DIFFERENCES IN FLICKER PARADIGM RESPONSE TIMES:

CHANGE BLINDNESS IN SNAKE PHOBICS

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Date

THESIS ABSTRACT

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This study is a replication of Wheeler (2003), expanding upon his exploration of the connection between snake phobia and change blindness, a phenomenon in which individuals do not recognize changes in their immediate environment. Employing Rensink's (1997) flicker paradigm, two experiments were conducted. In Experiment A, 12 snake-fearful and 15 control participants engaged in a change detection computer task involving central and marginal changes in fearsome and neutral stimuli before being assessed for snake phobia on the ADIS-IV. In Experiment B, assessment was carried out before the computer task. No significant group differences were present in either experiment, although a significant group difference emerged when the data were aggregated, suggesting that snake-fearful participants responded in a significantly different manner than controls, generally requiring more time on the tasks. Furthermore, location of change and content of stimuli had a significant effect on time to change detection. Finally, a significant three-way interaction was found in Experiment B and the aggregated data, whereby fearful individuals required more time to detect changes in fearsome marginal stimuli. This data is interpreted in terms of information processing, attention bias, and disengagement theories.

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Style manual or journal used: American Psychiatric Association Style Manual

Computer software used: Microsoft Windows 98, Eprime Software, SPSS

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INTRODUCTION

Beginning in the last quarter of the twentieth century, researchers have been studying the phenomenon of change blindness, positing that humans are not always accurate observers of seemingly defined events. We miss things, and are unaware of our omissions. In the last fifteen years or so, the flicker paradigm has been developed and incorporated into this research (Simons, 1996; Rensink, 2002), creating a novel method of studying change blindness. Rensink's research has been primary in extending this field of study, and he was the first to recognize the important role attention plays in change blindness. It seems that it requires less time for individuals to notice changes in scenes when their attention is, for some reason, drawn toward the change.

Attention is not a new area of study. The theory of attention bias, particularly in relation to anxiety and threat, has been popular for many years, growing out of the information processing literature. This theory suggests that anxious individuals have an attentional bias for relevant threat, whether they direct more attentional resources toward threatening stimuli, interpret ambiguous stimuli as threatening, or activate fear networks that connect danger to certain stimuli (MacLeod & Mathews, 1988; see Williams, Watts, MacLeod, & Mathews, 1988 and McNally, 1990 for reviews). Put simply, snake phobics may spend more time on tasks that include snake stimuli, social phobics may assume ambiguous stories have threatening endings, and so forth. More recent studies within the attention literature have suggested that anxious individuals, rather than spending more time with threatening stimuli, actually have difficulty disengaging once confronted with threatening stimuli (Fox, Russo, & Dutton, 2002). Fox, the primary researcher in this area, has labeled her theory "disengagement." Both information processing theories and the disengagement theory suggest that highly anxious individuals are drawn more to threatening stimuli than neutral stimuli, and to a greater extent than less anxious individuals. However, these theories manifest themselves differently in relevant research.

Only one study (Wheeler, 2003) has used the flicker paradigm and the concept of change blindness to examine the behavior and cognitive processes of snake phobics; a relevant connection may exist between snake phobics' vigilant behavior and the attention that is a central feature of change detection. Although Wheeler's study seemed to support the disengagement theory, demonstrating that snake fearful participants required more time to detect changes in neutral stimuli, it lacked the statistical power from which conclusive evidence could be drawn. This study replicated Wheeler's study on a significantly larger scale, and further investigated the relationship between snake phobics' cognitive patterns and change detection, examining what kind of cognitive phenomena occurred during a change detection task. New information in this field may be beneficial for establishing clues to cognitive processing in phobic persons.

Snake Phobia

Fear is a common feeling. Most people can name at least one thing of which they are afraid. Very young children are afraid of being separated from their parents, older children are afraid of the dark or imaginary creatures under their beds, and teenagers tend to be afraid of those things that can cause physical harm (Cox & Taylor, 1999). Among adults, however, extreme fear, or phobias, can be divided into three main categories:

specific, social, and agoraphobia. For the purposes of this study, we are interested in specific phobics, particularly adults who are fearful of snakes. Cox and Taylor (1999) report that 11% of adults have at least one animal phobia. With such a high base rate, it is likely that most people know at least one person who has an animal phobia, perhaps even a snake phobia.

Depending on an individual's situation, snake phobia can be a debilitating disorder. If a snake phobic lives in a Southeast Asian country where snakes are commonly encountered, he may have great difficulty leaving his house, for fear of running into a snake. However, in urban America, snakes are most often seen at zoos or in pet stores; a snake phobia, therefore, is not likely to prevent anyone from carrying on his daily life in a (mostly) normal way.

The evolutionary origin of specific phobias has received some attention in past years, and has been studied extensively. McNally (1987) provides a comprehensive review of the idea of preparedness and phobias. Preparedness serves as a theoretical explanation of extinction-resistant phobias. Initially proposed by Seligman (1971) to explain some of the unique characteristics of certain phobias, preparedness is considered an evolutionarily obtained tendency that makes it easier for humans to develop fears of those things or situations that once posed a threat to our ancestors' immediate safety. Seligman's research also suggests that it is more difficult to extinguish those fears once they have developed. Snake phobia, specifically, has been a subject of preparedness research. In the original experiment, participants demonstrated a greater resistance to extinction of "prepared" phobias (i.e. snakes, spiders) than to non-prepared phobias (i.e. mushrooms, flowers) (Seligman, 1971). However, in McNally's review (1987), he gathers evidence suggesting that “prepared” phobias are no more difficult to extinguish than other phobias; their longevity is actually a result of phobics’ avoidance of the therapeutic effects of exposure. More recent research has noted the “archaic” nature of such prepared phobias, and suggested that certain anxiety-regulation mechanisms, shaped through years of natural selection, have furthered the prevalence of seemingly irrelevant fears (i.e. snake phobia), rather than replacing them with more relevant fears (i.e. car phobia) (Marks & Nesse, 1994). Whatever caused or causes snake phobia, it remains clear that it is a relatively common problem among adults and changes the behavior of people who have the phobia, preventing or making less enjoyable walks in the woods or other outdoor activities.

