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Elinor Abado: Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration

Jasmin Sagi: Conceptualization, Methodology, Software, Validation, Investigation, Formal Analysis, Investigation, Writing - Original Draft

Nir Silber: Conceptualization, Methodology, Software, Validation, Investigation, Writing - Original Draft

Jan De Houwer: Conceptualization, Writing - Original Draft, Writing - Review & Editing

Tatjana Aue: Conceptualization, Methodology, Software, Writing - Original Draft, Writing - Review & Editing

Hadas Okon-Singer: Conceptualization, Methodology, Software, Validation, Resources, Writing - Original Draft, Writing - Review & Editing, Supervision, Funding acquisition

# Reducing attention bias in spider fear by manipulating expectancies

Elinor Abado[1,2], Jasmine Sagi[1,2], Nir Silber[1,2], Jan De Houwer[3], Tatjana Aue[4] and Hadas Okon-Singer[1,2]

1 – Department of Psychology, School of Psychological Sciences, University of Haifa, Haifa, Israel.

2 - The Integrated Brain and Behavior Research Center (IBBR), University of Haifa, Haifa, Israel.

3 - Department of Experimental Clinical and Health Psychology, Ghent University, Ghent, Belgium.

4 - Department of Psychology, University of Bern, Bern, Switzerland.

Correspondence:

Elinor Abado

University of Haifa

School of Social Sciences

Department of Psychology

Abba Khoushy Ave 199

Haifa, 3498838

eabado@staff.haifa.ac.il

Abstract

The present series of studies examines the causal interaction between expectancy and attention biases in spider fear. Previous studies found that a-priori expectancy does not affect attention bias toward spiders, as measured by detection of spider targets in a subsequent visual search array compared to detection of bird targets (i.e. neutral targets) that appeared equally often. In the present series of studies, target frequency was manipulated. Targets were preceded by a verbal cue stating the likelihood that a certain target would appear. The aim was to examine whether manipulation of expectancies toward either target affects attention bias. In Experiment 1, birds appeared more frequently than spiders. Among a representative sample of the student population, attention bias toward spiders was significantly reduced. Experiment 2 replicated these results with both low- and high-fearful participants. In Experiment 3, spiders appeared more frequently than birds. Attention bias was reduced among low- and high-fearful groups, but not as strongly as the reduction in Experiments 1 and 2. These results suggest that target salience plays a role in attention bias, in competition with expectancy. To our knowledge, this is the first study to show that varying expectancy can reduce attention bias, most importantly in high fear.

*Keywords*: spider phobia, attention, expectancy, bias, cognitive factors.

## Introduction

### Spider Phobia and Cognitive Biases

Specific phobia is the most prevalent anxiety disorder (Bandelow & Michaelis, 2015). Of the different types of specific phobia, animal phobia is one of the most prevalent (Stinson et al., 2007). As is the case with other anxiety disorders, animal phobia can cause impairments in everyday life, such as active avoidance of the feared stimulus and anxiety that is disproportional to the actual potential danger of encountering said stimulus (American Psychiatric Association, 2013).

The current article focuses on the causal relationship between expectancy bias and attention bias in spider phobia. Both of these biases have been shown to play major roles in the etiology and maintenance of anxiety disorders (for a review on attention bias toward negative stimuli, see Abado, Richter, & Okon-Singer, 2020; Okon-Singer, 2018; for a review on aversive anticipation in anxiety, see Grupe & Nitschke, 2013; for a review on both biases, see Aue & Okon-Singer, 2015). *Attention bias* is manifested in faster engagement with feared stimuli than with neutral stimuli (e.g., Mogg & Bradley, 2006), slower disengagement from feared stimuli compared to neutral ones (e.g., Yiend & Mathews, 2001) and avoidance of the feared stimuli (Cisler & Koster, 2010). Attention bias toward feared stimuli has also been found when the allocation of attentional resources to this stimulus deteriorates performance (Okon-Singer, Alyagon, Kofman, Tzelgov, & Henik, 2011; Exp. 1). It is important to note that attention bias exists in healthy populations as well, but it is more severe in clinical and sub-clinical populations (for reviews, see Abado et al., 2020 and Aue & Okon-Singer, 2015).

Encounter expectancy bias (henceforth expectancy bias) entails overestimation of the likelihood of encountering the feared stimulus. In the case of spider phobia,

expectancy bias occurs when individuals with spider phobia overestimate the likelihood of encountering a spider compared to non-fearful individuals (Aue & Hoeppli, 2012; see also Aue, Hoeppli, Piguet, Hofstetter, Rieger, & Vuilleumier, 2015).

Although both attention biases and expectancy biases are well-established in anxiety, only a few studies have examined possible relations between these biases. Aue, Guex, Chauvigné, and Okon-Singer (2013) investigated the influence of prior expectancies on attention deployment among participants with and without spider phobia. Expectancies were manipulated using a verbal cue indicating the likelihood that a certain target stimulus (i.e. a deviant picture among distractors) would appear in a subsequent visual search array. These cues included a spider cue ("spider 90%"), a non-threatening cue ("bird 90%") and an ambiguous cue ("spider-bird 50%" or "bird-spider 50%"). After receiving the cue, participants were shown a visual search array that contained nine pictures, including one target picture—bird or spider—which appeared among eight non-threatening distractors (pictures of butterflies). Specifically, each trial included eight pictures of butterflies and one picture of a spider or a bird. The results showed that while bird cues resulted in faster reaction times (RTs) to bird targets than did spider cues, spider detection was not influenced by the preceding cue in either group of participants. Moreover, RTs to spider targets were faster than RTs to bird targets in both groups—those with spider phobia and controls—corroborating the well-known attention bias for spiders (Aue et al. 2013a; Cisler & Koster, 2010). These results were replicated in a study examining physiological measures (Aue, Chauvigné, Bristle, Okon-Singer, & Guex, 2016), as well as in a recent functional magnetic resonance imaging (fMRI) study (Aue, Guex, Chauvigné, Okon-Singer, & Vuilleumier, 2019), suggesting that prior expectancies

have a restricted influence on attention deployment to threat. These studies show that while participants use cues to detect birds, cues do not influence the detection of spiders.

Current Set of Studies

In our previous studies, when bird and spider targets appeared equally often, expectancy only affected the detection of bird targets, while detection of spider targets remained unaffected. In the present set of studies, we therefore sought to examine whether manipulating the frequency of each type of cue and target can modulate this robust attention bias toward spider targets. For instance, making the appearance of spider cues and targets less likely might decrease their overall salience. Thus, we manipulated the frequencies of both types of targets, as birds appeared more often in Experiments 1 and 2, and spiders appeared more often in Experiment 3.

Such a manipulation might therefore hamper the elicitation of the "default" response for spider detection that was present during equal probability presentation of the stimuli. Specifically, in the first experiment, we examined a condition in which bird targets appear more often than spider targets (71% of trials), while maintaining the same cue congruency rate as in our previous studies (the target was correctly announced by the preceding cue in 71% of the cases). This experiment was conducted using a representative sample of students. The second experiment used the exact same paradigm as the first experiment, but additionally divided participants into groups characterized by low vs. high fear of spiders. In order to examine whether specific findings in these two experiments were due to the presence of more neutral compared to threatening targets, or due to the unbalanced frequencies in general, the third and final experiment employed the

exact same paradigm among low and high fearful participants – the only difference being that spider rather than bird targets were presented on 71% of trials.

Experiment 1

The aim of Experiment 1 was to test whether the robust attention bias toward spider, compared to bird targets, can be reduced by modulating the target frequency. To this end, we used a higher proportion of both bird cues and bird targets. Thus, while in previous studies participants reacted according to the preceding cue only when bird targets appeared, in the current study we examined whether increasing the proportions of bird cues and targets would enable participants to react according to the preceding cue when viewing spider targets as well.

