual cueing typically operates. Contextual cueing in real-scene search was not supported by the results. Perhaps wayfinding may be more explicit and proceduralized a process than those that would likely benefit a great deal from contextual cueing. Wayfinding may begin as an explicit process that then becomes implicit through repetition rather than one that begins as implicit or incidental learning and becomes explicit with growing awareness. Because contextual cueing is inherently implicit, it may not be a major contributor to wayfinding. In a study by Vilar, Rebelo, Noriega, Teles, and Mayhorn (2015) participants relied heavily on signs that guided them through the environment, even when the signs were contrary to the implicit path they had previously preferred. It seems as though explicit guides are the more important contributors to participants' performance on wayfinding tasks (Rebelo and Filgueiras, 2012; Vilar et al., 2015). Anecdotally, it is well known that passengers in cars do not learn routes as well as drivers do. Since wayfinding may be more of an explicit process, contextual cueing may not contribute to route

learning to a major degree. However, it is also possible that implicit spatial learning can make some contributions to wayfinding performance.

One contribution that implicit spatial learning can make is to facilitate the association of unique landmarks with particular paths along a route. In my research, it is clear that common landmarks are not particularly informative. However, perhaps contextual cueing can influence wayfinding only under specific circumstances. For example, highly unique landmarks may better stand out in a scene and may become implicitly linked with a target (or turn) location, which may help direct travel within an environment. In my research, the common distractors became embedded in the background. However, research by Hamburger and Roser (2014) suggested that participants learned landmarks better when they were easily recognizable famous buildings. Based on the data presented here, contextual cueing may not be one of the most important aspects of wayfinding and previous research involving real-scene contextual cueing may not directly apply directly to wayfinding situations. Nevertheless, unique landmarks may be helpful when learned implicitly.

A second way that implicit spatial learning can facilitate wayfinding is by helping identify which objects make for good landmarks and which objects do not. The results of this study suggest that there is a difference between stable and unstable objects. Information about what does and does not make a good landmark is part of an individual's knowledge base. Although individuals may be drawn explicitly to landmarks, explicit search may be guided by implicit knowledge about landmark quality. Information about categories and properties of items grouped into stable or unstable categories can help guide participants to choose to best landmark during a wayfinding task. Research suggests that individuals with intellectual disabilities select less efficient landmarks than a group of matched controls (Courbois, Blades, Farran, and

Sockeel, 2013). Individuals with intellectual disabilities chose landmarks that were less unique, contained fewer words, and were nonpermanent within the environment (Courbois, Blades, Farran, and Sockeel, 2013). Perhaps a form of contextual cueing that can train the difference between good quality and poor quality landmarks would be beneficial to persons with ID.

Limitations

There are some limitations to what I can conclude from the results. One limitation to Experiment 1 was that all the backgrounds, although slightly different, were relatively similar. Participants therefore may not have learned each individual slide but rather may have viewed the distractors as ever moving within the same display, which was unanticipated due to the relative newness of real-scene contextual cueing. The scene backgrounds were purposefully chosen to work as a real wayfinding activity where participants travel through a similar environment. Typically in real navigation individuals do not jump from a beach scene to a mountain scene. However, the backgrounds may have been too similar. As discussed earlier, this may explain why there were no contextual cueing effects. Experiment 1 indicated that participants may have trouble with a real-scene contextual cueing task and the supplementary study using identical backgrounds as experiment 1 confirmed. In the future, I would like to revisit this idea by designing a task involving distinct background scenes.

A second possible limitation is associated with the type of distractors that were chosen. The unstable landmarks contained all animate objects, which may limit the generalizability of the results. Animate objects may attract the attention of participants especially since they were all living things, further causing participants to ignore the stable distractors within the scenes. Also, the living distractors did not move within the displays, and in a real environment it is unlikely

that a cat would remain in one location. This experiment was designed to show that movement was a characteristic of the landmark, whether or not it was moved within the display. Moving the unstable, and therefore moveable, landmark wildly within the same display would have caused the landmark to no longer predict the location of the target. In the future, designing a task where unstable items actually move within a small area would help determine if participants were attributing unstable properties to the unstable yet nonmoving objects located within a picture.

Future Directions

Future directions may include designing a similar study with stable and unstable distractors within distinct real-scene backgrounds. Using city scenes, a mountain landscape, and a park may help participants keep from confusing backgrounds and see stable items as not moving around within the same display. Displays should be distinct enough to stand-alone yet also must be similar enough to rely on the distractors, and not the overall background, to predict the target location. In the current study, all scenes were very similar. Using distinct backgrounds would eliminate the potential for participants to view the target as moving within the same basic scene and would further investigate if real-scene contextual cueing is possible. Also using unique landmarks within scenes may help them to stand out. As mentioned previously, stable landmarks like stop signs and benches may become embedded in the background, becoming part of the overall scene. Previous research suggests that the most unique landmarks stand out and are relied on more heavily in wayfinding (Youngstrom and Stowbridge, 2012; Kitchin and Blades, 2002; Courbois, Blades, Farran, and Sockeel, 2013). The stable and unstable distractors in the current study may have fit too well within the scenes, causing participants to overlook these as potential

landmarks. In a future study it may be beneficial to include landmarks that are stable as well as unique and attention grabbing. Including stable landmarks like a large, intricate waterfall or a large memorial statue may cause participants to pay more attention to them. Wayfinding studies should also include real, moving landmarks. A maze designed so that unstable items actually move and stable items remain in place may help to put participants in more of a real-world environment.

Conclusions

Although it is a form of implicit spatial learning, results suggest that contextual cueing may not play a prominent role in the wayfinding capabilities of adults. Nevertheless, the results do indicate that different objects encountered within real world scenes may be processed in a fundamentally different way. Landmarks labeled as stable objects resulted in significantly greater visual search times after repeated exposure to them in a real world scene relative to what I labeled as unstable objects. The specific nature of this difference and how it develops are important topics for future research.

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February 27, 2015

THE UNIVERSITY OF

R E S E A R C H

Allison Thomas
Dept. of Psychology
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Box 870348

Re: IRB#: 15-OR-059 "Real-Scene Contextual Cueing: Why Trees are Better than Cats"

Dear Ms. Thomas:

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. You have also been granted the requested waiver of informed consent. 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 February 26, 2016. If your research will continue beyond this date, complete the relevant portions of the IRB Renewal Application. If you wish to modify the application, complete the Modification of an Approved Protocol Form.

When the study closes, complete the appropriate portions of the IRB Request for Study Closure Form.

Please use reproductions of the IRB approved stamped information sheets 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,

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