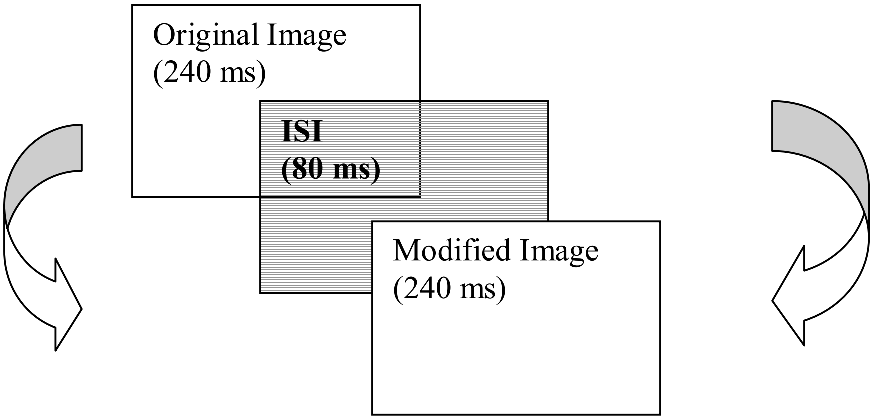
Change Detection

Most people think that they notice most things that happen in their environments. In fact, people tend to take pride in their skills of perception and observation. However, recent research has begun to demonstrate that humans are not the accurate observers they believe themselves to be. In a comprehensive review, Rensink (2002) outlines the concepts of change blindness and change detection, including the different circumstances under which each has been observed and possible cognitive mechanisms by which they might be explained. According to Rensink, study of change blindness has had three main phases: in the first, experimenters studied blindness to changes in position in dot arrays or in people’s faces when separated by a period of several seconds (Hochberg, 1968); in the second phase, attempts were made to organize these studies and researchers found that limitations of change detection were apparent in several different circumstances (Pashler, 1988; McConkie & Zola, 1979; Gur & Hilgard, 1975); and in the third, ongoing phase, more realistic stimuli are being used in repeated trials to examine the underlying cognitive mechanisms of change blindness (Simons, 1996; Rensink, O'Regan, & Clark, 1997).

The role of the saccadic eye movement has become increasingly important; it appears that humans have momentary "blindness" or suppression of visual encoding during the moments that their eyes change focus (Archambault, O'Donnell, & Schyns, 1999). This "blindness" makes the viewer less sensitive to seemingly large changes that occur in his or her immediate environment. The third phase of change detection research established the basis for the development of the flicker paradigm (Rensink et al., 1997), which has taken hold in the change detection literature and is just beginning to work its way into other cognitively-based domains. The flicker paradigm successfully and realistically re-creates the visual suppression of an eye saccade, an accomplishment not yet reached by previous researchers (Hollingworth, Schrock, & Henderson, 2001). Rensink (2000) considers vision to contain three separate aspects: seeing, described as a virtual representation of objects that one *needs* to notice (i.e. obstacles in one's direct path); sensing, which includes non-visual detection with or without conscious awareness (i.e. changes sensed without benefit of attention); and scrutinizing, which happens only with sustained visual attention. This visual attention is what lies at the heart of change detection and change blindness.

The flicker paradigm, as described by Rensink et al. (1997), consists of a computer task that includes an original image that repeatedly alternates with a modified image, separated by a blank screen, labeled an inter-stimulus interval (ISI).

Figure 1: Flicker Paradigm with Inter-Stimulus Interval



Rensink et al. experimented with several different time-spans for each component of the paradigm, and found that the lengths of time that created the most consistent, effective change blindness were 240 ms for each image and 80 ms for each ISI. With an ISI of less than 60-70 ms, the images were not separated by enough time to make the change-detection task a challenge. Furthermore, when the ISI was removed altogether, participants identified the changes almost immediately, supporting the necessity of the ISI. This result was replicated by Wheeler (2003). The ISI is the mechanism that most closely replicates the eye saccade, producing a moment of visual suppression that appears to create insensitivity to change on the part of the viewer.

Rensink, having developed the flicker paradigm to study the concept of change blindness, then used the paradigm to examine the cognitive mechanisms that lay beneath the change blindness that seemed to be common among people. Rensink et al. (1997) conducted three experiments based on the flicker paradigm. In the first experiment, when participants were simply shown the alternating pictures, in flicker paradigm format (240 ms for each image, with 80 ms of ISI), participants exhibited great difficulty identifying the change. In fact, the difficulty remained when image time was increased to 560 ms, negating the theory that the problem arose from insufficient viewing time. However, when the experimenter provided the participant with a verbal clue, change-detection time decreased drastically. Rensink et al. also investigated the differences between change-detection times demonstrated for changes in central (important, focal) features of the image and marginal (unimportant, background) features of the image. As expected, participants were significantly faster at recognizing changes that occurred within the central images, likely because individuals' attention was more quickly drawn to central images. Rensink et al. suggest that these data highlight attention as an important ingredient for change detection. He proposes that people are significantly less likely to see changes in objects that are not immediately relevant or important enough to draw our attention.

Mack (2003) outlines the same concept as Rensink et al. (1997), labeling the phenomenon inattentional blindness (IB). Mack defines IB as "the failure to see highly visible objects we may be looking at directly when our attention is elsewhere (p. 180)." One example of IB comes from recent work by Simons and Chabris (1999), who showed a video of a basketball game to participants. Upon subsequent questioning, only 21% of the participants reported noticing a woman who walked through the middle of the basketball court with an open umbrella. Rensink et al. and Mack would explain this phenomenon by noting the fact that most people watching the game were exclusively paying attention to the action surrounding the basketball. Therefore, the woman with the umbrella was unattended to and overlooked.

Different types of changes can be presented in change detection tasks, and the change that is selected will very likely affect whether, and how quickly, detection takes place. For example, Agostinelli, Sherman, and Fazio (1986) found that participants were better at detecting a deletion (removal of an object from an image) if they were told in advance that they would be asked about differences. When not pre-informed, participants showed superior change detection for additions (adding an object to the image). Furthermore, the meaningfulness an object carries for a participant will affect his ability to detect the change. Agostinelli et al. found a significant increase in accuracy for detecting changes in stimuli that had meaning for the participant. Although Agostinelli et al.'s study was conducted over a decade before Rensink et al. (1997) and Mack (2003), their earlier findings coalesce with the attentional theory. Presumably, participants will be more likely to pay attention to specific objects that have meaning for them.

Similarly, people who have learned to categorize objects as either general or specific show differential change blindness for those objects. For example, Archambault et al. (1999) trained participants to categorize computers and mugs into specific or general categories. She found that changes in "specific" objects were easier to detect for participants who had been trained to categorize them specifically than for those who had categorized them generally. Other research has also highlighted the importance of content in the change detection task. For example, Ro, Russell, and Lavie (2001) found that participants in a change detection task demonstrated a distinct advantage for pictures that contained upright human faces in multiple-object arrays. That is, participants detected changes taking place in human faces more accurately and rapidly than changes in other objects (e.g. appliances, foods, etc.). In both these experiments it appeared that more attention was paid to the objects with which the participant had more familiarity and to which he had attached more meaning.

