Attentional orienting to biologically fear-relevant stimuli: data from eye tracking using the continual alternation flicker paradigm

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ABSTRACT

Snakes are thought as fear-relevant stimuli (biologically prepared to be associated with fear) which can lead to an enhanced attentional capture when compared fear-irrelevant stimuli. Inherent limitations related to the key-press behaviour might be bypassed with the measurement of eye movements, since they are more closely related to attentional processes than reaction times. An eye tracking technique was combined with the flicker paradigm in two studies. A sample of university students was gathered. In both studies, an instruction to detect changes between the pair of scenes was given. Attentional orienting for the changing element in the scene was analyzed, as well the role of fear of snakes as a moderator variable. The results for both studies revealed a significant shorter time to first fixation for snake stimuli when compared to control stimuli. A facilitating effect of fear of snakes was also found for snakes, presenting the highly fear participants a shorter a time to first fixation for snake stimuli when compared to low-feared participants. The results are in line with current research that supports the advantage of snakes to grab attention due their evo-biological significance.

1. INTRODUCTION

A rapid detection of potential aversive stimulus is associated to greater chances of surviving and reproducing (Ledoux, 1996). Quick and efficient detection of a potential danger is made based on simple stimulus' features at any position in the visual field (Öhman & Mineka, 2001). In the large range of aversive stimuli, there are some specific fear-relevant stimuli (e.g. snakes) which are faster processed and automatically with an immediate attention-grabbing (Isbell, 2006; Öhman, Flykt, & Esteves, 2001).

Snakes are thought as phylogenetically fear-relevant stimuli and are faster processed than fear-irrelevant stimuli. For instance, snakes are detected more effectively than flowers (Öhman et al, 2001), non-phylogenetically fear relevant (cockroaches and lizards) and ontogenetically fear-relevant stimuli, e.g. guns (Fox, Griggs & Mouchlianitis, 2007). According to Isbell (2009), snakes are particular stimuli that played a critical role in visual system evolution. Several experimental studies suggest that snakes are faster captured and prioritized in terms of attention, independently of prior experience (e.g. LoBue & DeLoache, 2008) From this perspective, the adaptiveness of fear is related with the preparation for a potential danger. The speed with which an organism assesses threatening stimuli is directly related to its chances for survival (Bradley, Codispoti, Cuthbert & Lang, 2001). The fear system can be activated rather automatically, where a quick and preliminary perceptual analysis of a stimulus can simply initiate the dynamic defensive fear response cascade. According to Öhman & Mineka (2001), the fear circuit relies on limbic structures such as the amygdala, which might have emerged during the evolutionary transition from reptiles to mammals, resulting usually in escape and avoidance behaviours (Öhman, & Soares, 1994).

Although this "so-thought"adaptive process can be maladaptive in many instances, due to the fact that may facilitate the maintenance of excessive fear, as seen in a specific phobia (Larson, Schaefer, Siegle, Jackson, Anderle & Davidson, 2006). It seems that threat perception mediates the relation between stimulus and fear response intensity. Grounded on this, fear defensive responses depend on several characteristics of the individual (e.g. level of anxiety), which can act as facilitators for fear-relevant stimuli (Mogg & Bradley, 1998). It has been shown that threat recognition is exacerbated in phobic individuals (Öhman & Soares, 1994). Phobics are usually capable of recognizing and processing potential danger stimuli more quickly when compared to nonphobics (Williams, Watts, MacLeod, Mathews, 1997; Mayer, Muris, Vogel, Nojoredjo, Merckelbach, 2006; McGlynn, Wheeler, Wilamowska & Katz, 2008). This fast detection has been attributed to a continuous perceptual scan (hyperscan). Phobics tend to detect potential threatening stimuli without awareness, since the perceptual field is usually automatically scanned and attention is attracted, when necessary (Eysenck, 1992; Thorpe & Salkovskis, 1999).

