Examination of Disengagement of Snake Phobics' Attention from Images of Snakes

by

Zofia A. Wilamowska

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Approved by

F. Dudley McGlynn, Chair, Professor of Psychology
Roger K. Blashfield, Professor of Psychology
Christopher Correia, Associate Professor of Psychology
Jeffrey S. Katz, Associate Professor of Psychology

Abstract

Changes occur in a number of psychological processes during fear. For example, increases in fear and arousal are sometimes followed by a narrowing of attention (Easterbrook, 1959; Baddeley, 1972) and increased selectivity of attention to the environment (Easterbrook, 1959; MacLeod & Mathews, 1991). Selective attention in specific phobia has traditionally been studied via the Stroop Task and the Dot Probe Task; however, use of these paradigms has been questioned due to a lack of evidence in support of the attentional biases which they purport to measure.

The flicker task, developed by Rensink, O'Regan and Clark (1997), may offer a novel way to measure visual attention selectivity through change detection. In the flicker task brief blank-space intervals are interposed between repeated presentations of scene pairs to mimic the effects of eye movements. The second scene of each pair is changed at some point and the time or trials needed to detect that the scene has changed is recorded.

McGlynn et al. (2008) used the flicker task to investigate the relation between selective attention and fear in two studies. In both studies, half of the participants were snake phobic, half were not. Half of the image pairs used included a snake, half did not. Half of the scene changes were made to central-interest aspects of the scene, half were made to marginal-interest areas. McGlynn et al. found that for both snake-phobics and controls, change detection required fewer repetitions for objects that were of central interest than for objects that were of marginal interest. Additionally, for snake-phobics,

change detection required more repetitions in neutral stimuli than for controls. Results were explained with Fox's (2001) delayed disengagement theory. According to the delayed disengagement theory, in the McGlynn et al. study, phobic participants may have been still processing previous feared stimuli during the presentation of the neutral stimuli, and were delayed in their ability to focus on the neutral stimuli and detect changes among these image-pairs.

Like McGlynn et al. (2008), the current study examined the narrowing of attention among snake phobics via the flicker task. Thirteen snake phobics and fourteen snake-tolerant participants were exposed to 26 image-pairs, which depicted snakes in various contexts, via the flicker task. The second image of each pair contained one change made to the snake and one change made to an object other than the snake. The participants' task was to find "a change" between the rapidly cycling image pairs. It was hypothesized that snake phobics, in contrast to snake-tolerant participants, would show evidence of preferential attention to the changes made to the snake than to changes made to other aspects of the scene. It was also predicted that snake-phobic participants would require more repetitions than snake-tolerant participants to detect the changes in the other aspects of the scene than in the snake changes. Neither of the hypotheses was confirmed. The explanation is offered that the fearsome scenes used in the flicker task (snakes), where inappropriate due to their evolutionary significance. Stimuli for which there is no evolved biological predisposition to associate them with threat (e.g., guns) should be employed in the future.

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INTRODUCTION

One's ability to detect change has serious implications for one's well-being, whether the changes in our environments are the arrival of imminent threats, or opportunities to better ourselves or seek new challenges. However, it is surprising to find out that detecting change is not as easy as one would expect.

Research on change detection and change blindness has demonstrated that the key factor in being able to perceive a change in one's environment is the allocation of conscious attention in the direction of the change (Rensink, 2002; Rensink, O'Regan, Clark, & 1997; Mack, 2003; Simons, 2000). According to some, the study of attention among persons who have anxiety disorders has uncovered an attentional bias operating for pertinent feared or threatening stimuli (Mathews & MacLeod, 1985; MacLeod & Mathews, 1988; Williams, Watts, MacLeod, & Mathews, 1988; Mogg, Mathews, & Wienman, 1989; McNally, Rieman, & Kim, 1990; Kindt & Brosschot, 1997). The attentional resources of anxious individuals are directed toward the feared objects, presumably in order to facilitate identification of possible routes for escape (Ohman & Mineka, 2001). To use an example of snake phobics participating in a modified Stroop task, where half of the target stimuli are neutral and the other half are feared, the individuals would spend considerably more time color-naming the displays which contain the feared stimuli (Williams, Watts, MacLeod, & Mathews, 1988). Fox (1993, 1994, 2001, 2002) has further argued that anxious individuals are unable to disengage from processing the information contained in the threatening stimuli (currently coined "disengagement theory").

Interestingly, only one study (McGlynn, et al., 2008) has integrated the research on change detection with the phenomenon of attention bias in opidophobia (fear of snakes). Specifically, McGlynn et al. examined snake-phobic and snake-tolerant participants' detection of change in either a neutral or feared pair of scenes presented in a flicker task (described below). McGlynn et al.'s results inferentially supported Fox's (1993, 1994, 2001, 2002) disengagement theory; snake-phobic participants required more stimulus repetitions than did snake-tolerant participants to detect a change in some neutral stimuli, presumably because they had not disengaged from searching for prior feared stimuli. As detailed below, the current study is an extension of the McGlynn et al. experiment that uses two changes for each stimulus pair (one fearsome and one neutral) in images of snakes.

Snake Phobia

A specific phobia is defined as clinically significant anxiety provoked by exposure to a specific feared object or situation, often leading to the avoidance of the feared object or situation. (DSM IV-R, American Psychiatric Association, 2000). Specific phobias are typically grouped into five categories, namely: animal type (e.g., spiders or snakes), situational type (e.g., airplanes or enclosed spaces), natural environment type (e.g., thunderstorms or heights), blood-injection-injury type (e.g., seeing blood or receiving an injection), and other type (e.g., choking or contracting an illness). The lifetime prevalence of specific phobia was determined by Fredrikson, Annas, Fischer, Wik (1996) to be 19.9% (26.5 % for females and 12.4% for males) in a random sample of 1000 adults. More importantly, animal phobia had a lifetime prevalence of 5.2% (12.1% in women and 3.3% in men). Curtis, et al. (1998) published data from a US National Comorbidity Study and found that 49.5% of their respondents reported a lifetime prevalence of a specific phobia (22.2% of these fears were animal phobia). Given this high prevalence it is surprising to find out that specific phobia is currently the least researched anxiety disorder in the treatment literature, other than GAD (Boschen, 2008). As will be described below, numerous studies have shown that information processing biases for threatening information play a role in the etiology and maintenance of anxiety disorders. However, before we delve into those studies, it is important to discuss the information processing theories in specific phobia.

Information Processing Theories in Specific Phobias

Traditionally, the attributes of cognitive processing associated with anxiety disorders have been subsumed under generalized hypervigilance for threat-related stimuli; attention is narrowly focused on sources of possible threat. Easterbrook (1959) was one of the first to describe "narrowing of attention.' He suggested that narrowing of attention is a preoccupation with mood-congruent material that varies with the intensity of emotion. Specifically, the number of cues attended to decreases as emotional intensity increases, and does so at the expense of concurrent attention to mood-irrelevant or distractor stimuli.

It is well established that changes occur in a number of various psychological processes during fear. It is known, for example, that increases in fear and arousal can be followed by a narrowing of attention (Easterbrok, 1959; Baddeley, 1972) and increased selectivity in the environment (Easterbrook, 1959; MacLeod & Mattews, 1991). It has also been suggested, for example, in Bower's (1981) theory, that emotions are represented in mental networks of associations between memories, ideas, and concepts. Activation of one node in the associative network results in spreading activation through which the associated nodes are triggered. Bower's theory predicts mood-congruent biases in every stage of information processing. People would thus show a mood congruent perceptual, attentional, interpretational, and retrieval bias. For example, when a spider phobic is confronted with a fear-evoking stimulus (e.g., cobweb), the sight of the cobweb will activate his spider-phobic schema. This activation would result in the phobic becoming anxious, causing him to scan his environment for spiders, pay attention to other cues that would indicate the presence of spiders, and to perceive his immediate environment as potentially dangerous.

Beck and Clark (1996) also proposed a theory of processing bias in anxiety disorders. According to their schema theory, people acquire schemas, or cognitive representations that help us organize and interpret information, through personal experience. These schemas guide information processing and determine how and what information is attended to. In other words, these schemas act as a filter on information processing. Consequently, if individuals have a certain fear-relevant schema, they will exhibit a processing bias that favors fearsome stimuli; that is, they will selectively perceive, attend to, and remember threatening information

The action of attentional bias in anxious patients may also be conceptualized in terms of the "information structure" theory described by Foa and Kozak (1986). According to this theory, emotions are represented as a network in many structures, which is similar to Bower's (1981) theory of emotions and Beck and Clark's (1996) schema theory.

These structures are not limited to actual information about stimuli and responses but also include interpretations about their meaning for the individual. In the case of fear, these structures serve as motor programs for escape and avoidance behavior (Foa & Kozak, 1986). Hyper-attention to fear-associated stimuli may lead to a facilitated triggering of the fear network by these stimuli. When fear-associated stimuli are detected (e.g., cobweb), processing resources are automatically diverted from less salient cues to these feared stimuli in order to escape the danger as quickly as possible. According to this theory, hyper-attention (or selective attention) to feared stimuli facilitates early escape.

Information Processing and Attention Bias in Phobics

Almost all studies examining attentional biases in specific phobias have been based on individuals with spider phobias, and in most cases researchers have relied on a modified version of the Stroop (1935) task or the Visual Probe Task (MacLeod, Mathews, & Tata, 1986).

The standard Stroop requires the participant to suppress or inhibit a well-learned response (word reading) and instead implement a more novel response as quickly as possible (text color naming). Stimulus words used in the standard version of the Stroop are color names either concordant or discordant with text color (e.g., the word "red" written in red vs. blue ink).

Mathews and MacLeod (1985) modified Stroop's (1935) paradigm. Instead of using words that described colors, they used threatening words with anxious patients in order to examine anxious patients' attentional bias towards anxiety-provoking words.

This modified version of the Stroop task has come to be known as the "emotional Stroop task." In Matthews and MacLeod's experiment, patients were grouped on the basis of whether their worries were predominantly social (e.g., patients who found it embarrassing to talk to new people) or physical (e.g., patients who thought it was likely that they would have a heart attack). The patients were tested on four Stroop cards, each containing 96 stimuli (12 words repeated eight times). The words on the first card represented physical threat (e.g., "disease" and "cancer"), those on the second card represented social threat (e.g., "failure" and "pathetic"), and those on the two other cards contained non-threatening (mostly positive) words (e.g., "secure" and "holiday").

Mathews and MacLeod's (1985) data indicated that control participants showed no difference in color-naming latencies between threat and non-threat cards. By contrast, not only did patients with anxiety show slower color naming for threat words than for the non-threat words, but also there was a relation between the types of threat word that most disrupted color naming and the type of worries that predominated in the participant. Whereas all anxious participants were disrupted on social threat words, only physical worriers were disrupted on the physical threat words. Mathews and MacLeod's study demonstrated some sort of attention-related bias for threatening words in anxious individuals for whom these words had a personal fear-evoking value.

Mogg, Mathews, and Wienman (1989) replicated Mathews and Macleod (1985) study. In their experiment anxious patients were administrated the modified Stroop task in which the words were largely drawn from Mathews and MacLeod's study. Mogg et al. confirmed that generally anxious patients took longer to color-name threat words, compared to normal controls. The mean color-naming latencies for the physical threat words were longer for the phobics compared to non-phobics. The mean time to color-name social threat words was greater for phobics compared to the non-phobics. Mogg et al.'s study confirmed Mathews and MacLeod's finding of some kind of attentional bias in relation to anxiety-laden words in anxious patients. Most published studies based on the emotional Stroop task have found evidence of longer color-naming latencies for spider-related words in people with spider phobias (Kindt & Brosschot, 1997; Lavy & Van den Hout, 1993; Watts, McKenna, Sharock, & Trezise, 1986) and for snake-related words among people with snake phobias (Constantine, McNally, & Horning, 2001).

