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Instructed fear stimuli bias visual attention☆

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ABSTRACT

We investigated whether stimuli merely instructed to be fear-relevant can bias visual attention, even when the fear relation was never experienced before. Participants performed a dot-probe task with pictures of naturally fear-relevant (snake or spider) or -irrelevant (bird or butterfly) stimuli. Instructions indicated that two pictures (one naturally fear-relevant and one fear-irrelevant) could be followed by an electrical stimulation (i.e., instructed fear). In reality, no stimulation was administered. During the task, two pictures were presented on each side of the screen, after which participants had to determine as fast as possible on which side a black dot appeared. After a first phase, fear was reinstated by instructing participants that the device was not connected but now was (reinstatement phase). Participants were faster when the dot appeared on a location where an instructed fear picture was presented. This effect seemed independent of whether picture content was naturally fear-relevant, but was only found in the first half of each phase, suggesting rapid extinction due to the absence of stimulation, and rapid re-evaluation after reinstatement. A second experiment similarly showed that instructed fear biases attention, even when participants were explicitly instructed that no stimulation would be given during the dot-probe task. Together, these findings demonstrate that attention can be biased towards instructed fear stimuli, even when these fear relations were never experienced. Future studies should test whether this is specific to fear, or can be observed for all instructions that change the relevance of a given stimulus.

1. Introduction

For long, psychologists and psychotherapists exclusively relied on classical conditioning to explain the acquisition of (pathological) fear, with a few notable exceptions (e.g., Cook & Harris, 1937; Grings, 1973). In classical or Pavlovian fear conditioning, animals learn through experience to fear a neutral stimulus (conditioned stimulus, CS$^+$) after it has been paired with an aversive stimulus (unconditioned stimulus, US) – usually on more than one occasion. However, in his seminal paper entitled *The conditioning theory of fear-acquisition: a critical examination*, Rachman (1977) described several phenomena that could not be explained by classical conditioning alone. Rachman argued that there are three ways in which fear can be learned: by classical conditioning, by observation, and by instruction. Rachman further suggested that of all three pathways to fear, the instructional pathway has the weakest fear inducing effects, despite being the most common way of fear-learning for children. In fact, according to Rachman, this pathway is of crucial importance and probably the cause of most fears we experience in our adult life. Still, despite its vital importance, most fear conditioning research to date has focused on experience-based fear conditioning (i.e., via classical conditioning), rather than fear learning via instructions.

In contrast to Rachman's (1977) initial assumption, some studies have shown that the instructional pathway to fear can also show strong effects (for a review, see Koban, Jepma, Geuter, & Wager, 2017). For example, Olsson and Phelps (2004) compared fear learning via classical conditioning, observation, or instruction. In the classical conditioning condition, the CS$^+$ (picture of a face) was paired together with a US (aversive electrical stimulation). In the observation condition, a video was shown in which a person received the same US. In the instruction condition, the participants were just told that the CS$^+$ predicted the US. Interestingly, Olsson and Phelps (2004) found a similar degree of learning for all three conditions, as measured with the galvanic skin response. The learning of fear via instructions has also been shown to have more long term effects. Field, Lawson, and Banerjee (2008)

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investigated these long term effects in children between six and thirteen years old. They provided children with negative, positive or no information on images of (unknown) animals. Thereafter, they measured participants implicit attitudes towards these images on different times after the instructions (one week, one month, three months, and six months). This showed that the relations could not only be observed immediately after instructions, but also stayed relatively stable for negative information, even until six months after the information was provided. Together, these studies show that the acquisition of fear by instruction can be a robust and stable cause of fear.

In the present study, we wanted to extend the investigation of instructed fear into the domain of visual attention. More specifically, we aimed to investigate the impact of instructed fear relations on attentional biases in the dot-probe task (Macleod, Mathews, & Tata, 1986). The dot-probe paradigm measures attentional selection and was first developed by Macleod et al. (1986), based on the works of Posner, Snyder, and Davidson (1980). In this task, participants are presented with a fixation cross after which two images are displayed simultaneously on both sides of the screen for 500 ms. Immediately after the images have disappeared, a dot replaces one of the two images and the task is to react as fast as possible to the location of the dot. Macleod et al. (1986) first used this task to investigate whether high-anxious persons show an attentional bias for fearful stimuli, which was indeed what they observed: Participants were faster when the dot appeared on the location of a fearful stimulus, suggesting that attention was oriented towards this stimulus.

Further research has shown that most individuals show this general attentional bias for negative, threatening stimuli (but the effects remain much stronger for high-anxious people, Mogg & Bradley, 1998; Lipp & Derakshan, 2005; for reviews, see Puliafico & Kendall, 2006; Cisler & Koster, 2010), and it has been argued that this effect reflects the workings of an evolutionary adaptive system that allows us to efficiently detect dangerous and threatening stimuli in the environment (Oatley & Johnson-Laird's, 1987; Ôhman & Mineka, 2001). Most research on attentional bias towards threat has focused on the use of natural threatening stimuli (e.g., angry faces; Fox, Russo, & Dutton, 2002) or on conditioned stimuli (e.g., abstract shapes that were paired with shocks; e.g., Schmidt, Belopolsky, & Theeuwes, 2015; Van Damme, Crombez, Hermans, Koster, & Eccleston, 2006).