Method

**Participants.** Twenty-eight students from the University of Haifa (3 males; $M_{age}$ = 23.24, standard deviation (*SD)* = 4.45) took part in the experiment in exchange for course credit or payment. Power analysis using the G*Power software (version 3.1.9.4; Faul, Erdfelder, Buchner, & Lang, 2009) reveals that to reach standard power (0.8) with 0.05 error probability and using the "as in SPSS" option, 25 participants are needed overall in order to detect within-subject differences with a standard large effect size (*η2p* = 0.14), in accordance with the large effects found in Aue et al. 2013a, 2016, 2019. The nonsphericity correction was not changed (=1) as sphericity is irrelevant when there are only two levels in each factor. This analysis indicates that our experiment is sufficiently powered.

Participants had normal or corrected-to-normal vision and no psychiatric or neurological history. Prior to participation, they completed the Fear of Spiders

Questionnaire (FSQ; Szymanski & O'Donohue, 1995) via Qualtrics (https://www.qualtrics.com/) in order to assess their degree of spider fearfulness. The questionnaire includes 18 items regarding fear of spiders, ranging from 1 (“*strongly disagree*”) to 7 (“*strongly agree*”). The total scores are calculated by summing up the scores of the 18 items, such that a higher total score indicates higher fear levels, with a maximum score of 126. One participant out of the original 29 was excluded from the final analysis for being an outlier on both dependent measures (RT and accuracy; Z>|2.5|).

**Stimuli**. The experiment was run using E-Prime 3.0 (Psychology Software Tools, Pittsburgh, PA, USA). The search array included the same pictures that were used in our previous studies (Aue et al., 2013a, 2016, 2019) and included: 30 pictures of spiders (Dan-Glauser & Scherer, 2011), 30 pictures of birds collected from the internet, and 100 pictures of butterflies, also collected from the internet. Each trial consisted of a search array of nine black-and-white pictures (3×3) and each target had an equal probability to appear in any of the nine locations. The stimuli were matched for luminance and contrast. The pictures were presented on a 24 in. monitor in full-screen, and all pictures were equal in dimension (338×254 pixels).

Cues: Prior to viewing the search array on each trial, participants were shown one of two possible types of cues indicating the expectancy of encountering a particular type of target stimulus in the following trial. The cues specified either “Spider 90%” or “Bird 90%”, with a congruency rate of 71%. Bird targets appeared on 71% of trials (216 trials overall) and spider targets appeared on 24% of trials (72 trials overall). Five percent of the trials (15 trials overall) were "no target" (null) trials in which the search array

consisted of nine pictures of butterflies. See Table 1 for frequencies and number of trials for each condition.

Table 1

*Frequencies and number of trials in Experiment 1*

| Target | Bird | | Spider | | None |
|---|---|---|---|---|---|
| Cue | Bird | Spider | Bird | Spider | Bird |
| Frequencies | 75% | 25% | 25% | 75% | 100% |
| Number of Trials | 162 | 54 | 18 | 54 | 15 |
| Total | 216 (71%) | | 72 (24%) | | 15 (5%) |

*Note.* Please note, for each experiment, the cue stated "90% bird" or "90% spider", although the true predictive value of each cue was 71% in all experiments and in accordance with our previously published experiments. Please also note that when we refer to overall congruency, it also includes catch (i.e. no target) trials, which are considered incongruent.

**Design and procedure**. The experimental design was a 2 (cue: bird/spider) × 2 (target: bird/spider) within-subject design. Participants arrived at the lab and were given a verbal explanation about the procedure and possible inconveniences of the experiment, in addition to a written form explaining all of the above, which they took home with them. Before the beginning of the experiment, each participant took part in two practice blocks of ten trials each. The practice blocks included the same frequencies and probabilities as the actual experiment and were not included in the final analysis.

Each trial began with a fixation cross (500 ms), after which a cue specifying the probability of the target stimulus type in the next trial (expectancy cue - either 90% bird or 90% spider) appeared for 1,000 ms. Then, another fixation cross appeared, followed

by a search array, consisting of eight pictures of butterflies and one picture of either a bird or a spider. The null trials with no target consisted of nine pictures of butterflies. Participants were instructed to respond as quickly and as accurately as possible and to determine the category of the target stimulus by pressing the P and Q keys for spider or bird targets (counterbalanced) or the SPACE bar for no target. The search array was displayed for 2,000 ms or until response (see Figure 1). The participants performed the task in three blocks, each containing 101 trials. The entire experiment took between 20-30 minutes. The study was approved by the ethics committee of the Psychology Department at the University of Haifa (Approval Number 463/16).

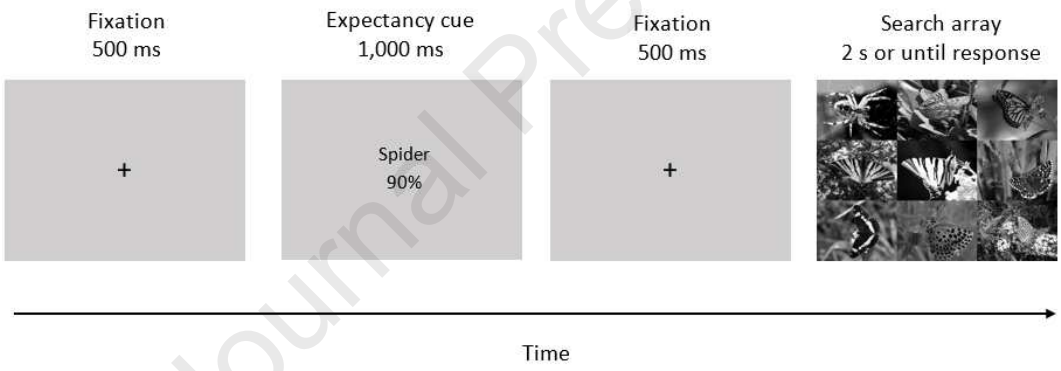


*Figure 1*. Task Sequence: An example of a 90% spider cue (in the experiment, the cue was given in Hebrew) followed by a search array with a spider target (left column, first row).



## Results

**FSQ scores.** The mean FSQ score was within the normal range: $M$ = 41.25, $SD$ = 26.66, range: 18-115. The sample was representative of the student population (Ginat-Frolich, Klein, Aderka, & Shechner, 2019).

**Reaction time.** A 2×2 repeated measures analysis of variance (ANOVA) with *cue* (spider, bird) and *target* (spider, bird) as the within-subject factors yielded a marginally significant main effect (two-tailed) for cue ($F(1,27) = 4.081$, $p = .053$, $\eta^2 p = .131$) such that participants' RT on trials with spider cues was shorter ($M$ = 1,031 ms) than the response time on trials with bird cues ($M$ = 1,058 ms). No main effect emerged for target ($F(1,27) = 1.118$, $p = 0.3$, $\eta^2 p = .04$; spider targets: $M$ = 1,031 ms; bird targets: $M$ = 1,058 ms). Most importantly, a cue × target interaction was found due to a congruency effect ($F(1,27) = 37.705$, $p < .001$, $\eta^2 p = .583$); see Figure 2A for the *M*s and *SD*s of the RTs in the different conditions). As congruency may refer to two instances (i.e. bird cue-spider target vs. spider cue-spider target; spider cue-bird target vs. bird cue-bird target; bird cue-spider target vs. bird cue-bird target; spider cue-bird target vs. spider cue-spider target), our analysis refers to both options. According to planned paired-samples t-tests conducted to analyze this interaction and the differences between the four relevant pairs were found to be significant, as depicted in Figure 2A. For this an all subsequent paired t-test analyses, the significance level was corrected due to the multiple comparisons that were conducted (i.e. 0.05/4 = 0.0125).