In order to examine attentional bias in spider phobics Watts, McKenna, Sharrock, and Trezise (1986) used both a general emotional Stroop task, containing threat words such as "fear," "death," and "grief", and a specific Stroop task containing spider-related words such as, "hairy" and "crawl." In their study, Watts et al. compared spider phobics' performance on the emotional Stroop task to their performance on the spider Stroop task. The purpose of this comparison was to see if spider phobics' attention was biased only towards fear related objects (like spiders) or whether their attention was biased towards a general array of threatening stimuli. Watts et al. found that spider phobic participants showed little disruption of color naming on general threat-related words compared with control participants, but they showed a very large interference in color-naming spider-related words. This finding indicated that spider phobics had an attentional bias only towards spider-related words.

Fox (1993, 1994, 2001, 2002) offered another perspective in relation to the attention bias literature. According to Fox, the Stroop paradigm is a poor test of selective attention because during the Stroop task participants selectively attend to different features of an object at one location rather than to the characteristics of objects at separate locations. As such, attention is restricted to perceiving and selecting which set of sensory data to analyze (Treisman, 1969).

According to Fox (1993), in order to remedy this problem of attention selectivity, a simple change in the stimulus display in the Stroop task would be to present the target stimulus (color) and the distractor stimulus (word) in separate spatial locations. Fox (1993) used a modified Stroop task in which color patches and the target stimuli were spatially separated. In this study, high-trait anxious and low-trait anxious participants were required to color-name centrally located color patches which had neutral, color, and threat-related words printed above and below that color patch. The results afforded support for the idea that anxiety is associated with attentional bias in that highly anxious participants required more time than did low anxious participants to color-name threatening words. However, highly anxious individuals also required more time to color-name non-threatening words than did non-anxious participants. To Fox this indicated that once highly anxious individuals were exposed to threatening stimuli, they were unable to disengage attention from them and turn their attention to non-threatening stimuli.

To further explore the implications of these findings, Fox (1994) employed Tipper's (1990) negative priming paradigm to determine whether high anxious participants differ from low anxious participants in showing reduced negative priming. Negative priming was described as a delay in response to a target location, if, on the preceding stimulus presentation, that location was one that had to be ignored. Explicitly, the participants were presented with a stimulus at a specific location in the display, then told to ignore that location in subsequent displays. In the displays that followed, the participants would show a lag in the naming of the stimulus that was located in the area they had been told to ignore.

In the Fox (1994) study, it was predicted that if highly anxious participants had a problem with ignoring distracting information, then they should demonstrate little or no negative priming. The participants were asked to press one of four keys; the correct key spatially corresponded to the location of a target stimulus in the display. The target stimuli were displayed alone or in the presence of a distractor stimulus (color words, neutral words, or threat related words). There were two objectives. The first was to determine if significant delays in participants' reaction times (interference) would occur in the presence of a distractor. The second aim of the experiment was to find out if interference, marked by delays in participants' reaction times, would occur when the target location of a stimulus matched the location of the distractor stimulus from the preceding display. In Fox's experiment following the presentation of the distractor stimulus at one location, highly anxious participants did not show the expected delay in identifying the target stimulus in the following display. In other words, highly anxious participants did not manifest negative priming effects.

Further experiments (Fox et al., 2001; Fox, Russo, & Dutton, 2002), using threat-related stimuli as target stimuli and either threat-related or neutral stimuli as distractors, also suggested that highly anxious individuals failed to show negative priming following threat. Fox concluded that high anxiety is associated with a general deficit in inhibiting/ignoring distracting information. In other words, these results suggest that high trait anxiety may be associated with a general inability to maintain attentional focus, rather than by an automatic attentional bias towards threatening information.

Ruiter & Brosschot (1994) suggest that emotional Stroop interference also reflects the greater cognitive effort required to shut out the perception of threatening stimuli. Many investigators have found that highly anxious individuals (high trait anxious or diagnosed with an anxiety disorder) have generally been slower to color name all stimuli, even neutral words (Fox 1993, 1994; Fox et al., 2001; Fox, Russo, & Dutton, 2002; Mathews, May, Mogg, & Eysenck, 1990; Wheeler, 2003). Again this raises the possibility that such individuals have a general difficulty maintaining attentional focus.

The visual dot probe improves on the Emotional Stroop by allowing multiple stimuli to compete for the capture, as well as the allocation of attention. Originally designed by MacLeod, Mathews and Tata (1986), in the visual probe detection task, participants are briefly shown a pair of stimuli spatially separated on the computer screen. One of the stimuli is fearsome while the other is not. Approximately 500 ms after the stimulus pairs are offset, a dot probe emerges at the location that was just occupied by one of the stimuli. Attentional allocation is measured by reaction time to the dot probe. When attention is previously directed to the location of the probe, it has been shown that responding to the probe will be faster. Using this paradigm, MacLeod et al. (1986) found that anxious participants detected probes faster when they appeared in the location previously occupied by threat words, supporting the hypervigilance theory that individuals with high anxiety preferentially allot their attention towards threat-related stimuli.

Wenzel and Holt (1999) applied MacLeod, Mathews, and Tata's (1986) dot probe paradigm to study attention allocation in individuals with spider phobia and blood injection injury phobia. It was hypothesized that spider-phobics would have faster response times when probes replaced spider-related words than when they replaced neutral words or blood-related words. Similarly, it was expected that individuals with blood injection injury phobia would have quicker response times to blood-related words than to neutral of spider-related words. Despite rigorous procedural replication of the MacLeod et al.'s methodology, Wenzel and Holt failed to replicate their findings. Phobic individuals did not have faster response times to the probes which replaced words related to their specific phobia, meaning that no attentional biases were found towards threat-related stimuli.

Mogg and Bradley (2006) also conducted a visual dot probe study to examine attentional bias in spider-phobic individuals. Participants in the study were shown two types of stimuli: fear-relevant (spiders) and neutral (cats) for different durations: 200ms, 500ms and 2000ms. Mogg and Bradley found fastest response times in the 200ms condition for spider phobics, signifying greater hypervigilance for spider-related stimuli. As stimulus duration increased, however, reaction times decreased for the spider-phobic group. The researchers reasoned that with increased stimulus durations the participants' attention shifted away from the threat-related stimulus to the neutral stimulus, perhaps signifying avoidance of the stimuli.

Despite this improvement from the Stroop task in creating a research paradigm that measures attention allocation, the dot probe task still fails to discriminate between the components of attention. For example, faster reaction time to probes at the location of a threat-relevant stimulus may be the result of: (1) orienting to that location first; (2) maintaining attention to that location, once fixated; or (3) a difficulty to disengage from the stimulus.

Change Blindness

Some researchers (e.g., de Ruiter & Brosschot, 1994; Thorpe & Salkovskis, 1997; Wenzel and Holt, 1999) have questioned the value of the emotional Stroop task and the visual dot probe task due to their dubious ecological validity and potential interpretative difficulties. As a result, a different approach to measuring attention bias is needed. An example of such an approach might be the flicker task that is used to study change detection. Most of us know what it is like to look at something but fail to see the obvious, such as a traffic light turning green. Such an inability to detect change has been termed as change blindness. Specifically, according to Rensink (2002) change blindness refers to the inability to detect large changes to objects and scenes. A familiar term which was introduced by Mack and Rock (1998) is called inattentional blindness and it refers to "the failure to see highly visible objects we may be looking at directly when our attention is elsewhere" Mack (2003, p. 180). Visual attention seems to be the critical factor in the elimination of change blindness. For the purpose of this discussion, visual attention is defined as "an internal mechanism for selecting certain visual codes for further processing at the expense of other visual codes" (Hollingsworth, Schrock, & Henderson, 2001, p. 296). It follows that attention enables change detection because it functions as a safeguard of representations of attended objects in visual short-term memory during the interstimulus interval, allowing for a comparison between the original and modified displays. In contrast, information which is not attended to will decay rapidly upon scene offset and will be overwritten by subsequent visual encoding. As a result, if there is no overlap between the changing and attended regions, the change between the displays will not be detected.

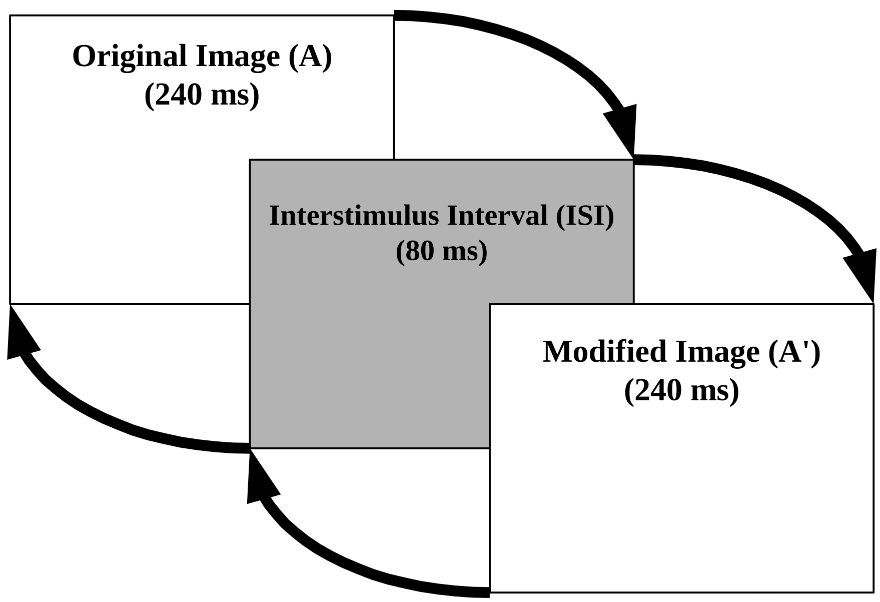
According to Rensink (2002), traditionally there have been several types of contingent change detection paradigms via which change blindness has been studied. The paradigms include: gap-contingencies, saccade-contingencies, blink-contingencies, splat-contingencies, occlusion contingencies, and cut-contingencies. In gap-contingent techniques a change between the presentation of the original stimulus and the altered stimulus is made during an interstimulus interval (Phillips, 1974; Pashler, 1988; Rensink, O'Regan, & Clark, 1997; Rensink, 2004). Using the saccade-contingent approaches, changes to the display are made during the participant's eye-movement (McKonkie & Zola, 1979; Grimes, 1996). In shift-contingent techniques the changes are made when the entire display is suddenly altered, because of a simulated saccade, such as a shift in the display (Sperling & Speelman, 1965). In blink-contingencies a change is made to the stimulus when the participants blink their eyes (O'Regan et al., 2000). In splat-contingencies the change is made at the same time as a brief distractor appears on the stimulus although not necessarily over the area that is changed (Rensink, O'Regan, & Clark, 2000). In occlusion-contingencies the change is made when the changing item is briefly "occluded" from the participants view (Simons & Levin, 1998). Finally, in cut-contingencies the change is made when a cut from one camera angle to another camera angle occurs (Levin & Simons 1997, 2000). Of interest here is gap-contingent change.

Phillips (1974) was one of the first researchers to study change blindness. He required participants to detect changes in displayed matrices consisting of partially filled grids of dots. In his gap-contingency paradigm, an initial display was succeeded by an interstimulus interval (ISI), and then followed by either an identical display or a display that differed by a single dot. Results of the study indicated that, even with large matrix displays, participants' performance was excellent when the ISI between the original and modified displays was less than about 100ms.

Pashler (1988) performed a series of experiments in which he attempted to determine the durations of stimulus and ISI displays that would create the greatest change blindness by means of the gap-contingency paradigm. Using an array of 10 alphanumeric characters as the original display, Pashler changed the display by masking the stimuli. Masking of the stimuli refers to a procedure whereby a stimulus (the target) is made difficult to detect because of a presentation of a second stimulus (the mask) in close temporal or spatial proximity to the original stimulus. Pashler tested a range of display durations ranging from 150ms to 500ms and three different ISI durations (34ms, 67ms, and 217ms). Pashler discovered that increasing the duration of the original and modified displays from 150 ms to 500ms produced only modest improvement in change detection. He found that change detection required fewest repetitions with 34 ms ISIs but only when no second stimulus (mask) was presented. When a mask was presented at the 34 ms ISIs by temporal proximity to the original stimulus, change detection increased to the level of the longer ISI conditions. Performance did not deteriorate much from 67 ms to 217 ms, and there was a clear, but much more modest, effect of masking in these conditions. Masking effects were reduced with the longer ISI, but never seemed to have disappeared.

