# High spider-fearful and low spider-fearful individuals differentially perceive the speed of approaching, but not receding, spider stimuli.

Julian Basanovic[1], Laurence Dean[1], John H. Riskind[2], Colin MacLeod[1]

[1] Centre for the Advancement of Research on Emotion,
School of Psychological Science, The University of Western Australia, Crawley, Australia
[2] Department of Psychology, George Mason University, Fairfax, Virginia, U.S.A.

Corresponding Author:
Julian Basanovic
School of Psychological Science, The University of Western Australia
E-mail: julian.basanovic@uwa.edu.au

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**Abstract**

The looming vulnerability model of fear predicts that high fearful individuals, as compared to low fearful individuals, will display a heightened tendency to perceive feared stimuli as moving disproportionately quickly when such stimuli are approaching, but not when they are receding. Experiments testing this prediction have been compromised by methodological limitations that preclude their ability to determine its validity. The present study employed a novel methodology designed to overcome these limitations to examine whether individuals with heightened levels of spider-fear exhibit this predicted perceptual bias. Two groups of participants who differed in spider-fear completed a perceptual task that presented stimulus pairs comprising spider and butterfly images under two movement conditions. In one condition images displayed approaching movement, while in the other condition images displayed receding movement. Participants were required to indicate which stimulus they perceived to move fastest. As predicted, it was found that participants with heightened spider-fear demonstrated a significantly greater tendency than low spider-fearful participants to perceive the spider stimuli as moving fastest, only when stimuli displayed approaching movement. Implications and avenues for future research are discussed.

High spider-fearful and low spider-fearful individuals differentially perceive the speed of approaching, but not receding, spider stimuli.

It is known that to the extent a stimulus is evaluated to be negatively valenced perceived approaching movement is associated with heightened negative emotional experience as compared to static or receding movement (Mühlberger, Neumann, Wieser, & Pauli, 2008). Perceiving such stimuli to be approaching rapidly may serve to amplify negative emotion, though it also is possible that negative emotion may increase the perception that such approaching stimuli are moving rapidly. According to the looming vulnerability model of fear, individuals with specific fears are characterized by a perceptual bias that operates to exaggerate the perceived speed of approaching feared stimuli, compared to that of approaching stimuli unrelated to their fears (Riskind & Williams, 2006; (Riskind et al., 1992; Riskind & Williams, 2006). That is, the looming vulnerability model predicts that individuals with heightened spider-fear, as compared to those low in spider-fear, will exhibit an elevated tendency to perceive spider stimuli as moving faster than non-spider stimuli when such stimuli are approaching, but not when they are receding.

Investigators have already demonstrated that people with heighted spider-fear do display certain perceptual biases. For example, such individuals display a tendency to relatively overestimate the size of spiders, compared to non-feared stimuli such as butterflies (Leibovich, Cohen, & Henik, 2016; Shiban et al., 2016; Vasey et al., 2012). They also tend to relatively overestimate the length of time they are exposed to spiders (Watts & Sharrock, 1984), a perceptual bias that has also been observed for other types of feared stimuli (Fayolle, Gil, & Droit-Volet, 2015; Grommet et al., 2011). There is also evidence that spider-fearful people may have an elevated inclination to perceive spiders as exhibiting approach movement. For example, Rachman and Cuk (1992) demonstrated that when viewing a live spider spider-fearful participants rated the spider as more often moving towards them. Nevertheless, it remains uncertain whether spider-fear is characterised by the biased perception of relative movement speed predicted by the looming vulnerability model, that is, the elevated tendency to perceive spider stimuli as moving faster than non-spider stimuli when such stimuli are approaching but not when they are receding.

