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Eye spy with my little eye: Motivational relevance of visual stimuli guide eye-movements at different processing stages

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ABSTRACT

Visual stimuli may be selected for priority at different stages within the processing stream, depending on how motivationally relevant they are to the perceiver. Here we examine the extent to which individual differences in motivational relevance of task-irrelevant images (spider, crash, baby, food and neutral) guide eye-movements to a simple "follow the cross" task in 96 participants. We found affective images vs. neutral images to be generally more distracting, as shown by faster first saccade latencies and greater deviation in the final landing position from the target cross. The most arousing images (spider and food), compared to neutral images, showed the largest trajectory deviations of the first saccade. Fear of spiders specifically predicted greater deviation in the final landing position on spider images. These results suggest that attentional biases towards arousing and motivationally relevant stimuli may occur at different processing stages.

1. Introduction

From moment to moment, humans are confronted with a multitude of dynamic visual stimuli. However, because humans have limited selective attention, only a subset of stimuli can be focused on at any given time (Driver, 2001). Visual stimuli that capture attention more readily than others likely contain significant information for survival (Brosch, Sander, Pourtois, & Scherer, 2008; LeDoux, 2000; Öhman & Mineka, 2001).

Initially, it was postulated that threat-related stimuli such as aggressive conspecifics and predatory animals were prioritized in attention over all other types of stimuli, as part of a fear system that has evolved to enable preconscious processing and immediate response (LeDoux, 2000; Öhman & Mineka, 2001). For example, a wealth of data have shown that threat-related stimuli presented in a scene or among distractors are often found very quickly (Pflugshaupt et al., 2007; Rinck & Becker, 2006; Soares, Esteves, & Flykt, 2009; but see Lipp, Derakshan, Waters, & Logies, 2004), they distract during search for a neutral target (Miltner, Krieschel, Hecht, Trippe, & Weiss, 2004; Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005) and are generally more discriminable from a background than neutral targets (Larson, Aronoff, & Stearns, 2007; Öhman et al., 2001; Rinck et al., 2005). Furthermore, Lipp et al. (2004) reported that even in participants low on spider fear, an attentional bias towards spider pictures was still present, suggesting a general mechanism of preferential processing of fear-relevant information.

More recently, the threat prioritization account has been countered by a number of studies suggesting attention to be captured by motivationally relevant stimuli more generally (Brosch et al., 2008; Schupp, Junghöfer, Weike, & Hamm, 2003). For example, studies in which both pleasant and unpleasant visual stimuli are presented demonstrate attentional modulation for both types of information. This effect is particularly strong when the information is highly arousing, such as images of mutilation, erotica, babies and food (e.g. Brosch et al., 2008; Schupp et al., 2003, 2007), of particular interest to the participant e.g., Doctor Who fans (Purkis, Lester, & Field, 2011) or relevant to the perceiver's current goals (e.g. Vogt, De Houwer, Moors, Van Damme, & Crombez, 2010). In short, it may not be the threat-relevant information per se that drives attentional capture, but the extent to which information is appraised as relevant to the perceiver.

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Recently, a study by McSorley and Morriss (2017) pitted the threat-prioritization and motivationally relevant accounts against each other by examining visual attention at different processing stages. Visual attention was assessed using a simple "follow the cross" task with flanking distractor images that varied in valence and arousal (e.g. babies, food, spiders and neutral). Individual differences in self-reported spider fear served as a grouping factor to assess the role of motivational relevance. Based upon previous studies of saccadic eye movements with non-emotional stimuli (McSorley, Cruickshank, & Inman, 2009) and threat-related stimuli (Miltner et al., 2004; Pflugshaupt et al., 2007; Rinck & Becker, 2006), eye movement metrics and dynamics were taken to reflect the real time, overt manifestation of a covert attentional system at different processing stages. For instance, first saccade latency is a temporal measure of initial attentional deployment. First saccade trajectory and its subsequent landing position are spatial measures of initial attentional deployment. Second saccade latency is a temporal measure of attentional disengagement from the initial attentional location. McSorley and Morriss (2017) found the spider-fearful and non-fearful group to show no difference in first saccade latency. Landing position deviations were greater for spiders and pleasant images for the spider-fearful group but only pleasant for the non-fearful group. Second saccade latencies were longer for the fearful than non-fearful group for spider images only. This pattern of results suggests that the impact of arousing images on saccade eye movements supports a general motivational relevance account rather than a specific threat-related priority.

