

# We prefer what we fear: A response preference bias mimics attentional capture in spider fear



Anke Haberkamp<sup>a,\*</sup>, Melanie Biafora<sup>b</sup>, Thomas Schmidt<sup>b</sup>, Katharina Weiß<sup>c</sup>

<sup>a</sup> Philipps-University Marburg, Germany

<sup>b</sup> University of Kaiserslautern, Germany

<sup>c</sup> University of Bielefeld, Germany

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## ABSTRACT

The extent to which emotionally significant stimuli capture visual attention remains elusive because a preference for reporting or choosing emotionally significant stimuli could mimic attentional capture by these stimuli. We conducted two prior-entry experiments to disentangle whether phobic and fear-relevant stimuli capture attention or merely produce a response bias in spider-fearful participants. Prior entry denotes the effect that attended stimuli are perceived earlier than unattended stimuli as indicated by temporal order judgments. We presented phobic (spiders), fear-relevant (snakes) and neutral stimuli in pairs with varying temporal onset. The participants' task was to indicate which stimulus was presented first (Experiment 1) or second (Experiment 2). In the first experiment, spider-fearful but not control participants indicated that they had perceived spiders as occurring earlier in time, suggesting a prior-entry effect for spiders in this group. But surprisingly, in the second experiment, spider-fearful participants indicated more frequently that they had seen spiders as being presented second. This finding rules out a genuine prior-entry effect and instead suggests a strong preference for the response option associated with the feared animal. This response bias may result from a hypervigilance toward the feared stimulus and contribute to maintaining avoidance behavior in individuals with specific phobias.

## 1. Introduction

Visual attention can be modulated in a top-down manner (for example through behavioural goals; e.g., when searching for a red dot) or in a bottom-up manner (for example through stimulus characteristics; e.g., when a red dot among green dots automatically captures attention and thereby “pops out”; Yantis, 2000). A crucial variable in the bottom-up modulation of attention is the saliency of a stimulus (e.g., Pashler, 1988; Theeuwes, 1992). The red circle among green circles will capture attention only because of its high saliency that results from the strong colour contrast between red and green. However, saliency does not only depend on stimulus characteristics but also on the emotional significance of a stimulus: fear-relevant stimuli (e.g., spiders or threatening faces) are more likely to capture attention compared to neutral stimuli (e.g., Eastwood, Smilek, & Merikle, 2001; Fox et al., 2000) and lead to faster visuomotor processing compared to neutral stimuli (Haberkamp & Schmidt, 2014; Haberkamp et al., 2013), probably following from the evolutionary advantage of being able to detect dangers in the environment (Mathews & Mackintosh, 1998). Although, recent studies emphasise attentional capture for emotionally significant

stimuli, the extent of such an effect remains elusive.

One way to measure attentional capture is to use *temporal order judgments (TOJs)*. In this task, two stimuli are presented with varying stimulus-onset asynchronies (SOAs), and attention is either directed to one of the two stimuli (*cued trials*) or remains undirected (*uncued trials*). In TOJs, the participants indicate which of the two stimuli appeared first (or, occasionally, second; e.g., Scharlau, 2004; Shore et al., 2001; Yates & Nicholls, 2009). Typically, attended stimuli are perceived earlier than unattended stimuli (Stelmach & Herdman, 1991; Titchener, 1908), a phenomenon known as *prior-entry effect*. For example, if a square and a diamond are presented simultaneously and an observer attends the square, she will perceive the square as occurring before the diamond. Prior-entry effects have been demonstrated within and between different modalities (vision: Scharlau, 2007; Weiß & Scharlau, 2011, 2012; audition: Kanai, Ikeda & Tayama, 2007; touch: Nicholls, 2009, 2011; ; bimodal (vision, touch): Spence, Shore & Klein, 2001; for an overview see Spence & Parise, 2010).

The prior-entry effect is technically defined as a shift in the so-called *point of subjective simultaneity (PSS)*, which denominates the SOA at which both order judgments are made equally often, that is, the

\* Corresponding author at: Philipps-University Marburg, Clinical Psychology and Psychotherapy, Gutenbergstrasse 18, 35032 Marburg, Germany.

E-mail addresses: [anke.haberkamp@staff.uni-marburg.de](mailto:anke.haberkamp@staff.uni-marburg.de) (A. Haberkamp), [melanie.biafora@sowi.uni-kl.de](mailto:melanie.biafora@sowi.uni-kl.de) (M. Biafora), [thomas.schmidt@sowi.uni-kl.de](mailto:thomas.schmidt@sowi.uni-kl.de) (T. Schmidt), [katharina.weiss@uni-bielefeld.de](mailto:katharina.weiss@uni-bielefeld.de) (K. Weiß).

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temporal interval between the stimuli at which both are perceived as appearing first with the same probability. Typically, the PSS in uncued trials is close to physical simultaneity whereas in cued trials the PSS is located at a temporal interval at which actually the uncued (i.e., unattended) stimulus is presented first. In other words, the unattended stimulus requires a headstart to be perceived simultaneously with the attended one.

Consistent with recent findings of attentional capture for fear-relevant stimuli (Yiend, 2010), West, Anderson, and Pratt (2009) reported that threatening faces capture attention and show a visual prior-entry effect compared to neutral faces (also Fecica & Stolz, 2008; but see Schettino, Loeys & Pourtois, 2013 for a failure to replicate prior entry by threat-relevant faces across a series of experiments). Equivalently, there is evidence from different experimental paradigms suggesting that spiders capture attention in spider-phobic individuals compared to neutral stimuli (Mogg & Bradley, 2006; Rinck & Becker, 2006; for a review on attentional bias in general see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007).

Several studies suggest that the key to these effects might not be that fear-related stimuli attract attention, but that it is difficult to disengage attention from them. Gerdes, Alpers, and Pauli (2008) measured eye movements in spider-phobic participants and report a difficulty to disengage attention from spider distractors, resulting in slower responses to task-relevant targets (for a similar finding in social anxiety see Taylor, Cross, & Amir, 2016).

Interestingly, their findings do not support attentional capture because the spider-phobic participants tended to fixate not only on spider distractors but on neutral distractors as well. This suggests a higher alertness or hypervigilance to distractors per se – as if any of the presented stimuli could possibly be a spider (constituting non-specific attentional capture; for similar results see Devue, Belopolsky, & Theeuwes, 2011).

Based on this evidence of an attentional bias in spider fear and the conceptually related – although mixed – evidence for prior-entry effects for threatening faces, a prior-entry effect for spider stimuli in spider-fearful participants seems plausible. However, there is also a large body of literature suggesting that spider-fearful individuals exhibit additional biases in information processing of fear-related stimuli which might well affect the results of prior-entry paradigms. For example, spider-fearful individuals show an *encounter expectancy bias*, that is, the tendency to overestimate the likelihood of facing spiders (Mühlberger, Wiedemann, Herrmann, & Pauli, 2006) as well as the consequences of such a confrontation (*consequences expectancy bias*; Aue & Okon-Singer, 2015). They also exhibit a *memory bias* by recalling past experiences with spiders in a distorted manner (Mitte, 2008) and a *size estimation bias* by overestimating the size of spiders (Shiban et al., 2016; Vasey et al., 2012). Finally, spider-fearful individuals show an *interpretation bias* where they interpret ambiguous situations as spider-relevant and, therefore, as threatening compared to non-anxious individuals (Haberkamp & Schmidt, 2015; Kolassa et al., 2007). In line with this interpretation bias, spider-fearful individuals have a more liberal criterion to indicate that they had seen a spider in contrast to non-anxious controls, indicating a *response bias* (Becker & Rinck, 2004) or *response preference* for spiders.