However, one question that remains is whether instructions regarding threat can bias attention as well. Finding such biases on the basis of instructions alone would go against fear conditioning theories as those of Ôhman and Mineka (2001), which state that the neural pathways that drive these automatic attentional biases, are impenetrable to conscious cognitive control. So far, one study by Field (2006) demonstrated that instructed fear for novel unseen animals can induce an attentional bias in children (see also, Reynolds, Field, & Askew, 2014). However, it is important to note that attentional processing in children differs from attentional processing in adults (Rueda et al., 2004) and the effects of instructed fear on visual attention in adults remains to be demonstrated. Furthermore, one can raise questions whether it was actually 'instructed' fear that drove the attention of the children in Field's study. The instructions about three unknown animals was given in a story-way fashion by an experimenter. Therefore, participants could have seen the emotional reactions expressed by the experimenter while (s)he was reading. Therefore, the fear learning in Field (2006) could have been a combination of instruction and observation.

A secondary goal of this study was to determine whether – if instructed fear can induce an attentional bias – this attentional bias would be greater for fear-relevant stimuli than fear-irrelevant stimuli. That is, in general, it has been shown that fear-relevant stimuli (e.g., pictures of snakes, spiders) show stronger and protracted effects of fear conditioning via classical conditioning than fear-irrelevant stimuli (e.g., pictures of birds, butterflies; Seligman, 1971). This phenomenon is often referred to as the effect of 'preparedness' in classical conditioning and relates to the idea that humans are biologically or evolutionary programmed to learn fear relations faster for certain stimuli. These prepared associations have been found to be less sensitive to extinction (McNally, 1987; Öhman, Eriksson, & Olofsson, 1975) and are more likely to lead to phobias (Mineka & Öhman, 2002; Ôhman & Mineka, 2001).

Therefore, we also studied whether the fear-relevant nature of certain stimuli also impacts the degree of fear learning via instructions. In a recent study, Mertens, Kuhn, et al. (2016) conducted two experiments in which they systematically compared whether fear learning via instruction is modulated by the fear relevance of these pictures. Their two experiments obtained mixed results. Specifically, Mertens, Kuhn, et al. (2016) did observe a differential effect on fear and US expectancy ratings for fear-relevant versus -irrelevant instructed fear in one experiment, but not in the other. Here, we hope to further inform this investigation by employing a different measure of fear learning, namely the hypothesized attentional bias towards instructed fear stimuli.

Finally, we also wanted to examine the effects of extinction and reinstatement on attentional processing of instructed fear. To this end, the experiment was interrupted after 240 trials with the pretext that the shocker was not working (see also, Raes, De Houwer, Verschuere, & De Raedt, 2011). The experimenter pretended to resolve the issue and gave another aversive stimulation (without being reminded of the specific instructed fear contingencies). After this procedure, the experiment continued. To detect extinction, the 240 trials of each phase (pre-reinstatement and reinstatement) were divided in two halves and analyzed separately. Previous research (Van Damme et al., 2006) has shown that conditioned stimuli bias attention, but that this attentional bias fades during extinction. However, after reinstatement, the attentional bias recurred. Here, we wanted to investigate whether this can also be observed for instructed fear conditioning.

2. Experiment 1

2.1. Method

2.1.1. Participants

Twenty Dutch-speaking undergraduate students from Ghent University (17 female, between 18 and 20 years old) participated in return for student credit. Each participant filled in an informed consent and was debriefed after the experiment about the goals of the experiment.

2.1.2. Material

2.1.2.1. Apparatus. The task was performed on a DELL laptop computer and programmed in E-Prime. The electric stimulus was generated by a constant current stimulator (DS7A, Digitimer, Hertfordshire, UK) and delivered through an electrode attached to the left ankle of the participant. The intensity of the electric stimulus was determined for each participant separately by the use of a stepwise work-up procedure until an aversive but tolerable intensity was reached (for a detailed description of this procedure see: Mertens & De Houwer, 2016).

2.1.2.2. Stimuli. The four images depicted a snake, a spider, a bird, and a butterfly, as used by Mertens, Kuhn, et al. (2016, Experiment 1; see also Olsson, Ebert, Banaji, & Phelps, 2005). The four stimuli were always presented in one of the twelve possible pairs: each possible combination of images, excluding pairs of identical images, was presented an equal amount of times. Each possible condition was presented 20 times per phase. In addition, the location of the picture that was followed by the dot could either be on the left or the right side. Therefore, there was actually a total of 24 different trial types. These 24 trials were displayed in a random order for ten cycles (= 240 trials). After the reinstatement instructions, another 10 cycles were administered.

2.1.3. Task procedure

Each dot-probe trial started with a fixation cross in the middle of the screen for 2 s. Next, the two images appeared on either side of the screen. Each image appeared at 30% of the middle of the screen. They were displayed for 500 ms, after which the dot (diameter, 5 mm) replaced one of the two images. The participant had to push the F button when the dot appeared on the left and the J button when the dot appeared on the right on a standard QWERTY keyboard. After the response there was an inter-trial interval of 1000 ms, followed by the next trial. An ITI of 1000 ms was chosen so that participants had time to anticipate a shock.