Investigation on attentional bias has been focused on anxiety disorders. Several paradigms such as emotional Stroop task (William, Mathews & MacLeod, 1996); dot-probe detection task (Fox, 1993), rapid serial visual presentation (Arend & Botella, 2002) or visual search (Öhman, Flykt & Esteves, 2001) are commonly used to understand attentional bias. However, the change detection paradigm (Rensink, O'Regan, & Clark, 1997) can provide an alternative method for research on biollogicaly fear-related attentional bias (Mayer *et al*., 2006). In this paradigm, a blank interval is presented between scenes, corresponding to the visual suppression caused by a saccadic eye movement (Rensink *et al*., 1997). This suppression leads to a failure in change detection. This effect has been termed as change blindness (see Simons & Levin, 1997, for a review). Acording to O'Regan and collaborators (2000), successful change detection depends on attending and a clearly encoding to specific features of a scene that are different between two points in time. In other words, change detection depends on the allocation of visual attention to the changing area (Rensink, 2000), where an enhanced attentional orienting toward to relevant visual codes lead to a faster reaction times (Nummenmaa, Hyönä & Calvo, 2007)

However, reactions time are a key-press behavior which occurs downstream of intervening response selection and skeletal muscle movement (Weierich, Treat & Hollingworth, 2008). In order to get more closed measures related to attentional processes an eye tracking technique can be used. The eye-tracking methodology has been successfully applied to investigate attentional bias, since allows getting measures related to eye movements with an online record of the time course of the initial orienting and the subsequent engagement of attention. (Nummenmaa, Hyönä & Calvo, 2007). Its successful application relies on findings by showing that in many visual tasks, attention shifts and gaze shifts are strongly coupled (Findlay & Gilchrist, 2003)

Some interesting studies have used eye measurements to investigate attentional processes on phylogenetically relevant stimuli (e.g. Hermans, Vansteenwegen, & Eelen, 1999; Rinck & Becker, 2006; Rosa, Esteves, Arriaga, submitted). As far as fear-relevant attentional bias literature show, the change paradigm is not usually combined with eye-tracking methodology. This paradigm was used, since visual change detection is a preparation for studying attentional orienting, which can be an index that conscious attention has been engaged.

In the present research, a continual alternation flicker paradigm (Cole, Kentridge , Gellatly & Heywood, 2003) was used to investigate whether participants are more likely to detect an appearance or disappearance of a snake among an array of stimuli compared to other non fear-relevant stimuli? In other words, does the appearance or disappearance of a snake capture more attention than other control stimuli when several stimuli are simultaneously presented (objects and other animals)? Does the fear of snakes facilitate attentional orienting on snakes? Across 2 studies, the present research examined the time to first fixation on the two experiments within the domain of visual change detection .It was hypothesized that attentional orienting is faster triggered by snakes than by other stimuli for low-and high-snake fearful participants. Further, as the attentional bias to snakes seems to be more pronounced in high-fearful participants (e.g. Öhman & Mineka, 2001), it is expected that high-fearful participants orient their attention faster to snakes than low-fearful participants .

1. EXPERIMENT 1

1.1. Method

1.1.1 Participants

Twenty eight participants were selected from 112 university students. Fourteen participants (3 males and 11 female) were psychometrically snake-fearful, fourteen were not (5 males and 9 female). The snake-fearful participants' average age was 29,29 (SD= 9.4) and non-snake-fearful participants' average age was 28,08 (SD= 5.2). Twenty four participants were Portuguese (85,7%) , two were Angolan (7,1%) and two were from Cape Verde (7,1%).

1.1.2. Measures

The Fear Survey Schedule-II or FSS-II (Geer, 1965) lists 51 commonly feared objects and real life events. Participants rate their fear of each object and event from 1 (none) – to 7 (terror) scale. One object listed is ‘‘snake’’. Higher scores indicate greater fear. The Snake Questionnaire (SNAQ, Klorman, Hastings, Weerts, Melamed & Lang, 1974) is a 30-item self-report scale, with a dichotomy response format (true/false), which enables the assessment of the cognitive-verbal component of the fear of snakes (FS). SNAQ has showed good reliability in previous research, ranging from .78 to .90 (Fredrikson, 1983; Klorman et al., 1974).

1.1.3 Apparatus

Stimuli were presented and eye movements recorded on a Tobii-T60 Eye Tracking System (Tobii Technology AB, Sweden), integrated into a TFT 17” monitor, and connected to an Intel core2duo 6550 Desktop computer. The stimuli presentation was controlled by Superlab version 4.0 for Windows from the Desktop computer. Gaze data of both eyes were recorded at 60 Hz with an average accuracy of 0.5 visual angle. Responses were made on a computer keyboard, however were excluded from the analysis.