All of these biases illustrate distorted information processing of spiders by spider-fearful individuals. Of these, a biased response preference is most likely to influence the results of a prior-entry study because spider-fearful individuals might report more frequently that they had seen the spider first – irrespective of the actually perceived temporal order of the presented stimuli. Here, we conduct two prior-entry experiments: first, to test whether we find a prior-entry effect for phobic and fear-relevant stimuli (in line with West et al., 2009 and other reports of attentional capture in spider-fearful individuals; Mogg & Bradley, 2006; Rinck & Becker, 2006); and second, whether this effect is actually caused by attentional capture or can rather be explained by a response preference.

Following West et al. (2009), we did not use additional visual cues to induce a prior-entry effect but rather assumed that the fear-relevant spider stimuli would capture attention in a bottom-up manner due to their emotional significance. Specifically, we presented pairs of natural images at varying SOAs to spider-fearful individuals and non-anxious controls; one image from an animal class (spiders, snakes, or butterflies), the other from a neutral non-animal class (mushrooms or flowers). Spiders represent *phobic* stimuli for the group of spider-fearful participants, but they are merely *fear-relevant* for the group of non-anxious controls. Snakes represent *fear-relevant* and butterflies *neutral* control stimuli for the two groups. In Experiment 1, we asked the participants which of the two stimuli was presented *first*. Results would be consistent with a prior-entry effect if spider-fearful individuals would report spider stimuli as occurring earlier in time compared to the fear-relevant (snakes) and neutral animal stimuli (butterflies; *within-group comparison*) and earlier than reported by the non-anxious control participants (*between-group comparison*). However, this pattern of results could also be explained by a response preference in spider-fearful individuals for reporting “spider” irrespective of the given task. Therefore, we conducted a second experiment with the same stimuli and a new set of participants in which we asked them which of the two stimuli was presented *second*. In this setting, a response preference (bias) would be demonstrated if the spider-fearful individuals would report the spider stimulus as occurring later in time than other stimuli and later than reported by non-anxious control participants. In other words, when spider-fearful participants show a response preference towards spider stimuli in general they would have the tendency to say “spider” more frequently irrespective of their task – thus, they would also indicate more often to have seen a spider second.

## 2. Experiment 1

### 2.1. Methods

The study was approved by the Ethical Committee of the Faculty of Psychology (Philipps-University Marburg).

#### 2.1.1. Participants

Twenty-eight participants recruited through the University of Kaiserslautern took part in the study. All participants had normal or corrected-to-normal visual acuity and received 6 € per hour as payment. All of them gave informed consent and were treated in accordance with the ethical guidelines of the American Psychological Association. They were all naïve to the purpose of the current study.

Fourteen participants reported being highly afraid of spiders but not of snakes (8 women and 6 men) and 14 participants reported being afraid of neither spiders nor snakes (11 women, 3 men). Before the experiment, all participants were screened for fear of spiders or snakes, using two spider questionnaires and one snake questionnaire (Table 1; German version of the “Spider Questionnaire” SPQ; Hamm, 2006; original version by Klorman, Weerts, Hastings, Melamed, & Lang, 1974; German questionnaire “Fragebogen zur Angst vor Spinnen [Fear of spiders questionnaire]” FAS; Rinck et al., 2002; German version of the “Snake Questionnaire” SNAQ; Hamm, 2006; original version by Klorman et al., 1974).

To ensure that the two groups differed substantially, non-anxious control participants had to score below the 25th percentile in the SPQ and spider-fearful participants had to score above the 75th percentile in the SPQ. All participants had to score below the 50th percentile in the SNAQ to exclude snake-fearful individuals from the study. For the FAS, only guideline values exist (for participants’ scores see Table 1).

Three spider-fearful participants and two non-anxious participants were excluded after the diagnostic session due to high scores in the snake questionnaire. One participant who reported being highly afraid of spiders was excluded due to low scores in the two spider questionnaires. These participants are not included in the number of

**Table 1**

Participants' mean scores (with standard deviations) for two spider and one snake questionnaire and for image evaluation (valence, arousal, and disgust) for each stimulus type and each group (non-anxious controls, spider-fearful participants). Bold letters indicate phobic image categories.

	Spider Fear	Controls	t(26)	p
<b>Measure</b>				
SPQ	18.79	2.00	-17.56*	$p < 0.001$
FAS	64.14	3.43	-11.36*	$p < 0.001$
SNAQ	5.00	1.86	-3.61*	$p = 0.002$
BDI	3.29	3.14	-0.13	ns
Age	24.50	25.79	0.48	ns
<b>Image rating – Valence</b>				
Spider	<b>-2.40 (0.85)</b>	-0.22 (1.04)	7.72	$p < 0.001$
Snake	-0.18 (0.72)	-0.36 (1.06)	2.69	ns
Butterfly	0.37 (0.81)	1.21 (1.08)	3.14	$p = 0.004$
Mushroom	0.11 (0.53)	0.10 (0.80)	-0.03	ns
Flower	0.80 (0.93)	0.99 (1.19)	0.65	ns
<b>Image rating – Arousal</b>				
Spider	<b>4.43 (1.49)</b>	1.06 (1.60)	-6.43	$p < 0.001$
Snake	0.39 (0.71)	0.80 (1.39)	1.18	ns
Butterfly	0.10 (0.33)	0.92 (1.61)	1.92	ns
Mushroom	0.17 (0.63)	0.65 (1.06)	1.72*	ns
Flower	0.18 (0.56)	0.64 (1.19)	1.60*	ns
<b>Image rating – Disgust</b>				
Spider	<b>4.94 (1.33)</b>	0.75 (0.98)	-11.81	$p < 0.001$
Snake	0.38 (0.66)	0.19 (0.52)	-1.50	ns
Butterfly	0.08 (0.32)	0.09 (0.34)	0.13	ns
Mushroom	0.27 (0.87)	0.28 (0.84)	0.02	ns
Flower	0.01 (0.05)	0.03 (0.18)	1.56*	ns

Note: Ratings on 6-point Likert scale (for valence ratings: -3 = "extremely unpleasant", 3 = "extremely pleasant"; for all other ratings: 0 = "not at all", 6 = "extremely"); ns = non significant; SPQ = Spider Questionnaire; FAS = Fear of Spiders Questionnaire; SNAQ = Snake Questionnaire; \*degrees of freedom adjusted due to unequal variance.

participants stated above.