Rensink, O'Regan, and Clark (1997) developed what has now commonly become known in the change detection literature as the flicker paradigm. The flicker paradigm is based on gap contingent change. An original image (A) and a modified image (A’) are displayed on a computer screen; the image pairs alternate repeatedly and a time interval or an ISI occurs between the paired images.

Figure 1. Flicker Paradigm



Rensink, O’Regan, and Clark (1997) much like Pashler (1988), performed several time trials to determine effects on change detection of differing durations that the image pairs and ISI were displayed. Rensink et al. determined that when the ISI was removed from the flicker paradigm, participants could immediately identify the change between the image pairs, presumably because the ISI was not present. Following Pashler’s findings, Rensink et al. determined that the best display durations, for creating change blindness was 240 ms for the stimuli and 80 ms for the ISIs. These time durations for the image pairs and ISI have also been employed by Rensink, O’Regan, and Clark (2000), and Rensink (2004). Research using the flicker paradigm has produced two primary findings. The first is that participants rarely detect changes during the first cycle of alternation (Rensink, O'Regan, & Clark, 1997). Second, changes to areas of a scene rated to be of "central interest" are detected faster than are changes to "marginal interest" areas. Central interest areas are rated as important or salient features of an image whereas marginal interest areas are rated as unimportant. In this respect Rensink et al. argued that this difference in detection performance was due to the fact that central interest areas were preferentially selected by visual attention. In studies of change detection, people are better able to report changes to attended than unattended objects. Central objects are more likely to attract attentional resources, and if we have a limited capacity for holding information across views, changes to objects that receive more effortful processing are more likely to be detected (Rensink, 2000).

The empirical approaches to studying change detection discussed thus far have employed still images as stimuli. Another area of research has chosen to focus on change detection in moving stimuli such as film. One of the first studies to perform an experiment using film was Neisser and Becklen (1975). In a study of selective looking, the researchers asked participants to view a film of two superimposed ball-passing games in which one group of players wore white uniforms and another group wore black uniforms. Participants were instructed to count the number of passes between members of one of the groups and to ignore the actions of the other team. During the game, a woman carrying an open umbrella walked from one side of the screen to the other. After viewing the video, the participants were subsequently asked to report whether they noticed anything unusual in the video. Only a fifth of the participants indicated the presence of the umbrella-carrying woman.

Simons and Chabris (1999) replicated Neisser and Becklen's (1975) study but instead of one unexpected event occurring during the video, they used two. Two conditions were developed for the study. In the first condition, replicating the stimuli used by Neisser and Becklen, a woman carrying an open umbrella walked across the screen. In the second condition, a person in a gorilla suit walked across the screen. Also, Simons and Chabris employed two video styles: (1) in the transparent condition, the white team, black team, and unexpected event were all filmed separately, and the three video streams were made partially transparent and then superimposed on each other by using digital-video editing software, and (2) in the opaque condition, all actors were filmed simultaneously and occluded one another and the basketballs. The participants' task for this study was again to count the number of passes between teams. Results indicate that across all conditions, more than half of the observers noticed the unexpected event. However, the umbrella-carrying woman was noticed more often than the gorilla overall. Interestingly, when participants were required to attend to the ball passes of the black team, they noticed the gorilla much more often than when they attended to the actions of the white team, seemingly indicating that people are more likely to notice an unexpected event that shares basic visual features (e.g., color) with the events they are attending to.

The findings of change blindness reported thus far have been based on artificial events, where participants were studied in controlled laboratory settings. An experiment reported by Simons, Chabris, Schnur, and Levin (2002) was carried out in a natural setting. An experimenter who was holding a basketball approached a pedestrian and asked for directions to a gymnasium. While the pedestrian provided directions, a group of people passed between the pedestrian and the experimenter, and one member of the group surreptitiously removed the basketball. After giving directions, the pedestrian was asked if he or she noticed anything unexpected happen or if he or she had noticed a change. Most pedestrians did not spontaneously report the change, however, when asked further leading questions, many reported the presence of the basketball and were even able to describe its features. Intriguingly, even though the participants did not notice the change, they were still able to recall specific features of the change object suggesting that they held represented details of the changed object in their memories.

A different approach to studying change blindness was developed by McConkie and Zola (1979), Grimes (1996), and Hollingworth, Schrock, and Henderson (2001). All three studies employed the use of an eye-tracking machine that records the positions and movements of the eyes; hence recording naturally occurring saccades. The premise behind the eye-tracker approach to studying change blindness is that as the participant's eyes begin to move, their targeted destination is calculated, and the stimulus in that location is altered before the eyes arrive. McConkie and Zola examined the synthesis of letter details by presenting sentences in which words were written with letters of alternating case presentation in the first image (as illustrated in line 1 below) and switching the case presentation of the letters in the successive image (as demonstrated in line 2 below).

1. ThE sPaCe ShUtTlE tHuNdErEd InTo ThE sKy On A cOlUmN oF sMoKe.
2. tHe SpAcE sHuTtLe ThUnDeReD iNtO tHe SkY oN a CoLuMn Of SmOkE.

The change that occurred in their study was based upon an overlap of the visual details of the two images. It was hypothesized that if the details of the letters were altered during an eye-movement, while the grammatical structure and the content structures of the text were sustained, any interference in the reading process could be credited to an inability to combine the visual details obtained from the two images. Results of this experiment demonstrated that not only did the experimental manipulation fail to produce any disruption to the reading process or the eye-movement patterns, but it also failed to produce the awareness that a change was occurring in the text. A plausible explanation for this finding is that the participants' attention was allocated to the semantic output produced by the text and, having most of their attentional resources focused on the meaning of sentence, the participants were unable to distribute attentional assets to the change, which was occurring right before their eyes.

Hollingsworth, Schrock, and Henderson (2001) also monitored participants' eye movements while they performed a gap-contingent change detection task. The purpose of their study was to determine whether fixation position (central vs. marginal) influenced the detection of scene changes in the flicker paradigm. Fixation position was differentiated from the orienting of visual attention by either instructing participants to maintain their eyes in a central fixation (no-movement condition) or allowing them to move their eyes freely (movement condition). The study also examined ease of change detection depending on the type of change occurring. Three change conditions were employed: deletions (an object was deleted from the scene), rotations (the object was rotated 90° about the horizontal axis of the object), and no change. Moreover, the experimenters examined the relation between participants' eye positions and change detection. The results indicated that the percentage of detected changes in the movement condition was higher than that in the no-movement condition, suggesting that there is a causal role for fixation position in the detection of change. There was also an effect of change condition; change detection was more successful for those image pairs where a deletion took place than in image pairs where an object rotation occurred. Finally, additional results demonstrate that the participants' eyes remained in the central region on only 7.7% of the trials indicating that the participants detected changes by fixating on various potential changes; not by monitoring extrafoveal regions of the scene.

Another study focusing on the types of change occurring in change detection paradigms was performed by Agostinelli, Sherman, Fazio, and Hearst (1986). The authors suggested that the recognition of change involved two stages: detection of change and identification of the change. Agostinelli et al. speculated that if participants were informed about the detection and identification tasks prior to having to perform them, then the participants would be more likely to focus extra attention to the specific features of the initial stimulus, which would later function as an entity for comparison. The researchers expected that deletions should be easier for the participants to detect than additions because the deleted feature is present in the comparison entity (original image). This prediction was confirmed by Agostinelli et al. in their experiment employing the flicker paradigm that used images of simple drawings of everyday objects as stimuli.

Mondy and Coltheart (2000) also investigated detection and identification rates involving different types of changes in natural scenes across successive views. The changes to the displays were: addition of objects, deletion of objects, object color changes, and object location changes. Comparisons showed that correct change identification was significantly more likely for deletions than for additions. Identification of an added object and of a color change to an object did not differ significantly. Location changes were significantly less likely to be identified than were additions and color changes. In a second experiment that used the same materials, Mondy and Coltheart investigated the effects of additions and deletions of unique and duplicate objects on change detection. They found that changes to whole objects were more frequently identified than were changes to objects that were part of a larger object. Furthermore, deletions were again more likely to be identified than were additions. These results confirmed the findings of Agostinelli et al.'s (1986), in that the deletion of an object from a scene is much easier to detect than is the addition of an object. Mondy and Coltheart argued that their results extend Agostinelli et al.'s findings in two important ways. First, the deletion/addition condition in Mondy and Coltheart's experiment was relevant to real world settings having greater complexity than Agostinelli et al.'s drawn objects. Secondly, Mondy and Coltheart demonstrated that the results of the deletion/addition conditions occur both when the objects are elements or characters of whole objects and when they are whole objects.

In a paper by Archambault, O'Donnell, and Schyns (1999) two change-detection experiments were reported, which tested the prediction that people would perceive the features of an object differently if they learned to categorize them differently – that is, at different levels of specificity. Accordingly, Archambault et al. claim that the "perceptual features that people extract from objects depend on how they typically categorize them" (Archambault et al., p .249) In their first experiment, two groups of participants were trained to categorize an identical set of 10 objects: half of the objects were computers, half of them were mugs. One group (computer-MUG) learned to categorize computers at a specific level where each object was individuated from the rest (e.g., “This is Peter’s computer”) and mugs at a general level (e.g., “This is a mug”). The other group (COMPUTER-mug) learned the opposite assignment of category level to objects - computers were categorized as general (e.g., “This is a computer”) and mugs as specific (This is Mary’s mug”). After categorization training was completed, the participants participated in a flicker paradigm using photographs of office scenes containing various office equipment including mugs and computers. The changes that occurred during the ISI were either the replacement of one type of mug with another mug, removal of a mug from the office scene, replacement of one type of computer with another computer, or removal of a computer from the office scene. Findings of the Archambault et al. study demonstrate that when participants knew an object at a specific or individuated level of categorization, they perceived the change of that object almost immediately. When the same object was known at a more general level, the same change took much longer to notice.

Ro, Russell, and Lavie (2001) compared detection of changes in human faces (which were categorized as having a more semantic value) versus other common objects (e.g., clothes) in a flicker paradigm. The researchers found that changes were detected far more rapidly and accurately in faces than in other objects. This advantage for faces, however, was found only for upright faces in multiple-object arrays, and was completely eliminated when displays showed one face only or when the pictures were inverted.

These findings imply a special status for faces in competition for selective attention, and are consistent with recent findings that facial expressions have a unique capacity to draw attention (Gauthier & Tarr, 1997; Kanwisher, McDermott, & Chun, 1997; Tanaka & Farah, 1993; Fox, et al. 2000). In Angelone, Levin, and Simons' (2003), study, participants were also better at detecting changes in a person's identity, which was primarily determined by the person's face, than changes to the articles of clothing that an actress was wearing and objects that she was carrying. However, it is important to note that the alteration of facial presentation does not necessarily lead to change detection. An important finding by Hochberg (1968) demonstrates that when displays of faces undergo a luminance reversal (as in a photographic negative) the ability to detect changes in faces is not affected.

Mayer et al. (2006) were the first to publish a study examining attentional bias in spider phobics via a change detection paradigm. They investigated whether threat-relevant stimuli (e.g., spiders) would be detected more often than non-threatening stimuli (e.g., shell, butterfly). In addition they were interested in whether spider-phobic participants would detect more threat-relevant stimuli than non-fearful control participants. For the purpose of this study, three types of stimuli were created. No changes were made to one-third of the stimuli. In another third of the stimuli, a small fear-irrelevant object gradually appeared on the screen. In the final third of the stimuli, a spider gradually appeared on the screen. In this change detection paradigm the stimuli were photographs in which the spider or non-threatening stimuli became progressively visible. The participants were instructed to respond as soon as they recognized the presence of the fear-relevant or neutral object in the stimuli. In accordance with the hypervigilance theory, Mayer et al. found that fear-relevant stimuli were detected faster than the neutral stimuli. A limitation of the study, which the current study has tried to improve one, was that Mayer et al. only investigated the frequency of detection of fear-relevant vs. neutral stimuli. They suggested that future studies examine the speed of detection of such changes through reaction time tasks.