1.1.4 Stimuli

Nineteen images (9 snakes and 10 neutral) were selected from the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention, 1999). First, the context (background) of all images was removed by alpha channelling using PhotoshopTM CS3 image-editing software. Later, all images were resized to a 150 x 150 px resolution each. Based on these images, eighteen scene pairs were made. Each first scene (original) was composed by nine images (elements) and its size was similar to the computer screen, i.e., 30 cm _ 23 cm. The nine elements were displayed on the three different scene regions (central, mid, peripheral), which were respectively equidistant from the centre of the scene. Size of the changing elements was circa 22 mm. In each second scene a neutral element changed into a snake or neutral element in the nine possible spots along the three areas. Fig. 1 depicts how elements were displayed.

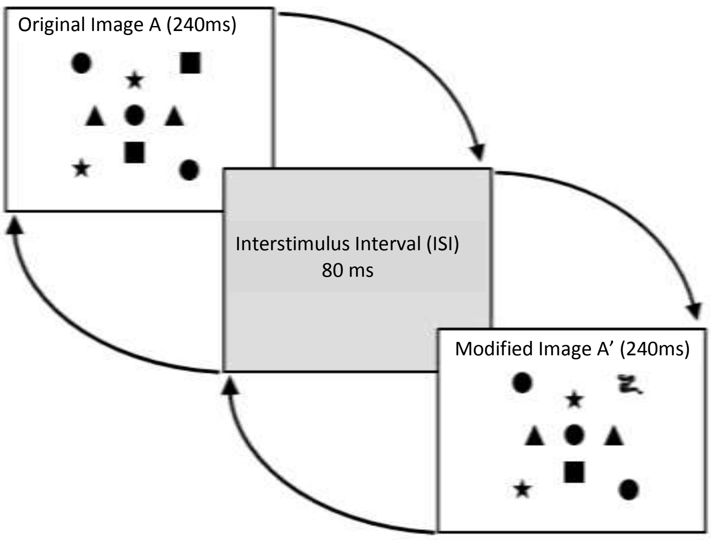

Figure 1. *The continual alternation flicker paradigm used in Experiments 1 and 2. In the flicker task participants are required to indicate on a computer keyboard when a change between images was detected. A gray blank screen presented for 80 ms between images was used to create change blindness and to impair change detection. Note that these example images were not among the experimental stimuli.*

1.2. Procedure

1.2.1 Participant selection

Initially 112 students were recruited trough Classroom announcements responded firstly to the FSS-II. In order to form two opposite groups, those who responded with 1 or 2 on the FSS-II ‘‘snake’’ item and who scored 6 or 7 invited to participate in the study, however the participants were naïve regarding the study’s purpose. The 14 snake-fearful participants chosen had a mean score of 6.64 (SD= .49) on the FSS-II ‘‘snake’’. The 14 snake-tolerant participants had a mean score of 1.71 (SD= .46) on the FSS-II ‘‘snake’’ item.

1.2.2 Experimental task

Participants came individually to the laboratory of experimental psychology and seated in an isolated and insonorized room. After the informed consent, the participants agreed and were free to withdraw at any time. All APA (2010) ethical guidelines were followed. They were instructed to detected differences between the first and second presentations of each scene and to press the keyboard spacebar once they detected the change. Pressing the spacebar stopped the cycling of scenes for 5 s. However, the reaction times were not used for analysis. Instead, the eye-tracker recorded the time for first fixation (TFF), considering an area-of-interest (AIO) of 150 by150 px defined for each changing element.

Before executing the experimental task, participants had to perform a training phase with two pair of scenes, as means to execute the task appropriately. With the propose of controlling a possible effect of the experimental task on responses, participants just filled out the Snake Questionnaire after 10 min of task completion. Immediately after, a debriefing was conducted to inform the participants about the real aim of the experiment. The participants were later thanked and dismissed.

1.3. Results

A 2 (Image: snakes vs. neutral) x 2 (Fear of snakes: low vs high) mrANOVA yielded a main effect of Image, F (1,26)= 64.16, p= .000, ηp^2=.71. Short TFF was found for images of snakes (M=1817,45) than for neutral images (M=1110,50; p = .000), as shown in Fig. 2. Contrarily to the expected, an Image x Fear of snakes interaction effect was not found, F(1,26)= .91, p = .347, ηp^2= .034.

