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Snake pictures draw more early attention than spider pictures in non-phobic women: Evidence from event-related brain potentials

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ABSTRACT

Snakes were probably the first predators of mammals and may have been important agents of evolutionary changes in the primate visual system allowing rapid visual detection of fearful stimuli (Isbell, 2006). By means of early and late attention-related brain potentials, we examined the hypothesis that more early visual attention is automatically allocated to snakes than to spiders. To measure the early posterior negativity (EPN), 24 healthy, non-phobic women watched the random rapid serial presentation of 600 snake pictures, 600 spider pictures, and 600 bird pictures (three pictures per second). To measure the late positive potential (LPP), they also watched similar pictures (30 pictures per stimulus category) in a non-speeded presentation. The EPN amplitude was largest for snake pictures, intermediate for spider pictures and smallest for bird pictures. The LPP was significantly larger for both snake and spider pictures when compared to bird pictures. Interestingly, spider fear (as measured by a questionnaire) was associated with EPN amplitude for spider pictures, whereas snake fear was not associated with EPN amplitude for snake pictures. The results suggest that ancestral priorities modulate the early capture of visual attention and that early attention to snakes is more innate and independent of reported fear.

1. Introduction

For our ancestors, the rapid visual detection of animals was a matter of life and death. Some animals were predators, other animals represented food. According to the animate monitoring hypothesis, the human attention system possesses a visual monitoring system equipped with ancestrally derived animal specific selection criteria (New, Cosmides, & Tooby, 2007). This system causes a stronger spontaneous allocation of attention to animals than to objects. Research with the visual change-detection paradigm for instance, has demonstrated that humans are faster and more accurate at detecting changes in animals than at detecting changes in inanimate objects, even if these inanimate objects (e.g., vehicles) can pose life-or-death importance (New et al., 2007).

Within the animate category however, some species might have been more life-threatening, and hence more fear relevant, to our ancestors than other species. From an evolutionary perspective, a specialized visual monitoring system that was focused on animals posing deadly threat, rather than on animals in general, would enable the fast mobilization of defense and would be highly adaptive (Öhman, 2007). Mineka and Öhman (2002) proposed an evolved fear module that is automatically activated by phylogenetically fear-relevant stimuli, and is largely independent of conscious cognition. The amygdala is supposedly the central brain area dedicated to this fear module. Although fear of potentially dangerous animals such as snakes or spiders is, at least in many modern societies, no longer relevant for survival, the fear module in the human brain still responds strikingly to stimuli representing these animals. The studies of Öhman and colleagues have demonstrated that fear-relevant stimuli such as snakes or spiders are more readily associated with aversive unconditioned stimuli than are fear-irrelevant stimuli such as flowers or mushrooms (e.g., Öhman & Soares, 1998; see for review, Öhman & Mineka, 2001). The superior aversive conditioning to snakes or spiders has been explained in terms of evolutionary "preparedness" (Mineka & Öhman, 2002; Seligman, 1970).

Snakes and spiders are typically bracketed together as it comes to superior Pavlovian conditioning to fear-evoking animal stimuli and facilitated attentional capture (Öhman, Flykt, & Esteves, 2001). For our evolutionary ancestors however, snakes were probably more life-threatening than spiders. According to Isbell (2006) snakes in particular provided predatory pressure on primate evolution. Snakes have a long evolutionary coexistence with primates and their predecessors and may have been their first predators. Old world monkeys, who experienced continuous predatory pressure from snakes, show fear of snakes and have a highly advanced visual system to perceive these hardly detectable animals. As Isbell suggested, the descendants from primates that left Africa and thus

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escaped predatory pressure from snakes show less fear of snakes and have a less advanced visual system.

In contrast to fear of snakes, fear of spiders could stem from a cultural origin rather than an evolutionary one. According to Davey (1994), the pervasive spider fear that is found in many Western societies, is the consequence of the disgust-relevant status of spiders. This status resulted from the spiders' association with illness, disease, and infection in European societies from the Middle Ages onward. In this era, the spider was a suitable displaced target for the anxieties caused by many devastating and incomprehensible epidemics. Irrespective of a possible cultural origin, spiders can be considered as fear-relevant, but low predator animals (Davey, Cavanagh, & Lamb, 2003), with spider fear driven by disgust rather than physical harm (De Jong & Muris, 2002; see also, Soares, Esteves, Lundqvist, & Öhman, 2009).

As snakes in particular caused evolutionary change in primate brains by predatory pressure (Isbell, 2006), it can be expected that in humans snakes activate the evolved specific neural circuitry of the fear module more strongly than spiders. As yet, fMRI studies have not demonstrated larger amygdala activation for snakes than for spiders, but in should be noted that these studies have not tested the explicit hypothesis of larger amygdala activation in response to snakes compared to spiders in non-phobic participants. Dilger et al. (2003) found higher left-sided amygdala activation for spiders than for snakes in spider phobics and no differential amygdala activation in controls (for both the spider > snake contrast and the snake > spider contrast). Goossens, Schruers, Peeters, Griez, and Sunaert (2007) found higher left amygdala activation in spider phobic participants than in control participants in response to spider vs. neutral pictures. In Goossens et al.'s study, no specific contrasts for larger activation in response to snakes vs. spiders were examined. Neurophysiological evidence for the animate monitoring hypothesis itself has been provided by an fMRI study with non-phobic individuals (Yang, Bellgowan, & Martin, 2012), which demonstrated that the amygdala responds to threatening animals such as snakes or spiders but not to weapons, although both animate and inanimate stimuli were rated as negative and high arousing by the participants. Again, no direct comparisons were made between the amygdala activation in response to snakes and the amygdala activation in response to spiders.