Though some studies, conducted with the aim of testing this prediction, have generated encouraging findings, methodological limitations prohibit firm conclusions concerning its validity. For example, Riskind et al. (1992) presented participants with video recordings of naturally moving spiders and rabbits, and asked participants to estimate the relative speed at which the animal moved in each video. Individuals with heightened spider-fear estimated approaching spiders to be moving faster relative to approaching rabbits. However, because the average movement speeds of the spiders and rabbits were not matched in these videos, the judgement that approaching spiders moved faster than approaching rabbits may not represent a perceptual bias. More recently, Vagnoni et al. (2012) examined participants' estimations of movement speed for approaching images of spiders, snakes, butterflies and rabbits, in a study where the average movement speeds of these stimuli was matched. However, rather than requiring participants to report the perceived relative speed of these stimuli, these investigators instead assessed perceived "time-to-collision". Participants observed each approaching image for a brief duration, after which it disappeared, and the participant was required to estimate when the stimulus would have collided with their person had it continued on its course. Vagnoni et al. (2012) observed that greater fear of spiders and snakes was associated with a reduction in estimated time-to-collision for such stimuli. While this is consistent with the possibility that the more fearful participants may have perceived feared stimuli to have been approaching with disproportionate relative speed, it could instead be explained by their perception that these stimuli were disproportionately close when they first appeared. That is, estimates of time-to-collision will reflect the combined influence of perceived movement speed and perceived initial proximity of the stimuli, so perceiving increased movement speed or decreased initial proximity would both reduce time-to-collision estimates. Moreover, the time-to-collision paradigm cannot measure individuals' estimations of the movement speed of receding stimuli. Hence, the study of Vagnoni et al. (2012) does not necessarily reveal whether fearful individuals perceived approaching feared stimuli to move more quickly than approaching non-feared stimuli, and does not reveal whether any observed effects are specific to approaching stimuli.

To overcome these limitations of earlier research a methodology is required in which the movement speed of spider stimuli and non-spider stimuli is controlled, estimations of stimulus movement speed are not influenced by perceived distance of the stimuli, and estimations of movement speed are measured for both approaching and receding stimuli. Hence, the aim of the present study was to implement such a methodology to test the prediction generated by the looming vulnerability model of fear. Specifically, that individuals with heightened spider-fear, as compared to individuals low in spider-fear, will exhibit a perceptual bias that results in the relative overestimation of the movement speed of feared stimuli as compared to non-feared stimuli, when such stimuli are approaching but not when they are receding.

Two groups of individuals who differed in level of spider-fear were recruited to complete a novel Movement Speed Discrimination Task. Our intention was to enable participants to directly report the perceived relative movement speed of spider and non-spider stimuli, rather than to infer this indirectly from estimated of time-to-collision or exposure duration. Hence, each trial presented two stimuli simultaneously, one of which was an image of a spider and the other an image of a butterfly. Both stimuli displayed apparent movement (the average speed of which was matched), whereby on one half of trials both images displayed approach movement and on the other half of trials both images displayed receding movement. Participants were required to report which of these two stimuli they perceived to have moved most quickly.

By comparing the perceived relative movement speeds of the spider and butterfly stimuli reported by participants high and low in spider-fear, when such stimuli were approaching and when they were receding, this methodology permitted a direct test of the prediction generated by the looming model of fear vulnerability. That is, that participants with heightened spider-fear, compared to those low in spider-fear, would more often report that the spider was the faster moving stimulus in the stimulus pair, but this group difference would be exhibited only when the two stimuli displayed approaching movement and would not be observed when these stimuli displayed receding movement.

## Method

### Participants

The study required two equally sized groups of participants that either experienced a heightened level of spider-fear or experience a low level of spider-fear. A power analysis conducted to determine a required sample size concluded a total sample size of 58 participants would be necessary to yield satisfactory statistical power[1]. Seventy-two undergraduate students were recruited from a larger cohort of seven hundred students

[1] 80% power (1-β = .80) to detect a medium sized ANOVA interaction effect involving between-subject and within-subject factors ($\eta_p^2$ = .06), in the presence of a small correlation (*r* = .1) amongst repeated measurements, when employing a .05 alpha criterion for significance (Faul, Erdfelder, Lang, & Buchner, 2007).

screened on the Fear of Spiders Questionnaire (FSQ). Thirty-six participants (Age, M = 18.97, SD = 2.90; 28 female) whose FSQ scores ranked in the highest third in the cohort were allocated to a High Spider-fear Group (FSQ score, M = 70.67, SD = 18.69, range = 41 to 116). Thirty-six participants (Age, M = 18.58, SD = 1.44; 17 female) whose FSQ scores ranked in the lowest third in the cohort were allocated to a Low Spider-fear Group (FSQ score, M = 4.33, SD = 3.83, range = 0 to 11). This gave rise to a between groups factor labelled Spider-fear Group (Low Spider-fear Group, High Spider-fear Group).