After the participant filled in the informed consent, the electrode was attached to the left ankle and the shock work-up procedure was initiated (see Mertens & De Houwer, 2016, for a full description of this procedure). Briefly, the work-up procedure determined a suitable shock intensity level for each participant separately. The participant was told that (s)he needed to indicate which intensity was highly unpleasant but still tolerable, and the work-up procedure ended when the participant indicated their maximum tolerable intensity level.

The computer program began with the following instructions in Dutch: “Dear participant, before we start the experiment, some practice trials will be administered. First a fixation cross will appear, FIXATE YOUR EYES WELL ON THIS CROSS. Then, two images will appear, followed by a dot on the right or the left of the screen. Push, according to the position of the dot AS FAST AS POSSIBLE on the correct button < left = f; right = j > ”.

After this, the familiarization with the dot-probe task began. This consisted of twelve trials with fear-irrelevant images (a rabbit and an antelope) that were not re-used during the main experiment. After these trials the following instructions appeared: “Now, four images will be displayed. Two of these images will be associated with the word SHOCK. This indicates that a shock can follow when one of these images appears. Pay attention to the four images.”

Next, the four images were simultaneously displayed on the screen in a vertical organization. Next to one fear-relevant and one fear-irrelevant image the word “SHOCK” was displayed. The two images that were instructed to be paired with an electrical stimulation were counterbalanced across subjects, leading to four different combinations. There were two orders in which the pictures could be displayed, which were also counterbalanced, resulting in eight between-subject combinations. The images were displayed to the participants for 30 s.

Thereafter, participants were instructed that: “Now, a test will follow. When you think that an image can be followed by a shock, press ‘s’. When you think that an image is not associated with a shock, press ‘l’”. The four images appeared three times in a random order. After each response, the word ‘correct’ or ‘incorrect’ appeared, depending on their accuracy. When the participant made a mistake, they were told to inform the experimenter who then restarted the experiment from the beginning. Otherwise, the participants continued to the dot-probe task. Specifically, the participants received the instructions: “In case you made a mistake, warn the experimenter. If you made no mistakes, proceed with the task: FIXATE AT THE BEGINNING OF EVERY TRIAL ON THE FIXATION CROSS. Next, two images will appear left and right, followed by a dot. Try to detect the dot as fast as possible and push the corresponding button < left = f; right = j > ”. Two participants made a mistake on this test, and needed one more presentation of the instructions after which they both correctly remembered the instructions and were allowed to initiate the experiment. Importantly, removing these two participants from the analysis did not change the statistical significance of the results.

The first block consisted of 240 trials. After these 240 trials ‘experiment interrupted’ appeared on the screen. The experimenter acted as if he had stopped the experiment and told that something seemed to be wrong with the stimulation device. In reality, nothing was wrong with the device, but this gave us the opportunity to administer another stimulation. This was to reinstate the anticipation of a shock. After the participant confirmed that (s)he had received the stimulation, (s)he was instructed to press ‘p’ from ‘proceed’ to proceed with the experiment. Again, 240 trials were administered. After these trials a ‘thank you’ was presented on the screen and the participant was asked to warn the experimenter that the experiment had ended. Finally, the participants were given two questionnaires and the electrode was detached.

2.1.4. Questionnaires

After the experiment, the participants needed to fill in two (paper) questionnaires. One measured their beliefs in the instructions. The participants had to rate on a scale from one to ten how clear the instructions were and how believable they found them. To control if the participants had remembered the instructions well, the four images were shown again. They had to write shock under the right image. The order in which the images were shown was random for each participant so no order effects could influence their answers. All the participants had remembered the instructions correctly at the end of the experiment, and indicated that the instructions were clear. One participant rated the credibility of the instructions particularly low. However, the main findings were independent of exclusion of this participant.

The second questionnaire was the STAI-version DY-2 (State-trait anxiety inventory – versie Dutch Y-2; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) of which only the Trait version was administered. This questionnaire measures people's general anxiety levels. This questionnaire allowed us to check for possible outliers in trait anxiety, which could potentially skew the results. Two subjects had a STAI score two standard deviations larger than the mean (mean = 39.15; SD = 10.89), but the results reached the same levels of significance with or without these two subjects.

2.2. Results

All participants made < 3% errors (mean accuracy = 99.0%, SD = 0.8%). All reaction times from error trials and the first trial of each phase were removed from the analysis. Moreover, reaction times faster than 100 ms, as well as those that exceeded the individual mean reaction time with > 2.5 standard deviations, were excluded from the analysis. Tables 1 and 2 report all mean reaction times and standard

Table 1

Reaction times as a function of instructed fear condition and fear relevance on the (relevant) dot location and (irrelevant) opposed location in the first phase of Experiment 1.

