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Very brief exposure II: The effects of unreportable stimuli on reducing phobic behavior ☆

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ABSTRACT

This experiment compared the effects of exposure to masked phobic stimuli at a very brief stimulus-onset asynchrony on spider-phobic and non-phobic individuals. Participants were identified through a widely used questionnaire and a Behavioral Avoidance Test (BAT) with a live, caged tarantula to establish baseline levels of avoidance. One week later, they were individually administered one of two continuous series of masked images: spiders or flowers. Preliminary masking experiments showed that independent samples of participants from the same populations failed to recognize these stimuli. Participants in the main experiment reported ratings of subjective distress immediately before and after the exposure manipulation. Then they engaged in the BAT once again. Very brief exposure to images of spiders reduced phobic participants' avoidance of the tarantula. No effects were evidenced on subjective distress, or on non-phobic participants. Theoretical implications for the non-conscious basis of fear are discussed.

1. Introduction

Over the past two decades, basic scientific research on fear has mounted a considerable challenge to the view of consciousness as an agent of cognitive control. Mounting behavioral and neuroscientific studies have shown that fear responses can be activated, conditioned and experientially evoked outside of awareness (Carlsson et al., 2004; Katkin, Wiens, & Ohman, 2001; LeDoux, 1996; Öhman & Soares, 1993, 1994, 1998; Morris, Ohman, & Dolan, 1998, 1999; Phelps, 2005; Ruys & Stapel, 2008). Neuroanatomical studies across mammal species have consistently identified a dual neural architecture of fear, implicating structures that are dissociable in terms of consciousness (Bechara et al., 1995; Fendt & Fanselow, 1999; LaBar, LeDoux, Spencer, & Phelps, 1995; Lang, Davis, & Ohman, 2001). More recently, similar findings have emerged in a variety of neuroimaging studies, which have demonstrated the activation of the human amygdala by non-conscious, fear-relevant stimuli (Etkin et al., 2004; Morris et al., 1998; Phelps, 2005; Whalen et al., 1998, 2004; Williams, Morris, McGlone, Abbott, & Mattingley, 2004). Thus, fear is currently viewed as primarily mediated by non-conscious processes that are relatively impenetrable to conscious, cognitive control: "Rather than presuming that various cognitive factors determine fear responding... they are often effects of such responses" (Öhman & Mineka, 2001, p. 514).

This body of research attesting to the non-conscious basis of fear converges on an intriguing question: if fear can be induced, acquired and experientially evoked outside of awareness, is it possible to reduce it under this same condition? For

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example, is it possible to reduce avoidance of a feared object *without conscious awareness*? The purpose of the current study was to address this question.

Tyrer, Horn, and Lee (1978; Lee, Tyrer, & Horn, 1983) tested what they called a subliminal exposure technique by presenting a brief film related to agoraphobia (e.g., crowded markets; busy roads; public transportation). Both subliminal and supraliminal exposure to the film reduced self-reported phobic symptoms and physiological responses in treatment-resistant agoraphobics. However, this study did not assess effects on avoidance of the feared object. Siegel and Weinberger (2009) developed a technique called *very brief exposure* (VBE) for this purpose. If priming with masked, fear-relevant stimuli generates non-conscious fear responses, it stands to reason that continuous exposure to such stimuli will eventually result in reduction of those responses. That is the logic of VBE. Spider-fearful participants were administered a continuous series of masked images of spiders, each for a brief duration (25-ms). A preliminary experiment found that an independent sample of such participants lacked subjective awareness of these stimuli. The main experiment compared the effects of very brief and clearly visible exposure to these stimuli on approaching a live, caged tarantula. Those administered VBE to spiders approached the tarantula more than those exposed to the same, clearly visible stimuli, and those administered VBE to trees (control stimuli). These differences between the groups were maintained on retesting 1 week later. In a similar vein and an independent laboratory, Weinberger, Siegel, Siefert, Drwal (2011) compared the effects of VBE on spider-fearful and non-fearful participants. VBE to images of spiders promoted approach towards a live tarantula among the former but not the latter group.

These initial experiments tested whether VBE influences approach towards a feared object – not if it reduces avoidance of that object from a baseline. Siegel and Weinberger (2009) reported such an effect based on a small sample. The purpose of the current study was to replicate this finding with a larger sample, and to build on it in two additional respects. First, it compares the effect of VBE on reducing avoidance of phobic versus non-phobic participants. This builds directly on Weinberger et al. (2011) as participants' self-reported fear of spiders or lack thereof was confirmed by a baseline assessment of avoidance of a live tarantula. We compared effects on phobic versus non- phobic samples because fear is a basic emotion. Thus, VBE may reduce phobic behavior in general. This would be theoretically intriguing, but less potentially valuable.