**Materials**

**Fear of Spiders Questionnaire (FSQ).** The Fear of Spiders Questionnaire (Szymanski & O'Donohue, 1995) is an 18 item questionnaire that measures spider-fear. Participants indicate the degree to which they experience a range of behaviours and thoughts characteristic of fear of spiders. Scores on the FSQ can range from 0 to 126, with higher scores reflecting greater spider-fear. The FSQ has been shown to have appropriate test-retest reliability, internal reliability, and construct validity amongst undergraduate student populations (Muris & Merckelbach, 1996; Szymanski & O'Donohue, 1995).

**Apparatus.** The Movement Speed Discrimination Task was run using a PC and a 22-inch widescreen colour monitor set at a resolution of 1920 × 1080 pixels and 60 Hz refresh rate. Responses during the task were made using a standard two button mouse.

**Stimulus images.** The Movement Speed Discrimination Task utilised 96 images of spiders and 96 colour images of non-spider stimuli[2]. We followed the lead of many previous researchers by employing images of butterflies as our non-spider stimuli (e.g. de Haan, Smit, Van der Stigchel, & Dijkerman, 2016; Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005;

[2] The set of images used in the experiment can be obtained by contacting the Corresponding Author.

Vagnoni et al., 2012). Stimulus images were developed from colour photographs of real spiders and butterflies. Each image was cropped to a square aspect ratio such that the animal extended to each outer edge of the image. The original background of each image was removed and replaced with a uniform white background. An additional set of 24 images of typical household objects (e.g. kitchenware) was prepared in an identical manner for use in an initial practice task. All images had a resolution of 390 x 390 pixels.

**Movement Speed Discrimination Task.**

The Movement Speed Discrimination Task was designed to assess the tendency for participants to perceive spiders to move faster than butterflies, under conditions where these stimuli displayed apparent approaching movements or apparent receding movements. The task contained 576 trials. Each trial commenced with the presentation of a central fixation cross in the centre of a white background. After 500 ms, this cross was removed and an image pair that comprised a spider image and a butterfly image was displayed. One image appeared on the left side of the screen and the other appeared on the right side of the screen. The spider image and butterfly image appeared in each location with equal frequency across trials. The centre of each image was 55 mm from the centre of the screen, resulting in a visual angle of 10.48° between the centres of the two stimulus images at a viewing distance of 60 cm.

The image pair was displayed for a duration of 500 ms, and across this duration the images either both dynamically increased in size in order to simulate approaching movement, or both dynamically decreased in size in order to simulate receding movement. The dynamic increase or decrease in size of two-dimensional stimuli has been demonstrated to simulate the perceptual qualities of approaching and receding stimuli (Franconeri & Simons, 2003; Gibson, 1958; Schiff, Caviness, & Gibson, 1962). This gave rise to a within-groups factor labelled Stimulus Movement Direction (Approaching Movement, Receding Movement). Within the approaching movement trials the average rate of size increase, conveying apparent approach movement, was exactly the same for the spider and butterfly images, and so the simulated approach speed of these two classes of images did not differ on average. Within the receding movement trials, the average rate of size decrease, conveying apparent receding movement, also was exactly the same for the spider and butterfly images, and so the simulated recede speed of these two classes of images likewise did not differ on average. To reduce the prospect of participants assuming that the speed of the two images was always identical, and hence ceasing to exercise perceptual judgement, on 50% of trials a small discrepancy (averaging 8%) in rate of size change between the two images was present. Across these trials the spider and butterfly image moved fastest with equal frequency. After presentation of the stimuli, participants were required to indicate which member of the image pair they perceived as moving fastest during the trial. Participants executed their response by pressing the left mouse-button if they had perceived the image on the left to move fastest and the right mouse-button if they had perceived the image on the right to move fastest. The task recorded the identity and latency of the button press. The subsequent trial commenced 1000 ms after a response was recorded. The task delivered trial conditions in a randomised order for each participant.