McGlynn et al. (2008) conducted two studies that explored change detection for neutral and fearsome stimuli presented in a flicker paradigm among snake phobic and snake-tolerant participants. McGlynn et al. used the gap-contingency technique with cycling presentations of the stimulus, where the change was made during an ISI (e.g. gray screen) between the presentation of the original stimulus and the modified stimulus. The stimuli used for the study were photographs of office scenes (neutral) and photographs of snakes (feared). The changes, which occurred between the stimulus pairs were: deletion (an object was removed from the modified scene), change in object's location, and change in object's color. The stimulus-pairs were displayed for 240 ms, while the ISI lasted for 80 ms. McGlynn et al.'s first hypothesis was that changes would be detected faster in central-interest locations than in the marginal-interest locations for both phobics and controls. Secondly, McGlynn et al. predicted that phobic individuals would require fewer cycles for change detection in fearsome stimuli than would snake-tolerant participants. Both of McGlynn et al.'s studies were identical; the second study was an exact procedural replication of the first. Findings from McGlynn et al. confirmed the prediction that central interest changes would be detected faster than marginal interest changes. Additionally, McGlynn et al. found that it phobics longer to detect the changes in the neutral stimuli. Finally, the results of McGlynn's second study demonstrated that in stimuli with changes located in the marginal-interest areas phobic individuals required more cycles for change detection on stimuli that were neutral than on stimuli that were feared. A plausible explanation of this finding is Fox's (1993, 1994, 2001, 2002) delayed disengagement theory. According to that explanation, McGlynn et al.'s phobic participants experienced an inability to disengage from a visual search for feared stimuli while viewing neutral stimuli, resulting in longer change detection times for the neutral stimuli.

McGlynn et al.'s (2008) findings were significant but not predicted. A limitation of McGlynn et al.'s study was that there was temporal separation between fearsome and neutral stimuli. In order to remedy this problem, the current study integrated both fearsome and neutral stimuli simultaneously into each stimulus set. The purpose of the present work was to conduct a study directly testing Fox's delayed disengagement theory by exposing participants to fearsome stimuli (images of snakes depicted in various contexts) that contain a change directly on the snake and a change to an object other than the snake. Based on Fox's delayed disengagement theory, phobic participants experience an inability to disengage from a visual search for fearsome stimuli. Because of this failure to disengage one's attention from processing fearsome stimuli, it was predicted that phobic participants would be ignorant of changes to objects other than the snake. As a result, it was hypothesized that snake phobics would detect the changes to the snake more often than changes to other aspects of the scene. In turn we predicted that there would be no difference in the location of change detected for snake-tolerant participants. In the event, that phobic participants did indicate some changes to other aspects of the scene, it was expected that on average the number of cycles necessary to detect changes to objects other than the snake for phobic participants would be greater than the average number of cycles necessary to detect a change in the snake. We believed that this would occur because even if participants were blind to the change on the snake, they would have difficulty disengaging their attention from the snake in order to search for a change in an object other than the snake. As a result of participants' failure to disengage their attention from the snake, they would require more image-pair cycles to identify the neutral change. Finally, because snake-tolerant individuals would not experience difficulty in disengaging from the snakes, it was hypothesized that snake-tolerant participants would require the same number of repetitions to detect the changes at both locations.

METHOD

Participants

Screening session participants. Four hundred and thirty seven participants were recruited from undergraduate psychology courses at Auburn University. All participants received half an hour of extra credit for completing the screening portion of the study. Fifty nine percent were female. Participant's ages ranged from 19 to 36 with the average being 20.18 (SD = 2.09). Eighty four percent were Caucasian, 14% African American, 1% Asian American, and 1% other.

Seventy-five individuals were recruited from the screening pool to participate in the second portion of the study. Approximately, two-thirds of these participants were assigned to the experimental session group (below) and one-third was delegated to the control group (below). The experimental session group was comprised of individuals 8who participated in the flicker tasks that contained images of snakes and the control group consisted of participants who completed the flicker task with neutral images. The scores on the SNAQ of these two groups were later compared to see whether the flicker task which contained images of snakes created a priming effect for the participants' responses on the SNAQ.

Experimental session participants. Forty-nine participants were recruited from the screening pool to participate in the experimental portion of the study. All participants received an hour of extra credit for completing the experimental portion of the study. Sixty-one percent were female. Participant's ages ranged from 19 to 36 with the average being 20.34 (SD = 2.99). Eighty–eight percent were Caucasian, 10% African American, and 1% Asian American.

The snake phobic group was comprised of thirteen participants (female = 12) who scored in the upper 10^{th} percentile on the SNAQ. Fourteen participants (female = 3) in the snake-tolerant group scored in the bottom 10^{th} percentile on the SNAQ. Participant's ages ranged from 19 to 27 with the average being 20.55 (SD = 1.98). Eighty-one percent were Caucasian, and nineteen percent were African American.

Control participants. Twenty-six participants were recruited from the screening pool to participate in the control portion of the study. All participants received an hour of extra credit for completing the control portion of the study. Seventy-three percent were female and twenty-seven percent were male. Participant's ages ranged from 19 to 26 with the average being 20.19 (SD = 2.00). Ninety–six percent were Caucasian and four percent were African American. Fourteen participants were selected to the snake-phobic group and twelve participants were selected to the snake-tolerant group. The two groups did not differ significantly in age or race.

Snake Phobia Measures

Fear Survey Schedule-II (FSS-II). The purpose of the FSS-II is to identify specific objects and situations that are anxiety provoking (see Appendix B). The FSS-II was originally developed by Wolpe and Lang (1964). The FSS-II is a self-report measure containing a list of 51 objects and situations that might be fear-evoking. The participants were instructed to rate their level of fear on each item. The items are rated on a seven-point Likert scale ranging from 0 (no fear) to 6 (terror). Only scores on item 39 (snakes) were noted in the current study. Mean scores on the FSS-II for normative samples of men and women were 75.78 (SD = 33.84) and 100.16 (SD = 36.11), respectively (Geer, 1965).

Snake Phobia Questionnaire (SNAQ). The purpose of the SNAQ is to quantify subjective fear of snakes (see Appendix C). The SNAQ was originally developed by Klorman, Weerts, Hastings, Melamed, and Lang (1974). The SNAQ is composed of 30 snake fear-relevant items that are answered in the true or false format. Klorman et al. (1974) surveyed 1,307 college students using the SNAQ and found the mean scores to be 7.79 (SD = 6.05) for females and 4.92 (SD=3.77) for males. Fredrikson (1983) reported that mean scores on the SNAQ among male and female college students were 5.80 (SD=3.82) and 9.06 (SD=6.09), respectively. In the same study, among individuals with snake phobias the mean score was 24.44 (SD=2.95).

Apparatus

Experimental events were controlled by a custom computer program written in Java (see Appendix F) on a Pentium 4 computer (Wilamowska, 2007). Stimuli were presented on a 17-inch Dell color monitor. The space bar on a computer keyboard was the manipulandum.

The Stimuli

The experimental protocol visual stimuli that were generated specifically for this study. The stimulus pairs were pictures of snakes where one change occurred either on or in the vicinity of the snake and one change occurred to an object other than the snake (see Appendix E). Pictures were found using the Google search engine and downloaded from the internet. For each original stimulus used, a modified image was created which was an exact replica of the original stimulus with the exception of either an object addition or an object deletion. The paired stimuli were presented with the original image (A) and the modified image (A') in the sequence A, A', A, A'…, with a gray screen (ISI) interposed between successive stimuli. Each stimulus was presented for 240 ms, and each ISI for 80ms. Stimulus pairs were presented in random order. A total of 26 image pairs were presented to each participant.

Images employed by Rensink, O'Regan, and Clark (1997) were used in the control portion of the study. Twenty-six images were selected from the Rensink et al. study and presented in random order to the control participants. Since the purpose of the control condition was provide a comparison as to whether the SNAQ scores would be elevated in as a result of priming by the experimental flicker task, the number of cycles necessary to change detection were not recorded for the control condition.

Procedure

Four hundred and thirty seven participants were recruited via the Sona System (an experiment management system for Auburn University's psychology department). Upon arriving, participants were asked to review and complete an informed consent form (see Appendix A) then asked to complete FSS-II. Only those participants who reported a significant fear of snakes on the FSS-II snake item (FSS-II = 5 or 6) or those who reported none or minimal fear of snakes on the FSS-II snake item (FSS-II = 0 or 1) were asked to participate in the second part of the study.

For the second part of the study, 49 participants were seated at a computer and received verbatim oral instructions (see Appendix D) on how to perform the flicker task. After the instructions, the participants engaged in a practice trial of the flicker task. Finally, the participants were asked to perform the experimental flicker task (below).

After completing the flicker task the participants were asked to complete the SNAQ. Those participants who reported none or minimal fear of snakes on the SNAQ (SNAQ $\leq$ 1) were assigned to the snake-tolerant group for data analysis. Participants who report a significant fear of snakes on the SNAQ (SNAQ $\geq$ 21) were assigned to the phobic group for data analysis. The participants were asked to complete the SNAQ after the flicker task in order to avoid participant discovery that snake phobia was being studied and thereby to avoid priming the participants for the flicker task. After completing the SNAQ the participants were thanked, debriefed about the experiment, and awarded extra credit on the Sona System.

The same procedure was followed for participants in the control condition as in the experimental condition with the exception of a different stimulus set used in the flicker task (below).

Flicker Procedure

The participants were instructed to observe the randomized series of 26 stimulus pairs and to press the space bar, when they detected a change between the two stimuli. As noted already, the original stimulus (A) and the modified stimulus (A') were presented for 240ms with an ISI, of 80ms. The computer, on which the flicker task was administered, recorded the number of repetitions for each stimulus pair and the amount time elapsed for each stimulus pair before the space bar was pressed. Also as noted already, one of the following changes was made to an object in each stimulus pair: deletion of object or addition of object.

The computer paused for 5000 ms after the participants pressed the space bar so that they could tell the experimenter where the change had taken place. After the pause the subsequent stimulus pair was presented. During the administration of the flicker task, a researcher sitting behind the participants recorded identification errors. Also this researcher recorded whether the change on snake or the change on the object other than the snake was detected by the participants for each stimulus pair.

RESULTS

Experimental Group vs. Control Group

The mean SNAQ score for the snake-phobic participants in the experimental group was 19.11 (SD=4.75). For the snake-phobic participants in the control group, the mean SNAQ score was 16.00 (SD=4.33). The means for the snake-tolerant group in the experimental and control conditions were 3.65 (SD=2.90) and 4.45 (SD = 3.67), respectively. There was no significant difference between the control group who saw no snakes during the flicker task and experimental group who saw snakes during the flicker task in SNAQ scores $F(1,73) = 0.862$, $p = .356$. There was no evidence of priming effects on SNAQ responding from snakes presented during the experimental flicker task.

The original number of participants in the experimental group was 49. As noted earlier they were selected from the screen pool by their scores on the FSS-II. In order to create two distinct experimental groups only the participants who scored in the top and bottom 10 percent of the SNAQ contributed data for analysis. For the snake-phobic group the mean score on the snake item of the FSS-II was 5.54 (SD = 0.52). The mean SNAQ score for this group was 23.77 (SD = 1.69). For the snake-tolerant group the mean on the snake item of the FSS-II was 0.29 (SD = 0.47) and the average on the SNAQ was 0.71 (SD = 0.47). The differences in the scores indicate clearly that two distinct groups, snake-phobic and snake-tolerant, provided data for analysis.