In addition, all spider-fearful participants were tested for specific anxiety disorders using a structured diagnostic interview ("Diagnostic Interview for Psychological Symptoms (DIPS)"; Schneider & Margraf, 2006), based on the DSM-IV-TR (American Psychiatric Association, 2000). We wanted to make sure that no generalized anxiety disorder existed which may lead to a response bias. Also, we wanted to check which criteria were fulfilled for specific phobia, especially spider phobia. All fearful participants except one met at least four criteria for specific phobia. The criterion that was not satisfied in most cases (criterion E) states that the individual's fear, anxiety, or avoidance causes significant distress or significant interference in the person's day-to-day life. For this reason, we will refer to participants in the experimental groups as "fearful" instead of "phobic".

In contrast to phobic individuals, depressed patients do not show an attentional bias towards negative stimuli (Eizenman et al., 2003) and it is unclear how depression and anxiety interact in paradigms which measure attentional bias (Bar-Haim et al., 2007). Therefore, all participants completed the Beck Depression Inventory II (BDI-II; Beck, Steer, & Brown, 1996). Three of the participants (two spider-fearful, one control) were excluded for depression scores above 10 which indicate the existence of a mild depression. These participants are also already subtracted from the number of participants reported above.

### 2.1.2. Apparatus, stimuli and procedure

The participants were seated in a dimly lit room in front of a colour cathode-ray monitor (1280 × 1024 pixels, retrace rate 85 Hz) at a viewing distance of approximately 70 cm. Five different types of grayscale images (spiders, snakes, butterflies, mushrooms, and flowers), each containing thirty different pictures, were presented against a lighter gray background (8.75 cd/m<sup>2</sup>). Each trial started with the appearance of the central fixation point (Fig. 1). After a varying delay, the first stimulus was displayed for 35 ms either to the left or to the right of the fixation point at 3.74° eccentricity (1 mm ≈ 0.08° of visual angle).

The second stimulus was shown for 35 ms at the opposite side of the fixation point at SOAs of 0 ms, 12 ms, 24 ms, 35 ms, or 47 ms. Image size was 4.16 × 4.16°. In each trial, animals (spider, snakes, or butterflies) and neutral non-animals (flowers or mushrooms) were presented in pairs, resulting in three possible conditions: "spider with neutral stimulus" (*phobia condition*<sup>1</sup>), "snake with neutral stimulus" (*fear condition*), and "butterfly with neutral stimulus" (*control condition*). In each block, only one type of animal (but both types of non-animals) could appear. Blocks were presented in a pseudo-random order. In each session, 27 blocks consisting of 32 trials were presented. In order to minimize the influence of a potential response preference towards spiders, participants were instructed to indicate whether the animal (and not the specific animal, e.g., spider) or the non-animal-stimulus occurred first. They did this by pressing one of two keys on the computer keyboard (one for "animal first", one for "non-animal first", with the assignment reversed for half of the participants). Response keys were arranged vertically to counteract effects of spatial compatibility.

Although for stimuli presented in the same sensory modality and without attentional manipulation, the PSS should theoretically coincide with physical simultaneity (SOA = 0), several studies revealed at least small deviations of the PSS from physical simultaneity (e.g., vision: Shore et al., 2001; tactile modality: Yates & Nicholls, 2011). These deviations are probably due to the influence of low-level feature differences between the stimuli on temporal perception. Here, we avoid possible effects of low-level feature differences by computing a priority effect between a control and experimental group that are presented with exactly the same stimuli; these differences could otherwise lead either to over- or underestimation of prior entry.

Participants received visual feedback on the correctness of their responses after each block. Each participant performed two 1.5-h sessions. The first session started with the diagnostic screening, which was followed by a 1-h computer experiment. The second session started with another 1-h computer experiment and was followed by an evaluation of the stimuli regarding valence, arousal, and disgust. All dimensions were rated on a six-point rating scale. Scales were coded so that high scores reflected high arousal and disgust, respectively. Positive scores in the valence ratings represent positive emotions towards the image, a score of zero means that neither positive nor negative emotions are involved, and negative scores reflect negative emotions (Table 1). Table 1 shows that the spider-fearful group rated spider images as more negative, more unpleasant, and more disgusting compared to non-anxious control participants. The two groups differed significantly on all three dimensions (all  $p < 0.001$ ). Note that non-anxious control participants rated butterflies as more pleasant on the valence scale compared to spider-fearful participants.

### 2.1.3. Data treatment and statistical methods

Practice blocks were not analyzed. Univariate analyses of variance (ANOVAs) were performed with Greenhouse-Geisser-corrected  $p$  values. We report  $F$  values with subscripts indicating the respective effect (e.g.,  $F_{G \times C}$  for the interaction of group and stimulus condition). In addition to  $p$ -values, we provide Bayes Factors (e.g. Dienes, 2014; Lee & Wagenmakers, 2014; Rouder, Speckman, Sun & Morey, 2009; Rouder, Morey, Speckman & Province, 2012) for the critical calculations. Bayes Factors indicate how likely it is that the observed data occurred under the null hypothesis than under some alternative hypothesis (specifically, under prior probability distributions of possible hypotheses). Whether a Bayes Factor favours an alternative hypothesis or the null hypothesis is indicated by the subscript of the Bayes Factor  $BF_{01}$  for the null hypothesis and  $BF_{10}$  for the alternative hypothesis. For instance, a Bayes Factor  $BF_{10}$  of 4 would indicate that the data are four times more likely under some alternative hypothesis than under the null hypothesis, whereas as a Bayes Factor  $BF_{01}$  of 4 would indicate that the data

<sup>1</sup> Note that conditions were named with respect to the spider-fearful group.

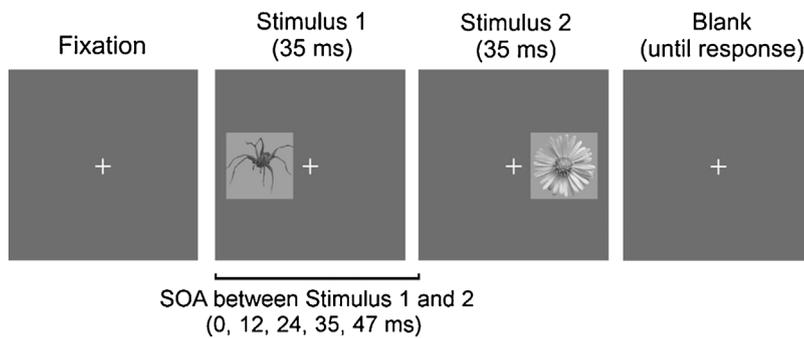


Fig. 1. Stimuli and Procedure. Stimulus 1 and 2 were presented at varied SOAs in the sequence displayed. The participants' task was to indicate which of the stimuli (animal or non-animal) was presented first (Experiment 1) or which of the stimuli was presented second (Experiment 2).

are four times more likely under the null hypothesis. For practical purposes Bayes Factors larger than 3 can be considered as “moderate” evidence for the alternative hypothesis or the null hypothesis. Bayes Factors larger than 10 provide “strong” evidence for the alternative hypothesis or the null hypothesis (e.g. Dienes, 2014; Lee & Wagenmakers, 2014). All Bayes Factors were Scaled-Information Bayes Factors with a scaling factor of  $r = 0.707$  appropriate for smaller expected effect sizes (Rouder et al., 2009; Rouder et al., 2012). The Bayes Factors were calculated by the R-package provided by Rouder and colleagues and can also be calculated by the online tool provided by Rouder and colleagues <http://pcl.missouri.edu/bayesfactor>. Psychometric functions for each of the three experimental conditions (“spider vs. neutral stimulus”/phobia condition, “snake vs. neutral stimulus”/fear condition, “butterfly vs. neutral stimulus”/control condition) were approximated by the Palamedes Matlab Toolbox (Version 1.6.3, Prins & Kingdom, 2009). Two parameters were derived from each resulting psychometric function: the PSS and the difference limen (DL) as a measure of temporal discrimination accuracy.