**Procedure**

Participants first read an information sheet and provided informed consent to participate in the study. They were next seated in front of the computer at a viewing distance of approximately 60 cm and given instructions for the Movement Speed Discrimination Task. Participants were instructed to attend to the fixation cross presented at the commencement of each trial and to indicate which of the two subsequently presented images they perceived and having moved fastest on that trial, by pressing the corresponding left or right mouse-button. Participants were given no direction concerning how they should reach their judgement and were given no information that could influence their expectancy concerning the relative movement speed of the two stimuli. Participants completed a short practice version of the task that employed the practice stimulus set before completing the Movement Speed Discrimination Task. After completing the Movement Speed Discrimination Task participants were debriefed.

## Results

Prior to examining the validity of the hypothesis under test, the analytic procedure first examined the proportion of responses in which participants were accurate in identifying the image that had moved fastest on those trials where one image had moved faster than the other. As anticipated, proportion of accurate of responses varied widely across participants though was centred at an accuracy rate that was considered reasonable given the task parameters (M = 69.48%, SD = 8.68%, range = 48.15% to 84.49%).

Analysis next turned to examine the hypothesis under test. For each participant, the proportion of trials on which the spider was perceived as moving fastest was computed across all trials, though separately for the conditions in which stimuli displayed approaching movements and for the conditions in which stimuli displayed receding movement. These data are shown in Table 1.

A 2 x 2 mixed-design ANOVA was carried out on these data. This analysis considered Spider-fear Group (Low Spider-fear Group, High Spider-fear Group) as the between-group factor, and Stimulus Movement Direction (Approaching Movement, Receding Movement) as the within-group factor. The analysis revealed a significant main effect of Spider-fear Group, $F(1, 70) = 7.48$, $p = .008$, $\eta_p^2 = .10$, and a significant main effect of Stimulus Movement

Direction, $F(1, 70) = 112.95$, $p < .001$, $\eta_p^2 = .62$. Most importantly, as predicted both of these main effects were subsumed within a significant two-way interaction effect[3] of Spider-fear Group and Stimulus Movement Direction, $F(1, 70) = 4.52$, $p = .037$, $\eta_p^2 = .06$. In order to determine whether the nature of this two-way interaction was consistent with the experimental prediction the simple main effect of Spider-fear Group was computed separately at each level of the Stimulus Movement Direction factor. These analyses revealed that there was no significant simple main effect of Spider-fear Group in the Receding Movement condition, $F(1, 70) = .08$, $p = .78$, $\eta_p^2 < .01$. However, there was significant simple main effect of Spider-fear Group in the Approaching Movement condition, $F(1, 70) = 12.60$, $p < .001$, $\eta_p^2 = .15$, reflecting that participants in the High Spider-fear Group demonstrated a heightened proportion of trials on which the spider was perceived to move fastest, as compared to participants in the Low Spider-fear Group (.37 vs .29). Thus, when stimuli displayed apparent approaching movement, but not when they displayed apparent receding movement, participants in the High Spider-fear Group demonstrated a greater tendency to perceive the spider as moving fastest than did participants in the Low Spider-fear Group.

Correlational analysis also were employed to examine the association between spider-fear, and the relative perceived movement speed of the spiders and butterflies, when these stimuli were approaching or receding. Scores on the FSQ were positively correlated with the proportion of trials on which the spider stimulus was perceived to move fastest, when stimuli displayed apparent approaching movement, $r = .38$, $p = .001$. In contrast, FSQ scores showed no significant correlation with the proportion of trials on which the spiders were

[3] Post-hoc analyses determined that this interaction effect was not moderated by the magnitude of the relative difference in movement speed between stimulus pair images.

perceived to move fastest when stimuli displayed apparent receding movement, $r = .07$, $p = .59$.