Dot-location:		First half				Second half			
Other location:		Instructed fear (IF)		Instructed neutral (IN)		Instructed fear (IF)		Instructed neutral (IN)	
		Fr	Fi	Fr	Fi	Fr	Fi	Fr	Fi
IF	Fr		346 (41)	358 (41)	348 (35)		351 (67)	341 (40)	345 (54)
	Fi	347 (43)		350 (39)	352 (46)	340 (38)		348 (62)	359 (88)
IN	Fr	348 (35)	353 (42)		354 (44)	356 (64)	344 (52)		349 (54)
	Fi	353 (47)	348 (43)	353 (35)		349 (57)	357 (59)	369 (102)	

Note: Fr = fear relevant; Fi = fear irrelevant; values = mean (standard deviation).

Table 2
Reaction times as a function of instructed fear condition and fear relevance on the (relevant) dot location and (irrelevant) opposed location in the second (reinstatement) phase of Experiment 1.

Dot-location:		First half				Second half			
Other location:		Instructed fear (IF)		Instructed neutral (IN)		Instructed fear (IF)		Instructed neutral (IN)	
		Fr	Fi	Fr	Fi	Fr	Fi	Fr	Fi
IF	Fr		336 (48)	335 (49)	325 (49)		343 (53)	337 (36)	336 (40)
	Fi	338 (35)		334 (40)	332 (32)	349 (56)		346 (40)	344 (36)
IN	Fr	333 (45)	324 (35)		330 (31)	344 (46)	333 (39)		342 (53)
	Fi	330 (45)	320 (29)	333 (46)		345 (41)	335 (43)	345 (37)	

Note: Fr = fear relevant; Fi = fear irrelevant; values = mean (standard deviation).

deviations for all different possible combinations in the first phase and reinstatement phase, respectively.

Two main repeated-measures ANOVAs were used to analyze the data. One to study the effect of instructed fear on attention, and another to examine the effect of fear relevance. In a first ANOVA, we wanted to investigate whether attention was more biased towards fear conditioned pictures (CS^+), than pictures that were not associated to an aversive stimulation (CS^-). To this end, this analysis only focused on picture pairs in which only one picture was a CS^+ and the other a CS^-. We created the factor instructed fear congruency which indicated whether the dot had appeared on the CS^+ side (i.e. congruent trials) or the CS^- side (i.e. incongruent trials). The factor fear relevance context indicated whether both pictures where either fear-relevant or fear-irrelevant (note that, in this analysis, the fear relevance of both pictures was kept constant to exclude confounding effects of fear relevance on instructed fear congruency). Last, we also included the factors phase and phase half. The two phases were divided by the reinstatement instructions (the "first phase" and the "reinstatement phase"). These two phases were also further subdivided into two halves to detect extinction effects (i.e., factor phase half).

This ANOVA with the above-mentioned four factors showed a significant effect of phase, $F(1, 19) = 20.54$, $p < 0.001$, $\eta p^2 = 0.520$. The reaction times were significantly faster in the second phase (most likely due to learning effects). However, there was no main effect of instructed fear congruency, $F(1, 19) = 1.51$, $p = 0.234$, $\eta p^2 = 0.074$. Interestingly, the interaction between phase half and instructed fear congruency did reach significance, $F(1, 19) = 6.73$, $p < 0.05$, $\eta p^2 = 0.262$, indicating a significant difference between the effects of congruency in the first and second half of a phase. None of the other main effects or interactions reached significance (all $ps > 0.05$).

To further determine the impact of phase half on instructed fear congruency, we ran separate ANOVA's for each phase half. This analysis indicated a significant effect for instructed fear congruency in the first half of each phase, $F(1, 19) = 8.98$, $p < 0.01$, $\eta p^2 = 0.321$, but not the second half, $F(1, 19) < 1$, $p = 0.356$, $\eta p^2 = 0.045$. As can be seen on Fig. 1, instructed fear biased attention shortly after the instructions or reinstatement, but this attentional bias faded away in the second half of the block. Importantly, this congruency effect was not modulated by fear relevance context, $F(1, 19) < 1$, $p = 0.818$, $\eta p^2 = 0.003$, suggesting that this effect was independent from the nature of the conditioned stimuli.

In a second overall ANOVA, we investigated the attentional bias towards naturally fear-relevant pictures (snake or spider) versus fear-irrelevant pictures (bird or butterfly). To this end, we only focused on trials where only on one side of the screen a fear-relevant picture was presented. The included factors were instructed fear context, fear relevance congruency and phase and phase half. In close analogy to the first overall ANOVA, the factor instructed fear context contrasted trials that only contained CS^+ pictures to trials with only CS^- pictures. Fear relevance congruency coded for whether the dot appeared where the fear-relevant picture had been presented (congruent) versus the fear-irrelevant picture (incongruent).

There was again a significant main effect of phase, $F(1, 19) = 9.73$, $p < 0.01$, $\eta p^2 = 0.339$. However, no effect of fear relevance congruency was found, $F(1, 19) = 1.64$, $p = 0.216$, $\eta p^2 = 0.079$, nor any interaction with the factor fear relevance congruency (all $p > 0.2$). If anything, the numerical main effect of fear relevance congruency was in the opposite direction.