Information Processing and Attention Bias

Stroop (1935) was one of the first researchers to develop a paradigm by which researchers could observe an attentional bias toward emotionally-relevant words. In his aptly-named Stroop Colour-naming Task, participants are asked to verbally express the color in which the name of another color is written; the written color can be the same as or different from the color of the ink. As expected, participants in the original study required more time to name mis-matched colors than co-incident colors (e.g. RED printed in green was more difficult than RED printed in red). Since his original study, researchers have used the Stroop task to conduct experiments on attentional bias, examining whether the task requires more time with words that have a particular meaning for an individual. This task has become increasingly useful for studying anxious individuals, operating under the premise that the allocation of information-processing resources toward one's fear decreases the level of resources available for another task. Dalgleish and Watts (1990) have reviewed the research and noted that a variety of anxious individuals have an attention bias toward anxiety-invoking stimuli. Mathews and MacLeod (1985) conducted an experiment which supported the notion that anxious individuals are slower with modified Stroop tasks overall, but have particular difficulty with threat-related words. Furthermore, Mogg, Mathews, and Weinman (1989) found that patients with generalized anxiety disorder (GAD) required more time to name the colors of threatening words than neutral words. Similar results have been found with panic disorder clients (McNally, Riemann, & Kim, 1990) and individuals with high levels of trait anxiety (Richards & French, 1990).

McNally (1990) reviewed research suggesting that threatening stimuli are uniquely processed by anxious individuals. Specifically, ambiguous stimuli, situations or pictures that could or could not be interpreted in a threatening manner, are significantly more likely to be interpreted as threatening by those individuals for whom the threat is relevant (McNally & Foa, 1987). McNally and Foa demonstrated that agoraphobic individuals, when asked to create an ending for an ambivalent vignette, were significantly more likely to end the story negatively, framing the entire vignette in a threatening fashion. McNally also discussed Lang's (1988) bioinformational theory of emotion. Lang's theory suggests that fearsome or threatening stimuli activate a network of remembered information regarding the fearsome stimuli, fear responses, and their meanings. In clinically anxious individuals, this network builds a "pathological memory structure," in which fearsome stimuli are linked to information about danger. Confronting a snake phobic with a snake, for example, may set off links in his or her memory to information supporting the dangerous stimulus value of snakes.

Disengagement Theory

Research during the last decade or so, primarily led by Fox (1993a, 1993b, 1994, 2002) and growing out of the attention bias literature, has supported a theory suggesting that highly anxious individuals may disengage from otherenvironmental stimuli when exposed to specific threatening cues. Instead of simply allocating more attention to threatening stimuli and less to neutral stimuli, as indicated by attention bias, Fox's research indicates that anxious individuals require more time to turn their attention toward non-threatening stimuli. This seemingly subtle difference results in anxious participants, when confronted with a task that involves both neutral and threatening stimuli, spending more time on the parts of the task that involve neutral stimuli, as opposed to spending extra time completing tasks with threatening stimuli. In one of her early studies, Fox (1993a) presented color, neutral, and threatening stimuli in a modified Stroop paradigm to high and low trait-anxious individuals. Although she did achieve the attentional bias that traditional theory would have predicted (i.e. high trait-anxious participants took more time than low trait-anxious participants to color-name threatening stimuli), she also found that high trait-anxious participants were slower on color (non-threatening) stimuli. She proposed that her data supported the idea that once exposed to threatening stimuli, attention is simply more difficult to maintain for anxious individuals. Furthermore, Fox, Russo, and Dutton (2002) also found that highly anxious participants confronted with threatening stimuli (i.e. pictures of angry faces) had greater difficulty than low-anxious participants when asked to disengage and focus on neutral stimuli. In a similar study, Fox, Russo, Bowles, and Dutton (2001) found that disengagement after presentation of threatening stimuli occurred in lieu of the previously expected attentional bias. That is, participants spent more time with neutral stimuli than with threatening stimuli and anxious individuals did not spend more time than control participants with threatening stimuli.

Wheeler (2003) conducted an experiment that examined the different change-detection patterns of snake-fearful and control participants. Using the flicker paradigm, Wheeler measured change-detection times of snake-fearful and control participants who viewed both neutral and “fearsome” stimuli. Neutral stimuli included pictures of mundane sites (i.e. offices, storage rooms, desks), while fearsome stimuli included a snake somewhere in the picture. The snake was the central focus of some pictures, and part of the background of other pictures. Furthermore, like Rensink's (1997) ground-breaking study, the change taking place in the picture was either "central" or "marginal." In a central-change picture, the change took place in whatever area was considered the focal point of the picture, while in a marginal-change picture the change took place somewhere other than the focal point. (It is worth mentioning that the "center" of the picture is not always the geographical center, but the center of interest.) Wheeler found that snake-fearful participants were neither faster nor slower than control participants at detecting changes in the fearsome pictures, but they did demonstrate slower change-detection times when asked to find changes in neutral stimuli. This finding might be analogous to Fox's results with highly anxious participants (2002). Whereas Fox's highly anxious participants seemed to have difficulty disengaging when confronted with threatening faces, Wheeler's snake phobic participants seemed to have difficulty disengaging when confronted with snake stimuli. Anxious participants in both experiments required more time when confronted with a task involving neutral stimuli. Disengagement is merely one explanation of Wheeler's results. It is possible that these participants might have interpreted neutral stimuli as threatening, automatically accessing a fear network suggesting that a threat could be present somewhere in the picture. However, all the factors that may have affected Wheeler's results are unknown, making replication an important next step.

Evidence has certainly accumulated to support the apparent role that attention plays both in change blindness and in the cognitive functioning of anxious individuals. If participants are more likely to pay attention to something that contains meaning for them, whether that meaning arises from familiarity, categorization, learning, or some other factor, and if participants are more likely to see differences in images that draw their attention, it may follow that participants are more likely to see differences in images that have more meaning for them. However, a question remains about what would activate a level of meaning for snake fearful individuals. McNally and Foa's (1987) research suggests that ambiguous stimuli can be interpreted as threatening by anxious individuals, and once snake fearful participants are primed with snake stimuli, it is possible that even neutral stimuli will capture their attention, due to the perceived possibility of threat. With several different theories regarding the outcome of combined threat and attention, it is still unknown whether anxious individuals will identify changes in neutral pictures more quickly than control participants, as Wheeler's experiment suggests, or require more time to identify changes in fearsome pictures, as some of the attention bias and information processing literature suggests. Highly trait-anxious people demonstrate increased sensitivity to those environmental cues that suggest the presence of threat (MacLeod & Mathews, 1988; Williams, Watts, MacLeod, & Mathews, 1988; Fox, 1993), suggesting that snake phobics may have unique cognitive processes when confronted with snake stimuli. It is beneficial to investigate what these cognitive processes are and whether particular stimuli can sufficiently draw a participant's attention in order to somehow affect the change detection process.

Current Study

Literature supports the idea that change blindness, or inattentional blindness, can be investigated effectively with the flicker paradigm, during which an original and modified image are flashed back and forth to a participant, with a brief inter-stimulus interval (ISI) separating each presentation of an image. It seems that participants are significantly less likely to see changes in images that have little meaning to them, or for some reason fail to catch their attention. When a verbal clue is given, or participants have been primed in some way to look at the area of the image in which a change takes place, they are significantly quicker at identifying the change.