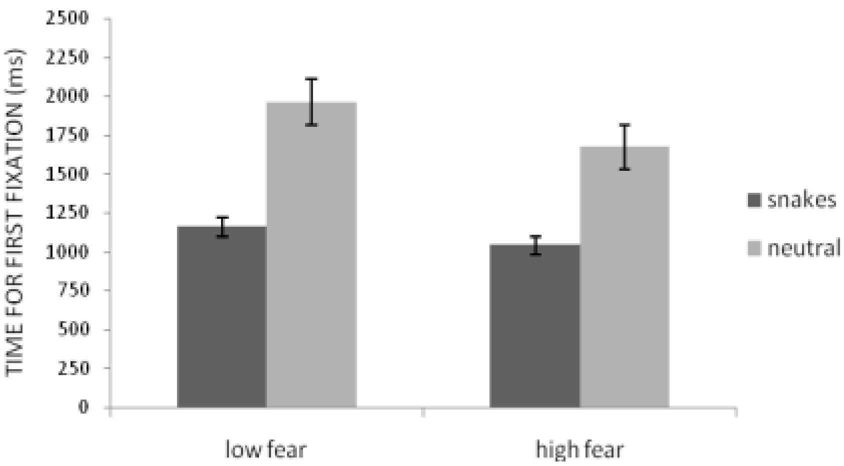

***Figure 2**. Mean TFF to change detection for the high-and low-feared participants for snake and neutral images*

1.4. Discussion

The image changes were quickly detected when the snake images were presented. This supports the hypothesis that orienting is biased toward biologically fear-relevant visual stimuli. The participants detected quicker the emotional element in the scenes. From an evolutionary view, an effective threat detection system must ensure that orienting of attention is directed to potential threats, such as snakes are (Mogg & Bradley, 1998). The results are in line Öhman’s pre-attentive model (Öhman,2000), which advocates that an exploratory visual scan is activated when a fear relevant stimulus enters in the human visual field, facilitating orientation and allocation of attention.

Unexpectedly, a preferential orientation of attention for threatening stimuli was not more pronounced in fearful subject as suggested by Eysenck's (1992) hypervigilance theory. Due to selectivity and preparedness of fearful participants to threatening stimuli, an amplifiered effect of fear of snakes was expected. One plausible explanation for non-significant results might be related to the median cutoff value used to define fear antagonist groups. It can be argued that the high- and low-fear groups did not differ sufficiently in terms of fear as they were defined by means of a median-split procedure. In other words, there is a possibility that there was no clinically meaningful difference in fear levels between both groups.

A possible comment on the stimuli used in the present experiment is concerned with neutral images. That is, if the neutral images consisted of objects, a facilitated pop-out effect to snakes might have occurred. It may well be the case that it was easier for participants to actively search for snakes than for neutral images. In order to control snakes' visual salience, a second experiment with images belonging to the same supra-category, i.e. animals, was performed.

2. EXPERIMENT 2

2.1. Method

2.1.1. Participants

Experiment 2 was a procedural replication of Experiment 1. It was conducted in the same location and made use of the same equipment and procedures. However the neutral images were replaced by non-feared animal images. It differed also with respect to the numbers of participants. Thirty (new) participants were selected from 121 university students. Fifthteen participants (5 males and 10 female) were psychometrically snake-fearful, fifthteen were not (2 males and 13 female). The snake-fearful participants' average age was 24,53 (SD= 7.2) and non-snake-fearful participants' average age was 30,00 (SD= 8.8). Twenty six participants were Portuguese (86,7%) , two were Angolan (6,7%) and two were from Cape Verde (6,7%). The 15 fearful participants had a mean score of 1.67 (SD=.48) on the FSS-II ''snake'' item and the 15 non-fearful participants had a mean score of 6.53 (SD=.51) on the same item.

2.2. Results

Participants with low fear of snakes were differentiated from participants with high fear of snakes based on SNAQ median score (Mdn=11,5). The snake-fearful group average score on SNAQ was 17,6 (SD= 4.30) and non-snake-fearful group average score on SNAQ was 8,7 (SD= 1.57).

A 2 (Image: snakes vs. non-feared animals) x 2 (Fear of snakes: low vs high) mrANOVA yielded a main effect of Image, F(1,26)= 64.09; p= .000, ηp^2= .69. Short TFF was found for snakes (M=1159,92) than for non-feared animals (M=1889,05; p= .000), as shown in Fig. 3. An Image x Fear of snakes interaction was found, F(1,26)=5.06; p = .033, ηp^2=.153, consistent with our initial hypothesis. For low-feared participants, a short TFF was found for snakes, than non-feared animals. For high-feared participants the same direction effect was found for snakes, in the manner that TFF for snakes was significantly shorter in the high-feared group than in low-feared group t(29)= 3.62; p= .001, but not for images of non-feared animals.