In a behavioral study employing a visual search paradigm, participants with high snake fear detected snakes faster than spiders, while participants with high spider fear detected spiders faster than snakes (Öhman et al., 2001). In another study with this visual search paradigm (Soares et al., 2009), the detection of spiders was highly selective for spider fearful participants. The results were ambiguous for snake fearful participants, who exhibited no differences in detection speed between snakes and spiders. The influence of increasing numbers of distractors was less for snakes than for spiders, indicating more efficient search for snake targets than for spider targets. Soares et al. concluded that the detection of snakes may be primarily dependent on bottom-up processes whereas the detection of spiders may more dependent on top-down processes.

The evidence that snakes draw more early attention than spiders is sparse. The focus of previous research on spider phobic or snake phobic individuals renders these studies suboptimal for drawing conclusions about possible differences between the early visual processing of snakes and spiders in the general population. To test the hypothesis that more early visual attention is automatically allocated to snakes relative to spiders, the present event-related potential (ERP) study was done in a sample of non-phobic women.

The ERP technique allows the examination of the time-course of the neural response to snake and spider pictures. Given the automatic attentional capture of fear-relevant stimuli, it can be hypothesized that early visual activity as reflected in early ERPs is modulated by phylogenetic fear. In the present study, the early automatic attentional capture of emotionally relevant stimuli is represented by the P1 response and the early posterior negativity (EPN). We investigated these early ERP components by showing snake, spider and small-bird pictures in a rapid serial visual presentation (RSVP) paradigm. With the RSVP paradigm, a continuous stream of emotional and neutral pictures is presented at a rate of several (typically three) pictures per second, while participants are passively viewing. The RSVP paradigm requires the rapid processing of emotional stimuli under a high processing load, which makes good evolutionary sense (Junghöfer, Bradley, Elbert, & Lang, 2001).

The P1, peaking between 80 and 130 ms post stimulus onset at occipital sites, reflects early visual processing and is sensitive to attentional manipulations and physical stimulus characteristics. It can be expected that enhanced attention to negative stimuli modulates the P1 component. Results concerning the emotional modulation of the P1 however, have been mixed, probably because of task differences and differences in sensory features of the emotional stimuli (Hajcak, Weinberg, MacNamara, & Foti, 2012). A number of studies indeed have found larger P1 amplitudes in response to negative than in response to positive or neutral pictures (see for review, Olofsson, Nordin, Sequeira, & Polich, 2008), but other studies have found larger P1 amplitudes in response to positive pictures than in response to negative pictures (Alorda, Serrano-Pedraza, Campos-Bueno, Sierra-Vázquez, & Montoya, 2007; Van Strien, Langeslag, Strekalova, Gootjes, & Franken, 2009). With the RSVP paradigm, neither Junghöfer et al. (2001) nor Van Strien, Franken, and Huijding (2009) found emotional modulation of the P1 amplitude at lateral occipital sites.

The EPN is a component that reflects early selective visual processing of emotionally significant information. The EPN is most pronounced between 225 and 300 ms post stimulus onset, at lateral occipital electrodes (Schupp, Flaisch, Stockburger, & Junghöfer, 2006). Junghöfer et al. (2001) employed the RSVP of emotional pictures while recording ERPs. With a 3 Hz presentation rate, they found the largest differences between low and high arousing pictures at the N260 (EPN) component over lateral occipital cortices. The EPN is associated with the functioning of the motivational systems of approach and avoidance and is augmented particularly by stimuli of evolutionary significance (Schupp, Junghöfer, Weike, & Hamm, 2003). The EPN emotion effect is not sensitive to stimulus repetition (Schupp, Stockburger, et al., 2006).

Van Strien, Franken, and Huijding (2009) investigated the EPN in response to the RSVP of neutral, negatively valenced emotional, and spider pictures in a non-phobic sample. They found that pictures of spiders yielded higher (i.e., more negative going) EPN amplitudes than neutral and negative pictures. Furthermore, they found that this early automatic response to spider pictures was modulated by the extent of fear of spiders, as indicated by the participants' scores on a spider phobia questionnaire.

The early and automatic attentional capturing of fear-relevant stimuli is followed by sustained processing to assure that these stimuli gain access to capacity-limited processes associated with focused attention and conscious recognition. ERP studies show that the early negative-going potential over occipital regions, is followed by an increased late positive potential (LPP) over centroparietal regions (Schupp, Flaisch, et al., 2006) The LPP starts about 300 ms after stimulus onset and may last for hundreds of milliseconds to seconds, depending on the duration of the emotional stimuli (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). The LPP is more positive-going when people watch emotionally intense and arousing pictures.

In response to spider pictures, spider phobic persons show more enhanced LPP components than non-phobic persons (Kolassa, Musial, Mohr, Trippe, & Miltner, 2005; Leutgeb, Schäfer, & Schienle, 2009). Michalowski et al. (2009) also found enhanced LPP amplitudes to spider pictures in spider phobic participants. Because