Some research has supported the preparedness theory of snake phobia. It is possible that people with an extreme fear of snakes have, for some reason, not had their evolutionarily-based snake-fearing tendencies extinguished (Seligman, 1971). Like other anxious people, they may remain relatively sensitive to environmental cues that suggest the presence of threatening stimuli, specifically snakes. According to the disengagement theory, they may be less able to recover from the fear of snake presence so as to focus on other environmental stimuli. Similarly, it seems reasonable that snake phobics, with an intense anxiety directly related to the presence or fear of snakes, demonstrate the same kind of attentional bias that highly anxious participants do when confronted with anxiety-inducing stimuli. When snake phobics are confronted with snake-related stimuli, they may be analogous to any other highly anxious participants confronted with anxiety-inducing stimuli. Therefore, comparisons can be made between the behavior of snake phobics and that of trait-anxious individuals from previous literature.

Taken together, it seems sensible that snake-fearful people would have an attentional bias toward snake-related stimuli, spending more time with tasks that included such stimuli. However, these same participants may initially interpret neutral stimuli as potentially threatening, spending extra time on tasks that included neutral stimuli as well.

Given these theories, it is unclear whether snake fearful participants will require more time to identify changes on neutral or fearsome stimuli. Wheeler (2003) found that snake-fearful participants took significantly longer to find changes in neutral stimuli, suggesting that possibly these participants devote so much attention to snake stimuli that when these fear-relevant stimuli disappear it is difficult for them to disengage.

Wheeler’s (2003) experiment was exploratory, so replication of his results is necessary before any conclusions can be offered. The current study was designed to exactly replicate Wheeler’s experiment (Experiment A), as well as to slightly modify it with post hoc assessment of which participants are snake-fearful and which are not (Experiment B). Both experiments expand upon Wheeler’s study, more than doubling the number of participants and both snake and neutral stimulus sets, creating a more powerful set of results, from which more reliable conclusions can be drawn. For example, Wheeler used six participants in both his control and snake-fearful groups, whereas the current study uses 15 participants in each control cell and 12 participants in each snake-fearful cell. Furthermore, we have improved upon the 16 stimulus sets that Wheeler used in the original experiment (i.e. reduced variability in difficulty level), eliminated four of them, and added 28 more sets for a total of 40 stimulus sets. The greater number of participants increases the potential power of our results, and the use of 40 rather than 16 stimulus sets controls for a number of variables, including practice effects. Furthermore, the greater number of stimulus sets allows a closer look at order effects, to examine the differential effect on neutral stimulus change-detection time of a preceding snake versus a preceding neutral stimulus.

From our first replication (Experiment A), we hypothesized that one of two differences will emerge. Possibly, fearful participants would show slower change-detection for neutral stimuli, as happened in Wheeler's (2003) research, supporting the disengagement theory. Alternatively, snake-fearful participants would require more time to detect changes on fearsome stimuli, as suggested by some of the attention bias and information processing literature. In an effort to reduce the priming effects that can occur with extended snake-related questioning immediately prior to the task, we ran the same experiment with post hoc questioning (Experiment B); participants were not assessed for snake fearfulness until after the change-detection task. We hypothesized that the post hoc assessments would reduce the differences between groups, but not to a point of insignificance. Finally, we hypothesized that Wheeler's (2003) central/marginal findings would be replicated, in that change-detection times would be significantly faster for those pictures in which the change takes place in the interest center of the picture. Change-detection times should be slower for those pictures in which the change is marginal.

METHOD

Participants

Fifty-four participants were selected from undergraduate psychology students at Auburn University, a primarily Caucasian, upper-middle-class institution. The undergraduate population, although not a random sampling of the general population, includes a broad variety of psychopathology, including a standard base rate of snake-fearful students. Students in psychology classes were recruited by offering extra credit for participating in a "Cognitive Psychology" screening task. As a result of these recruiting attempts, 170 students filled out packets that included five different questionnaires, including three personality surveys, a nonsense intelligence test obtained from the Internet, and the Fear Survey Schedule—Third Edition (FSS-III; Wolpe & Lang, 1964). The purpose of the screening packet was to identify participants who were either very fearful of snakes or not at all fearful. In order to prevent the participants from recognizing the purpose of the research, the FSS-III was positioned in the middle of the packet. Each participant was scored according to how they ranked their fear of snakes: 0 = None, 1 = Very little, 2 = A little, 3 = Some, 4 = Much, 5 = Very much, 6 = Terror. All participants who ranked their fear between 2 and 4 received one hour's worth of extra credit and were not contacted again. Any participant who ranked their fear as none, very little, very much, or terror received a follow-up email inviting them to set up an appointment for further research, estimated to take between 30 and 60 minutes. Those who responded to the email were scheduled for the experiment. Through this screening process, fifty-six individuals who endorsed a significant fear of snakes (very much or terror) were invited to participate in the experiment; thirty-five individuals actually followed through with the experiment. Of these participants, twenty-four met the criteria we had chosen for snake phobia. Additionally, fifty-two individuals who endorsed little to no fear of snakes were invited back, thirty-five of whom returned. Of this group, thirty-one participants met the criteria to qualify as controls. Notably, in Wheeler's (2003) study, it was prohibitively difficult to find clinically phobic individuals. Therefore, for the purposes of this study, we used experimental participants who endorsed a "very severe fear" of snakes, a ranking of 7 or 8 on a 0-to-8 point scale, during the Anxiety Disorders Interview Schedule-Fourth Edition (ADIS-IV; DiNardo, Brown, & Barlow, 1994). Participants who reported "no fear" of snakes on the ADIS-IV, a ranking of 0 or 1, were used as control participants. Data from individuals who ranked their fear of snakes between the cut-offs for the control and experimental groups were not included in the analyses.

Design

As noted already, this research project produced two experiments, each of which utilized 15 control and 12 snake-fearful participants. The experiments included identical components, but presented the components in reverse order. Specifically, each experiment required each participant to engage in a computer task which involved detecting changes in neutral scenes and scenes with a snake. Each experiment also involved an advanced clinical psychology graduate student guiding the participant through the specific phobia module of the ADIS-IV. In Experiment A, participants were administered the ADIS-IV before completing the computer task; in Experiment B, the computer task was completed before administration of the ADIS-IV. Each experiment was based on a 2x2x2 design to investigate potential differences in trials to change-detection between fearful and non-fearful participants on neutral vs. snake stimuli and central vs. marginal changes. Furthermore, the participants in Experiment A were compared to those in Experiment B to evaluate priming or suppression effects of ADIS-IV participation.