2.2. Results

Firstly, we performed a mixed analysis of variance (ANOVA) of PSS-values with the between-subjects factor *group* ( $G$ , non-anxious control vs. spider-fearful participants) and the within-subjects factor *condition* ( $C$ , phobia condition, fear condition, and control condition). None of the main effects was significant: main effect of group,  $F_G(1, 26) = 0.53, p = 0.47, \eta_p = 0.02$  and the main effect of condition,  $F_C(1.27, 33.09) = 2.54, p = 0.11, \eta_p = 0.09$ . The interaction  $Group \times Condition$  was significant,  $F_{G \times C}(1.27, 33.09) = 5.20, p < 0.05, \eta_p = 0.17$ . Bonferroni-adjusted post-hoc comparisons revealed that this interaction was due to a significant difference between the control group and the spider-fearful group in the phobia condition as well as significant differences within the spider-fearful group between the phobia and the fear condition and the phobia and the control condition. Specifically, the spider-fearful participants showed a larger PSS-value ( $M = 6.02$ ) than the participants of the control group ( $M = -0.41$ ),  $t(26) = -2.07, p < .05, BF_{10} = 2.274$ , suggesting a *between-group-prior-entry effect* for spiders of about 6.5 ms. Note however, that this between-group prior-entry effect should be treated with caution because the Bayes Factor below 3 (Dienes, 2014; Lee & Wagenmakers, 2014) indicates that although the effect is statistically significant, the data might be too noisy to derive a decision for the effect with certainty. Furthermore, spider-fearful participants had larger PSS-values for the phobia condition ( $M = 6.02$ ) than for the fear condition ( $M = -0.99$ ) and the control condition ( $M = -0.76$ ). This suggests that spider-fearful participants processed spider pictures 6.5 ms faster than control participants (Fig. 2) and about 7 ms faster than pictures of butterflies and snakes. Secondly, we analyzed DL-values with the same ANOVA and found no differences in temporal discrimination performance between spider-fearful and control participants or between different types of images (main effect of group:  $F_G(1, 26) = 0.01, p = 0.92, \eta_p = 0.00$ ; main effect of condition,  $F_C(2, 52) = 0.60, p = 0.55, \eta_p = 0.02$ ;

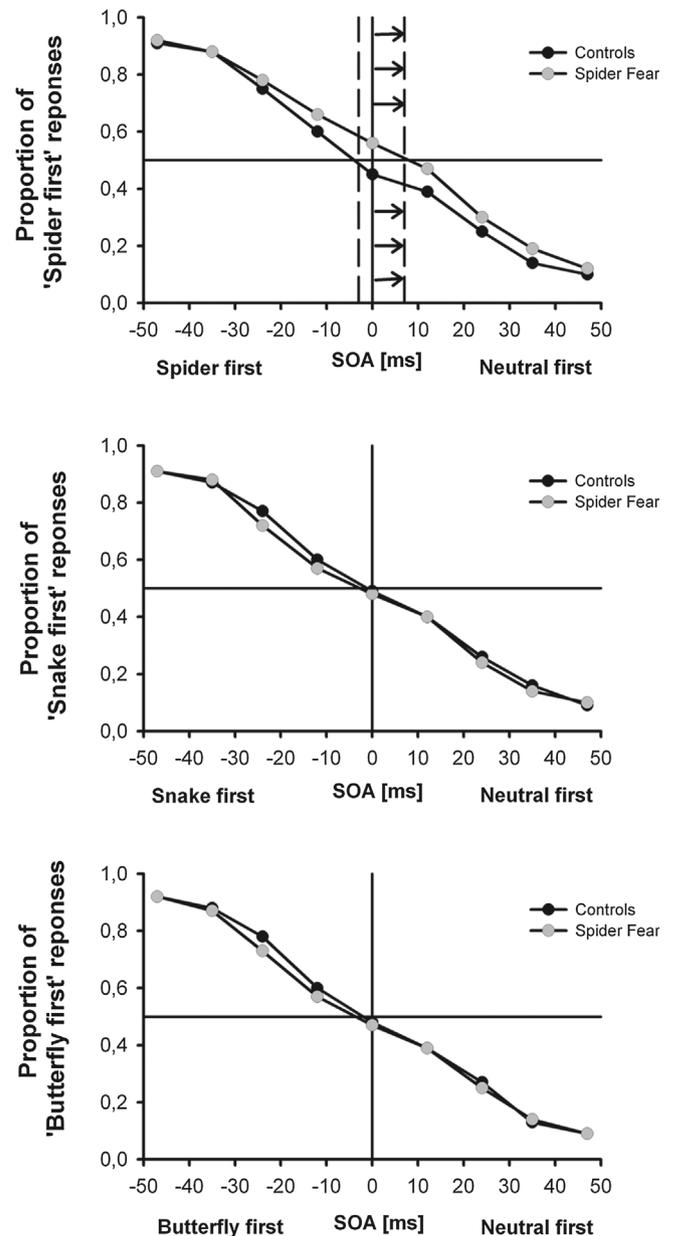


Fig. 2. In each panel, proportion of ‘animal first’ responses are plotted as a function of SOA between the two images (negative SOAs indicating that the animal picture was presented first). Neutral stimuli (flowers or mushrooms) were presented together with spiders (phobia condition), snakes (fear condition), or butterflies (control condition). Results of the two groups are indicated by the gray (spider-fearful group) and black dots (control group). Note that the plots here and in all remaining figures are based on the raw data. Therefore, the differences between the plotted lines can differ from those between the fitted functions.