**Accuracy**. A 2×2 repeated measures ANOVA with cue (spider, bird) and target (spider, bird) as the within-subject factors yielded a main effect for target ($F(1,27) = 6.602$, $p = .016$, $\eta^2 p = .196$) such that participants' accuracy rate was lower for spider targets ($M$ = .82) than for bird targets ($M$ = .86). No main effect emerged for cue ($F(1,27) = 0.412$, $p = .527$; $\eta^2 p = .015$; spider cues: $M$ = .84; bird cues: $M$ = .83). In addition, a cue × target interaction was found ($F(1,27) = 9.877$, $p < 0.01$, $\eta^2 p = .268$). Planned paired-samples t-tests conducted in order to analyze this interaction yielded differences between

each of the tested pairs, except for spider/bird vs. spider/spider, as shown in Figure 2B. The bird/spider vs. spider/spider contrast approached our criterion for significance. ($p$ = 0.013).

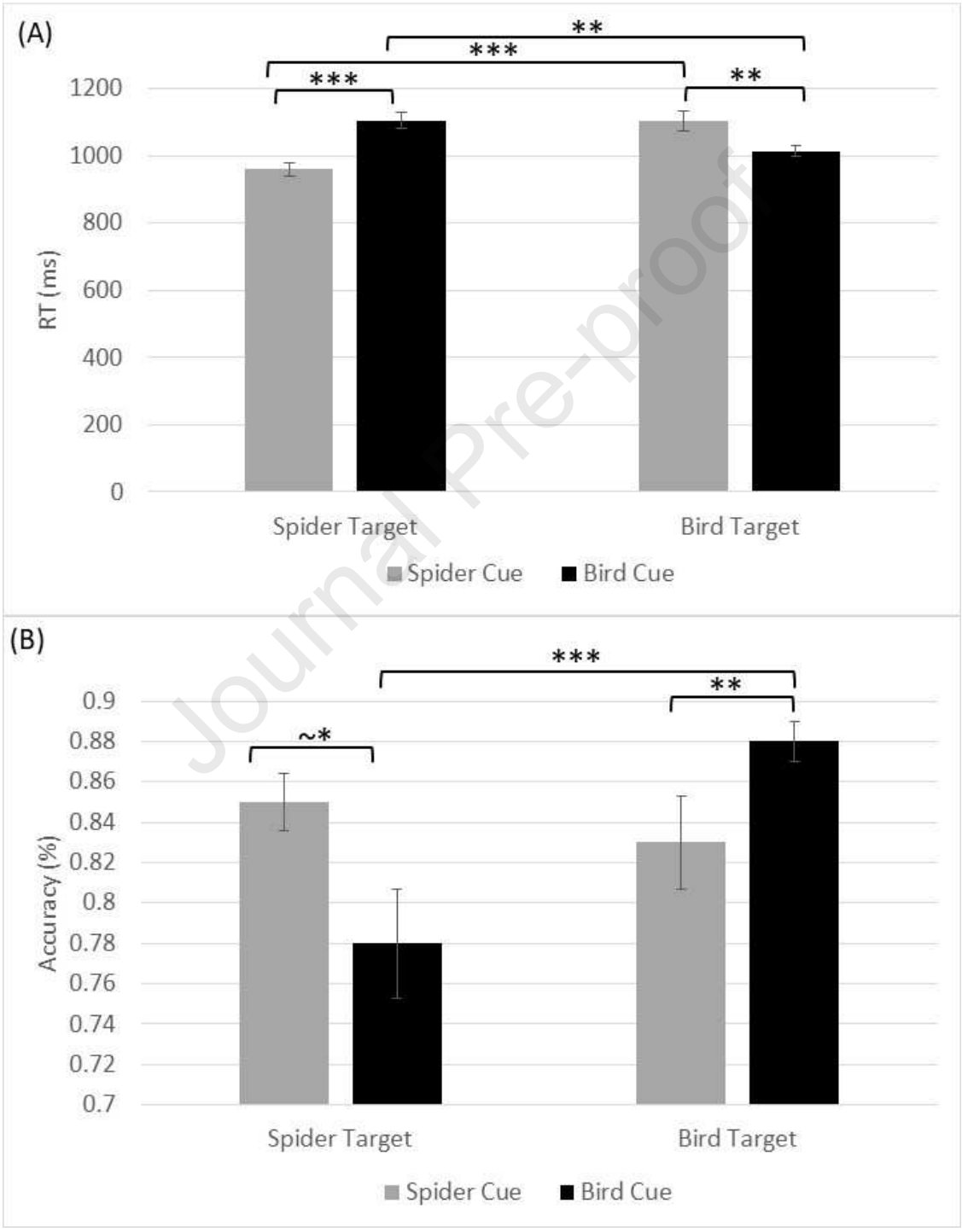

*Figure 2.* RT (panel A) and accuracy rates (panel B) for the cue × target interaction in Experiment 1. Error bars depict standard errors. ~*p = 0.013, **p < .0025, ***p < .00025 (corrected for multiple comparisons)

Discussion

The RT and accuracy results of Experiment 1 revealed an interaction between cue and target such that trials with congruency between the cue stimulus and the target stimulus resulted in faster reaction and higher accuracy. The fact that this effect arose in the current study but not previous studies can be explained by the higher proportion of bird cues and targets in the present study than in previous studies. When a specific target appears more frequently than the other, participants might be more inclined to rely on the presented cues and to use them more often during detection. Hence, increasing the frequency of a specific target might encourage participants to use the cues more often in their detection of spiders. Our results suggest that attention to threat is context-dependent and can be modulated with adapted manipulations. Of note, another difference between this experiment and previous ones is that the current experiment did not include ambiguous cues, which may have enhanced cue salience in the current experiment. Nonetheless, in previous experiments cues were still used to detect bird targets, but not spider targets, thus creating a limited cueing effect which was not found in the current experiment.

The knowledge gained from this study can be implemented in therapeutic settings in order to effectively decrease biases among populations with high levels of spider or other phobias. Contextual reframing of expectancies may help even if attention to threatening stimuli in the environment is strongly shielded as suggested by the findings of our previous experiments (Aue et al. 2013a, 2016, 2019). Yet to be able to draw firm

conclusions for therapeutic settings, we need to demonstrate the influence of expectancy on the detection of spider targets not only in a normal population but also in a population characterized by a particularly strong fear of spiders. Correspondingly, Experiment 2 was designed to explore whether attention bias and the relation between expectancy cues and attention bias can be modified even when the level of fear is high. Experiment 2 further allowed us to examine whether the findings of Experiment 1 would be replicated in a control group of individuals with low fear of spiders.

Experiment 2

The aim of Experiment 2 was similar to the aim of Experiment 1, in that it examined whether a change of frequencies of a specific target can reduce attention bias toward spiders. Specifically, the aim of Experiment 2 was twofold. First, we sought to replicate the findings of Experiment 1 among a group of participants with low levels of fear of spiders. Second and more importantly, we sought to examine whether participants with high levels of fear of spiders would exhibit similar findings (i.e. both spider and bird cues would affect reactions to spider and bird targets) or whether they would still exhibit prioritized and shielded (i.e. a cueing effect that is limited to bird targets) responses to spider targets, as indicated by previous findings with respect to balanced expectancy manipulations (Aue et al., 2013a, 2016, 2019). In the case of the former, both groups will show faster RTs to targets preceded by congruent cues for both spider and bird targets. Hence, we examined two fear groups and specifically explored the three-way group × cue × target interaction.