Participants were assigned to fearful/non-fearful groups on the basis of their screening data, but were not considered actual participants until they had demonstrated either no or extreme fear of snakes in the clinical interview. Due to the risk of diffusion across groups, Experiment B was conducted before Experiment A; participants were also requested not to discuss the details of the study outside of the experimental lab. The first participants to respond to the request for volunteers were assigned to Experiment B, the post hoc design, and the computer task remained the first component until all participant slots had been filled with individuals who fit the criteria for the experiment. Once all slots had been filled, individuals who had screened into the study were presented with the ADIS-IV before the computer task and were considered part of Experiment A. To prevent overlap of volunteers, participant names were recorded separate from the data, and participants from Experiment B were excluded from Experiment A. Furthermore, information distributed regarding the screening specified that individuals could participate only once.

Stimuli

Forty stimulus sets were created. Twelve of the stimulus sets were used in previous research (Wheeler, 2003), and twenty-eight were created specifically for this project. Twenty of the stimulus sets were “fearsome;” that is, they depicted a snake as either the focal point or somewhere in the background. Twenty stimulus sets were “neutral,” depicting benign environmental stimuli (e.g. office areas, trees and bushes, drinking fountains, etc.). Once obtained, a copy was made of each picture to be used as a stimulus. The copy was then altered to include a “change” (e.g. a disappearing spot on a snake, a changing shape of a shadow). Half of the changes (ten of the fearsome stimuli and ten of the neutral stimuli) were designed to be “central” and half were designed to be “marginal.” In accordance with previous research (Rensink, 1997; Wheeler, 2003), central changes did not necessarily occur in the center of the picture, but rather at the focal point of the picture (e.g. the eye of a snake, a plant in an otherwise empty room). Marginal changes occurred outside the picture’s focal point (e.g. a spot on the back end of a snake, a line on a wall). More specifically, the focal point was defined as the point to which the viewer’s eye was drawn. In two of the pictures, the environment was allowed to change naturally and a new picture was taken at the identical location and angle (e.g. a snake was allowed to change position on the floor). In order to confirm whether changes were central or marginal, extra pictures were made and eight graduate students were asked to participate in the flicker paradigm task and queried about the changes. Changes that at least 7 of the 8 graduate students consistently considered to be happening at the focal point of the picture were considered central and those that involved more in-depth searching and scanning were considered marginal. Pictures that contained changes that were overlooked by at least half of the graduate students were eliminated from the study.

Measures and Apparatus

Fear Survey Schedule—III: During the screening process, participants filled out the Fear Survey Schedule—Third Edition (FSS-III; Wolpe & Lang, 1964), a survey that allows individuals to mark a box under the level of fear they feel for a variety of objects or events. (See appendix A). “Snakes” is one of 28 different items that participants are asked to rank on a scale that includes “none,” “very little,” “a little,” “some,” “much,” “very much,” and “terror.” Individuals who ranked their fear level as *none* or *very little* were invited back as potential control participants and those who ranked their fear as *very much* or *terror* were invited back as potential snake-fearful participants. The dimensions underlying the FSS-III have been demonstrated to have sufficient reliability for research purposes (Arrindell, Emmelkamp, & van der Ende, 1984), as well as good construct validity and internal consistency (Spinks, 1980).

Anxiety Disorders Interview Schedule—Fourth Edition: Either before or after the computer task, participants were taken through the specific phobia module of the Anxiety Disorders Interview Schedule—Fourth Edition (ADIS-IV; DiNardo, Brown, & Barlow, 1994) with a graduate student in clinical psychology. The ADIS-IV is a comprehensive diagnostic interview schedule designed to obtain clinical data regarding symptoms of a variety of anxiety disorders. The ADIS-IV has been continually improved and re-designed to allow it to flow thematically between the disorders and provide specific information about severity and frequency of various disorders, also providing information relevant for differential diagnosis. The ADIS-IV has good interrater reliability and good validity and is considered the gold standard among clinical interviews for anxiety disorders (Brown, Di Nardo, & Barlow, 1994). Furthermore, it was used by Wheeler

(2003) to classify participants as snake-fearful or control, and therefore is the clear choice for this replication experiment.

E-Prime Studio and Photoshop: The flicker task for this experiment was created using E-Prime software, the standard psychological software for computer experiments. Stimuli were presented full-screen on a 14-inch monitor and participants were seated approximately 25 inches away from the screen. Most of the pictures used as stimuli were taken manually with a digital camera while some were found on the Internet. Each picture was sized to fit the computer monitor at 760 x 480 pixels, and a copy was made of each. Changes were primarily made using PhotoShop tools, including the Clone Stamp and the Healing Brush.

Procedure

Directly preceding the change-detection trials, each participant in Experiment A was interviewed by a clinical psychology graduate student, using the phobia module of the Anxiety Disorder Interview Schedule (ADIS-IV). The change-detection trials were administered by trained undergraduate research assistants who were familiar with all 40 sets of pictures. Both the interviewer and the research assistant were blind to each participant's screening result (potentially snake-fearful or control). Each stimulus set included one index picture and one computer-altered version of the index picture. Upon adjacent comparison, one difference between the two pictures was apparent, at either the focal point of the picture (central) or elsewhere (marginal). Each participant received oral instructions for the task, which were repeated on the computer monitor when he or she began the experiment. Contingent upon a keystroke by the participant, each stimulus set (index picture, inter-stimulus interval, altered picture, inter-stimulus interval, etc.) was repeatedly flashed to the participant using the flicker paradigm (Rensink et al., 1997) until the participant correctly identified what was different between the two. When he or she recognized the difference, he or she hit the spacebar and verbally identified and/or pointed out the change to the examiner, who was sitting silently behind him or her. Each participant was presented with the same two practice stimulus sets, which were selected for their ease of detection as well as their neutral content. No participant failed to identify the change in either practice set. After the practice session, the participant pressed the spacebar to begin the experimental session. All 40 sets were then presented, randomly re-ordered for every participant; each picture flashed for 240 ms, with 80 ms blank pauses between the index picture and the altered picture. Upon recognition of the change and consequent keystroke, the pictures ceased flashing and the participant could press another key to resume with the next stimulus set. If a participant was unable to identify the change within two minutes (120,000 milliseconds), the pictures stopped flashing and the time to detection was recorded as 120,000 ms. If and when a participant mistakenly identified a change, the data for that stimulus set were dropped. When he or she completed the task, the participant received a concise debriefing and an extra credit voucher, as well as a list of references for mental health resources throughout the community. Each participant in Experiment B received administration of the ADIS-IV after he or she completed the change-detection trials; participants were run until post hoc screenings had discovered 12 snake-fearful participants. Again, control and experimental participants were selected from the same screening pools.

RESULTS

This experiment was designed to test for group differences between snake-fearful and control participants, as well as within-group differences, based on location of the change within the picture (central or marginal) and content of the stimulus (fearsome or neutral). These two factors will be referred to as *location* and *stimulus*. The design was created to evaluate the effects of ADIS-IV participation by varying the order in which the study components were presented. Participants in Experiment A were administered the ADIS-IV and then worked through the computer task, while participants in Experiment B performed the computer task before administration of the ADIS-IV. Because of this design, the data were analyzed separately by experiment, then aggregated for further analysis. For each data set, a repeated measures three-factor (2x2x2) analysis of variance (ANOVA) was conducted, with location, stimulus, and group membership (snake-fearful or control) as fixed factors and milliseconds to change detection as the dependent variable. The results were examined for main effects of location, stimulus, and group, as well as interaction effects of location by group, stimulus by group, location by stimulus, and location by stimulus by group. In addition, when the data were aggregated, a four-factor (2x2x2x2) ANOVA was conducted, with experiment membership as a fourth fixed factor (in addition to location, stimulus, and group membership).