Second, the current study investigated the effects of VBE on conscious distress as well as phobic avoidance. A comparison of these effects has significant implications for the relationship between conscious cognition and emotion. It's one thing to suggest the primacy of unconscious processes over conscious cognition in the elicitation of fear. As noted above, relevant unconscious phenomena are robust. The prevailing theoretical paradigm of emotional automaticity explains these phenomena convincingly (LeDoux, 1996; Öhman & Mineka, 2001). It's quite another thing, however, to suggest that fear can be reduced in the absence of cognitive control. Models of fear reduction heavily emphasize the regulatory role of conscious cognition. For example, disconfirmation of catastrophic beliefs theory holds that fear is reduced when a person realizes that her fear of an object/situation is unwarranted. Supporting this view, phobics overestimate the danger of phobic objects (Cavanagh & Davey, 2004; Thorpe & Salkovskis, 1997). Accordingly, this theory holds that one must directly confront feared objects or situations with full conscious awareness – or undergo *exposure* (Anton & Swinson, 2000; Emmelkamp, 2004) – in order to reduce fear. Similarly, new learning theory holds that when fear is reduced as a result of exposure to a feared object, old beliefs are not merely disconfirmed: new beliefs are formed (Bouton, Mineka, & Barlow, 2001; Foa, 1997; Schiller et al., 2010). When a phobic person encounters his feared object and "nothing bad happens", a new learning experience occurs that is independent of the learning that resulted in fear of the object in the first place. Supporting this model, people who previously feared an object form new beliefs when they overcome their fear. At the same time, their fears tend to return during times of stress, showing that the old learning never went away (Barlow, 2002). In this theory, awareness of the new learning experience is also necessary.

There are also practical and humane implications to the effect of VBE on subjective distress. Exposure is an infamously unpleasant experience. People experience much distress when they confront what they fear. This is a considerable obstacle in bringing those who suffer from phobias to treatment (Magee, Eaton, Wittchen, McGonagle, & Kessler, 1996). There is a likely relationship between awareness of exposure and the experience of distress: lack of awareness may diminish distress, and thereby make exposure less aversive. Therefore, prior to proceeding to the main experiment, we conducted preliminary masking experiments to assess awareness of the exposure stimuli.

2. Preliminary experiments: masking the stimuli

A backwards masking procedure was used to present the stimuli (Holender, 1986; Öhman & Soares, 1994). A target stimulus is flashed and immediately followed by a masking stimulus. With suitable stimulus-onset asynchrony (SOA) between the two stimuli, an effective mask prevents recognition of the target. Öhman and Soares (1993, 1994) found that when the SOA between pictures of spiders and an effective mask was 30-ms or less, both fearful and non-fearful participants identified them no better than chance in forced-choice discrimination tasks. We replicated this finding for the stimuli used in the current study with a sample of 12 spider-fearful participants (identified as described below) using an SOA of 25-ms.[1] The masking stimulus was an array of capital letters (ABCD) that was shown to be effective in prior studies (Siegel & Weinberger, 2009). It

[1] The SOA is primarily a function of the refresh rate of the monitor, or how quickly it regenerates stimuli on the screen. SuperLab has an option wherein the target stimulus is erased before the masking stimulus is presented on the next refresh cycle. This keeps the target stimulus on the screen for approximately one-half a refresh cycle, or 8-ms, making the SOA approximately 25-ms (personal communication, SuperLab).

was presented for 120-ms after each target. Masked images of spiders and flowers (also described below) and double mask trials were presented in a random sequence. The latter trials, in which the mask was also the target, served as a control condition to assess response biases (i.e., the tendency to respond with "spider" or "flower"). Participants were told that they would be presented with a series of stimuli that they may or may not recognize. Regardless, their task was to identify each stimulus as either a spider or a flower. The inter-trial interval was 5 s to provide adequate time to respond to each trial. One very phobic participant was excluded from the data analysis because her spider response bias was 0%. Spider images were correctly identified 52% of the time; response bias was 57%. Flower images were correctly identified 59% of the time. Thus, discrimination of spiders did not exceed response bias rates, indicating chance-level performance. Öhman and Soares (1994) also found that fearful participants correctly identified flowers somewhat more often than spiders.

A significant limitation of this preliminary experiment was a difference in design from the main experiment. Whereas a forced-choice task varies the presentation of different categories of masked stimuli within subjects (e.g., spiders and flowers), VBE entails continuous presentation of a particular category of masked stimuli (e.g., spiders or flowers). Thus, participants are significantly more likely to develop awareness of the stimuli in the latter case. Because the target stimuli are presented continuously in VBE, awareness of them needs to be assessed continuously. That can only be done subjectively – by asking participants what they see (Holender, 1986). The subjective nature of awareness is also directly relevant to exposure. As Tyrer et al. (1978) showed, if participants lack subjective awareness of exposure stimuli, they are unlikely to experience distress. Thus, a second preliminary experiment was conducted to rigorously assess subjective awareness of the stimuli during VBE.