Method

**Participants.** Sixty-eight students from the University of Haifa (10 males; $M_{age}$ = 22.87, *SD* = 3.88), 34 with high levels of fear of spiders and 34 with low levels of spider fear, participated in the study in exchange for course credit or payment. Power analysis using the G*Power software (version 3.1.9.4; Faul et al., 2009) focusing on the three-way interaction between cue, target and group reveals that to reach standard power (0.8) with 0.05 error probability and using the "as in SPSS" option, 26 participants are needed overall (i.e. 13 in each fear group) in order to detect within-between subject differences with a standard large effect size ($\eta 2p$ = 0.14) in accordance with the large effects found in Aue et al. 2013a, 2016, 2019. The nonsphericity correction was not changed (=1) as sphericity is irrelevant when there are only two levels in each factor. Thus, the experiment was sufficiently powered.

For non-significant results, Bayesian statistical analyses were conducted using the software JASP (Wagenmakers et al., 2018). Specifically, we used the Bayes Inclusion factor based on matched models, representing the evidence for all models containing a particular effect to equivalent models stripped of that effect ($BF_{Inlcusion}$).

Participants had normal or corrected-to normal-vision and no psychiatric or neurological history. Prior to the experiment, participants completed the Fear of Spiders Questionnaire (FSQ; Szymanski & O'Donohue, 1995) via Qualtrics in order to identify them as having high or low fear of spiders. The total scores are calculated by summing up the scores of the 18 items, such that a higher total score indicates higher fear levels, with a maximum score of 126. Participants with an FSQ score of ≥ 68 were classified as "high in fear", and participants with a lower score were classified as "low in fear". Due to the

variance between the different FSQ scores employed in previous studies (e.g., Muris, Mayer, & Merckelbach, 1998, Muris & Mercklebach, 1996, Ginat-Frolich et al., 2019), we have employed a slightly stricter criteria, which is 68 (for more on our use of the FSQ and its validity in differentiation between low and high fear participants, see the Supplementary Material). Three participants of the original 71 were excluded from the final analysis; one did not respond throughout the experiment, and the remaining two were outliers on one of the dependent measures (i.e. RT or accuracy; Z>|2.5|).

**Stimuli.** The stimuli were identical to those used in Experiment 1.

**Design and procedure.** The experimental design was a 2×2×2 mixed design, with *group* (low/high fear) serving as a between-subject factor and *cue* (bird, spider) and *target* (bird, spider) serving as within-subject factors. The experimental procedure was identical to the one used in Experiment 1. The study was approved by the ethics committee of the Psychology Department at the University of Haifa (Approval Number 463/16).

Results

**FSQ scores.** The average FSQ score was 32.82 (*SD* = 13.44) for the low-fear group and 95.00 (*SD* = 14.95) for the high-fear group ($t(66) = -18.03$, $p < 0.001$).

**Reaction Times.** A 2 × 2 × 2 repeated measures analysis of variance (ANOVA) did not show a main effect for group ($F(1, 66) = 1.96$, $p = .17$, $\eta^2 p = .029$), indicating that RTs did not generally differ between the two groups (low fear: *M* = 1,018 ms; high fear: *M* = 987.01 ms). We found a main effect for target ($F(1, 66) = 42.51$, $p < .001$, $\eta^2 p = .39$), such that responses to spider targets (*M* = 955.46 ms) were faster than responses to bird targets (*M* = 1,050 ms). There was also a main effect for cue ($F(1, 66) = 6.23$, $p = .015$,

$\eta^2p$ = .09), such that RTs for targets following spider cues (*M* = 993.81 ms) were shorter than for targets following bird cues (*M* = 1,012 ms). These effects were classified by a two-way interaction between cue and target factors ($F(1, 66) = 91.29$, $p < .001$, $\eta^2p$ = .580) due to a congruency effect between cue and target. As congruency may refer to two instances (i.e. bird cue-spider target vs. spider cue-spider target; spider cue-bird target vs. bird cue-bird target; bird cue-spider target vs. bird cue-bird target; spider cue-bird target vs. spider cue-spider target), our analysis refers to both options. Planned paired sample t-tests revealed differences between the four relevant tested pairs, except for the bird (cue)/spider (target) vs. the bird/bird pair in each fear group, as shown in Figure 3A.

The 2 × 2 × 2 interaction of cue, target and group failed to reach significance ($F(1, 66) = 3.59$, $p = .063$, $\eta 2p = .052$, $BF_{Inclusion} = 0.720$). In both low- and high-fear groups, an interaction emerged between cue and target ($F(1, 33) = 38.22$, $p < .001$, $\eta 2p$ = .54; $F(1, 33) = 53.18$, $p < .001$, $\eta 2p = .62$, for low fear and high fear, respectively). Table 2 shows the *Mean*s (*M*s) and *SD*s of the RTs in the different conditions as a function of group.

Table 2

*Ms (and SDs) of the RTs in the different task conditions as a function of group in Experiment 2*

| Group | Cue | Target | |
|---|---|---|---|
| | | Bird | Spider |
| Low-fear | Bird | 1,028 (110.78) | 1,024(131.22) |
| | Spider | 1,081(123.33) | 940 (114.39) |
| High-fear | Bird | 1,004 (86.19) | 989 (152.40) |

| | | | |
|---|---|---|---|
| | Spider | 1,086 (120.11) | 866 (120.13) |

**Accuracy.** A 2 × 2 × 2 repeated-measures ANOVA did not reveal a main effect for group, $F(1, 66) = 0.75$, $p = .39$, $\eta^2 p = .011$, indicating that the groups did not generally differ between on accuracy (low fear: $M = .84$; high fear: $M = .85$). We found a main effect for target ($F(1, 66) = 12.46$, $p < .01$, $\eta^2 p = .16$), such that accuracy was higher on trials with bird targets ($M = .87$) than on trials with spider targets ($M = .83$), while no main effect emerged for cue ($F(1, 66) = 2.49$, $p = .12$, $\eta^2 p = .036$). Importantly, we found a two-way interaction between cue and target, ($F(1, 66) = 46.93$, $p < .001$, $\eta^2 p = .42$) such that accuracy was higher on congruent trials. Planned paired sample t-tests showed differences between the four relevant tested pairs, except for the spider (cue)/spider (target) pair vs. the spider/bird pair in each fear group, as shown in Figure 3B.