As noted, the software program created to run this flicker paradigm was designed to flicker until the participant pressed the space bar and pointed out the change or for two minutes (120,000 ms or 187.5 trials), at which point the flickering ceased. Upon cessation, the participant was informed of the change and told to press the Enter key to resume the task. These non-responses were coded in the database as 0. To check the significance of these non-responses, a frequency test was run on all timed-out responses. This frequency check demonstrated that 87% of the non-responses occurred with stimuli that had marginal changes. Only 6 of the 46 non-responses were related to stimuli with central changes. In order to most closely mimic the essence of the non-responses, all of the "0" responses were set at 120,000 ms, the highest possible time. Similarly, a majority of the participants made at least one mistake during the course of the experiment, mis-identifying the change. Because they were asked to verbally or physically point out the change to the research assistant, the assistant was able to record the pictures that were mistakenly identified. All such mistakes were eliminated from the database before analyses were run. Notably, at least one snake-fearful participant prematurely pressed the spacebar, thereby ceasing the flickering, on several of the fearsome stimuli, stating that the pictures were "bothersome." These data were eliminated, but serve to help illuminate the cognitive processes of at least one of the snake-fearful participants. Importantly, no one participant had their entire data set eliminated from analysis due to extreme numbers of mistakes or time-outs.

Experiment A

The mean time (in milliseconds) required for each group to detect the change in the stimulus sets is recorded in Table 1. For ease of reference, neutral marginal stimuli are coded as NM, neutral central stimuli are NC, fearsome marginal are FM, and fearsome central are FC.

Table 1

Mean Change to Detection Times for Experiment A

	Mean				Standard Deviation			
Group	NM	NC	FM	FC	NM	NC	FM	FC
Control	37,863	8,180	27,160	9,587	16,996	5,261	8,819	5,171
Fearful	41,681	11,107	34,273	10,118	12,620	8,425	10,326	5,495

As expected, there was a significant main effect ($F_{1,25} = 224.41$, $p = 0$) for location: centrally-located changes were found in significantly less time than marginally-located changes. This result replicates Rensink (1997) and Wheeler (2003). There was also a significant main effect ($F_{1,25} = 6.43$, $p = .02$) for stimulus: overall, the changes in the fearsome stimuli were detected more quickly than the changes in the neutral stimuli. There was no significant main effect for group ($F_{1,25} = 2.0$, $p = .17$). The interaction effect of location by stimulus was also significant ($F_{1,25} = 8.61$, $p <.01$): the difference in time to change detection for central vs. marginal changes was greater for the neutral stimuli than for the fearsome stimuli. The interaction of location by stimulus by group did not reach significance, suggesting that neither group spent more or less time than the other group finding a specific type of change (e.g. central-fearsome, marginal-neutral, etc.).

Experiment B

The mean time (in milliseconds) required for each group to detect the change in the stimulus sets is recorded in Table 2.

Table 2

Mean Change to Detection Times for Experiment B

	Mean				Standard Deviation			
Group	NM	NC	FM	FC	NM	NC	FM	FC
Control	46,505	9,254	27,806	11,522	16,429	4,620	10,720	6,977
Fearful	46,399	13,983	39,389	15,161	17,168	8,571	13,295	8,953

As in Experiment A, there was a significant main effect ($F_{1,26} = 217.39$, $p = 0$) for location: centrally-located changes were found in significantly less time by participants than were marginally-located changes, again replicating Rensink (1997) and Wheeler (2003). There was also a significant main effect ($F_{1,26} = 11.67$, $p < .01$) for stimulus: overall, the changes in the fearsome stimuli were detected more quickly than were the changes in the neutral stimuli. There was no significant main effect for group ($F_{1,26} = 2.33$, $p = .14$). The interaction effect of location by stimulus was again significant ($F_{1,26} = 21.29$, $p = 0$): as with Experiment A, the effect of increased difficulty for marginal changes was greater for the neutral stimuli than for the fearsome stimuli. However, in Experiment B, this effect was significantly greater for fearful participants, ($F_{1,26} = 4.09$, $p = .05$), distinguishing the response times of these participants from those in Experiment A. Simply put, fearful individuals took longer than did control individuals to detect the changes in the fearsome marginal stimuli.

Aggregated Data

In order to test for significant differences with a larger data set, the data from the two experiments were aggregated and the same statistical analyses were conducted

($N_{fearful} = 24$, $N_{control} = 31$). The mean times (in milliseconds) required for each aggregated group to detect changes in the stimulus sets are recorded in Table 3.

Table 3

Mean Change to Detection Times for Aggregated Data

	Mean				Standard Deviation			
Group	NM	NC	FM	FC	NM	NC	FM	FC
Control	42,324	8,734	27,494	10,586	17,001	4,887	9,688	6,147
Fearful	44,040	12,545	36,831	12,639	14,931	8,440	11,931	7,707

Once again, there was a significant main effect ($F_{1,51} = 17.24$, $p = 0$) for location: centrally-located changes were found in significantly less time than were marginally-located changes. This result replicates Rensink (1997) and Wheeler (2003). There was also a significant main effect ($F_{1,51} = 436.87$, $p = 0$) for stimulus: changes in fearsome stimuli were detected more rapidly than were changes in the neutral stimuli. Within the aggregated data, there was a significant main effect for group ($F_{1,51} = 4.57$, $p = .04$): snake-fearful participants spent more time searching for changes than did control participants. Furthermore, the interaction effect of location by stimulus remained significant ($F_{1,51} = 28.2$, $p = 0$): the effect of increased detection time for marginal versus central changes was greater for the neutral stimuli than for the fearsome stimuli. In the aggregated data set, the three-way interaction of location by stimulus by group also was significant ($F_{1,51} = 4.32$, $p = .04$): the most time was required for snake-fearful participants to detect changes in fearsome, marginal stimuli. Finally, with the addition of experiment membership (order) as the fourth factor, a main effect for order was not significant ($F_{1,51} = 3.0$, $p = .09$). Furthermore, the interaction effects of location by order

($F_{1,51} = .02$, $p = .9$) and stimulus by order ($F_{1,51} = .11$, $p = .74$) were not significant. The three-way interactions of location by order by group ($F_{1,51} = 1.88$, $p = .18$) and stimulus by location by order ($F_{1,51} = .64$, $p = .43$) were not significant; neither was the four-way interaction of stimulus by location by order by group ($F_{1,51} = 1.39$, $p = .25$). In order to obtain a thorough picture of the effect of experiment membership, a one-way ANOVA was conducted with order as the fixed factor and the type of stimulus (i.e. neutral-marginal, neutral-central, fearsome-marginal, fearsome-central) as the dependent variable. When the data were divided this way, a significant effect was found within the fearsome-central stimuli ($F_{1,53} = 3.82$, $p = .056$). No other significant effects were found, indicating that the order in which experimental components were presented made a significant difference on how participants responded to the centrally-placed changes in the fearsome stimuli sets. More specifically, participants in Experiment B (i.e. received the ADIS-IV after the computer task) required more time to detect these specific changes than did those participants in Experiment A.