Overall accuracy was very high, with three subjects reaching 100% accuracy, another ten subjects made between 1 and 5 errors (out of 480 trials), five subjects 6 to 10 errors, and the remaining two made 12 and 13 errors, respectively. Still, we analyzed these errors to see whether they were more likely to occur on the conditions where participants performed fastest, which could indicate a speed-accuracy tradeoff. ANOVAs similar to the above, but on the error rates, showed no significant effect of instructed fear congruency, or fear relevance congruency, $F(1, 19) = 2.269$, $p = 0.148$, $F(1, 19) = 1.792$, $p = 0.197$, respectively (if anything, they showed a similar effect of congruency with higher error rates on incongruent trials). Instead, both analyses showed a main effect of phase, both Fs (1, 19) > 6.181, $p < 0.05$,

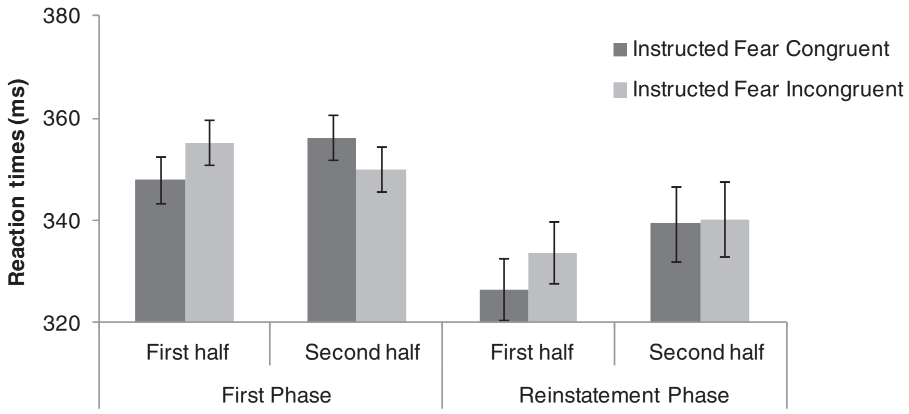

Fig. 1. Mean reaction times in the dot probe task. The whiskers reflect the confidence intervals for the separate congruency effects per phase and phase half. (Campbell & Thompson, 2012; Jarmasz & Hollands, 2009).

showing more errors occurring in the second (reinstatement) phase than in the first phase. Last, no interactions with both types of congruency were observed, except for a significant interaction between phase and fear relevance congruency, $F(1, 19) = 6.782$, $p < 0.05$, hinting at the observation that people made more errors to incongruent as opposed to congruent trials in the second, $F(1, 19) = 4.130$, $p = 0.056$, but not the first phase, $F(1, 19) < 1$. While this effect could be interpreted to suggest attention was biased towards fear relevant stimuli (in the second phase of the experiment), we believe it is very important to remain cautious in interpreting this effect, given the overall low error rate.

2.3. Discussion

In this first experiment, we observed how instructed fear stimuli could bias attention towards the instructed to-be-fearful stimulus, independent of its inherent fearful nature. Although the results suggested that no fear relevance effect could be observed, we should interpret this result with caution. Specifically, the main effect of fear relevance has been shown to be small in effect size, especially in a normal non-anxious population (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007). In hindsight, our experiment, with a sample size of 20 subjects, was not fit to detect an effect with a small effect size with 80% statistical power. However, the effect size of the instructed fear congruency effect (for the first half of each phase) was Cohen's $d_z = 0.67$ (Lakens, 2013), which can be considered in between medium (0.5) and large (0.8) in size, according to Cohen (1988).

In the second experiment, we decided to zoom in on this effect of instructed fear and set out to replicate the main observation from Experiment 1, but in a different design. In doing so, we wanted to address at least two possible concerns. First and foremost, it was possible in Experiment 1 that the participant expected the US (i.e., electrical stimulation) to occur during the dot probe task, as it was not well-specified when exactly the participant could expect the US following the CS^+. If the attentional bias is really automatic, it should be observed even when participants are explicitly instructed that it could not occur during the dot-probe task. Second, participants were presented with the instructions more than once during instruction presentation, and underwent elaborate testing whether they memorized the instructions correctly. Arguably, although no US was presented, these multiple presentations of the instructions and their pairings with the US could possibly allow for an involvement of "experience-based" mechanisms in learning the pairings. Previous studies already indicated that the repeated presentation of instructed fear stimuli is still different from presenting actual CS-US pairings (Braem et al., 2017; Raes, De Houwer, De Schryver, Brass, & Kalisch, 2014; Mertens, Raes, & De Houwer, 2016). However, we also wanted to address this issue within our second experiment by presenting the instruction only once, and briefly.

To this end, we employed a design inspired by paradigms from the task instruction implementation literature (Liefooghe, Wenke, & De Houwer, 2012; Meiran, Pereg, Kessler, Cole, & Braver, 2015), where multiple different instructions were presented throughout the experiment. Specifically, participants were presented with new task instructions on every run, which consisted of an instruction presentation screen, followed by four to sixteen dot-probe trials, and, finally, stimulus presentation. Importantly, participants were instructed that no US would be administered during the dot-probe trials. The amount of dot-probe trials was varied to ascertain that participants remained prepared for the actual CS presentation (for a similar reasoning, see Liefooghe et al., 2012; Meiran et al., 2015). Last, this approach using repeated short runs of dot-probe trials further allowed us to assess how short lived the attentional bias actually was. Namely, if the dot-probe effect in Experiment 1 was "only" an after-effect of instruction presentation, it should rapidly decay over the first few trials.