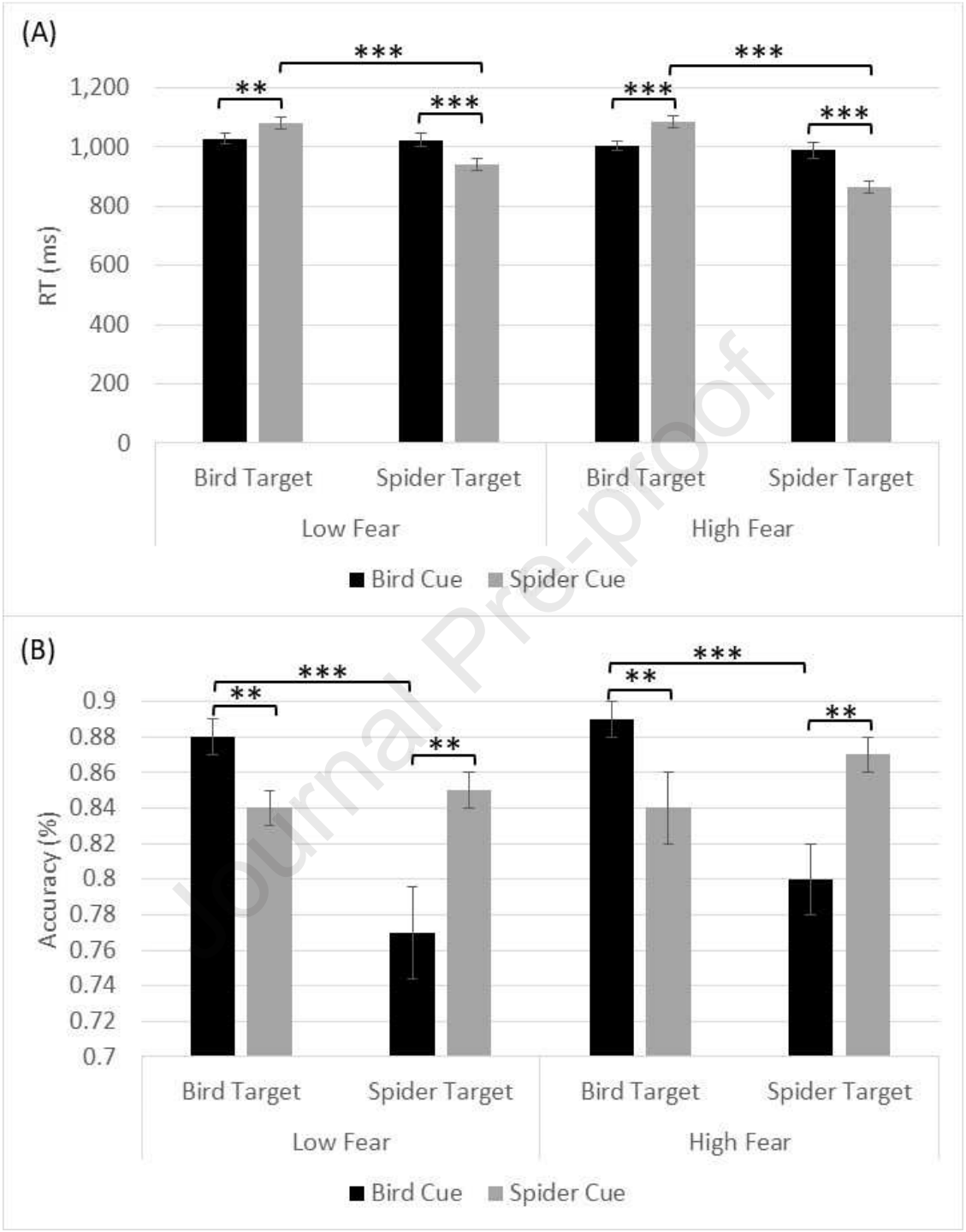


*Figure 3.* RT and accuracy rates for the cue × target interaction in Experiment 2. Error bars depict standard errors. **p < .0025, ***p < .00025 (corrected for multiple comparisons).

We found no effect of group ($F(1, 66) = 0.75$, $p = .39$, $\eta 2p = .011$) and no three-way interaction among cue, target and group ($F(1, 66) = 0.002$, $p = .97$, $\eta 2p = .000$, $BF_{Inclusion} = 0.252$). In both low and high fear groups, an interaction emerged between cue and target ($F(1, 33) = 19.64$, $p < .001$, $\eta 2p = .370$; $F(1, 33) = 29.32$, $p < .001$, $\eta 2p = .470$, for low fear and high fear, respectively). Table 3 depicts the *M*s and *SD*s of the RTs in the different conditions as a function of group.

Table 3

*Means and SDs of accuracy in the different task conditions as a function of group in Experiment 2*

| Group | Cue | Target | |
|---|---|---|---|
| | | Bird | Spider |
| Low-fear | Bird | .88 (.06) | .77 (.15) |
| | Spider | .84 (.08) | .85 (.08) |
| High-fear | Bird | .89 (.04) | .80 (.10) |
| | Spider | .84 (.11) | .87 (.08) |



Discussion

Experiment 2 was identical to Experiment 1 except for the inclusion of a comparison between participants with low and high fear of spiders. The interaction between cue and target both on accuracy measures and on RT measures revealed a congruency effect between cue and target, replicating the findings of Experiment 1. In other words, in contrast to our previous research (Aue et al., 2013a, 2016, 2019) in which cues had an impact only when a bird target appeared, in Experiment 2 a higher proportion of non-threatening cues and targets yielded a cueing effect for spider targets. This effect

is of major clinical significance as it was achieved among both groups of participants, those with low fear of spiders, and more importantly, those with a high degree of fear of spiders. Hence, changing the context may help attenuate the symptoms of highly fearful individuals in clinical settings (see elaboration in the general discussion about the use of cognitive and perceptual training for alleviating fear overgeneralization).

Experiment 3

Similarly to Experiments 1 and 2, Experiment 3 also examined whether a shift of frequencies can reduce attention bias toward spiders. Specifically, the third experiment sought to examine whether an expectancy manipulation in favor of neutral stimuli specifically causes the reduction in attention bias, or whether any expectancy manipulation in favor of any specific target could lead to this result. In other words, we sought to examine whether the modulation of attention bias found in Experiments 1 and 2 was due to higher percentage of *neutral (non-threatening)* stimuli or due to the fact that one stimulus appeared in the majority of the trials, no matter what type of target concerned. In order to answer this question, in the third experiment we showed spider cues and targets more frequently than bird cues and targets (71% of trials). The stimuli were shown to participants with low and high levels of fear of spiders.

Method

**Participants**. Seventy students from the University of Haifa (9 males; $M_{age}$ = 23.77, *SD* = 4.63), 35 with high levels of fear of spiders and 35 with low levels of spider fear, participated in the study in exchange for course credit or payment. As was the case in Experiment 2, this number of participants is sufficient in order to detect large within-

between groups effects. Participants were classified into fear group using the same cut-off as Experiment 2 (i.e. an FSQ score of 68). Participants had normal or corrected to normal vision and no psychiatric or neurological history. Fourteen participants of the original 84 participants were excluded from the final analysis: three due to technical issues, four because they were extreme outliers (i.e. accuracy < 44%, compared to an average of 85%) and seven because they were outliers in one or both of the dependent measures (|Z| > 2.5).

**Stimuli**. Due to comorbidity between specific phobia, other anxiety disorders and depression (Stinson et al., 2007), before the beginning of the experiment participants completed two more questionnaires in the lab, in addition to the previously used FSQ and cutoff score: the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the Beck Depression Inventory (BDI, developed by Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) in order to assess their anxiety and depression levels, respectively.

**Design and Procedure**. The design and procedure were identical to Experiment 2, except that spider targets appeared on 71% of trials, bird targets on 24% of trials and no target on 5% of trials (i.e. catch trials). While in Experiments 1 and 2, catch trials always included bird cues, in Experiment 3 catch trials always included spider cues, so as to keep the experiments balanced. The study was approved by the ethics committee of the Psychology Department at the University of Haifa (Approval Number 479/18).

Results

**FSQ scores.** The average FSQ score was 30.83 (*SD* = 12.33) for the low-fear group and 92.23 (*SD* = 12.69) for the high-fear group ($t(68) = -20.53$, $p < 0.001$).

**STAI scores.** The means of both state anxiety (*M* = 33.95, *SD* = 10.75, range: 20 - 71) and trait anxiety (*M* = 38.82, *SD* = 9.97, range: 21 - 63) were within the normal range (Spielberger et al., 1983). Only state anxiety significantly differed between the fear groups (low fear: *M* = 30.71, *SD* = 7.70; high fear: *M* = 37.2, *SD* = 12.43; *t*(56.55 = -2.63; *p* = .011; trait anxiety: low fear: *M* = 37.31, *SD* = 9.77; high fear: *M* = 40.34, *SD* = 10.08; *t*(68) = -1.28; *p* = .206). Moreover, the inclusion of state and trait anxiety scores as covariates did not contribute to the analysis models reported below. Furthermore, the effects of these covariates themselves were not significant.