DISCUSSION

Experiment A

Participants in Experiment A completed the snake module of the ADIS-IV before completing the computer portion of the experiment. Although we had predicted that the snake-fearful participants would require more time than control participants to detect the changes in the neutral stimuli, the results did not provide support for our hypothesis. Furthermore, they failed to replicate Wheeler's (2003) results. In fact, the data did not indicate that group membership had any effect on times to change detection in the flicker paradigm. Both groups (snake-fearful and control) spent more time searching for the changes in neutral stimuli, as well as those stimuli with marginal changes.

It is difficult to interpret the significantly higher times to detection of the changes in neutral stimuli. Possibly, pictures of snakes are more salient and draw attention more rapidly whether the participant is fearful or not. If so, Rensink's (1997) and Mack's (2003) attentional theory of change blindness would support the idea that these changes would be found more quickly due to the greater attention paid to the entire picture. Furthermore, whether one is fearful or not, pictures of snakes may be more novel and less familiar than pictures of desks or water fountains, automatically drawing greater, but not necessarily threatening, attention. The result may have been due to the fact that the changes in the neutral pictures were simply more complex than those in the fearsome pictures. Future researchers may want to utilize a measure of difficulty in order to control for the factor of complexity level. Several of these pictures were taken outdoors, and more than one participant commented on their dislike of “the outdoor ones,” primarily because they considered them the most difficult changes to detect.

It is less surprising that changes that occurred in the interest center of the pictures were found significantly more quickly; this result replicates Rensink (1997) and Wheeler (2003), and again supports the theory that attention plays a significant role in change detection. Neither group had significantly more or less difficulty than the other group with any of the pictures.

Experiment B

Participants in Experiment B completed the computer task before answering questions from the snake module of the ADIS-IV. We had suspected that these participants, free of expectations (i.e. they did not have any warning the experiment involved snakes), would show a lesser effect than the participants in Experiment A. The data failed to support our expectation, suggesting instead that the priming effect of talking about snakes and answering questions about snakes decreases the main effect of group differences. All of the effects in Experiment B were slightly greater than those in Experiment A, particularly the significant ($p = .05$) three-way interaction of location by stimulus by group. These fearful participants showed more difficulty than those in Experiment A with the marginal changes on fearsome pictures. It is possible that the snake-related interview provided a sort of warning that the experiment would be dealing with snakes, which may have allowed participants in Experiment A more time to collect themselves and deal with the task at hand. In a recent review, Mathews (2004) gathered evidence for the theory that strong top-down inhibitory processes may be activated when a threat is anticipated. The control exercised by the anterior cingulate and dorsolateral frontal cortex could serve to suppress anxiety when a "warning" is given, rather than "priming" an individual for greater anxiety. It is possible that a significant portion of participants in Experiment A had activated their inhibitory processes, serving to overcome the bottom-up threat evaluated by the amygdala and hippocampus. Those in Experiment B had no warning, and were forced to deal with their fear while trying to detect changes in pictures.

Aggregated Data

The aggregated data showed that snake-fearful participants required more time than did control participants to recognize marginally-placed changes in fearsome stimuli. The effect was not significant for either experiment, possibly a consequence of the relatively small number of participants in each. For that reason, we combined the data from the two groups and found that a significant group difference, as well as a significant location by stimulus by group interaction, emerged. This supports the theory that snake-fearful people react in a different way to relevant fearsome stimuli than controls. We had wondered if, like Wheeler (2003), we would find that snake-fearful participants were slower when detecting changes on neutral stimuli, due to a possible misinterpretation of the neutral stimuli as potentially threatening, or merely because of difficulty disengaging from fearsome stimuli. Instead, our data supported the idea that snake-fearful individuals are comparable to controls when detecting central changes on all stimuli and marginal changes on neutral stimuli. When looking for marginal changes on fearsome stimuli, snake-fearful individuals require more time. This finding supports theories posited by attentional bias literature, which proposes that anxious individuals, when exposed to anxiety-invoking stimuli, become distracted on a task. Much of their information-processing resources are allocated toward attending to the fear, leaving fewer available for a cognitive task. It is possible that when confronted with the dual task of confronting a formidable fear (fear of snakes), and engaging in a relatively difficult (marginal) task, activation of the fear network (Lang, 1988) causes relatively more disruption than would occur on a less difficult task. Detecting the changes on central fearsome stimuli may have been low enough on a scale of difficulty that accomplishing the task quickly was relatively easy, even while confronted with anxiety.

The lack of a significant main effect for order allows us to assume there was not a significant overall order effect on the participants. The priming or suppression effect that could have resulted from the reversing of the two components in our experiment did not seem to appear. However, when the data were analyzed on a smaller scale, a significant difference on response times to centrally placed changes in fearsome stimuli emerged between the two experimental groups. Because the participants who completed the ADIS-IV before going through the computer task required less time to detect these changes, it is possible that suppression played a selective role in their cognitive processing.

General Discussion

The results of our experiment offer marginal support for the idea of attention bias, and no support for the disengagement theory. Our results appear to be analogous to many of the results found using the Stroop task, replicating the attention bias that has been demonstrated by anxious individuals in other experiments (McNally, Rieman, & Kim, 1990; Mogg, Mathews, & Weinman, 1989). However, the Stroop task in its original format deals exclusively with words, highly symbolic stimuli, while our study exclusively used pictures. Intuitively, one could conclude that the emotional valence of pictures is much greater than that of words. However, at least some research has shown that attention bias is similar when words (symbolic stimuli) and pictures (visual stimuli) are directly compared (Kindt & Brosschot, 1997). Kindt and Brosschot's modified Stroop task compared the information processing of spider phobics using threatening words and pictures and found a marked attention bias for phobic individuals that did not differ by mode of presentation. The experiment had its limitations, namely that the pictures could not be integrated into a Stroop paradigm as thoroughly as words. However, our study, presenting threatening pictorial stimuli in a relatively new paradigm partially supports Kindt and Brosschot's finding that an attentional bias exists with visual as well as symbolic stimuli.