3. Experiment 2

3.1. Method

3.1.1. Participants

Twenty Dutch-speaking participants took part in the 30 min experiment (17 female, between 19 and 25 years old) in return for 6 euro. Although we did not perform this power analysis before data collection, the effect size of the instructed fear congruency effect in Experiment 1 (Cohen's $d_z = 0.67$) also suggests 20 subjects are needed to obtain a statistical power of 80%. Each participant filled in an informed consent.

3.1.2. Material

3.1.2.1. Apparatus. The task was performed on a DELL laptop computer and programmed in Notepad with tscope5 (Stevens, Lammertyn, Verbruggen, & Vandierendonck, 2006). The US was the same, and its intensity was determined by the same procedure, as in Experiment 1.

3.1.2.2. Stimuli. The stimuli consisted of 56 abstract colored shape images (Aminoff, Gronau, & Bar, 2006; Goris, Deschrijver, Trapp, Brass, & Braem, 2017; Trapp, Shenhav, Bitzer, & Bar, 2015). The images were randomly divided in 28 pairs per subject, which on their turn were randomly assigned to one of the runs (see below).

3.1.3. Task procedure

Participants were instructed that they would see new fear instructions at the beginning of each run, which indicated that one shape (CS^+) would be followed by an electrical stimulation (US), if presented later on, and another shape (CS^-) that would never be followed by the US. Crucially, and different from Experiment 1, participants were eventually presented with either the CS^+ or CS^-, and in case the CS^+ was presented, it was always followed by the US. However, importantly, in between instruction presentation and presentation of the CS (and US), participants were presented with a variable number of four to sixteen dot-probe trials (see below). That is, participants were presented with the dot-probe trials before any pairing between the CS and US was actually experienced. Importantly, participants were explicitly instructed to not expect any stimulations during the dot-probe task, but only following a centrally presented CS^+. Participants also knew the dot-probe task would always be presented first, and the dot-probe task had ended when one of the two CSs was presented centrally. This centrally presented CS always remained on screen for 5 s before an US was administered, giving participants a sufficient amount of time to anticipate the US.

Each run started with the display of the instructions for 5000 ms, during which instructions were given in the form of "if *image 1* then shock" on the upper half of the screen and "if *image 2* then no shock" on the lower half of the screen, or vice versa (the order in which both instructions were shown was randomized across runs). After the instruction screen, a fixation cross was displayed for 750 ms, upon which the participants were first presented with the dot-probe task. As in Experiment 1, the two CSs appeared left and right from the fixation cross for 500 ms, after which the two CSs disappeared, and a dot was presented on one of the two locations. The location of the CSs and dot was counterbalanced within run and presented in a randomized order. The task and response mapping was the same as in Experiment 1, and after the response or response deadline of 2000 ms, the next trial started. After four, eight, or sixteen dot-probe trials, one of the two CSs was presented in the center of the screen for 5 s. In case the CS^+ was presented, the offset of its presentation was always followed by a US. The delay between two runs was 1500 ms. The 28 runs were organized in four blocks of seven runs interspersed by self-paced breaks. Each block contained four runs with four dot-probe trials, two runs with eight dot-probe trials and one run with sixteen dot-probe trials, in a random order.

3.1.4. Questionnaires

Similar to Experiment 1, participants filled in the STAI questionnaire at the end of the experiment. None of the subjects had a STAI score larger than two SDs from the mean (mean = 43.5, SD = 9.99).

3.2. Results

Two participants had an accuracy of 86% and 83% respectively. Because these two subjects had an exceptionally low accuracy (for a dot-probe task), more than two SDs below the mean, we removed them from the analyses. The remaining participants had a mean accuracy of 98.0% (SD = 1.5%; range = 94–100%). Similar to Experiment 1, reaction times from error trials were removed from the analysis. Moreover, reaction times faster than 100 ms, as well as those that exceeded the individual mean reaction time with > 2.5 standard deviations, were excluded from the analysis. Although Experiment 2 had no explicit practice phase, we treated the first 12 trials as practice trials, and removed these from the analyses (because the training phase in Experiment 1 was also 12 trials).

Similar to Experiment 1, we ran an ANOVA with the factor instructed fear congruency which indicated whether the dot had appeared on the CS^{+} side (i.e. congruent trials) or the CS^{-} side (i.e. incongruent trials). We also included the factor time with four conditions, which took into account whether a trial belonged to the first four, second four, third four, or last four trials. This way, in close analogy to Experiment 1, we could explore the evolution of the hypothesized dot-probe effect over time, while now also zooming in on the first few trials after the instruction. In contrast to Experiment 1, where the factor phase half only contrasted the first 120 trials to the next 120 trials, the analyses of Experiment 2 were set up to test whether the dot-probe effects actually prevail for some trials or quickly decay after instruction presentation (see also, Meiran et al., 2015). Note that although one-tailed directional testing is allowed, especially given the results of Experiment 1, we report two-tailed tests only.