**BDI scores.** The mean BDI score was within the normal range: *M* = 10.39, *SD* = 8.70, range: 0 - 37 (Beck, Steer, & Brown, 1996). We found that the BDI scores for both fear groups did not differ (low fear: *M* = 8.60, *SD* = 8.35; high fear: *M* = 12.17, *SD* = 8.8; *t*(68) = -1.74; *p* = .09). Moreover, the inclusion of depression scores as covariates did not contribute to the analysis models reported below. Furthermore, the effects of this covariate itself was not significant.

**Reaction Times.** A 2 × 2 × 2 repeated measures analysis of variance (ANOVA) was conducted on the RT data, with *group* (high spider fearful, low spider fearful) as the between-subject factor and *cue* (bird, spider) and *target* (bird, spider) as the within-subject factors. No main effect emerged for group (*F*(1, 68) = .33, *p* = .566, $\eta^2 p$ = .005), indicating that RTs did not generally differ between the two groups (low fear: *M* = 1,002 ms; high fear: *M* = 991.36 ms). A main effect did emerge for target (*F*(1, 68) = 136.68, *p* < *.001*, $\eta^2 p$ = .668), such that responses to spider targets (*M* = 908.76 ms) were faster than responses to bird targets (*M* = 1,085 ms). There was also a main effect for cue (*F*(1, 68) = 24.21, *p* < *.001*, $\eta^2 p$ = .263), such that RTs for targets following bird cues (*M* =

980.56 ms) were shorter than for targets following spider cues (*M* = 1,013 ms). These effects were classified by a two-way interaction between cue and target factors ($F(1, 68) = 103.49$, $p < .001$, $\eta^2p = .603$), due to a congruency effect. As congruency may refer to two instances (i.e. bird cue-spider target vs. spider cue-spider target; spider cue-bird target vs. bird cue-bird target; bird cue-spider target vs. bird cue-bird target; spider cue-bird target vs. spider cue-spider target), our analysis refers to both options. This effect was found in all contrasts except for the bird (cue) – spider (target) pair vs. bird-bird pair, in which participants responded faster on incongruent trials. In other words, following bird cues, participants responded faster to spider targets than to bird targets. This might be due to the existence of a general attention bias to spiders. However, the fact that the cues nevertheless affected detection of spider targets shows that this bias can be modulated. Planned paired sample t-tests revealed differences between the four relevant tested pairs in each fear group, as shown in Figure 4A.

The 2 × 2 × 2 interaction among cue, target and group was not significant ($F(1, 68) = 1.53$, $p = 0.221$, $\eta 2p = .022$, $BF_{Inclusion} = 0.435$). In both low- and high-fear groups, an interaction emerged between cue and target ($F(1, 34) = 81.30$, $p < .001$, $\eta 2p = .705$; $F(1, 34) = 33.30$, $p < .001$, $\eta 2p = .495$, for low fear and high fear, respectively). Table 4 shows the *M*s and *SD*s of the RTs in the different conditions as a function of group.

Table 4

*Ms (and SDs) of the RTs in the different task conditions as a function of group in Experiment 3.*

| Group | Cue | Target | |
|---|---|---|---|
| | | Bird | Spider |
| Low-fear | Bird | 1,023 (119.35) | 939 (104.77) |
| | Spider | 1,154 (119.07) | 894 (102.67) |
| High-fear | Bird | 1,035 (122.90) | 923 (110.84) |
| | Spider | 1,127 (124.18) | 878 (99.51) |

**Accuracy.** A 2 × 2 × 2 repeated-measures ANOVA was conducted on accuracy rates, with *group* (high spider fear, low spider fear) as the between-subject factor and *cue* (bird, spider) and *target* (bird, spider) as the within-subject factors. We did not find a main effect for group, $F(1, 68) = 0.086$, $p = 0.77$, $\eta^2p = .001$, showing that accuracy did not generally differ between the two groups (low fear: $M = .84$; high fear: $M = .84$). We found a main effect for target ($F(1, 68) = 36.60$, $p < .001$, $\eta^2p = .350$), such that accuracy was higher on trials with spider targets ($M = .87$) than on trials with bird targets ($M = .80$). A main effect also emerged for cue ($F(1, 68) = 4.81$, $p = .032$, $\eta^2p = .066$), such that accuracy following bird cues ($M = .85$) was higher than following spider cues ($M = .83$). Importantly, we found a two-way interaction between cue and target, ($F(1, 68) = 23.91$, $p < .001$, $\eta^2p = .260$). Planned paired sample t-tests showed several differences in accuracy between the four relevant tested pairs, as shown in Figure 4B. Specifically, in the low fear group, the following contrasts were significant: spider (cue)/bird (target) vs. spider/spider and spider/bird vs. bird/bird. The bird/spider vs. spider/spider contrast

approached significance ($p$ = 0.031). In the high fear group, the following contrasts were significant: spider/bird vs. spider/spider and spider/bird vs. bird/bird. The bird/spider vs. bird/bird contrast approached significance ($p$ = 0.023).

