Sex difference in awareness of threat: A meta-analysis of sex differences in attentional orienting in the dot probe task.

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Abstract.

It has been argued that females are more important to infant survival than males and that his may lead to their increased fear. One way of increasing female survival chances would be to increase their sensitivity to threat. The dot-probe task has been used to investigate attentional bias. In this meta-analysis we combine the results of dot-probe experiments and explicitly examine sex differences in attentional orienting bias. Overall there is little evidence to support the existence of sex differences and these results are considered in terms of evolutionary impact.

It has been proposed that greater fear in women has been sexually selected based on their critical role in ensuring infants' survival (Campbell, 1999; 2013). This is in counterpoint to the argument that men are more willing to engage in risky behaviour as it improves male reproductive success (Daly & Wilson, 1988). Sear and Mace (2008) demonstrated the importance of a mother to the chances of infant survival in a review of 28 societies lacking access to contraception and western medical care. Whereas in every case the survival of the mother increased the child's chance of survival, they found that in 68% of cases the survival of the father had no impact. As the survival of the mother is so important, women who had better ability to detect and respond to danger, and also to avoid risk themselves would be more likely to survive and produce more surviving children. Therefore, fear may have evolutionary advantages for women.

The evidence for sex differences in fear are shown in: spontaneous involvement in risky activities (Byrnes, Miller and Schaffer, 1999), self-reported fear (Brebner, 2003), decision making under risk (Nelson, 2015), and fear conditioning (Sheynin et al., 2014). There are a number of mechanisms that could produce this sex difference in fear. For example, it is possible that women are sensitive to the presence of threatening stimuli than men or it could be that the strength of reaction in the fear system (amygdala, hypothalamus, ventromedial and orbitofrontal cortices) is higher in women, or it could be that women have a greater subjective awareness of fear. For the first proposition, the sensitivity of the fear system could be enhanced by reducing its firing threshold for attention to threat and this has been examined experimentally by using tasks which capitalize on the 'pop out' effect of feared over neutral stimuli. In the present meta-analysis we start to investigate the possibility that there are sex differences in awareness of threat by looking at studies that measure attentional bias to threat.

For good evolutionary reasons, fear-inducing stimuli preferentially capture attention (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Yiend, 2010). Several measures of attentional bias have been developed (see van Bockstaele et al., 2014) and one of the most widely used is the dot probe task. Two stimuli (one of which is threatening) appear

simultaneously at different locations on a monitor (e.g. right and left). After a short exposure time both stimuli disappear, a probe appears at one of the two locations and participants are asked to indicate as quickly as possible its spatial location. A bias toward threat is inferred when the reaction time on congruent trials (the probe appears at the same location as the threatening stimulus) is faster than incongruent trails (the probe appears at the location of the neutral stimulus). Typically, the bias index is computed by subtracting congruent trails from incongruent trials such that a positive value indicates bias toward threat (attentional vigilance) and a negative value a bias away from threat (attentional avoidance). It has been suggested that individuals may show avoidance of mild threats but vigilance to more dangerous threats (Mogg & Bradley, 1998). In a meta-analysis (Bar-Heim et al., 2007), stimuli used in laboratory studies did not produce a bias in non-clinical and low-vulnerability samples (d = -0.01) but a moderate vigilance bias was found in anxious samples (d = 0.45). Sex differences were not examined but given that women are more prone to anxiety than men, the dot probe technique might be expected to reveal greater threat vigilance in women. Such a sex difference would suggest that women have a more sensitive fear system (a difference in attentional engagement) rather than a stronger fear reaction (physiologically or behaviourally).

Although sex differences in the dot probe task are rarely reported, the large number of published studies suggested that such data was likely to be available, at least from more recent studies. A meta-analysis of these studies would enable us to test the hypothesis that greater fear in women can be attributed to their higher sensitivity to threatening stimuli. Females would be expected to show a stronger orienting bias than males.

Data Collection

A Web of Science search using the terms 'attention* bias* AND fear AND probe' identified 108 studies since 2011. A total of 35 studies used non-clinical samples (N=35) and were automatic candidates for inclusion. Studies of patients with clinical anxiety or selected high-anxiety groups were not included, but any study that included a healthy adult control group of men and women was followed up. Data on sex differences were received from 15 authors providing data on 23 studies,

however one study was omitted as it had only one male participant. Data were coded such that a positive value indicated threat vigilance. The female mean was subtracted from the male mean so that a positive effect size indicates a higher mean score in men. It should be noted that sample sizes are small for these studies and their purpose was not to examine sex differences.