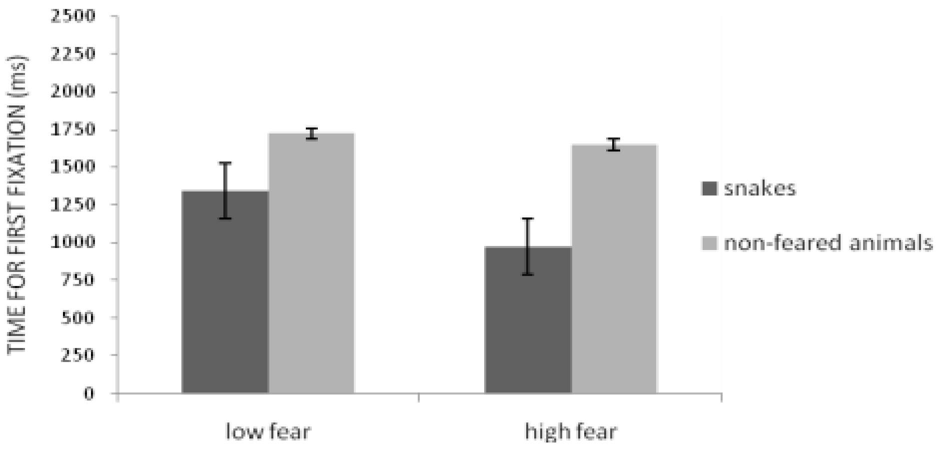

Figure. 3. *Mean TFF to change detection for the high-and low-feared participants for images of snake and images of non-feared animals.*

2.3 Discussion

In the Experiment 2 snakes were detected as quickly as in Experiment 1. Despite a controlled pop-out effect, similar results were found for both experiments. Our data suggests that the perceptual system is biased towards early and reliable recognition of threat-related stimulus, such as snakes (e.g., Calvo & Lang, 2005). Due to evolutionary importance, snakes, are attention "grabbers" (Tooby & Cosmides, 1990), as they tend to be processed faster than neutral stimuli (Öhman et al, 2001) and non-phylogenetically fear relevant stimuli (Fox, Griggs & Mouchlianitis, 2007).

Furthermore, attentional orientating differ between participants with high fear of snakes and low fear of snakes, showing a quicker attentional capture to snakes, that is, short time to fixate the region where snakes were presented. This result could be related to their sensitivity and preparedness of high-feared participants to snakes (Hamm & Weike, 2005; Larson et al., 2006) According Mogg and Bradley (1998) to both high- and low- participants more easily detect threatening stimuli as compared to non-threatening stimuli, although this detection system is thought to be more sensitive in participants who are high on fear of snakes This fast detection may be explained due to an exacerbated visual scanning. In phobics, the perceptual field tends to be hyperscanned and attention is easily attracted to potential threatening stimuli (Thorpe & Salkovskis, 1999).

3. CONCLUSIONS

Both studies described here provide evidence that biologically fear-relevant stimuli orient attention quicker than fear-irrelevant stimuli. As Öhman and collaborators (2001) advocate, snakes may include some elementary perceptual features that make them easy targets for the automatic capture of attention. Snakes were faster discriminated and processed when competing with other stimuli in the visual field. The results suggest that the human attentional system was probably shaped throughout the evolutionary process to help detect accurately stimuli which are crucial to the predatory defense system (Isbell, 2006). Obviously, the inconsistency of a moderating effect of fear of snakes on attentional orienting may be explained by the fairly low fear of snakes, and this may have hindered us in finding differences in threat detection between high- and low-feared participants. Finally, it should be kept in mind that participant's level of fear is a rather broad vulnerability factor, which may not be sensitive enough to tap change detection in the rather restricted domain of snake fear. According to Riskind and colleagues (2000), a looming maladaptive style , i.e., the automatic tendency to process threat-related cues and to formulate appraisals of increasing magnitude and severity of potential threats can be a more specific vulnerability factor than fear itself.

In future research, variables such as visual acuity and tiredness should be also taken in account, since may contribute to a decrease of attention. It would be appealing to examine whether biased orientation of attention occur with other biologically fear-relevant stimuli (e.g spiders). Future studies could combine the change detection paradigm with some background variations, that is, to examine whether a congruent context to snakes (e.g. landscapes) can elicit a faster attentional orientating to snakes.

In summary, these studies present clear evidence that orienting of attention to potentially threat fulfils an important function for survival. In terms of attentional orienting, snakes “take it all”, that is, they are earlier detected (over non-relevant stimuli) for further processing to determine the exact nature of the threat and to quick initiate a fight or flight response.

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