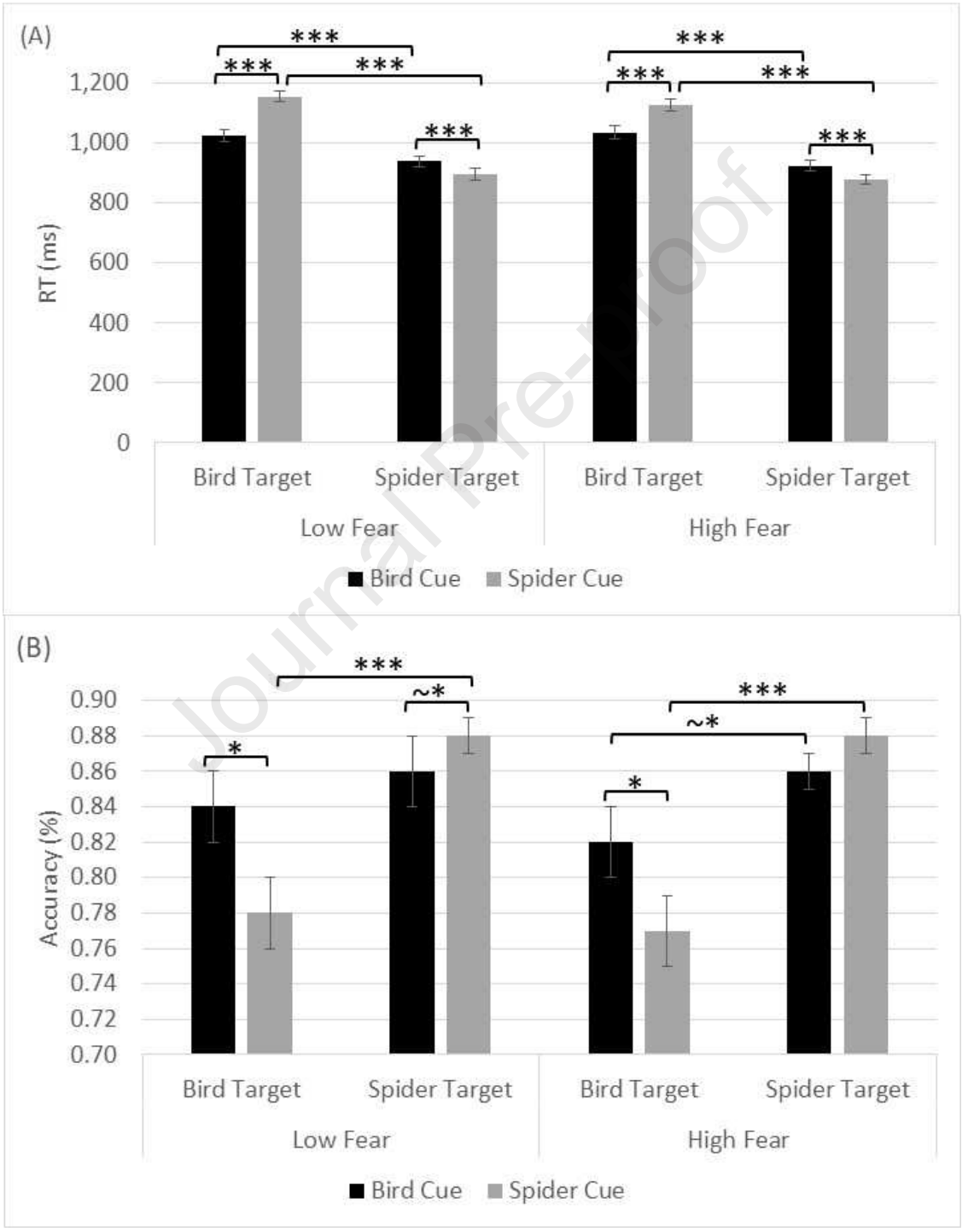

*Figure 4.* Accuracy rates for the cue × target interaction in Experiment 3. Error bars depict standard errors. ~* $0.023 \leq p \leq 0.031$, *p < .0125, **p < .0025, ***p < .00025 (corrected for multiple comparisons).

We found no interaction among cue, target and group ($F(1, 68) = 0.39$, $p = .534$, $\eta 2p = .006$, $BF_{Inclusion} = 0.296$). In both the low- and the high-fear groups, an interaction emerged between cue and target ($F(1, 34) = 13.99$, $p = .001$, $\eta 2p = .292$, and $F(1, 34) = 9.95$, $p = .003$, $\eta 2p = .226$, for the low- and the high-fear groups, respectively). *M*s and *SD*s of the RTs in the different conditions as a function of group are shown in Table 5.

Table 5

*Ms and SDs of accuracy in the different task conditions as a function of group*

| Group | Cue | Target | |
|---|---|---|---|
| | | Bird | Spider |
| Low-fear | Bird | .84 (.10) | .86 (.09) |
| | Spider | .78 (.12) | .88 (.06) |
| High-fear | Bird | .82 (.11) | .86 (.07) |
| | Spider | .77 (.14) | .88 (.04) |

Discussion

Experiment 3 was identical to Experiment 2 except for the reversal of frequent targets (i.e. spiders instead of birds being presented in the majority of cases). The results show that while attention bias toward spiders was found among both fear groups, it was also modulated by expectancy. For both types of targets, following spider cues participants responded faster and more accurately on congruent trials than on incongruent trials. In addition, main effects toward spiders emerged on both RT and accuracy measures. Both on accuracy measures and on RT measures, the interaction between cue and target

revealed a congruency effect. Notably, the congruency effect in Experiment 3 was not as strong as in Experiments 1 and 2. Specifically, when looking at the congruency effects of cues on the detection of spider targets, the size of the congruency effect in Experiment 2 was larger than that in Experiment 3. In other words, the difference between congruent and incongruent trials in which spider targets appeared is larger in Experiment 2, compared to Experiment 3 (see General Discussion and Supplementary Material for further discussion and analysis of congruency effects across experiments). Importantly though, results of Experiment 3 still show that even a change in frequency of the threatening stimulus can modulate reactions toward spider targets, compared to bird targets. Furthermore, as was found in Experiments 1 and 2, no differences emerged between the two fear groups in Experiment 3, indicating that both groups equally benefited from the manipulation, further contributing to the potential clinical benefit of manipulating expectancy, of either type of target, in order to reduce attention bias (see General Discussion for a an in-depth consideration of this topic)."



General Discussion

The current results add to our previous findings (Aue et al. 2013a, 2016, 2019) by indicating that attention bias in participants with both low and high levels of spider phobia can be modulated using an adequate expectancy manipulation. In the first experiment, which used a representative sample from the student population, we found that when expectancies are manipulated toward birds (i.e., bird cues and targets appear in 71% of trials), participants benefit from cues that precede each visual search array—even in the case of spider targets. These results were replicated in the second experiment, in which the exact same paradigm was used with the addition of a comparison between two

groups: low spider fear and high spider fear. A similar pattern of results in both fear groups was found in the third experiment, in which spiders were the frequent target. Taken together, these results suggest that a change of frequencies, in any direction, can reduce attention bias toward spiders among low and high fearful participants. This relationship between frequencies and attention bias can be further modulated by the type of frequent target (i.e. threatening vs. neutral).

It is important to note that there was substantial similarity in FSQ scores across participants. Thus, the representative sample in Experiment 1 had a mean score of 41.25. Similarly, the low fear groups in Experiments 2 and 3 had a score of 32.82 and 30.83, respectively. The same consistency can be found in the high fear groups in Experiments 2 and 3, with each group scoring 95.00, and 92.23, respectively. The consistency of these numbers thus makes it easier to compare between the experiments. In our previous studies (Aue et al., 2013a, 2016, 2019), both groups (i.e., low and high fear of spider) exhibited strong attention bias toward spiders compared to birds. As the main difference between the current study and these previous experiments is the proportion of targets, we suggest that the reduced attention bias may be explained by a change in participants' uncertainty regarding the target's appearance. In general, intolerance of uncertainty plays a major role in anxiety disorders, as it complements expectancy bias (i.e. overestimation of the probability of encountering threatening stimuli/situations; for a review on the role of intolerance of uncertainty in anxiety, see Grupe & Nitschke, 2013). Hefner and Curtin (2012) have manipulated the probability of an electric shock (20%, 60%, 100%) and found that under uncertain conditions (20% and 60%), startle response was greater than under the certain condition (100%). Similar findings were found in an ERP study (Gole,

Schäfer, & Schienle, 2012): In an affective cueing paradigm, cues predicted the certainty and the valence of the upcoming picture. Cues were either certainly-negative, certainly-positive or ambiguous, much like the cues used in our own previous studies (Aue et al., 2013a, 2016, 2019). The findings indicated that expectancy cues, as well as participants' trait intolerance of uncertainty, had a moderating effect on aversive anticipation. Thus, the uncertainty manipulated in the experiment as well as participants' trait intolerance of uncertainty play a role in attention bias (Gole et al., 2012). Taken together, these results demonstrate that certainty and valence interact and modulate emotional responses.

It is important to note that while some studies manipulate certainty using manipulation of frequency of the occurrence of a specific event (e.g., Hefner & Curtin. 2012), other studies manipulate the validity rate of cues (e.g., Gole et al, 2012; 100% validity). In our own studies, we only manipulated the frequency of a target across experiments, while keeping the validity rate constant. This rate (71%) is mostly valid, but not so valid that participants can simply press according to the cue while ignoring the actual target. In addition, shifting the frequencies in any direction might increase subjective predictability of the cues (even more so because there are no ambiguously cued trials), so that the participants pay greater attention to the cues altogether.

A previous ERP study, which manipulated certainty while participants viewed emotional pictures, found that valence indeed modulated the relationship between uncertainty and reactions toward emotional pictures. During early sensory phases, uncertainty was found to reduce attention toward negative pictures, but during later processing stages this effect was reversed. No such relationship between certainty and attention was found when participants viewed positive pictures (Lin et al., 2015). These

findings suggest differences between early and late processing stages in the effect of uncertainty on emotional reaction, and further highlight the complex nature of the factors that modulate emotional reactions. Unlike our own studies, which provide one specific stimulus in each pictures the study of Lin et al. (2015) presented visually complex scenes. Therefore, it is possible that participants in our studies processed the targets faster compared to the study of Lin et al., resulting in the effect they found only during later processing stages. Future studies using ERP may shed light on the impact of uncertainty and salience, as well as the complexity of the targets, during emotional reactions to threat.