Though the hypothesis and prediction under test specifically concerned the probability that high fearful, as compared to low fearful, participants would identify the spider image as having moved fastest, it was observed that the present methodology was amenable to a signal detection analysis approach. For those readers who may be interested in such an approach, these additional post-hoc analyses are available in Online Resource 1.

**Discussion**

The aim of this study was to test a key prediction generated by the looming vulnerability model of fear. Specifically, we tested the prediction that individuals with heightened spider-fear would display a greater tendency than individuals low in spider-fear to perceive the spider stimuli as moving relatively faster when stimuli approaching, but that this difference between high and low spider-fearful individuals would not be exhibited when such stimuli are receding. The results supported this prediction. Participants with heightened levels of spider-fear were more likely than participants low in spider-fear to perceive spiders as moving faster than butterflies under conditions where these stimuli displayed apparent approach movement, but not under conditions where these stimuli displayed apparent receding movement.

These results provide support for the looming vulnerability model of fear (Riskind & Wahl, 1992; Riskind & Williams, 2006). They also lend weight to the conclusion, drawn in reports of previous studies, that individuals with elevated spider-fear are characterised by an increased tendency to perceive approaching spiders as moving faster relative to those low in spider-fear, (Riskind et al., 1992; Vagnoni et al., 2012). Crucially, however, the present study adopted a methodology that overcomes limitations in the design of these studies.

Specifically, this current study equated the average movement speed of spider and non-spider stimuli, and compared fear-linked differences in participants' perception of the relative movement speed of stimuli that were approaching, with stimuli that were receding. Hence, the present study has demonstrated the operation of this fear-linked perceptual bias under the tightly controlled conditions necessary to adequately verify its existence.

While the observed pattern of differences between high and low spider-fearful participants in their perceived relative movement speed of approaching and receding spiders and butterflies supports the prediction generated by the looming vulnerability model, it should be noted that participants did not generally perceive the spiders to move faster than the butterflies. Rather, across participants and conditions butterflies were perceived to be the faster moving stimuli on the majority of trials. It is possible that this may reflect structural differences between the spider and butterfly images. For example, the brightly coloured vivid patterning of the butterfly stimuli may have given rise to stronger apparent motion effects as stimuli changed size than was the case for the more uniform dull shade of the spider stimuli. Nevertheless, the general tendency for participants to most often report perceiving that the butterfly moved most quickly was significantly attenuated in the high spider-fear group, compared to the low spider-fear group, when the stimulus pair displayed apparent approach movement.

It should also be noted that the present findings do not pinpoint the effect driving the observed difference between high and low spider-fearful individuals. For example, the observed difference between the two fear groups may equally be described as a biased tendency for high-fearful individuals to perceive the spider as approaching disproportionately fast, or low-fearful individuals to perceive the spider as approaching disproportionately slow, when stimuli approach. The validity of these alterative explanations, which each describe a different effect driving the observed differences between groups, deserves further investigation. Nonetheless, either of these explanations would remain consistent with our prediction, and the associated finding that heightened spider-fear was characterized by an increase in the proportion of trials on which the spiders were perceived to move more quickly than the butterflies, but only when stimuli were approaching.