2.1. Method

2.1.1. Participants

In what they thought was an independent study, the Fear of Spiders Questionnaire (FSQ, Szymanski & O'Donohue, 1995) was administered to 650 undergraduates enrolled in natural science courses at a public, northeastern liberal arts college. Those who scored in the top 15% (most fearful) and bottom 50% (not fearful) of the distribution of scores of the FSQ were contacted to participate. To validate these self-reports, participants engaged in a Behavioral Avoidance Test (BAT) with a live tarantula, described below. This screening resulted in samples of 10 "*spider-phobic*" and 10 "*non-phobic*" participants. Average age was 19.3 (SD = 2.45). Participants provided informed consent and were paid $10.

2.1.2. Design

To duplicate the conditions of the main experiment below, participants were exposed to a continuous series of masked images of either spiders or flowers. Thus, the design was a 2×2, Stimulus Type $\times$ Group (phobic or non-phobic) factorial, both variables being between-subjects.

2.1.3. Measures and equipment

The *Fear of Spiders Questionnaire* (FSQ, Szymanski & O'Donohue, 1995) is a widely used instrument to identify individuals who are relatively high or low in fear of spiders. Filler questions designed to disguise the intent of the questionnaire concerned fear of heights, snakes and needles, and sensation-seeking. These items were not scored.

A *Behavioral Avoidance Test* (BAT) was used to confirm participants' reported fear of spiders. Participants are asked to complete a series of tasks that are ordered in a graded fashion. Early tasks require little proximity to a feared object; later tasks require more proximity and involvement with it. A BAT is concluded when a participant indicates that he or she is unwilling to complete a task, or fails to complete a task. The BAT was an eleven-point scale of willingness to approach a tarantula in a 10-gallon fish tank. It can be found in the Appendix A.

2.1.3.1. Stimuli, software and hardware. In considerable preliminary work, 25 images each of spiders and flowers were downloaded from websites of entomology and botany departments on the World Wide Web, and adjusted to fit within a window of 500×500 pixels. The mean number of pixels, mean luminance, and mean contrast of luminance of the two image categories did not differ. The masking stimulus was an array of capital letters, 520×520 pixels, that totally covered the area where the target images appeared. The images were presented by the 4.0.1 version of the SuperLab program on a 2007 Dell desktop PC equipped with a high-speed video card and a standard 19 in. monitor. Screen resolution was 1024×768 pixels and refresh rate was 60 Hz. Images were viewed at a distance of approximately 65 cm and thus within horizontal and vertical visual angles of 8.6°.

2.1.3.2. Subjective awareness measures. As described below, participants first reported what they saw after each target stimulus was flashed on the screen. To address possible response bias, they were then given a funneled interview that was designed to elicit information about their knowledge of the stimuli. It can be found in the Appendix A.

2.1.4. Procedure

Participants were run individually. The instructions spoken to them were: "An X will appear in the middle of the computer screen. Focus on the X at all times. Then there will be a flash, followed by some capital letters. If you see something between the X and the capital letters, I want you to tell me what you think it was. If you're not sure, you can take a guess. The cycle will then repeat itself many times: the X, followed by a flash, followed by the capital letters. Each time, if you see something between the X and the capital letters, tell me what you think it was. You will have a few seconds to say what you saw. Do you understand?'' Just before presenting the stimuli, the experimenter reminded the participant to report what he saw after each stimulus was flashed on the computer screen. The task began with a large X appearing in the center of the screen for 1 s for the participant to fixate on. This was followed by a flash, the target stimulus (an image of a spider or flower) for 25-ms. Immediately following the target stimulus, a row of capital letters appeared as a mask for 120-ms. This process – a large X, followed by a target stimulus, and then the mask – was repeated 25 times, so that each participant was exposed to 25 images of the target stimulus in each condition. The interval of each stimulus trial was approximately 2 s. The inter-trial interval was 5 s so that the participant would have adequate time to report what she saw on each trial. The experimenter recorded the participant's response to each flash verbatim, one after another. If the participant did not say anything after the first three flashes, the experimenter gently prompted him each time by asking: ''Did you see something?'' If the participant said something like, ''I don't know'', the experimenter reminded him that he could take a guess. To simulate the exposure administration in the main experiment, the experimenter stopped prompting the participant after the third trial.

Immediately after this computer task, participants were administered the funneled interview. Their responses were recorded verbatim.