It is interesting to note, that while attention bias was reduced in both the 71% bird targets and 71% spider targets experiments, compared to the 50%-50% experiments reported in our previous studies (Aue et al., 2013a, 2016, 2019; see Supplementary Material for relevant analyses), there was nevertheless a main effect of target in both experiments. In other words: our manipulation modulated – but not diminished – the attention bias in favor of spider targets. This effect highlights the complexity of the different factors that play a role during emotional reaction to threat (Okon-Singer, Lichtenstein-Vidne, & Cohen, 2013). Related to this, the reduction in attention bias towards spider targets was less pronounced in the 71% spider experiment compared to the 71% bird experiment (see Supplementary Material for relevant analyses). This latter finding also suggests an interaction between threat value (salience of spiders/lack thereof of birds) and cognitive factors (uncertainty/expectancy of encountering a specific target. For a review on the interaction between the different factors in anxiety disorders, see

Sussman, Jin, & Mohanty, 2016). Future studies may shed light on the role of each factor by manipulating the degree of uncertainty and/or salience and threat value.

Implications for the Clinical Context

Research on attention bias suggests that fear and anxiety may contribute to attention bias, and vice versa. There seems to be a vicious cycle that maintains fear, anxiety and attention bias (for a review, see Van Bockstaele et al., 2014). Thus, learning how to control, modify and attenuate attention bias might break the upward spiral of threat-related negativity. These findings are especially important in the therapeutic context, where manipulation of attention bias can be of assistance (Shechner et al., 2012).

Attention bias modification (ABM) usually depends on manipulating the appearance of threatening and neutral stimuli in order to increase attend or avoid reactions (for review on ABM, see Mogg, Waters, & Bradley, 2017; see also Shani, Zilcha-Mano, & Okon-Singer, 2019, for cognitive training using machine learning as an alternative to existing trainings). We propose that an additional consideration of the interaction between attention bias and other cognitive biases and factors (expectancy bias, in our studies) helps explain even greater variance in emotional responses (see also Dolcos et al., 2019, for details on different forms of attention trainings).

To the best of our knowledge, the current series of studies is the first to show that attention bias can be modified by manipulating expectancies. Future developments should focus on cognitive trainings aimed at reducing attention bias by manipulating a-priori expectancy. Along these lines, Ginat-Frolich, Klein, Katz, and Shechner (2017) showed that perceptual training can reduce fear overgeneralization and improve participants' perception of threatening stimuli post-fear conditioning. A similar

perceptual training procedure was used with participants with spider phobia and significantly reduced avoidance of spiders (Ginat-Frolich et al., 2019). These results indicate that training to differentiate between threatening and non-threatening stimuli can reduce fear generalization, which is often found in spider phobia (Becker & Rinck, 2004). Thus, expectancy training regarding the likelihood of the appearance of spiders may lead to similar results.

Limitations, Conclusions and Future Research.

In contrast to previous studies (Aue et al., 2013a, 2016, 2019), the current study did not include ambiguous cues (i.e. "spider bird 50%"). The inclusion of such cues may have led to somewhat different results (see Supplementary Material on the contribution, or lack thereof, of ambiguous cues). Hence, it is possible that the exclusion of this condition rendered the cues less relevant overall, although in each experiment participants did manage to respond according to the cues. Another difference between the current experiment and previous ones is that while we presented the search array for 2,000 ms, previous studies have presented it for 2,500 ms (Aue et al., 2013a, 2016, 2019). This slight change in presentation time was done in order to balance the overall time that it took to complete the experiments, as our change of frequencies lead to a smaller amount of trials containing a certain target, and yet a large enough number of trials was needed for the less frequent conditions in order to detect a effect. Nonetheless, the same results were found toward bird targets, such that cues lead to the same congruence effect in bird targets, while the change of frequency lead to the congruency effects in spider targets, which was not present in previous studies.

Birds and butterflies were chosen as non-threatening stimuli based on previous studies, which have asked participants to rate these animals in terms of how unpleasant they are (e.g. Leibovich, Cohen, & Henik, 2016) and due to the fact that they have been previously used as such (Aue et al., 2013a, 2016, 2019). However, fear of these animals has not been measured in the current studies and this could have affected our results. Importantly, the existence of such fears would have led to different and noisier results. In other words, such fears would have yielded the opposite pattern of findings than those hypothesized and found. As our results yielded very large effect sizes, it seems unlikely that such a factor intervened, at least not to a large extent. Nonetheless, fear of birds or butterflies indeed could be considered a possible individual difference variable.

In the theoretical cognitive context, future studies should investigate whether the causal relationship between expectancy and attention is bidirectional. For instance, recent studies suggest a bidirectional relationship between attention and optimistic expectancies (Kress & Aue, 2019; Kress, Bristle, & Aue, 2018). Correspondingly, while we measured attention bias after manipulating expectancy in the current series of experiments, the results of other studies suggest that expectancies may also be influenced by attention deployment among participants with and without spider phobia (Aue et al., 2013b). Thus, subsequent studies should measure expectancy bias toward spiders and examine whether this bias is causally influenced by attention bias.

In addition, in order to clarify the role of higher cognitive factors, future studies should use the exact same paradigm as the one we used and add trials that include both bird and spider targets in the same matrix. This design can be used to test whether participants respond first to spider targets, indicating the use of lower level processes, or

first to bird targets, indicating the use of higher cognitive processes (for more details on the interaction of different factors in anxiety, see Sussman, Jin, & Mohanty, 2019). We encourage future studies to continue to examine the relation between expectancy and attention. Along these lines, a recent paradigm was developed, in which cues are indicative both of the location and of the threat value of the probe in a visual probe paradigm (Gladwin, Möbius, McLoughlin, & Tyndall, 2019). We believe that such integrative paradigms have great potential for revealing the complexities in the interaction between expectancy bias and attention bias, among other cognitive biases.

In the clinical context, future studies should examine the effect of manipulations of expectancy on attention bias among participants with high levels of fear or anxiety in the context of cognitive training. As Ginat-Frolich et al. (2019) showed, perceptual training successfully reduced avoidance of spiders and improved phobic participants' perceptual sensitivity, biased interpretation and overgeneralization. Although perception and expectancy are different cognitive functions, both are early occurring processes, and thus perhaps training perception to reduce fear of spiders can also shed light on training of expectancy to reduce fear. Furthermore, Kress and Aue (2019) showed that ABM can enhance optimistic expectancies, and that this relationship between attention and expectancies is bidirectional (Kress et al., 2018). Thus, expectancy training regarding the likelihood of the appearance of spiders may lead to reduction of phobia symptoms by reducing attention bias toward spiders

In conclusion, although some stimuli, such as spiders, are considered to be highly aversive by the general population, humans still maintain the ability to adapt and reorient

their expectancies and reactions by learning from context. Rather than following blind fear, this is perhaps the most adaptive behavior of all.

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Conflict of Interest

The authors declare no conflict of interest.

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Highlights:

- Increasing frequency of neutral targets reduced attention bias toward spiders
- More frequent threatening targets also reduced attention bias, to a lesser extent
- Decreasing uncertainty contributes to the effect of expectancy in attention bias
- These effects were found among low and high fearful participants
- This is the first study to show that expectancy can reduce attention bias

**AUTHOR DECLARATION TEMPLATE**

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

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Elinor Abado (on behalf of all authors)