The presently observed association between heightened fear and perceived movement speed of approaching feared stimuli does not permit conclusions about its causal nature. However, as pointed out by Riskind and colleagues (2012; 1999), if this perceptual effect causally contributes to heightened fear then fear may be attenuated by manipulations that reduce the perceived movement speed of approaching feared stimuli. Indeed, it has been demonstrated that perceived approach movements made by spider stimuli increase the degree to which spider stimuli are appraised as threatening and can serve to elevate fear (Mcnally & Steketee, 1985; Mobbs et al., 2010; Riskind & Maddux, 1993). Though not yet addressed with respect to spider-fear, there is evidence that manipulating the perceived approach movement of contamination relevant stimuli can influence contamination-fear in the immediate and short-term. For example, Riskind, Wheeler, Picerno (1997) gave participants with contamination-fear equivalent exposure to videos showing moving contamination-relevant stimuli with differing imagery instructions. Relative to a control condition, an imagery condition that reduced the perceived approach movement reduced fear responses during viewing of these stimuli, whereas an imagery condition that increased the perceived approach movement was associated with increased fear responses. Dorfan and Woody (2006) replicated these findings, and showed that these emotional effects remained evident 10 minutes after the viewing task. Critically however, it is important to note that short-term reduction in distress or fear does not necessarily predict long-term reductions. Indeed, strategies that can successfully reduce distress during or immediately following exposure training, such as safety behaviours and signals, can be detrimental to long-term reduction in fear (Sloan & Telch, 2002). Thus, future research would profitably investigate whether interventions based on the manipulation of perceived movement speed do yield long-term therapeutic effects in fear reduction. For the moment however, the findings from these studies suggest that variation in the perceived movement speed of approaching feared stimuli may causally contribute to variation in fear.

Extensions of the present work should also investigate whether the presently observed group difference in pattern of perceived movement speed is a distinctive feature of specific fear. While correlational analysis confirmed that individual differences in our FSQ measure of spider-fear were significantly correlated with our measure of this bias, this study did not assess other dimensions of affect that might be associated with spider-fear, such as depression or state anxiety. Future studies may seek to include such measures to determine whether the variation in perceived relative movement speed of approaching spiders continues to predict FSQ scores when other affective measures are controlled for. It would also be of value to include measures of other fear-linked processing biases to determine whether these are independent of fear-linked differences in perceived movement speed. For example, it is well-established that high-fearful individuals display an attentional bias towards feared-stimuli (Lipp & Derakshan, 2005; Mogg & Bradley, 2006; Pflugshaupt et al., 2005; Rinck & Becker, 2006; Rinck et al., 2005; Vrijsen, Fleurkens, Nieuwboer, & Rinck, 2009). In principle, it may be that greater attention towards fear relevant member of the stimulus pairs in the present study served to increase perceived movement speed. However, this account of the present findings is challenged by Basanovic et al.’s (2017) demonstration that fear-linked differences in attentional vigilance to spider are eliminated when stimuli display approaching movement. Nonetheless, the concurrent assessment of these attentional and perpetual bias measures would reveal whether the presently observed fear-linked differences in the perceived movement speed of feared stimuli are mediated by, or are independent from, fear-linked differences in attentional bias to feared stimuli.

Further research will be necessary to establish whether bias in perceived movement speed is also characteristic of other forms of specific-fear. It seems plausible that some specific fears, particularly those wherein reduced proximity between an individual and a moving feared stimulus is associated with elevated threat (e.g. animal fears), may be characterised by the presence of this same type of perceptual bias. However, when feared stimuli are more static in nature, as for example when fear involves heights, water, or inanimate objects, then fear-linked biases involving perceived speed of movement may either be absent or more complex in nature, potentially involving perceived relative speed of one's own approach and avoidance movements. For example, height-fearful individuals required to move towards the edge of a high ledge could perceive the speed of their own movement to be disproportionately quick. Prior research identifies some examples in which perceptions of approaching threat may contribute to the genesis or maintenance of other forms of elevated fear and anxiety. For example, research has demonstrated that individuals who have obsessional fears of contamination often report perceiving that contaminants are rapidly moving toward them (Riskind, Abreu, Strauss, & Holt, 1997; Riskind, Wheeler, et al., 1997), and individuals who fear acquiring AIDS report perceiving the HIV virus as rapidly approaching (Riskind & Maddux, 1994). Nonetheless, further research will be required to determine whether the fear-linked bias in the perception of movement speed presently found to characterise spider-fear generalises across other forms of specific fear.