Comparison of Change Found

This experiment was designed to evaluate differences between snake-phobic and snake-tolerant participants in the frequency of detecting changes involving a snake or changes in other aspects of scenes. The means for number of detected changes to the snake and detected changes to objects other than the snake among snake –phobic and snake-tolerant participants are presented in Table 1.

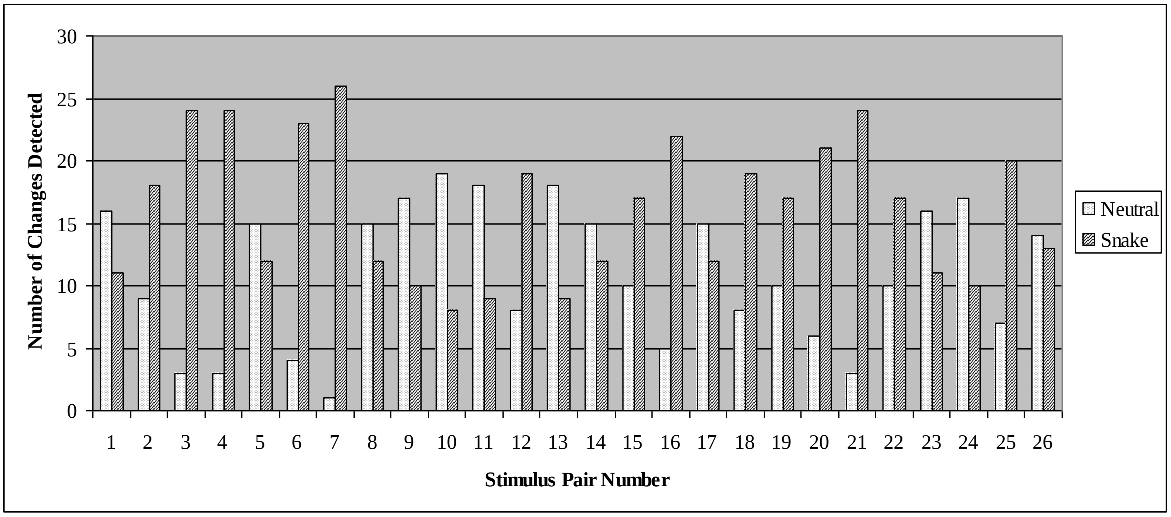
Table 1. Means and Standard Deviations for the Number of Detected Changes to the Snake vs. Detected Changes to Other Objects

	Snake-phobic Group		Snake-Tolerant Group	
	M	SD	M	SD
Number of Changes to the Snake	16.46	3.71	14.71	3.22
Number of Changes to Objects Other than the Snake	9.53	3.71	11.29	3.22

To examine the difference between groups in the number of repetitions to change detection in each location, a repeated measures analysis of variance (ANOVA) was conducted. Each of the 27 participants provided one value either for the snake or the off-snake location of change detection for each of the 26 stimuli. The 702 values were analyzed with a 2 Groups (snake-phobic vs. snake-tolerant) x 2 Locations of Change (on-snake vs. away from snake) repeated measures analysis of variance. Location of change and group membership were analyzed as fixed factors. There was no significant interaction for Group Membership x Location of Change, $F(1, 25) = 1.714$, $p = 0.202$. There was a significant main effect for Location of Change, $F(1,25) = 15.044$, $p=.001$; changes made to the snake were discovered more often than were changes made to other aspects of the scene (see Table 1). As a main effect this means that the difference existed for both groups.

The finding that snake-tolerant participants were more likely to detect changes on the snake than changes away from the snake was surprising. Since all of the stimuli used in the experimental-group version of the flicker task included images of snakes, a post hoc hypothesis was considered: the participants in both the snake-phobic and snake-tolerant groups learned that a change was probably going to occur in the vicinity of the snake, and were, therefore, focused on searching for a change near the snake. To test this hypothesis, the number of changes detected (snake and other) were graphed out across the ordinal positions of all 26 stimulus pairs (see Figure 2) and inspected to see if detection of changes on the snake became more and more common over trials. There was no such trend on inspection. In addition, three chi square tests comparing the location of change for snake-phobic and snake-tolerant participants were performed, one on data from each of the first three ordinal image pairs. The chi square tests revealed that there was no significant difference between groups in the type of change that was detected prior to experience with the experimental flicker task ($\chi^2(1, N=27) = 0.304$, $p=0.58$; $\chi^2(1, N=27) = 0.074$, $p=0.79$; $\chi^2(1, N=27) =0.296$, $p=.59$).

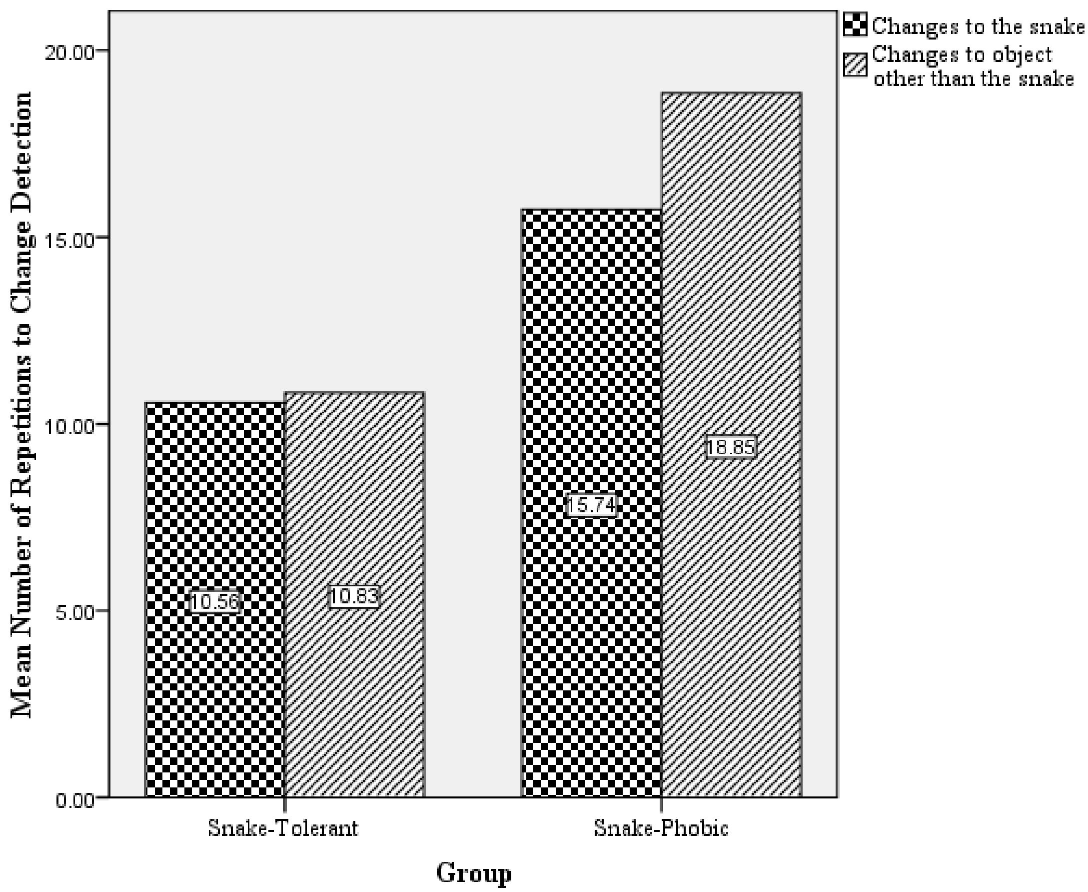
Figure 2. Bar Graph of Number of Changes Detected to the Snake Versus the "Other" Change Across all Stimulus Pairs for Both Groups.



Comparison of Repetitions Required to Change Detection

An additional aim of this study was to examine between-group differences in the number of repetitions before the changes were detected. To examine the difference between groups in the number of repetitions before change detection in each location another 2 (Groups) x 2 (Locations of Change) repeated measures ANOVA was conducted. There was a significant main effect found for Groups $F(1,25) = 7.608$, $p = 0.011$; snake-phobics required more repetitions to detect the changes than snake-tolerant group participants (see Figure 3). The was no significant main effect for Location of Change, $F(1, 25) = .841$, $p=.368$.

Figure 3. Bar Graph of Mean Number of Repetitions to Change Detection for Groups across Locations of Change



DISCUSSION

Twenty six computer-generated images of snakes-in-scenes were shown in briefly separated pairs to 27 snake-phobic or snake-tolerant participants. The second image of each image pair differed from the first image of the pair in two ways: (1) by showing a change on the snake itself (on-snake change), and (2) by showing a change in the context away from the snake (off-snake change). The participant was instructed to find the change. The main datum of interest was the location of the change that was detected (i.e., on-snake change or off-snake change). Of interest was any differences between snake-phobic and snake-tolerant participants vis a vis that datum.

The results of the experiment are discussed below. In general there were no differences between snake-phobic and snake-tolerant participants. Attention bias toward threat has been shown repeatedly via a number of different experimental preparations. Hence, the failure to show attention bias in the work reported here probably reflect one or more shortcomings in the experiment. Accordingly, the following discussion has a methodological focus.

The flicker task, developed by Rensink, O'Regan, and Clark (1997), has been repeatedly used in experimental psychology to examine visual attention selectivity through change detection (Archambault, O'Donnell, & Schyns, 1999; Mondy & Coltheart, 2000; Hollingsworth, Schrock, & Henderson, 2001; Ro, Russell, & Lavie, 2001). McGlynn et al. (2008) were the first to employ the flicker task to study attentional bias related to anxiety (snake phobia). In their first experiment, McGlynn et al. found that snake-phobic participants required more repetitions than did snake-tolerant participants to detect changes in visual stimuli that were devoid of snake. Their second experiment showed that snake-phobic participants took longer than did the others to detect changes in marginal-interest areas of scene pairs that were without snakes. McGlynn et al. stated that their findings were consistent with Fox's delayed disengagement interpretation of results from dot-probe experiments - in which phobic participants' attentional response is characterized by an inability to direct attention away from threat-related information (Fox 1993, 1994, 2001, 2002). McGlynn et al. posited that in their experiments snake-phobics were relatively reluctant to disengage from a visual search for snake-related stimuli and were, therefore, relatively inattentive to marginal-interest changes in images that did not include snakes.

The present study expanded upon McGlynn et al.'s (2008) work by exposing participants to fearsome stimuli (computer images of snakes depicted in various contexts) that contained one change to the snake and one change to an object other than the snake. As a result of including snake-related changes and non snake-related changes simultaneously, we were able to test Fox's (1993) delayed disengagement hypothesis. This was accomplished by examining the number of times snake-phobics, compared to snake-tolerant participants, saw the snake change versus the non-snake change. It was predicted that the average number of repetitions necessary to detect changes to objects other than the snake would be greater than the average number of cycles necessary to detect changes to the snake for snake-phobic participants. In other words, if snake-phobics required more repetitions to find changes to objects other than the snake, this would signify that these participants were having difficulty disengaging their attention from the snakes in the stimulus pairs. Results from the present study failed to support this hypothesis. There was a small difference in the mean number of repetitions needed to detect the changes to the snake over the changes to objects other than the snake for snake-phobic participants. Based on this pattern, it appears that the snake-phobic participants required more repetitions to detect changes in the objects other than the snake than to detect changes in the snake. However, this difference was not statistically significant. A larger sample of participants would increase statistical power and likely produce stronger results.

In a study of change detection Mayer et al. (2006) found that spider phobics detected changes in fearsome stimuli more often than changes in neutral stimuli. Based on these findings it was hypothesized in our experiment that snake-phobic participants on average would detect changes to the snake more often than the other changes. The present study replicated Mayer et al's findings. However, snake-tolerant participants also were more likely on average to detect the changes to the snake versus the other changes. A number of plausible explanations of this result can be found.