The ANOVA showed a main effect of time, $F(1, 15) = 8.93$, $p < 0.01$, $\eta p^2 = 0.641$, suggesting reaction times decreased over time. Moreover, there was a main effect of instructed fear congruency, $F(1, 17) = 4.80$, $p < 0.05$, $\eta p^2 = 0.220$, showing faster reaction times on congruent (357 ms) than incongruent (365 ms) trials (including the two participants with low accuracy yielded $F(1, 19) = 3.94$, $p = 0.062$, $\eta p^2 = 0.172$). Interestingly, the interaction between time and instructed fear congruency was far from significant, $F(3, 15) < 1$, $p = 0.788$, $\eta p^2 = 0.066$, suggesting that the dot-probe effect did not decay over the first sixteen trials following instructions (Fig. 2). A similar analysis of the error rates showed no significant effects, all $Fs < 1$. If anything, the error rates were higher on incongruent (2.1) than congruent trials (1.6%), ruling out a speed-accuracy tradeoff.

If people are flexible in the importance or fear they attribute to a new CS based on their most recent experience, the dot-probe effect could be modulated by reinforcement history. Therefore, in this additional analysis, we tested whether the dot-probe effect differed in size depending on whether or not it followed a sequence where the CS^{+} was followed by an electrical stimulation. However, this ANOVA showed no such modulation of the dot-probe effect by previous CS, $F(1, 17) < 1$, $p = 0.546$, $\eta p^2 = 0.022$.

4. General discussion

With this research we wanted to investigate whether instructed fear learning can bias visual attention, and whether the fear relevance of stimuli would modulate this effect of instructed fear. Using the dot-probe task, Experiment 1 showed that participants were faster to respond to the location of the dot when this location just featured a presentation of an instructed CS^{+} versus CS^{-} in the first half of each phase, suggesting that the initial instructions (and reinstatement) had an immediate impact on visual attention in the absence of any actual fear conditioning. Furthermore, this effect of instructed conditioning faded away, or even reversed, after repeated presentation of the stimuli without the instructed US which likely demonstrates extinction of the verbally installed attention bias due to the absence of the US. Last, we did not find that fear-relevance of the CSs modulated the effect of instructed conditioning (but see below). In Experiment 2, we replicated the general observation that responses were faster when the location of the dot matched that of the instructed CS^{+} presentation location rather than the instructed CS^{-}, further supporting the hypothesis that instructed fear can induce automatic attentional biases, much like experience-based fear can.

Our study adds to other studies on instructed fear learning by demonstrating that verbally instructed fear can also impact visual attention in an adult sample. This is an important addition to this growing research domain because attention biases have been found to be related to exaggerated fear and delayed extinction in anxiety patients (Fani et al., 2012), and further validates the multiple pathways theory for the acquisition of fear of Rachman (1977). The present findings also go against the idea that attentional biases to fearful stimuli would be specific to experience-based fear relations. Öhman and Mineka (2001) put forward an influential theory that the automatic visual detection of fearful stimuli relies on neural pathways (centered around the amygdala) that serve the experience-based Pavlovian learning of fear relations, and are impenetrable to conscious cognitive control. In contrast, learning via instructions is thought to require conscious cognitive control. In fact, many fear conditioning researchers have proposed that fear learning via experience might rely on more evolutionary older pathways that allow for a more automatized processing, than fear learning via instructions does (Grillon, 2009; Ledoux, 2014; Olsson & Phelps, 2004). Interestingly, the present results challenge the idea that automatic attentional biases are specific to experience-based fear relations, as our findings show that a similar automaticity can be achieved based on instructions alone. This is particularly illustrated by the results of Experiment 2 in which we found that the effects of instructions persisted despite the fact that participants were also explicitly instructed that no shocks would be delivered during the dot

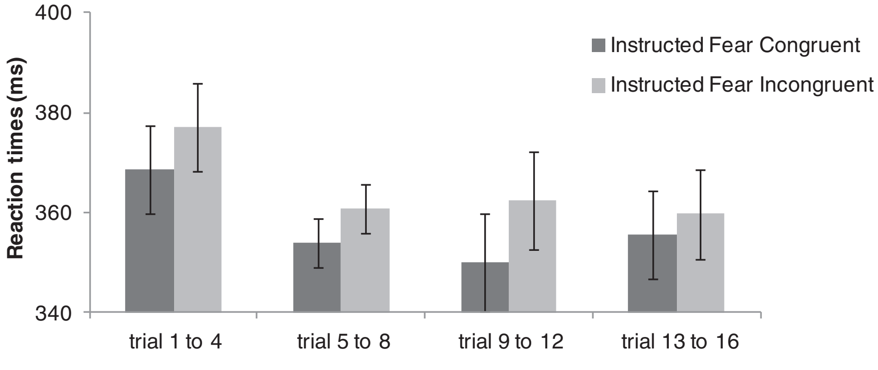

Fig. 2. Mean reaction times in the dot probe task per four trials following the instructions. The whiskers reflect the confidence intervals for the separate congruency effects per four trials. (Campbell & Thompson, 2012; Jarmasz & Hollands, 2009).

probe phase.