Although the present study assessed individuals who reported elevated levels of spider-fear, these participants were not selected on the basis of their meeting diagnostic criteria for specific phobia. This precludes the possibility of drawing strong conclusions concerning the involvement of the presently observed perceptual bias in clinical manifestations of spider-fear. Of note however, is that in the present study a large number of participants allocated to the high spider-fear group did report levels of spider-fear that fell within the range that would be reported by clinically spider-fearful individuals (Muris & Merckelbach, 1996). Thus it seems plausible that the pattern of biased motion perception, involving spider stimuli, presently observed in the current sample of high fearful individuals, may also be evident in individuals with clinically significant symptoms of spider-fear. Nevertheless, as the clinical diagnosis of specific-fear is based not only on high levels of fear, but also on extreme behavioural avoidance, it will be necessary to investigate clinically diagnosed samples in order to determine whether such manifestations of spider-fear are characterised by the same pattern of perceptual bias shown by individuals with heightened spider-fear in the current experiment. The methodology adopted within the current study could easily be extended to clinical samples in order to experimentally address this issue.

Thus, there is much scope for future work to build upon the foundation laid by the present study. For the moment, we have shown that participants with heightened spider-fear were more likely than those low in spider-fear to perceive spider stimuli as moving relatively fast, but only when such stimuli were approaching and not when they were receding. This pattern of findings is consistent with the predictions of the looming vulnerability model of fear. We hope that the methodology developed in this study will prove useful to investigators who seek to better understand the biases that characterise heightened fear.

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Table 1. *Mean proportion of responses in which participants identified the spider as having moved fastest, for each movement condition and spider-fear group; M (SD).*

| | Spider-fear Group | |
|---|---|---|
| Stimulus Movement Direction | Low Spider-fear Group | High Spider-fear Group |
| Approaching Movement | .29 (.08) | .37 (.11) |
| Recede Movement | .51 (.11) | .52 (.09) |

**High spider-fearful and low spider-fearful individuals differentially perceive the speed of approaching, but not receding, spider stimuli.**

**Online Resource 1**

Though the hypothesis under test concerned the likelihood that high fearful, as compared to low fearful, participants would identify the spider image as having moved fastest, it was observed that a signal detection analysis could reveal participants' sensitivity to detecting differences in movement speed, or biased responding identifying movement speed, on those trials in which the spider and butterfly images moved at difference speeds. Furthermore, it was observed that restricting examination of the probability that participants would identify the spider image as having moved fasters to those trials in which images moved at the same speed could also reflect biased responding. Each of these analyses is discussed in turn.

**Signal detection analyses.**

Signal detection indices were computers across those trials in which the spider and butterfly images moved at difference speeds. For each participant, an index of sensitivity to spider movement speed (d’) and an index of biased responding favouring identification of the spider as having moved fastest (*c*) was computed (Macmillan & Creelman, 2005). For the sensitivity index (d’) larger values reflected greater sensitivity in detecting when spider images had moved faster, or slower, than the butterfly image. For response bias index (*c*), increasingly negative values reflect greater bias towards identifying spider images as moving fastest, while increasingly positive values reflect greater bias towards identifying butterfly images as moving fastest, and a value of zero (0) reflected no bias at all. These measures are present in Table 1 below.

Table 1. *Signal detection indices computed across trials in which images moved at different speeds, for each movement condition and spider-fear group; M (SD).*

| | Spider-fear Group | |
|---|---|---|
| Stimulus Movement Direction | Low Spider-fear Group | High Spider-fear Group |
| Approaching Movement | d’ = .91 (.38)<br>*c* = .70 (.31) | d’ =.73 (.36)<br>*c* = .39 (.32) |
| Recede Movement | d’ =.98 (.48)<br>*c* = -.03 (.36) | d’ =.78 (.45)<br>*c* = -.02 (.26) |

Note: For sensitivity index (d’) larger values reflect greater sensitivity to stimulus movement. For response bias index (*c*), more negative values reflect greater bias towards identifying spider images as moving fastest, while more positive values reflect greater bias towards identifying butterfly images as moving fastest, and a value of zero (0) reflects no bias at all.