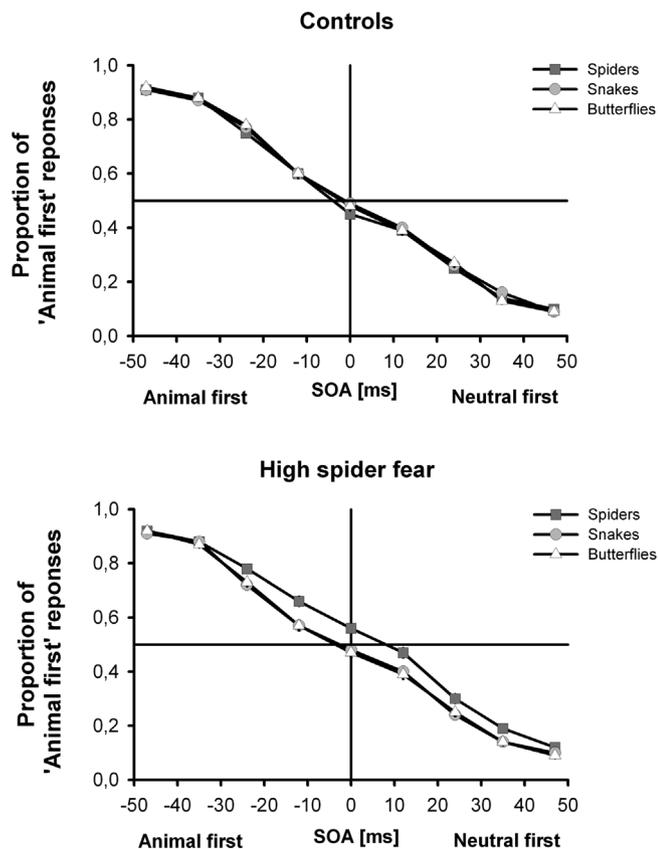


Fig. 3. Responses are plotted for the two different groups (Upper panel: non-anxious controls, lower panel: high spider fear). Each line indicates one condition (rectangles: phobia condition/spiders, circles: fear condition/snakes, and triangles: control condition/butterflies).

interaction,  $F_{G \times C}(2, 52) = 0.58, p = 0.57, \eta_p = 0.02$ .

To test whether spider stimuli are processed faster than neutral stimuli, dependent-samples  $t$ -tests were calculated for PSS-values of the phobia and the control condition for each group. No significant difference was found in the control group (phobia condition:  $M = -0.41$  vs. control condition:  $M = 0.81, t(13) = -1.51, p = 0.154, BF_{01} = 1.06$ ). There was a marginally significant difference (albeit prior to Bonferroni correction) in the spider-fearful group (phobia condition:  $M = 6.02$  vs. control condition:  $M = -0.76, t(13) = 2.05, p = 0.062; BF_{10} = 1.90, Fig. 3$ ). Neither group showed any difference between the merely fear-relevant snake and the control pictures, both  $t < 1$ , (control group:  $t(13) = 0.02, p = 0.99, BF_{01} = 2.83$ ; spider-fearful group:  $t(13) = -0.26, p = 0.80, BF_{01} = 2.74$ ).

As a measure of task reliability, we report split-half reliabilities for PSS-values and DL-values in the Appendix.

### 2.3. Discussion

The purpose of Experiment 1 was to investigate whether the attentional bias towards spiders that was reported in recent studies for individuals with spider phobia (e.g., Mogg & Bradley, 2006; Rinck & Becker, 2006) is strong enough to trigger a prior-entry effect. There are two possibilities how such a prior-entry effect could show up in the data: First, *between* groups – spider-fearful participants should process spider images faster than non-anxious control participants – and secondly, *within*-groups – spider-fearful individuals should process spider images faster compared to images of butterflies. The results of Experiment 1 suggest that spider-fearful participants processed spiders 6.5 ms faster than non-anxious control participants did, and 7 ms faster than neutral images. This effect has a magnitude comparable to the one

elicited by threatening faces in the study by West et al. (2009). They reported prior-entry effects ranging from 6 to 8 ms for pictures of schematic faces, and one exceptional large prior-entry effect of 18 ms for pictures of real faces.

However, unfortunately the results of Experiment 1 do not allow a decision about prior-entry for spiders with certainty due to two reasons: First, the results might also be explained by a preference of spider-fearful participants for the “spider” response option whenever a spider image is presented (here, the “spider first” response; Becker & Rinck, 2004). If spider-fearful participants are biased towards choosing the spider-related response (relative to non-fearful participants), the effect of this response bias on the psychometric function would be indistinguishable from a genuine prior-entry effect. Second, although we obtained a significant *between*-group prior-entry effect for spiders in Experiment 1 and a marginally significant *within*-group prior-entry effect, the Bayes Factors ( $< 3$ ) of both effects indicate that the data of Experiment 1 might be too noisy to draw a conclusion about the effects with certainty. Therefore, we tried to replicate the results of Experiment 1 under conditions that allow distinguishing between a real prior entry effect and response bias with a slightly larger effect size than in Experiment 1.

### 3. Experiment 2

To replicate the Results of Experiment 1 and test the possible alternative explanation of a response bias for spiders, we conducted Experiment 2 using the same stimuli and SOAs with a new and larger set of participants; only this time we changed the instruction to asking which of the two stimuli was presented *second*. In case the prior-entry effect of Experiment 1 was driven by an attentional bias, spider-fearful participants would perceive spiders as occurring earlier in time and, thus, indicate less often to have seen a spider second in comparison to neutral stimuli (within-group prior-entry effect) as well as compared to the non-anxious control group (between-group prior-entry effect). In contrast, a general preference for the spider-related response would lead to the paradoxical effect that spider-fearful individuals were now more likely to indicate that the spider appeared second.

#### 3.1. Methods

##### 3.1.1. Participants

Thirty-nine new participants recruited through the University of Kaiserslautern took part in the experiment. All participants had normal or corrected-to-normal visual acuity and received 7 € per hour as payment. In addition, all of them gave informed consent and were treated in accordance with the ethical guidelines of the American Psychological Association. They were naïve to the purpose of the current study.

Before the experiment was run, participants were screened for fear of spiders or snakes as reported in Experiment 1 using the SPQ, FAS, and SNAQ. They also filled out the BDI-II to control for depression (Table 2). All of the questionnaires were administered anonymously and on-screen using Presentation® software. Immediately afterwards the program informed the participants about their group affiliation assignment (spider-fearful group, control group, or exclusion).

Based on the questionnaires, participants were divided into an experimental group of nineteen *spider-fearfuls* (11 women and 8 men, mean age 24.5) and a control group of twenty *non-anxious* participants (13 women and 7 men, mean age 23.7). Like in Experiment 1, all spider-fearful participants were tested for specific anxiety disorders using a structured diagnostic interview (“Diagnostic Interview for Psychological Symptoms (DIPS)”; Schneider & Margraf, 2006). Seven spider-fearful participants met all six criteria, nine participants met at least five criteria, two met at least four and only one met only three criteria for specific phobia.

One participant from the experimental group was excluded due to a

**Table 2**

Mean scores (and standard deviations) for two spider questionnaires (SPQ, FAS) and one snake questionnaire (SNAQ) and for image evaluation (valence, arousal, and disgust). The evaluation is illustrated for each stimulus type and each group (spider-fearful participants and control group). Bold letters indicate phobic image categories.