In a dot probe experiment conducted by MacLeod et al. (2002) participants were briefly presented with pairs of words (one word was threat-related in meaning while the other had a neutral connotation). Following the termination of this display, a small dot appeared in the location previously occupied by either word. Participants were instructed to press a response button whenever they detected the presence of the dot. Participants, who were without pre-existing emotional biases, were randomly assigned to two groups. In the first group, the participants were trained to detect threat-related words while ignoring the words with neutral meanings. In the second group, the reverse was true. The results demonstrated that both groups were faster when the “trained” word locations were probed. That is, individuals trained to detect probes supplanting threat-related words were faster at detecting the probes which replaced threat-related words. Conversely, participants who were trained to detect neutral words had faster responses to probes which substituted neutral words.

Following the results of MacLeod et al. (2002), it is probable that attentional bias for the snake changes was unintentionally “trained” in the participants here. In other words, participants in both groups may have been primed by the experiment itself to detect changes made to the snake. As soon as the first couple of scenes of the flicker task were shown, the participants probably deduced that snakes were somehow important in the experiment. Aside from possible diffusion in the laboratory, participants could not have known about the focus on snakes before the first few stimulus pairs were shown. Therefore the type of change detected on the first three stimulus pairs only was studied comparing location of change detections (snake vs. other) for the snake-phobic vs. snake-tolerant participants. Interestingly, the absence of difference in the type of change detected between snake-fearful and snake-tolerant participants appeared even for the first few stimulus pair shown. That result also argues against some sort of “priming” as a way to explain the equivalence of fearful and tolerant participants as the remaining 23 scenes were shown. As a result, they were more likely to focus their attention on finding changes on the snake, irregardless of their snake-phobia status.

Two tentative explanations of the equivalent change detection for phobic and tolerant participants may be derived from Seligman’s (1971) preparedness theory related to phobias. According to this theory, humans are evolutionarily prepared to efficiently learn to fear objects and situations that threatened the survival of our ancestors. In other words, humans appear to have an evolved a predisposition to associate life threatening objects and situations with fears. This theory was later expanded upon by Ohman and Mineka (2001) by proposing the existence of an evolved fear module. This is a putative neural system that is relatively independent from more developed and controlled cognition. Also the evolved fear module is automatically activated by and “selectively sensitive” to evolutionarily threat-relevant objects and situations. Accordingly, the module is a system that aids in mammalian survival by protecting and warning against evolutionarily significant threats such as snakes.

It is true that certain people are self-identified snake-phobics, while others are not. However, based on the fear module theory, discussed above, it is possible that even those individuals who have identified themselves as snake-tolerant would exhibit a bias towards images of snakes because of their evolutionarily prepared fear modules. Put another way, evolution rendered the snakes in the stimulus of central-interest. This means that snakes, and the changes made in the vicinity of the snakes, were more salient and, by definition, more readily detectable (Rensink, O’Regan, & Clark, 1997). Furthermore, the work of McGlynn et al. (2008) showed that changes to objects in central interest regions are detected more readily than are those located in the marginal interest regions by both snake-tolerant and snake-phobic individuals. In the current study changes on the snake were preferentially detected even by snake-tolerant participants. That current result might simply mean that the snakes were of central interest for all participants.

Another hypothesis of the current study was that there would be no fewer differences between the average number of cycles necessary to detect changes to the snake versus changes to objects other than the snake among snake-tolerant participants. The hypothesis was supported by the finding that snake-tolerant participants' average number of repetitions necessary to change detection was equivalent for both locations of changes.

Finally, in order to attenuate expectancy effects on the flicker paradigm, participants completed the flicker task prior to answering questions about their fear of snakes on the SNAQ. However, as a result of choosing to administer the SNAQ to the participants after the flicker task, it was important to find out whether the flicker task unintentionally primed the participants for the SNAQ, causing their scores to be elevated. To test for the presence of that sort of bias, some participants (experimental group) were given the SNAQ after completing the flicker task that contained images of snakes. Another group of participants (control group) was given the SNAQ after participating in a flicker task which contained neutral stimuli only. Upon comparing the SNAQ scores of that group with SNAQ scores of the experimental group, it was determined that the flicker task containing images of snakes did not influence participants' responses to the SNAQ.

Limitations and Some Future Directions

The current study employed Auburn University students as participants for the study. Some would argue that the sample used was a sub-clinical snake-phobia sample and that it would be difficult to predict that results from this sub-clinical population generalize to a clinical population (e.g., Bernstein & Paul, 1971). Further research should employ a clinical population. Another limitation of the study was the unequal distribution of males and females across both groups: the snake-phobic group contained significantly more females than the snake-tolerant group. Although, females are said to have higher prevalence of animal phobia (Fredrikson et al., 1996), future research should include equal numbers of males and females in order to avoid a potential gender bias. Additionally, the present procedures used stimuli which have shown to have evolutionary significance (i.e. snakes). In future studies benefit might accrue to using phobias for which there is no evolutionary preparedness (e.g., flight, guns).

Most research on attentional bias concerns automatic attention. Automatic attention refers to the allocation of attention which occurs outside of conscious awareness. Although not overtly stated, the hypotheses of this study refer to automatic attention. However, according to Rensink, O'Regan and Clark (1997), the flicker task is, instead, a measure that examines the delegation of strategic attention (i.e. the voluntary and deliberate allocation of attention). As such, it appears that the hypotheses of this study were wrong, or more importantly, the flicker task is not be a good paradigm for testing automatic attention. According to Rensink (2000), participation in the flicker task involves a serial search through the changing scene, during which salient objects (i.e. areas of central interest) capture attention first. In the present study, the snakes constituted the salient features in the scenes, and were, consequently areas which initially captured the participants' attention. This is probably why both groups were more likely to detect changes that occur in the vicinity of the snakes. As a result, future research will benefit from creating scenes in which snakes are not in or do not constitute central-interest region. This might be done by creating scenes with a variety of creatures (snakes, spiders, roaches) or by creating scenes in which snakes are not prominent (e.g., placed in a far corner of a scene in which a picnic basket is judged as of central interest). In that way one creates an opportunity for phobic fear to, in effect, transform the image and that, for phobics, the snake becomes of central interest.

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APPENDIX A

INFORMED CONSENT
FOR
-Measuring Change Blindness in Specific Phobias-

You are invited to participate in a research study of the role of attention in those who experience significant fear of snakes or spiders. This study is being conducted by Zofia Wilamowska, graduate student, under the supervision of F. Dudley McGlynn, Ph.D. We hope to learn if one's attention is different when one is experiencing anxiety. You must be at least 19 years of age to participate.

If you decide to participate, we will ask you to complete a questionnaire that takes about 10 minutes of your time. You will earn 30 minutes of extra credit for attempting to complete this form. Some who complete this form will then be asked to look at pictures on a computer screen that will display images that contain snakes or spiders. This will take about 20 minutes and an additional 30 minutes of extra credit will be provided after attempting to view the images displayed on the computer.

Other participants, immediately after completing the first questionnaire, will be asked to complete a second questionnaire that takes approximately 5 more minutes.

30 minutes of extra credit will be awarded for these questionnaires. Some of those who complete the second questionnaire will be invited to make an appointment to respond to a set of interview questions, which will take approximately 30 minutes. Another 30 minutes of extra credit will be provided for this group of participants. Some who decide to respond to interview questions will then be invited to view the computer images described above. Thirty (30) minutes of extra credit will be offered; this would be a total of one and a half (1.5) hours at this stage, for those who are invited and decided to view the images. Again, viewing the images should take approximately 20 minutes.

Some who are fearful of snakes or spiders might feel some discomfort when viewing the images displayed on the computer. There will not be presentation of any live snakes or spiders during the study. You may withdraw from participation at any time, without penalty, and you may withdraw any data that has been collected about yourself, as long as the data is identifiable. Your decision whether or not to participate will not jeopardize your future relations with Auburn University or the Psychology department.

A benefit available to all who participate is extra credit. One might be able to earn up to one and a half (1.5) hours of extra credit; however, all who participate are guaranteed to receive 30 minutes of extra credit. This is a RESEARCH project and not a treatment for fear of snakes or spiders. Referral information will be available for those who wish to seek treatment for such a fear. The results of this study may lead to a new

Initials _____

line of research in the area of phobia by offering a new method of laboratory assessment.

Any information obtained in connection with this study and that can be identified with you will remain confidential. Only the principle investigator (Zofia Wilamowska) and faculty supervisor (F.D. McGlynn) will have direct access to identifiable information. All questionnaires will be coded and not contain any identifying demographic information of the participants. Data from the interview computer task will be secured in the same manner. All code lists will be destroyed once data collection has ended and is no longer needed. Information collected through your participation will be used to fulfill an educational requirement for a doctoral dissertation, may be published in a professional journal, and/or presented at a professional meeting. If so, none of your identifiable information will be included. If you have any questions we invite you to ask them now.

Your decision whether or not to participate will not jeopardize your future relationship with Auburn University or the Department of Psychology.

If you have any questions we invite you to ask them now. If you have questions later, Zofia Wilamowska (wilamza@auburn.edu, 334-844-5658) will be happy to answer them. You may also contact Dr. McGlynn, Ph.D. (mcglyfd@auburn.edu, 344-844-6472) if needed. You will be provided a copy of this form to keep.

For more information regarding you rights as a research participant you may contact the Office of Human Subjects Research or the Institutional Review Board by phone (334) 844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

Participant's signature Date	Investigator's signature Date
Printed name	Printed name

APPENDIX B

Fear Survey Schedule II (FSS-II)

Instructions: Below are 51 different stimuli that can cause fear in people. Please rate how much fear you feel using the following rating scale and record your answer in the space provided.

0 = None   1 = Very little fear   2 = A little fear   3 = Some fear

4 = Much fear   5 = Very much fear   6 = Terror

_______1. Sharp objects
_______2. Being a passenger in a car
_______3. Dead bodies
_______4. Suffocating
_______5. Failing a test
_______6. Looking foolish
_______7. Being a passenger in an airplane
_______8. Worms
_______9. Arguing with parents
_______10. Rats and mice
_______11. Life after death
_______12. Hypodermic needles
_______13. Being criticized
_______14. Meeting someone for the first time
_______15. Roller coasters
_______16. Being alone
_______17. Making mistakes
_______18. Being misunderstood
_______19. Death
_______27. Being with drunks
_______28. Illness or injury to loved ones
_______29. Being self-conscious
_______30. Driving a car
_______31. Meeting authority
_______32. Mental illness
_______33. Closed places
_______34. Boating
_______35. Spiders
_______36. Thunderstorms
_______37. Not being a success
_______38. God
_______39. Snakes
_______40. Being with a member of the opposite sex
_______41. Cemeteries
_______42. Speaking before a group
_______43. Seeing a fight
_______44. Death of a loved one
_______45. Dark places

_______20. Being in a fight
_______21. Crowded places
_______22. Blood
_______23. Heights
_______24. Being a leader
_______25. Swimming alone
_______26. Illness
_______46. Strange dogs
_______47. Deep water
_______48. Stinging insects
_______49. Untimely or early death
_______50. Losing a job
_______51. Automobile accident

APPENDIX C

Snake Questionnaire (SNAQ)

Instructions: Answer each of the following statements either True or False as you feel they generally apply to you. If the statement is true most of the time or mostly true for you, you would answer **true**. If it is mostly false or false most of the time, mark it **false**. Indicate your answer by placing a mark (**X**) in the appropriate column.