Most of the findings supporting either a threat prioritization account or a motivational relevance account are based on behavioral measures of attentional bias, such as the dot-probe task or the visual search task. The measurement of eye movements supplements this work in important ways: (1) the real-time capture of overt attentional processes, and (2) the high resolution quantification of the time course of such processes. In the current study, we intended to replicate and extend McSorley and Morriss (2017) by examining people's eye movements while they completed a simple "follow the cross" task while distracting, task-irrelevant, arousing images were shown flanking the target cross. As before, we included arousing images depicting spiders and arousing but pleasant scenes (babies and food), but we also included threat-relevant but non-spider related scenes (e.g. a crash). Neutral images depicting common household objects served as control. A large cross-sectional sample that varied in their fear of spiders took part and the impact of task-irrelevant images on successful task completion was assessed. Furthermore, addressing shortcomings in the McSorley and Morriss (2017) study, we collected ratings of valence and arousal for the images, and self-reported fear of spiders, state and trait anxiety, to assess coherence between ratings, questionnaires and eye movement metrics. Lastly, we directly compared the specificity of motivational relevance of fear of spiders against broader measures of anxious disposition upon ratings and eye movement metrics.

If motivationally relevant images are generally given priority of processing then their presence in the display environment should elicit quicker saccadic responses when compared with neutral images. Furthermore, if this priority for motivationally relevant images continues in the processing stream then they should be difficult to inhibit and deviations in saccade trajectory and landing position should be towards the distractor. This may extend to heightened engagement for motivationally relevant images with second saccade latencies being lengthened as disengagement from images with motivationally relevant content proves more difficult. Beyond this, if there is a specific processing priority we would expect this pattern to be related to individual differences in the extent of motivational relevance of the stimulus (e.g. fear of spiders). We expected spider images to elicit quicker responses and greater impact on saccade deviation as fear of spiders increases, i.e., saccades will be pulled towards spider images for more spider fearful people as they find these images more difficult to inhibit. Furthermore, we might expect the response time for the second saccade onset (the time difference from the end of the first saccade to the onset of the second saccade) to be longer as the dispositional fear of spiders increases, as those who find spiders more fearful should find it more difficult to disengage from the spider stimuli, i.e., they fixate on spider fearful stimuli for longer. We further tested the specificity of self-reported fear of spiders, by comparing it with broader measures of anxiety, such as state and trait anxiety.

2. Method

2.1. Participants

96 people (86 females) with an age range of 18 to 41 took part. All observers had normal, or corrected to normal, vision and were recruited through the University or Reading's Psychology Department Research Panel for course credit, adverts placed around the campus area, and word of mouth. Local ethical approval was obtained and all participants gave their informed consent prior to inclusion.

2.2. Materials

2.2.1. Questionnaires

Self-reported spider fear was assessed on the Fear of Spiders Questionnaire (FSQ; Szymanski & O'Donohue, 1995) while trait and state anxiety were assessed using the State-Trait Anxiety inventory (STAI-X1 and STAI-X2; Spielberger et al., 1983).

2.2.2. Images

The 40 images used were largely taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005; see Appendix A for IAPS numbers) with additional spider and food images found from a variety of sources, resulting in total in 10 threat-related pictures of various spiders (Spiders), 10 negative images of accidents (Crash), 10 positive images of food and babies (Food, Baby) and 10 neutral images of everyday objects such as chairs, tables (Neutral).

2.2.3. Image valence and arousal ratings

To determine the affective value of the stimuli within this sample, subjective ratings of the stimuli were collected and, in line with the International Affective Picture System (IAPS), were rated on a 9-point Likert scale. Arousal ratings ranged from very calm (1) to very excited (9) and valence ratings ranged from very negative (1) to very positive (9). The images were presented in random order, in color using E-Prime software.

2.2.4. "Follow the cross" task

Fixation and saccade targets were a cross ("+"), each line was 1° in length. Targets were shown 8° to the left or right of fixation on the horizontal meridian. A single image appeared either above or below the saccade target, the center of which was 2.1° from the center of the target cross, with the nearest edge being 1° away (See Fig. 1). The centers of these images were at an angle of 27.5° from the initial fixation point i.e., relatively "near" the target in order to allow the distractor image to influence the saccade and for the extent of this to be modulated by its content. All images were 2.2° by 2.93° in size.