	Spider Fear	Controls	t(37)	p
<b>Measure</b>				
SPQ	20.11	2.50	-16.11*	p < 0.001
FAS	67.79	4.10	-15.43*	p < 0.001
SNAQ	4.95	3.35	-2.04	p = 0.049
BDI-II	4.05	3.60	-0.51	ns
Age	24.53	23.70	-0.85	ns
<b>Image rating – Valence</b>				
Spider	<b>-2.21 (0.41)</b>	-0.17 (0.98)	8.56*	p < 0.001
Snake	0.07 (1.00)	0.11 (0.79)	0.13	ns
Butterfly	1.52 (0.84)	1.02 (0.73)	-1.96 <sup>a</sup>	ns
Mushroom	0.17 (1.15)	0.12 (0.54)	-0.16 <sup>a</sup>	ns
Flower	1.26 (1.33)	1.00 (0.69)	-1.8	ns
<b>Image rating – Arousal</b>				
Spider	<b>4.35 (0.98)</b>	0.97 (1.12)	-9.98	p < 0.001
Snake	0.84 (0.65)	0.72 (0.96)	-4.7	ns
Butterfly	0.20 (0.28)	0.21 (0.28)	0.12 <sup>a</sup>	ns
Mushroom	0.25 (0.32)	0.23 (0.44)	-0.11 <sup>a</sup>	ns
Flower	0.26 (0.38)	0.18 (0.29)	-0.66	ns
<b>Image rating – Disgust</b>				
Spider	<b>4.80 (0.76)</b>	1.37 (1.37)	-9.75*	p < 0.001
Snake	0.44 (0.55)	0.50 (0.78)	0.28	ns
Butterfly	0.17 (0.23)	0.12 (0.26)	-0.64 <sup>a</sup>	ns
Mushroom	0.53 (0.68)	0.37 (0.77)	-0.65 <sup>a</sup>	ns
Flower	0.08 (0.13)	0.07 (0.21)	-0.13	ns

Note: Ratings on 6-point Likert scale (for valence ratings: -3 = “extremely unpleasant”, 3 = “extremely pleasant”; for all other ratings: 0 = ‘not at all’, 6 = “extremely”); ns = non significant; SPQ = Spider Questionnaire; FAS = Fear of Spiders Questionnaire; SNAQ = Snake Questionnaire; BDI-II = Beck Depression Inventory II; <sup>a</sup>reduced degrees of freedom due to missing data of one participant t(35); \*degrees of freedom adjusted due to unequal variance.

technical problem recording the data. This participant is already subtracted from the number of participants reported above.

3.1.2. Apparatus, stimuli and procedure

Apparatus, stimuli, and procedure were identical to Experiment 1 (Fig. 1), with two exceptions. Firstly, we changed the instructions so that participants now had to decide whether the animal or the non-animal stimulus was presented *second*. Secondly, we extended the longest SOA from 47 ms to 59 ms to ensure that all participants were well able to discriminate the temporal order at this SOA.

Table 2 shows that the spider-fearful group rated spider stimuli as more negative, more unpleasant, and more disgusting compared to non-anxious control participants. Regarding the image ratings the two groups differed significantly in their evaluations on all three dimensions (all p < 0.001).

3.1.3. Data treatment and statistical methods

See Experiment 1.

3.2. Results

As in Experiment 1, we first performed an ANOVA of PSS-values with the between-subjects factor *group* (G, non-anxious control vs. spider-fearful participants) and the within-subjects factor *condition* (C, phobia condition, fear condition, and control condition). The main effect of Condition,  $F_C(1.53, 56.65) = 3.70, p < 0.05, \eta_p = 0.09$  and the main effect of Group,  $F_G(1, 37) = 7.29, p < 0.05, \eta_p = 0.17$  were significant, as well as the interaction Group × Condition,  $F_{G \times C}(1.53, 56.65) = 4.90, p < 0.05, \eta_p = 0.12$ . Bonferroni-adjusted post-hoc comparisons revealed that the main effect of Condition was due to a marginally significant difference between the phobia condition and the control condition: The PSS value in the control condition ( $M = 0.03$ )

was larger than in the phobia condition ( $M = -2.17$ ), indicating that participants (spider-fearful and control participants pooled) reported spiders to appear *later* than butterflies. The main effect of Group was due to a significant difference between spider-fearful ( $M = -3.74$ ) and control participants ( $M = 1.59$ ), indicating that spider-fearful participants reported to see all animals (including spiders) about 5.5 ms later than control participants (i.e., opposite to the effect in Experiment 1). The interaction was due to significant differences between spider-fearful participants and control participants in the phobia condition ( $M = -6.21$  vs.  $M = 1.86, t(37) = 2.92, p < 0.01, BF_{10} = 10.21$ ) and in the fear condition ( $M = -3.51$  vs.  $M = 1.34, t(37) = 2.56, p < 0.05, BF_{10} = 5.20$ ), as well as a marginally significant difference in the control condition ( $M = -1.50$  vs.  $M = 1.56, t(37) = 1.75, p = 0.09, BF_{10} = 1.43$ ); Fig. 4. Also, analyses within the spider-fearful group showed a significant difference between the phobia condition

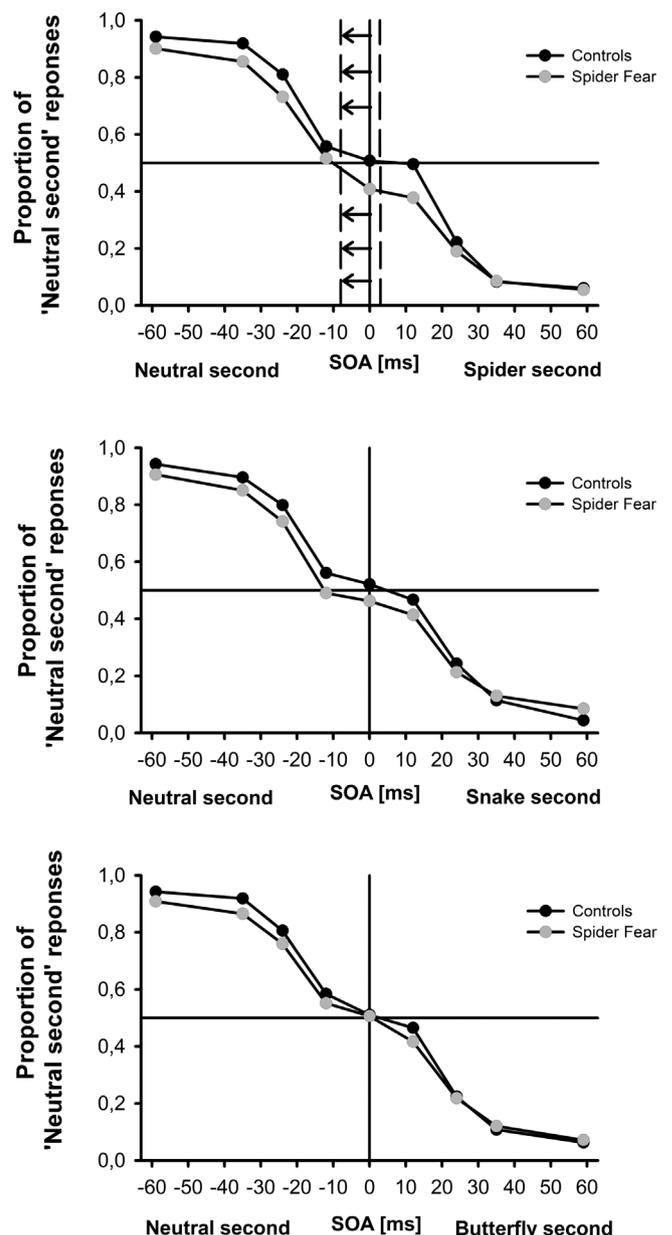


Fig. 4. In each panel, proportion of ‘non-animal second’ responses is plotted as a function of SOA between the two images (negative SOAs indicating that the neutral picture was presented second and animal picture first, respectively). Neutral stimuli (flowers or mushrooms) were presented together with spiders (phobia condition), snakes (fear condition), or butterflies (control condition). Results of the two groups are indicated by the black (control group) and gray dots (spider-fearful group).