Attention bias has been associated with disorders other than phobias as well. For example, Jones, Jones, Smith, and Copley (2003) recently conducted an experiment using the flicker paradigm with alcohol and cannabis users. Participants included lighter and heavier users of alcohol, and social and non-users of cannabis. Each group was exposed to a change detection task that included relevant substance images and neutral images. Jones et al. found that heavier users of alcohol and social users of cannabis detected the relevant substance-related changes more rapidly than lighter or non-users, and more quickly than they detected the neutral changes. Meanwhile, lighter and non-users detected the neutral changes more quickly than the other groups, and more rapidly than the substance-related changes. One potential confound in this experiment is familiarity; lighter users of alcohol and non-users of cannabis would have less knowledge of substance-related objects, and the effect may be partially related to the discrepancy between the groups. The issue of familiarity was controlled for in McNally et al.'s (1990) Stroop task, in which clinicians who treat panic disorder comprised the control group and panic disorder clients comprised the experimental group. Both groups participated in a Stroop task with panic-relevant and neutral words. Assumedly, clinicians should be at least as familiar with threatening panic-related words as participants who suffered from panic disorder, therefore eliminating the confound of familiarity. Even with this issue controlled for, the attention bias was pronounced for anxious participants.

As previously discussed, a few different schools of thought exist regarding the relationship between attention and anxiety. One theory suggests that when anxious individuals are presented with a task simultaneous with presentation of threatening stimuli, their performance on the task diminishes. Lang's (1988) bioinformational theory supports the idea that threatening tasks activate a "pathological memory structure" that connects fearsome stimuli with remembered fearful responses, and assigns an overall meaning of danger to the task. In an attention bias situation, more information-processing resources are allocated to the fear network, leaving fewer resources available for completing the task. The theory has been borne out by countless tasks, primarily modified Stroop tasks, and has been reviewed by Watts and Dalgleish (1990) and written into a book by Williams, Watts, MacLeod, and Mathews (1988). Information processing research also has uncovered evidence that anxious individuals are more likely than non-anxious individuals to interpret ambiguous stimuli as threatening (McNally & Foa, 1987). When this occurs, it is possible that seemingly non-threatening tasks may require more of the attentional resources of an anxious individual, as he or she attempts to identify the presence or absence of a threat. Wheeler's (2003) research may be partially explained by this phenomenon. Another theory, developed more recently, has been dominated primarily by research conducted by Fox and her colleagues (1993a, 1993b, 1994, 2001, 2002), and also may provide some explanation for Wheeler's results. This theory suggests that exposure to threatening stimuli makes general maintenance of attention more difficult. Cognitive resources are selectively allocated for anxiety, and disengagement from the anxiety-invoking stimuli becomes a challenge. In essence, when an anxious individual is confronted with threatening stimuli, he or she has difficulty disengaging from those stimuli in order to conduct another task. Wheeler's experiment appeared to test this theory, asking snake-fearful individuals to detect changes on both fearsome and neutral stimuli; he found that disengagement did seem to present a problem in that fearful individuals had significantly more difficulty than controls detecting changes in neutral stimuli. On the other hand, his fearful participants may have incorrectly interpreted his neutral stimuli as threatening, also resulting in the increased time to detection of neutral stimuli. Our study failed to replicate these results, therefore failing to support the theory of disengagement in snake-fearful individuals. Wheeler's results may have been misleading, occurring because two or three of his six fearful individuals had a great deal of difficulty disengaging from the fearsome stimuli for one reason or another. Because there were only six individuals in each group (fearful and control), a few outliers had the potential to skew the results. Furthermore, each participant in Wheeler's experiment only observed changes in sixteen total stimuli. In the current study, 24 fearful and 31 non-fearful (control) individuals participated in the task, significantly increasing the power of the results, and 40 total stimuli were used. The greater number of stimuli increase the credibility of each participant's results by limiting the influence of any one stimulus set with which a participant required an unusually high or low amount of time.

Limitations and Further Research

An essential component of this study, and others addressing individuals in a state of acute anxiety, is the process of inducing a state of arousal as a result of fear or anxiety. In this study, it was assumed that fearsome pictures of snakes would arouse a significant level of fear in the snake fearful subjects, perhaps to the point of cognitive dysregulation. However, if the stimuli lacked the salience to induce such a state of arousal, it would be useless to attempt to draw conclusions based on group differences. This very lack of salience may have contributed to the relatively small, if still significant, differences between snake fearful and control groups. Future researchers may want to incorporate a measure of physiological arousal, such as heart rate or skin conductance, in order to identify participants who show the biological effects of fear.

The level of difficulty was not constant across the neutral and fearsome stimuli sets. For example, participants consistently required less time to detect changes in fearsome stimuli than in neutral stimuli. Many theories could account for this difference, but future researchers would be well-advised to utilize a difficulty index prior to experimentation in order to objectively assess the difficulty of each stimulus set. This would allow them to hold constant the difficulty both within and between stimulus types, and likely provide cleaner data that could be more effectively interpreted.

Another important limitation of this study is the number of non-responses and mistakenly identified changes. Although we dealt with each issue the best way possible, it was an important loss of data and could have affected our results. In order to minimize the amount of non-responses, future researchers may want to present the stimuli to a population similar to that to whom the experiment will be presented, eliminating those pictures that a significant number of people miss. Participant errors are difficult to avoid, but future researchers should make an effort to encourage all participants that the change will be apparent; wild guesses should be avoided.

In order to most accurately replicate Wheeler (2003), all changes on fearsome stimuli occurred directly on the snake, most likely the point of central interest. Although we balanced central and marginal changes according to where on the snake the eye was drawn, a significant stimuli effect was still observed. Future research should balance the location of the change according to whether it is on the snake or away from the snake, in order to better control central and marginal fearsome changes.

This experiment is new in that it is the first, other than Wheeler, to use the flicker paradigm with an anxious population. Until now, the flicker paradigm and the concept of change detection have been used most heavily in the field of cognition, with recent experiments using it to study the cognitive functioning of alcohol and cannabis users. The results of our experiment suggest that the flicker paradigm may be effective as a means of judging attentional bias, allowing researchers to study pictorial attention biases as well as linguistic, which are already being studied through use of the modified Stroop task.

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Appendix A

FSS-III-R

You are being asked to rate your fear or anxiety level for common situations and events, and all answers are confidential. This information will be used for future selection of participants in a fear-related research project. Please read each description and make a check next to the level of anxiety that would best describe your reactions if you were confronted by that particular situation.

	None	Very little	A little	Some	Much	Very Much	Terror
Sharp Objects							
Being a passenger in a car							
Dead bodies							
Suffocating							
Cockroaches							
Looking foolish							
Being a passenger on an airplane							
Worms							
Arguing with parents							
Rats and mice							
Life and death							
Hypodermic needles							
Meeting with someone for the first time							
Being criticized							
Roller coasters							
Small, closed-in spaces							
Being alone							
Being misunderstood							
Snakes							
Being in a fight							
Crowded places							
Blood							
Heights							
Being a leader							
Swimming alone							
Spiders							
Being with drunks							
Dark places							