Our findings are also in line with those of Mertens, Kuhn, et al. (2016, Experiment 1). In their experiment, using the same stimuli as the present study, they also observed an influence of verbal fear instructions, which was not modulated by the fear-relevance of the pictures, as shown by both skin conductance and self-report measures. As discussed by Mertens, Raes, and De Houwer (2016), the absence of a modulatory effect of fear-relevance on instructed fear may partly be explained by the subtle nature of prepared learning effects. Even in studies employing direct conditioning to install fear, only mixed evidence for prepared learning effects have been obtained (Davey, 1992; McNally, 1987). Furthermore, modulatory effects of fear relevance may only be observed under specific circumstances, such as when ambiguity is high (Mertens, Raes, and De Houwer, 2016) or during an extended extinction period (Davey, 1992). The current study may thus have lacked sufficient power (see also our discussion of Experiment 1 regarding the main effect of fear relevance) or the right circumstances to detect modulatory effects of fear relevance. Therefore, the question whether prepared learning can be obtained for instructed fear learning requires further scrutiny. Future research could address this question by installing a longer extinction period after the instructed fear.

Earlier studies that investigated working memory effects on visual attention (e.g., Soto, Hodsoll, Rotshtein, & Humphreys, 2008) relied on instructions regarding future actions (i.e., attention is biased towards stimuli that are associated with a specific response; see also Tibboel, Liefooghe, & De Houwer, 2015). However, the current study shows that merely instructing participants about contingencies between neutral stimuli and threatening stimuli can also have an effect on attentional processing, even though these stimuli were not associated with a response, and attending to these stimuli would not lead to better outcomes. In other words, the present findings are the first to show that instructed stimulus-stimulus pairings can result in bottom-up attentional biases. However, these parallel observations from the action control literature do raise the issue of whether both kind of instruction-based effects might not reflect some kind of general “relevance” effect. That is, just like biases in visual attention have been observed for all kinds of stimuli that were made salient by their affective value or affective relation, it is possible that the present instructed fear effect could be true for all kinds of instructions that raise the affective value or salience (or “relevance”) of a given stimulus. Similarly, earlier fear conditioning studies have shown that self-relevance is an important factor in determining the speed of learning new fear relations (e.g., Stussi, Brosch, & Sander, 2015). An in-depth treatment of this idea would go beyond the scope of the present article. However, future research should explore whether, for example, the exponentially increasing number of studies on attentional biases to previously rewarded stimuli (for a review, see Anderson, 2017) can be observed for merely instructed reward relations, too.

Future studies should also determine whether the present findings reflect an effect of attentional capture or, instead, a failure to disengage attention away from the instructed fear stimulus. Our choice of a 500 ms stimulus presentation time is in line with many previous dot-probe paradigms, but has been argued to be sensitive to a failure to disengage, rather than attentional capture (Fox, Russo, Bowles, & Dutton, 2001). Employing various presentation times should allow future studies to track the temporal dynamics of the attentional bias towards instructed fear stimuli. Similarly, while the present study shows attention was biased, it cannot guarantee this was at the level of visual attention. That is, our study cannot rule out the possibility that the location of instructed fear stimuli initiated a spatially corresponding response preparation, which interrupted response preparation processes following incongruent dot (location) presentation (e.g., Fox et al., 2001). Future research can test this possibility by assigning only a single response button which has to be pressed only when the dot is presented (relative to when it is not; see also, Fox et al., 2001, Experiment 4), and study whether the attentional bias can still be observed.

Finally, we did not observe an attentional bias for fear relevant versus irrelevant stimuli. As noted above, the absence of this effect could be due to low statistical power. However, the absence of our effect is also in line with a recent study by Vogt, De Houwer, Crombez, and Vandamme (2013). In their study, it was found that attention in a dot probe task can be modulated by recent goals, even in a population of high anxious participants. Specifically, Vogt et al. (2013) found an attentional bias towards goal-relevant pictures (which had just been associated with the winning of point), when this picture appeared either next to a neutral or fearful picture, overriding the typical attentional bias to fearful stimuli. Even though the content of the goal-relevant picture was similar to other stimuli, it had an influence on the participants behavior in the dot-probe task. In our experiment, a similar process might have occurred. It seems plausible that participants retained the goal to detect the pictures which were associated with an aversive stimulation to anticipate on the possibility of receiving a stimulation. This attentional bias interfered with the attentional preparedness for fear-relevant stimuli. This finding can support the idea that attention is allocated to stimuli in the environment that are goal-relevant in a certain moment (Vogt et al., 2013).

In summary, we can conclude that instructional fear-learning can impact on visual attention in a dot-probe paradigm. Dots were detected faster when they replaced a CS$^+$, irrespective whether this CS$^+$ was a fear-relevant or fear-irrelevant stimulus. In the second half of both phases the effects disappeared, suggesting effects of extinction. Finally, we did not find evidence that visual attention was impacted by fear relevance, possibly due to goal competition.

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