and the control condition ( $M = -6.21$  vs.  $M = -1.50$ ) as well as a marginally significant difference between the phobia and the fear condition ( $M = -6.21$  vs.  $M = -3.51$ ). In other words, spider-fearful participants reported to see spiders about 5 ms later than butterflies, and spiders (about 8 ms) and snakes (about 5 ms) later than participants in the control group. Secondly, we analyzed DL-values with the same ANOVA and found a marginally significant main effect of condition,  $F_C(1.64,60.81) = 2.61$ ,  $p = 0.092$ ,  $\eta_p = 0.07$  and a marginally significant interaction of Condition x Group  $F_{G \times C}(1.64,60.81) = 3.08$ ,  $p = 0.063$ ,  $\eta_p = 0.08$ . Bonferroni-adjusted post-hoc comparisons revealed that the interaction was due to a significant difference in temporal discrimination between spiders ( $M = -22.87$ ) and snakes ( $M = -26.09$ ) in the spider-fearful group as well as a marginally significant difference between spider-fearful participants and participants in the control group for the fear condition ( $M = -21.71$  vs.  $M = -26.09$ ). This implies that temporal discrimination for spiders was better than for snakes in the spider-fearful group and that the temporal discrimination for snakes was better in the non-anxious control group than in the spider-fearful group.

To test whether spider stimuli were reported to be perceived earlier than neutral stimuli, dependent-sample  $t$ -tests were calculated for PSS-values of the phobia and of the control condition for each group. No significant difference was found in the control group (phobia condition:  $M = 1.86$  vs. control condition:  $M = 1.56$ ,  $t(19) = .25$ ,  $p = 0.80$ ,  $BF_{01} = 3.22$ ). However, there was a significant difference in the spider-fearful group (phobia condition:  $M = -6.21$  vs. control condition:  $M = -1.50$ ,  $t(18) = -2.98$ ,  $p < 0.01$ ,  $BF_{10} = 9.01$ ; Fig. 5). To test for a prior-entry effect for merely fear-relevant snakes in the spider-fearful or control group, dependent-samples  $t$ -tests for PSS-values in the fear and control conditions were calculated for each group. The  $t$ -test was not significant for the control group ( $t(19) = -0.33$ ,  $p = 0.75$ ,

$BF_{01} = 3.15$ ), but for the spider-fearful group (fear condition:  $M = -3.51$  vs. control condition:  $M = -1.50$ ,  $t(18) = -2.16$ ,  $p < 0.05$ ,  $BF_{10} = 2.19$ ). Note that this difference is only marginally significant after Bonferroni correction whereas the difference between the phobia condition and the control condition remains significant. Note that all significant differences are opposite in sign compared to prior-entry effects for spider images.

Again, we report split-half reliabilities for PSS-values and DL-values in the Appendix.

### 3.3. Discussion 2

In Experiment 1, we asked participants which of the two stimuli (animal vs. non-animal) was presented *first*. In line with an anticipated prior-entry effect for spiders, spider-fearful individuals indicated more frequently to have seen the spider first in comparison to non-anxious individuals and to neutral images, suggesting a prior-entry effect for phobic images. However, these results could also be explained by a response preference or response bias in spider-fearful individuals, and the results did not appear to be statistically robust. Thus, we conducted the second experiment as a conceptual replication and control experiment and indeed found that spider-fearful participants now indicated more frequently to have perceived the spider *second* in comparison to the butterflies of the control condition, and also in comparison to non-anxious participants. Thus, whereas Experiment 1 suggests a prior-entry effect of phobic stimuli, Experiment 2 demonstrates an effect of opposite sign which is also statistically more robust. Taken together, these findings show that spider-fearful participants have a general tendency to prefer the spider-related response, irrespective of whether this response means “spider first” or “spider second”.

## 4. General discussion

The present study is based on previous findings that fear-relevant and phobic stimuli automatically capture attention (Yiend, 2010). Based on the study by West et al. (2009) we used a prior-entry paradigm to investigate whether spider images automatically capture attention in spider-fearful individuals or whether the effects are merely based on a preference for the spider-related response (e.g., Jaśkowski, 1993; Stelmach & Herdman 1991). We observed a response pattern in line with a general response preference for the spider-related response option: Spider-fearful participants not only preferred the response indicating that spiders appeared *first* (suggesting a prior-entry effect; Exp. 1), but also the response indicating that spiders appeared *second* (which would suggest the exact opposite effect; Exp. 2). This response bias is specific to phobic images as it was neither observed in control participants nor with fear-related (but not phobic) or neutral stimuli. Clearly, it is irreconcilable with a genuine prior-entry effect as previously proposed for emotional faces (Fecica & Stolz, 2008; West et al., 2009). However, our finding is in line with results by Schettino and colleagues (2013) who conducted a series of five carefully controlled experiments to replicate prior-entry effects for fear-relevant faces but failed. Therefore, our findings cast further doubt on the idea that fear-relevant and phobic stimuli automatically elicit a prior-entry effect. Thereby, our results are in contrast to studies reporting attentional capture or preferential processing for other emotionally relevant stimuli, like emotional faces (e.g., Eastwood et al., 2001; Fox et al., 2000). How can this be explained?

The lack of an effect of our fear-relevant stimuli (pictures of snakes) is easy to explain: the pictures might have failed to reach emotional significance in either group, as indicated by neutral valence and low arousal and disgust ratings. Consequently, they would not be expected to capture attention. Still, this finding fits the mixed evidence for attentional effects of fear-relevant stimuli – at least in non-anxious control participants. Such attentional effects have been found in some studies (Fox et al., 2000; Lipp & Waters, 2007; Öhman et al., 2001;