A 2 x 2 mixed-design ANOVA was carried out on d’ sensitivity indices. This analysis considered Spider-fear Group (Low Spider-fear Group, High Spider-fear Group) as the between-group factor, and Stimulus Movement Direction (Approaching Movement, Receding Movement) as the within-group factor. The analysis revealed a significant main effect of Spider-fear Group, $F(1, 70) = 4.29$, $p = .042$, $\eta_p^2 = .06$. This reflected the fact that low spider-fearful participants demonstrated higher levels of sensitivity to spider movement (M = .95), as compared to high spider-fearful individuals (M = .75). The analysis also demonstrated a trend towards a main effect of Stimulus Movement Direction, $F(1, 70) =$

3.93, $p = .051$, $\eta_p^2 = .05$, suggesting that, in general, participants demonstrated greater sensitivity to spider movement when stimuli were receding (M = .88), as compared to approaching (M = .82). The interaction effect between these factors was not significant, $F(1, 70) = 0.06$, $p = .80$, $\eta_p^2 < .001$.

Next, a 2 x 2 mixed-design ANOVA was carried out on *c* bias indices. This analysis considered Spider-fear Group (Low Spider-fear Group, High Spider-fear Group) as the between-group factor, and Stimulus Movement Direction (Approaching Movement, Receding Movement) as the within-group factor. The analysis revealed a significant main effect of Spider-fear Group, $F(1, 70) = 8.96$, $p = .004$, $\eta_p^2 = .11$, as well as a significant main effect of Stimulus Movement Direction, $F(1, 70) = 106.82$, $p < .001$, $\eta_p^2 = .60$. However, these main effects were subsumed within a significant interaction effect between these factors, $F(1, 70) = 8.24$, $p = .005$, $\eta_p^2 = .11$.

In order to determine the nature of this two-way interaction the simple main effect of Spider-fear Group was computed separately at each level of the Stimulus Movement Direction factor. Consistent with the primary analysis reported in the main text, these analyses revealed that there was no significant simple main effect of Spider-fear Group in the Receding Movement condition, F(1, 70) = .008, $p = .93$, $\eta_p^2 < .001$ reflecting that, when images receded, participants in the High Spider-fear Group and Low Spider-fear Group did not differ in their tendency perceive the spider as moving fastest. However, there was significant simple main effect of Spider-fear Group in the Approaching Movement condition, $F(1, 70) = 17.09$, p < .001, $\eta_p^2 = .20$, reflecting that, when images approached, participants in the High Spider-fear Group demonstrated a heightened tendency to perceive the spider as moving fastest, as compared to participants in the Low Spider-fear Group.

**Analysis of participant responses on trials where stimulus images moved at the same speed.**

Lastly, analyses examined the probability that participants reported the spider image as having moved fastest across those trial in which spider and butterfly images moved at the same speed. These data are presented in Table 2 below.

Table 2. *Mean proportion of responses in which participants identified the spider as having moved fastest on those trials where images moved at the same speed, for each movement condition and spider-fear group; M (SD).*

| | Spider-fear Group | |
|---|---|---|
| Stimulus Movement Direction | Low Spider-fear Group | High Spider-fear Group |
| Approaching Movement | .27 (.10) | .34 (.14) |
| Recede Movement | .52 (.15) | .54 (.13) |

A 2 x 2 mixed-design ANOVA was carried out on these data. This analysis considered Spider-fear Group (Low Spider-fear Group, High Spider-fear Group) as the between-group factor, and Stimulus Movement Direction (Approaching Movement, Receding Movement) as the within-group factor. The analysis revealed a significant main effect of Stimulus Movement Direction, $F(1, 70) = 90.78$, $p < .001$, $\eta_p^2 = .56$. This reflected the fact that, in general, participants demonstrated a greater tendency to report spider images as moving fastest when stimuli receded (M = .53), as compared to approached (M = .31). The analysis also demonstrated a main effect of Spider-fear Group, $F(1, 70) = 5.35$, $p = .02$, $\eta_p^2 = .07$, reflecting that, in general, participants in the High Spider-fear Group (.44) more often reported the spider as moving fastest across trials, as compared to the Low Spider-fear Group (.39). No significant interaction effect involving the two factors was observed, $F(1, 70) = 1.33$, $p = .25$, $\eta_p^2 = .02$.

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