TRUE	FALSE		
_______	_______	1.	I avoid going to parks or on camping trips because there may be snakes about.
_______	_______	2.	I would feel some anxiety holding a toy snake in my hand.
_______	_______	3.	If a picture of a snake appears on the screen during a motion picture, I turn me head away.
_______	_______	4.	I dislike looking at pictures of snakes in a magazine.
_______	_______	5.	Although it may not be so, I think of snakes as slimy.
_______	_______	6.	I enjoy watching snakes at the zoo.
_______	_______	7.	I am terrified by the thought of touching a harmless snake.
_______	_______	8.	If someone says that there are snakes anywhere about, I become alert and on edge.
_______	_______	9.	I would not go swimming at the beach if snakes had ever been reported in the area.
_______	_______	10.	I would feel uncomfortable wearing a snakeskin belt.
_______	_______	11.	When I see a snake, I feel tense and restless.
_______	_______	12.	I enjoy reading articles about snakes and other reptiles.
_______	_______	13.	I feel sick when I see a snake.
_______	_______	14.	Snakes are sometimes useful.
_______	_______	15.	I shudder when I think of snakes.
_______	_______	16.	I don’t mind being near a non-poisonous snake is there is someone there in whom I have confidence.
_______	_______	17.	Some snakes are very attractive to look at.
_______	_______	18.	I don’t believe anyone could hold a snake without some fear.
_______	_______	19.	The way snakes move is repulsive.
_______	_______	20.	It wouldn’t bother me to touch a dead snake with a long stick.

_______	_______	21.	If I came upon a snake in the woods I would probably run.
_______	_______	22.	I’m more afraid of snakes than any other animal.
_______	_______	23.	I would not want to travel “down south’ or in tropical countries because of the greater prevalence of snakes.
_______	_______	24.	I wouldn’t take a course in biology if I thought I might have to dissect a snake.
_______	_______	25.	I have no fear of non-poisonous snakes.
_______	_______	26.	Not only am I afraid of snakes, but worms and most reptiles make me feel anxious.
_______	_______	27.	Snakes are very graceful animals.
_______	_______	28.	I think that I’m no more afraid of snakes that the average person.
_______	_______	29.	I would prefer not to finish a story if something about snakes was introduced into the plot.
_______	_______	30.	Even if I was late for a very important appointment, the thought of snakes would stop me from taking a shortcut through an open field.

APPENDIX D

Flicker Task Instructions

You have been selected to participate in a portion of this study that will require the use of a computer. At this computer, I am going to show you several pairs of pictures. Each pair of pictures is going to be identical with the exception of one small detail. I want you to find what is different between each pair of pictures as quickly as you can. Once you have found the difference, click the left button on the mouse or press the space bar. After pressing either the space bar or the left mouse button, verbally indicate the change that you noticed.

Do you have any questions thus far?

We are going to do a practice trial. Remember to hit the left mouse button or the space bar as soon as you can see what small detail is changing between images. Don’t forget to verbally indicate the change that you noticed.

Do you have any questions?

The program will stop automatically when you have finished all of picture pairs. This part of the experiment will take approximately 25 minutes.

I need to inform you that some of these pictures are going to show snakes or spiders in them. Remember your informed consent that you signed, which states that you are free to leave at any time, as you are a volunteering participant of this study. Please be assured that you are not in any danger of coming into contact with a real snake or spider, only pictures of them.

Any questions?

APPENDIX E

Stimulus pairs used in the Flicker Task

Michael Takash / The Daytona Beach News-Journal

Michael Takash / The Daytona Beach News-Journal


Herpetological
Field Equipment
2002-2003
ISU
123
SESAME STREET


Herpetological
Field Equipment
2002-2003
ISU
123
SESAME STREET



















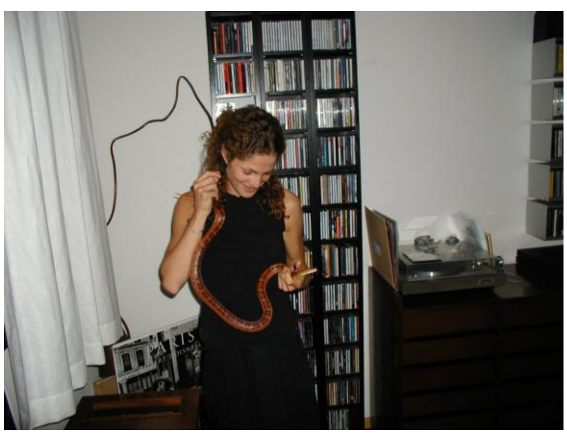
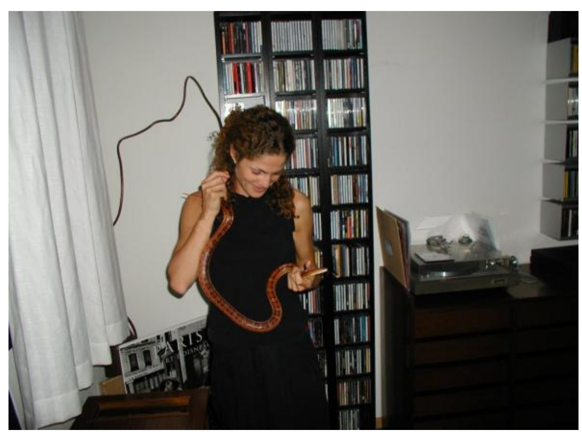






APPENDIX F

Listing of program code (in Java programming language) for the Flicker Task

Main File

```
import java.io.*;
import java.lang.*;


public class Main
{
 static String practice = new String ("First, we are going to do a practice trial. Remember
to hit the space bar as soon as you can see what small detail is changing between the
images. Don’t forget to verbally indicate the change that you noticed.");
 static String experiment = new String ("  ");
  public static void main (String[] args) throws Exception
  {

  InputWindow setup = new InputWindow ();

  while(setup.doneflag!=1){Thread.currentThread().sleep(100);}
  InstructionsWindow info = new InstructionsWindow (practice);

  while(info.donereading!=1){Thread.currentThread().sleep(100);}
  FlickerWindow temp = new FlickerWindow ("Practice", setup.output_file_name,
setup.temp_pics);
/* */
  while(!temp.donedisplaying){Thread.currentThread().sleep(100);}
  InstructionsWindow info2 = new InstructionsWindow (experiment);

  while(info2.donereading!=1){Thread.currentThread().sleep(100);}
  FlickerWindow exp = new FlickerWindow ("Experiment", setup.output_file_name,
setup.input_pics);
/* */
  while(!exp.donedisplaying){Thread.currentThread().sleep(100);}
  Finished done = new Finished ();
  }
```

```
}
```

Input Window File

```
import javax.swing.*;
import java.awt.*;
import java.io.*;
import java.lang.reflect.*;
import java.util.*;
import java.awt.event.*;

class InputWindow extends JFrame implements ActionListener
{
  String[] input_pics = new String[40];
  //practice pictures
  String[] temp_pics = new String[10];

  String input_file_name = new String("Input.txt");
  String temp_file_name = new String ("temp.txt");
  String output_file_name = new String ("Output.txt");
  String patient_id;

  //default values are set; otherwise it should be = 0
  int doneflag = 0;
  static int isi = 80;
  static int sdt = 240;
  static int iti = 5000;

  JLabel practice_label = new JLabel ("Practice File:");
  JTextField practice_text = new JTextField (25);
  JButton practice_button = new JButton ("Browse");

  JLabel input_label = new JLabel ("Input File:");
  JTextField input_text = new JTextField (25);
  JButton input_button = new JButton ("Browse");

  JLabel output_label = new JLabel ("Output File:");
  JTextField output_text = new JTextField (25);
  JButton output_button = new JButton ("Browse");
  JFileChooser chooser = new JFileChooser ();

  JLabel interstim = new JLabel ("InterStimulus Interval (ms):");
  JTextField interstimtx = new JTextField (5);

  JLabel stimdis = new JLabel ("Stimulus Display Time (ms):");
  JTextField stimdistx = new JTextField (5);
```

```
JLabel intertrial = new JLabel ("InterTrial Interval (ms):");
JTextField intertrialtx = new JTextField (5);

JLabel patientid = new JLabel ("Patient Id");
JTextField patientidtx = new JTextField (10);

JButton donedata = new JButton ("All Data Provided");

public InputWindow ()
{  //This is window setup
  super ("Setup");
  setSize (800, 500);
  setDefaultCloseOperation (JFrame.EXIT_ON_CLOSE);
  setVisible (true);

  //This is the layout
  Container content = getContentPane ();
  GridBagLayout lay =  new GridBagLayout ();
  GridBagConstraints pos = new GridBagConstraints ();
  pos.weightx = .5;
  pos.weighty =  .5;
  content.setLayout (lay);

  //The Stuff you see
  pos.gridx = 0; pos.gridy = 0;
  content.add(practice_label, pos);
  pos.gridx = 0; pos.gridy = 1;
  content.add(practice_text, pos);
  pos.gridx = 1; pos.gridy = 1;
  content.add(practice_button, pos);
  practice_button.addActionListener(this);

  pos.gridx = 0; pos.gridy = 2;
  content.add(input_label, pos);
  pos.gridx = 0; pos.gridy = 3;
  content.add(input_text, pos);
  pos.gridx = 1; pos.gridy = 3;
  content.add(input_button, pos);
  input_button.addActionListener(this);

  pos.gridx = 0; pos.gridy = 4;
  content.add(output_label, pos);
  pos.gridx = 0; pos.gridy = 5;
  content.add(output_text, pos);
  pos.gridx = 1; pos.gridy = 5;
```

```
    content.add(output_button, pos);
    output_button.addActionListener(this);

    pos.gridx = 0; pos.gridy = 6;
    content.add(interstim, pos);
    pos.gridx = 1; pos.gridy = 6;
    content.add(interstimtx, pos);
    interstimtx.setText("" + isi);

    pos.gridx = 0; pos.gridy = 7;
    content.add(stimdis, pos);
    pos.gridx = 1; pos.gridy = 7;
    content.add(stimdistx, pos);
    stimdistx.setText("" + sdt);

    pos.gridx = 0; pos.gridy = 8;
    content.add(intertrial, pos);
    pos.gridx = 1; pos.gridy = 8;
    content.add(intertrialtx, pos);
    intertrialtx.setText("" + iti);

    pos.gridx = 0; pos.gridy = 9;
    content.add(patientid, pos);
    pos.gridx = 1; pos.gridy = 9;
    content.add(patientidtx, pos);

    pos.gridx = 0; pos.gridy = 10;
    content.add(donedata, pos);
    donedata.addActionListener(this);

    setContentPane(content);



  }

//Actions done by clicking on buttons
  public void actionPerformed (ActionEvent event){
    if (event.getSource() == donedata) {
      try {
        iti = Integer.parseInt(intertrialtx.getText());
        sdt = Integer.parseInt(stimdistx.getText());
        isi = Integer.parseInt(interstimtx.getText());
        if(iti < 0 || sdt < 0 || isi < 0) throw new Exception("invalid number");
      }catch(Exception ex)
```

```
      {
        JOptionPane.showMessageDialog(this, "Invalid Number for iti, sdt, or isi.  Please
enter an integer > 0", "Error", JOptionPane.ERROR_MESSAGE);
        return;
      }
      temp_file_name = practice_text.getText();
      input_file_name = input_text.getText();
      patient_id = patientidtx.getText();
      java.util.Calendar cal = java.util.Calendar.getInstance();
      output_file_name = (new File(output_text.getText(), "output_" + patient_id + "_" +
cal.get(Calendar.YEAR) + "_" + (cal.get(Calendar.MONTH)+1) + "_" +
cal.get(Calendar.DAY_OF_MONTH) + "_" + cal.get(Calendar.HOUR) + "_" +
cal.get(Calendar.MINUTE) + ".csv")).getAbsolutePath();
System.out.println("outfile: " + output_file_name);
      temp_pics = filereader (temp_file_name);
      input_pics = filereader (input_file_name);
      String errmsg = null;
      if(errmsg == null && (patient_id == null || patient_id.equals("")) ) errmsg = "Invalid
Patient ID";
      if(errmsg == null && !isValidFilename(temp_file_name)) errmsg = "Invalid Practice
File";
      if(errmsg == null && !isValidFilename(input_file_name)) errmsg = "Invalid Input
File";
      if(errmsg == null && !isValidFilename(output_text.getText())) errmsg = "Invalid
Output Directory";
      if(errmsg == null && temp_pics == null) errmsg = "Error Reading Practice Input
File";
      if(errmsg == null && input_pics == null) errmsg = "Error Reading Experiment Input
File";
      if(errmsg != null)
      {
        JOptionPane.showMessageDialog(this, errmsg, "Error",
JOptionPane.ERROR_MESSAGE);
        return;
      }
      setVisible(false);
      doneflag = 1;
      System.out.println ("clicked on donedata");
    }
    if (event.getSource() == practice_button)
    {
      JFileChooser fc = new JFileChooser();
      int retVal = fc.showOpenDialog(this);
      if(retVal == JFileChooser.APPROVE_OPTION) {
        File f = fc.getSelectedFile();
```

```
      practice_text.setText(f.getAbsolutePath());
      temp_file_name = practice_text.getText();
    }
  }
  if (event.getSource() == input_button)
  {
    JFileChooser fc = new JFileChooser();
    int retVal = fc.showOpenDialog(this);
    if(retVal == JFileChooser.APPROVE_OPTION) {
      File f = fc.getSelectedFile();
      input_text.setText(f.getAbsolutePath());
      input_file_name = input_text.getText();
    }
  }
  if (event.getSource() == output_button)
  {
    JFileChooser fc = new JFileChooser();
    fc.setFileSelectionMode(JFileChooser.DIRECTORIES_ONLY);
    int retVal = fc.showOpenDialog(this);
    if(retVal == JFileChooser.APPROVE_OPTION) {
      File f = fc.getSelectedFile();
      output_text.setText(f.getAbsolutePath());
      //output_file_name = output_text.getText();
    }
  }
}

private boolean isValidFilename(String f)
{
  File file = new File(f);
  if(file.exists()) return true;
  if(file.canRead()) return true;
  if(file.canWrite()) return true;
  return false;
}

//Function to put image names into an array
public String[] filereader (String name)
{
  java.util.ArrayList a = new java.util.ArrayList();
  try
  {
    int i = 0;
    FileReader file = new FileReader (name);
    BufferedReader buffer = new BufferedReader (file);
```

```
      String textline = null;
      while ((textline = buffer.readLine()) !=null){
        System.out.println (textline);
        a.add(textline);
      }
      buffer.close ();
      String[] res = new String[a.size()];
      for(int j = 0; j < res.length; j++) res[j] = (String)a.get(j);
      return res;
    }
    catch (IOException e) {System.out.println(e); return null;}
  }
}
```