Results

The effect sizes for each study are presented in Table 1. Effect sizes were calculated for all studies with over three male and three female participants. Hedges g was used as an effect measure as it makes an allowance for small sample sizes. A negative g value indicates that the female sample showed a greater orienting bias. Studies were also grouped into those using facial stimuli, using threatening pictures, using illness or pain stimuli, using spiders and studies in which the level of stress was also manipulated. Effect sizes across studies varied in valence and magnitude (from g = -.75 to g = 1.22). The overall value of g = 0.048 with a 95% Confidence Interval of +/- 0.12, indicates no appreciable sex difference. If we examine the groups of studies by type of threat stimulus used for faces g = 0.133 CI +/- 0.24, for threatening pictures g = 0.113 CI +/- 0.26, for illness g = -.104 CI +/- 0.2, for spiders g = 0.113 CI +/- 0.45, and when the participant stress is manipulated g = 0.233 CI +/- 0.4, there is little evidence of a consistent sex difference in any of these clusters. In every case the 95% Confidence Interval includes a zero effect. It is particularly important that the studies using faces do not show a strong effect as these stimuli might be regarded as the most important from an evolutionary perspective (Carlson & Mujica-Parodi, 2015). There is no significant correlation between g and the size of the sample ($r(22)= -.001$ $p = .99$), and if we only choose those studies with at least 20 participants in each group, the effect size still suggests no difference between sexes (g = 0.004 CI +/- 0.15). Furthermore, the study with the largest sample (McDermott et al., 2013) had a g value of -.05.

While this sample of studies is not comprehensive, it suggests that sex differences in fear are not driven by differences in attention to threat. However, firm conclusions are compromised by the fact that despite its popularity, the task itself has been criticised for poor internal consistency, test-retest

reliability (Schmukle, 2005) and hence poor convergent validity (typically less than r = .10) with other tasks measuring attention bias (Van Bockstaele et al., 2014). One might indeed argue that women's higher levels of anxiety and fear might have been used to try and establish the construct validity of attentional bias measures.

Discussion

Meta-analysis of 23 dot-probe studies provided no evidence that women's attention was captured by threatening stimuli more than men's. It is important to remember that none of the studies used were designed to examine sex differences and that they had mostly small sample sizes, which is often the case in dot-probe studies. It is also important to recognize that the meta-analysis cannot be regarded as comprehensive in that it was based on data that the authors received from their requests. There is, however, no reason to believe that this would be an unusual sample of studies. The overall effect size whether broken down by study type was very small, and the direction of the effect was not consistent. It would, however, be useful if a study specifically designed to examine sex differences in sensitivity to threat was conducted and it would make sense for fearful and threatening faces to be used as the stimuli.

Although there is no evidence to support the argument for increased sensitivity in women, two conceptual and operational distinctions in the attention literature merit further examination in terms of sex differences. One is the question of whether sex differences might reside in women's delayed disengagement from threat rather than speedier engagement of attention. These two processes can be experimentally distinguished (Yiend, 2010). A difference in latency to disengage would indicate that women engage in more sustained exploration of stimuli after they are established as threatening, rather than detecting threat more swiftly. A difficulty in disengagement is characteristic of individuals high in anxiety (Fox, Russo, & Dutton, 2002; Koster, Crombez, Verschuere, & De Houwer, 2006). However, evidence for a sex difference in disengagement currently remains equivocal (Sass et al., 2010; Tan, Ma, Gao, Wu, & Fang, 2011; Tran, Lamplmayr, Pintzinger, & Pfabigan, 2013; Pintzinger, Pfabigan, Tran, Kryspin-Exner & Lamm, 2016). Few studies

have examined both attention orienting and disengagement in the same experiment (Carlson & Mujica-Parodi, 2015), and it would make sense to include this in a targeted study on sex differences.

A second and connected distinction is between selective attention to threat and hypervigilance (Richards, Benson, Donnelly & Hadwin, 2014). Hypervigilance operates in the absence as well as the presence of threats and although costly in terms of maintaining on-task attention, it enhances threat detection. There is some evidence that women show increased vigilance in response to uncertainty when they anticipate the subsequent arrival of a feared stimulus (Grillon, 2008)

From an evolutionary perspective, it is likely that recalibrating the sensitivity of the fear system carries costs which likely outweigh the advantages gained in terms of increased safety or processing speed. These costs include the Type 1 ('false positive') error of mobilising physiological, psychological and behavioural fear responses when they are not needed. A too-sensitive threat detection system would 'over-detect' threats resulting in an excessive number of false alarms and chronic strain on the system. In the face of repeated and chronic stress, the balance between the Hypothalamic Pituitary Adrenal stress axis and the Hypothalamic Pituitary Gonadal reproductive axis is disturbed resulting in depleted estrogen levels and reduced ovarian function (Toufexis, Rivarola, Lara, & Viau, 2014). Threats to successful female reproduction would be expected to constrain the extent to which the fear system could be made more sensitive. We would argue that the mechanism for increased fear in women is probably not based on attentional bias to threat.

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* Indicates a study included in the meta-analysis of dot probe tasks.

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