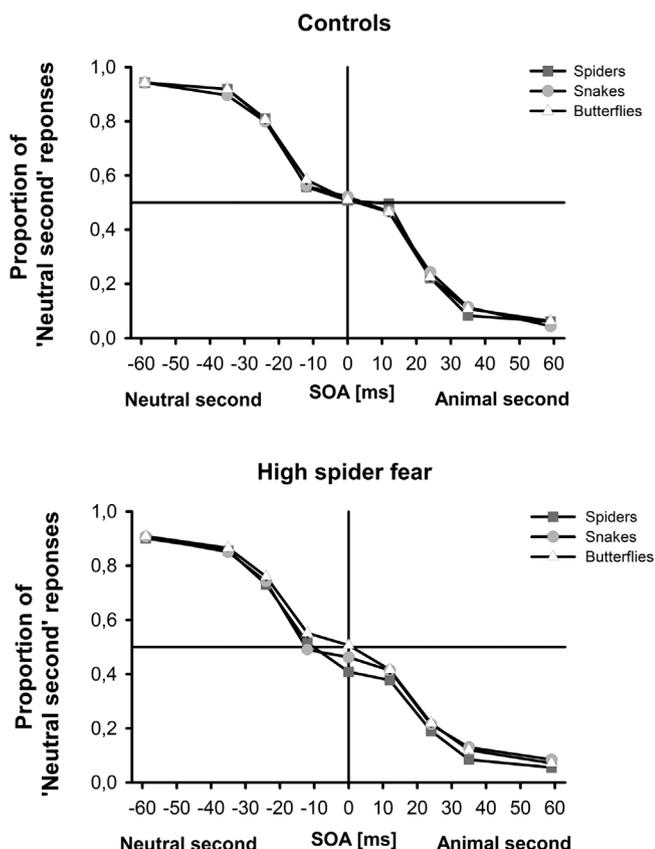


Fig. 5. Responses are plotted for the two different groups. Each line indicates one condition (rectangles: phobia condition/spiders, circles: fear condition/snakes, and triangles: control condition/butterflies).

Williams, Moss, Bradshaw, & Mattingley, 2005) but not in others (Haberkamp et al., 2013; Tipples, Young, Quinlan, Broks, & Ellis, 2002; Schmidt & Schmidt, 2013).

At the same time, a lack of emotional significance does not explain the effects for the phobic stimuli (naturalistic pictures of spiders) in the spider-fearful participants. Those stimuli are bound to be more effective in eliciting an emotional response than those typically used in most previous studies (e.g., schematic faces presented to non-fearful individuals). Thus, attentional capture in that specific case should definitely be stronger, not weaker, than in West et al.'s experiments.

#### 4.1. Methodological considerations

In accordance with the procedure used by West et al. (2009) we did not visually cue the stimuli but assumed that they would automatically capture attention and thus elicit a prior entry effect. The SOAs were comparable to those in West et al. (2009) to capture the full range of the psychometric function. Additionally, the two response buttons were aligned on a vertical axis to prevent effects of spatial stimulus-response compatibility (Schneider & Bavelier, 2003). However, one possible explanation for the discrepancy between our results and those by West et al. might be the lack of a control condition in their experiments. They calculated prior-entry effects as PSS-deviations from zero, not as the differences in PSS-values between an emotionally relevant and a non-emotional control condition. Thus, prior-entry effects were not corrected for possible non-emotional influences; for example, differences in low-level features between the different target stimuli. However, such low-level feature differences can produce non-zero PSS-values also in control conditions (Shore et al., 2001; Yates & Nicholls, 2011). Consequently, calculating a prior-entry effect as PSS-deviation from zero may under- or overestimate the true magnitude of the prior entry effect.

If we assume that phobic stimuli do not produce genuine prior-entry effects when including sufficient control conditions, it is still not clear why previous studies did find attentional effects of fear-relevant or phobic stimuli (Bar-Haim et al., 2007). We suggest that this might follow from an insufficient sensitivity of temporal order judgments (TOJs) compared to other experimental paradigms. A prominent factor that distinguishes TOJs and prior-entry paradigms from many other paradigms is the unlimited response time. As a result of that, participants are able to use post-perceptual cognitive strategies like specific response tactics to complete the task – consequently, the processing of the emotionally relevant information involves later stages of stimulus processing where top-down rather than bottom-up mechanisms influence participants' responses. This might prevent early and automatic attentional capture to show in temporal-order judgments compared to other paradigms with speeded responses.

#### 4.2. Response preference in spider fear: limitations and implications for future studies

The aim of the current study was to replicate findings that threatening stimuli capture attention (West et al., 2009; Fecica & Stolz, 2008) and therefore generate a prior-entry effect in spider-fearful participants. Thus, our design was based on the study by West et al. (2009) with additional control conditions. Even though in Experiment 1 only 14 individuals per group participated – fewer than in West et al. (2009) – we countered this limitation by including two sessions with twice as many trials as in West et al. (2009). These changes allowed for precise estimates of the parameters of the psychometric functions, and also for calculating the prior-entry effect relative to the relevant control conditions. In Experiment 1, the SOAs ranged from 0 (where the two pictures were presented simultaneously) to 47 ms. The longest SOA turned out to be too short for some of the participants to correctly identify the presented order of pictures. Thus, in Experiment 2, we extended the longest SOA to 59 ms, and indeed the accuracy of

responses increased accordingly, which improved the statistical fit of the psychometric functions. Finally, the experimental group was a subclinical rather than a clinical sample; that is, not all of the spider-fearful participants met all the criteria to be diagnosed as having clinically relevant spider phobia. This was due to practical recruiting reasons. However, we suppose that the observed effect should be even more pronounced in individuals with clinical spider phobia. Thus, testing subclinical spider-fearful individuals might rather underestimate than overestimate the observed response bias. Also, we observed strong effects of feared stimuli in previous studies with subclinical samples in spider as well as blood-injury-injection phobia (cf. Haberkamp & Schmidt, 2014; Haberkamp et al., 2013; Haberkamp & Schmidt, 2015), showing that subclinical samples are sufficient to demonstrate similar effects.

In sum, our findings clearly suggest that spider-fearful participants prefer the response option associated with spiders, irrespective of whether this response indicates “spider appeared first” or “spider appeared second”. This is in line with a study by Becker and Rinck (2004), who used a signal-detection paradigm to show that spider-fearful individuals did not have higher sensitivity for detecting masked spider stimuli (in comparison to neutral butterflies) but rather exhibited a more liberal criterion to indicate that they had seen a spider. Similarly, spider-fearful individuals are more likely to classify visually ambiguous stimuli as spiders (Haberkamp & Schmidt, 2015; Kolassa et al., 2007). Here, we demonstrate that this response bias can mimic a prior-entry effect in TOJ tasks where observers are merely asked whether the fear-related image appeared *first*. To disentangle potential attentional effects of fear-relevant or phobic stimuli from a mere response bias it is critical to include a control task that asks whether the fear-related image appeared *second*, with opposite effects in both tasks effectively ruling out explanations in terms of a genuine prior-entry effect.

Finally, we want to point out that a response bias towards spiders may have clinical relevance for the development of the phobia. A possible advantage of response bias is that spider-fearful individuals detect spiders sooner and more easily than non-fearful individuals, allowing them to anticipate a potential encounter and giving them more control over it. Paradoxically, this measure of precaution would also lead to a higher number of “false scares”, which in turn would increase alertness, stress levels, and the motivation to avoid the feared stimulus. A response bias towards phobic stimuli is therefore protecting individuals with specific phobias on a short-term basis but is likely contributing to maintain the phobia on a long-term basis.

#### Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.janxdis.2017.10.008>.

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