Instruction Window File

```
import javax.swing.*;
import java.awt.*;
import java.io.*;
import java.lang.reflect.*;
import java.util.*;
import java.awt.event.*;


class InstructionsWindow extends JFrame implements ActionListener
{
  int donereading = 0;
  JLabel info_label = new JLabel ("Instructions", SwingConstants.CENTER);
  JTextArea info_text = new JTextArea ("At this computer, you are going to be shown
several pairs of pictures. Each pair of pictures is going to be identical with the exception
of one small detail. We want you to find what is different between each pair of pictures as
quickly as you can. Once you have found the difference, press the space bar. After
pressing the space bar, verbally indicate the change that you noticed.",20,20);
  JLabel questions =  new JLabel ("Do you have any questions thus far?",
SwingConstants.CENTER);
  JTextArea changing = new JTextArea (3,20);
  JButton info_button = new JButton ("Continue");

public InstructionsWindow (String swap)
  {  //This is window setup
    super ("Instructions");
    Dimension sc = Toolkit.getDefaultToolkit().getScreenSize();
    //setSize (500, 500);
    setSize(sc);
    setDefaultCloseOperation (JFrame.EXIT_ON_CLOSE);
    setVisible (true);

    Container content = getContentPane ();
    GridLayout lay =  new GridLayout (5,1);
    content.setLayout (lay);

    //The Stuff you see

    content.add(info_label);
    info_text.setLineWrap(true);
    info_text.setWrapStyleWord(true);
    content.add(info_text);
    content.add(questions);
```

```
    changing.insert(swap, 0);
    changing.setLineWrap(true);
    changing.setWrapStyleWord(true);
    content.add(changing);



     content.add(info_button);
     info_button.addActionListener(this);


    setContentPane(content);
  }
public void actionPerformed (ActionEvent event)
{ if (event.getSource () == info_button)
  { donereading = 1;
    setVisible(false);
  }
}
}
```

Flicker Window File

```
import javax.swing.*;
import java.awt.*;
import java.awt.image.*;
import java.io.*;
import java.lang.reflect.*;
import java.util.*;
import java.awt.event.*;
import javax.imageio.*;
import java.lang.*;

class FlickerWindow extends JFrame implements KeyListener
{
  int i = 0;
  int length = 0;
  int k = 1;
  boolean keystroke = false;

  Image[] pics;// = new Image [40];
  String[] imageNames;
  Image currentImage;
  long drawTime;
  long keyPressedTime;
  JLabel info_label = new JLabel ("Instructions");
  JTextArea info_text = new JTextArea (2,25);
  JButton info_button = new JButton ("Continue");
  Image gray, black;
  PrintWriter dataFile;
  public boolean donedisplaying = false;

//in milliseconds
  int showImageTime = 240;
  int showGrayTime  = 80;
  int showBlackTime = 5000;

  //int imagexlocation = 0;
  //int imageylocation = 0;
  //int imagewidth = 700;
  //int imageheight = 500;
  Dimension screenSize;

  public FlickerWindow (String header, String outputFile, String[] a) throws Exception
  {  //This is window setup
```

```
    super ("Experiment");
    this.showImageTime = InputWindow.sdt;
    this.showGrayTime = InputWindow.isi;
    this.showBlackTime = InputWindow.iti;

    Dimension sc = Toolkit.getDefaultToolkit().getScreenSize();
    setSize (sc);
    screenSize = sc;

    dataFile = new PrintWriter(new FileWriter(outputFile, true));
    dataFile.println(header);
    dataFile.println(new java.util.Date());
    dataFile.println("Pair, Image In Pair, Image Name, Time from Beginning, Time from
Pair Start, Cycle Count, Actual Cycle Count");
    imageNames = a;
    //Class cl = a.getClass();
    //if (!cl.isArray()) return;
    pics = new Image[a.length];
    Image tempimg;
    try {
          gray = ImageIO.read(new File((String)"gray.jpg"));
          tempimg = new BufferedImage(sc.width, sc.height,
BufferedImage.TYPE_INT_RGB);
          if(tempimg == null) System.err.println("GAAAH");
          Graphics g = tempimg.getGraphics();
          g.drawImage(gray, 0, 0, sc.width, sc.height, null);
          g.dispose();
          gray = tempimg;
          black = ImageIO.read(new File((String)"black.jpg"));
          tempimg = new BufferedImage(sc.width, sc.height,
BufferedImage.TYPE_INT_RGB);
          g = tempimg.getGraphics();
          g.drawImage(black, 0, 0, sc.width, sc.height, null);
          g.dispose();
          black = tempimg;
          currentImage = gray;
    }catch(IOException e) {
    }
    for(i=0; i<a.length; i++)
    {
      System.out.println(Array.get(a,i));
      if (a[i]!=null)
      {
        try
        {
```

```
        pics[i] = ImageIO.read(new File((String)Array.get(a,i)));
        if(sc.width <  pics[i].getWidth(null) || sc.height < pics[i].getHeight(null))
        {
          int newwidth = sc.width;
          int newheight = sc.height;
          int oldwidth = pics[i].getWidth(null);
          int oldheight = pics[i].getHeight(null);
          double ratio = ((double)oldwidth)/((double)oldheight);
          newwidth = (int)(ratio*newheight);
          if(newwidth > sc.width)
          {
            newwidth = sc.width;
            newheight = (int)(newwidth/ratio);
          }

          tempimg = new BufferedImage(newwidth, newheight,
BufferedImage.TYPE_INT_RGB);
          Graphics g = tempimg.getGraphics();
          g.drawImage(pics[i], 0, 0, newwidth, newheight, null);
          g.dispose();
          pics[i] = tempimg;
        }
        length++;
        //System.out.println ("inside of try");
      }
      catch (IOException e)
      {
        e.printStackTrace();
      }
    }
  }
  //imagexlocation = sc.width/2 - imagewidth/2;
  //imageylocation = sc.height/2 - imageheight/2;

  setDefaultCloseOperation (JFrame.EXIT_ON_CLOSE);
  addKeyListener (this);
  ImageSwitcherThread t = new ImageSwitcherThread(this);
  t.start();
  setVisible (true);
 }
 public void paint (Graphics g)
 {
  //g.drawImage (currentImage,0,0,700,500,null);
  //g.drawImage
(currentImage,imagexlocation,imageylocation,imagewidth,imageheight,null);
```

```
    int x = screenSize.width/2 - currentImage.getWidth(null)/2;
    int y = screenSize.height/2 - currentImage.getHeight(null)/2;
    g.drawImage (currentImage, x, y, currentImage.getWidth(null),
currentImage.getHeight(null), null);
  }
  public void keyPressed (KeyEvent e)
  {
    keystroke = true;
    keyPressedTime = System.currentTimeMillis();
    System.out.println("keystroke happened");
  }

  public void keyReleased (KeyEvent e){}

  public void keyTyped (KeyEvent e){}

  class ImageSwitcherThread extends Thread
  {
    JFrame frame;
    public ImageSwitcherThread(JFrame currFrame)
    {
      this.frame = currFrame;
    }
    public void run()
    {
      currentImage = gray;
      i = 0;
      long beginTime = System.currentTimeMillis();
      while(i+1 < imageNames.length)
      {
        k = 1;
        keystroke = false;
        long pairStartTime = System.currentTimeMillis();
        int paircounter = 0;
        while(!keystroke)
        {
          k = (k + 1) & 0x1;
          //System.out.println("Displaying image: " + (i+k));
          currentImage = pics[i + k];
          //frame.paintImmediately();
          repaint();
          drawTime = System.currentTimeMillis();
          while((System.currentTimeMillis() - drawTime) < showImageTime) {this.yield();}
          currentImage = gray;
          //paintImmediately();
```

```
          repaint();
          drawTime = System.currentTimeMillis();
          while((System.currentTimeMillis() - drawTime) < showGrayTime) {this.yield();}
          paircounter++;
        }
        currentImage = black;
        //paintImmediately();
        repaint();
        dataFile.println(i + ", " + k + ", " + imageNames[i+k] + ", "
                    + (keyPressedTime - beginTime) + ", " + (keyPressedTime -
pairStartTime) + ", " + (paircounter/2) + ", " + (paircounter/2.0));
        drawTime = System.currentTimeMillis();
        i = i + 2;
        while((System.currentTimeMillis() - drawTime) < showBlackTime) {this.yield();}
      }
      dataFile.println("");
      dataFile.close();
      donedisplaying = true;
      setVisible(false);
    }
  }
}
```

Finished File

```
import javax.swing.*;
import java.awt.*;
import java.io.*;
import java.lang.reflect.*;
import java.util.*;
import java.awt.event.*;


class Finished extends JFrame //implements ActionListener
{
  JLabel thankslabel = new JLabel ("You Are Done!!! Thank You for Participating in Our 
Experiment.");
  Font customFont = new Font ("You Are Done!!! Thank You for Participating in Our 
Experiment.", Font.PLAIN, 32);
  JButton exit_button = new JButton ("Exit");

public Finished ()
  {  //This is window setup
    super ("All Done");
    Dimension sc = Toolkit.getDefaultToolkit().getScreenSize();
    setSize (sc);
    setDefaultCloseOperation (JFrame.EXIT_ON_CLOSE);
    setVisible (true);

    Container content = getContentPane ();
    GridBagLayout lay =  new GridBagLayout ();
    GridBagConstraints pos = new GridBagConstraints ();
    pos.weightx = .5;
    pos.weighty =  .5;
    content.setLayout (lay);

    //The Stuff you see
    pos.gridx = 0; pos.gridy = 0;
    content.add(thankslabel, pos);
    thankslabel.setFont (customFont);
    pos.gridx = 0; pos.gridy = 1;
    content.add(exit_button, pos);
   // practice_button.addActionListener(this);
  }
}
```