3. Results and discussion

Phobic and non-phobic participants failed to identify 24 of the 25 spider images, and all of the flower images. A spider image that was identified by two phobic participants was somewhat darker than the masking stimulus, which likely contributed to it being noticed. It was excluded along with a flower image chosen at random, so that an equal number (24) of spider and flower images were used in the main experiment below. It is important to note that any subjective measure of awareness has an inherent limitation. People vary in their willingness to self-report awareness of masked stimuli, or exhibit *response bias* (Wiens, Emmerich, & Katkin, 1997). In this masking experiment, we tried to address this limitation by first asking participants to self-report immediately after presentation of each masked image, and then complete a funneled interview at the end of the task that was designed to elicit information that they may have been tentative to initially report. While it is unlikely that participants were unwilling to report on their awareness of the images during the interview as well as the computer task, this possibility cannot be ruled out. The issue of awareness of the exposure stimuli is taken up in Section 5.

4. Main experiment

This experiment compared the effects of very brief exposure (VBE) to the stimuli from the preliminary experiment on reducing avoidance of a live tarantula exhibited by spider-phobic and non-phobic individuals. Based on prior findings, the hypothesis was an interaction between VBE and the participant variable: VBE to images of spiders would reduce avoidance among spider-phobic but not non-phobic participants. An effect on non-phobic participants was not expected because they should not respond as much during VBE to fear-relevant stimuli, and hence be unaffected when they subsequently approach the tarantula. VBE was not expected to affect subjective distress of either sample because effectively masked stimuli should not generate significant conscious responses.

4.1. Method

4.1.1. Participants

Potential participants were recruited from the same source and in the same manner described above. Those who self-identified as fearful of spiders but did not avoid the tarantula on the BAT were excluded (15% of potential participants). One participant who self-identified as non-fearful but did not approach the tarantula more than the average phobic participant was excluded. Three participants discontinued the BAT because the tarantula moved unexpectedly, confounding measurement of their avoidance, and thus were excluded. This screening resulted in samples of 36 ''*spider-phobic*'' and 35 ''*non-phobic*'' participants. Reflecting the gender distributions of these populations in psychology classes, there were 30 female and six male spider-phobic participants, and 22 female and 13 male non-phobic participants. The average age was 19.7. Participants provided informed consent and were paid $20 for completing the 2-week study.

4.1.2. Design

This study followed the same 2×2 design as the preliminary experiment with a repeated measure. The independent variable was type of exposure: 24 masked images of either spiders or flowers (25-ms SOA), presented as described above. The participant variable was phobic or non-phobic of spiders, operationalized as described above. Effects on avoidance of a feared object and subjective distress were measured before and immediately after the exposure manipulation.

4.1.3. Measures

The aforementioned *Behavioral Avoidance Test* (BAT) was used to measure avoidance of spiders. BATs are frequently employed to measure clinical improvements in spider phobia (e.g., Garcia-Palacious, Hoffman, Carlin, Furness, & Botella, 2002).

For each task completed, a point is scored (i.e., a participant that completes the first four tasks receives a score of 4). Thus, a *higher* score indicates greater proximity to the feared object, and hence *less* fear. The BAT can be found in the Appendix A.

A *subjective units of distress scale* (SUDs) was used to measured participants' subjective distress. This is a self-report measure commonly used by clinicians practicing exposure therapy. The participant rates her fear from 0 to 10, with higher numbers indicating greater distress.

4.1.4. Procedure

On the first week of the study, participants engaged in the BAT. The experimenter introduced the BAT by explaining that there was a spider in a glass aquarium covered with a blanket in the next room located roughly 12 ft from the door. The experimenter gave the participant a list of approach tasks that described what she would be asked to do. She was told that she could discontinue at any time and did not have to do any of the tasks. Participants were told that they should first state if they were or were not willing to complete a task, and not to begin any task until told to do so. After explaining the BAT and answering questions, the experimenter led the participant to the door of the room containing the spider. Participants were first asked if they would be willing to enter the room with the covered spider and stand next to the door, roughly 12 ft from the covered aquarium containing the spider. If the participant said she was willing, the experimenter told them to go ahead and enter the room and stand by the door. The experimenter then asked them if they would be willing to come within 5 ft of the covered aquarium. If the participant said she was willing, the experimenter then asked her to complete the task. Each of the nine tasks was presented in this manner, with the experimenter first asking if the participant was willing. If the participant said she was willing, she was instructed to complete the task. The BAT was discontinued when a participant indicated that they were unwilling to complete a task, when a participant indicated they were willing to complete a task but then discontinued the task prior to completing it, or when a participant indicated they were willing to complete the final task. For the first nine tasks, participants received a point only if they were able to fully complete the task. However, if a participant said that they were willing to complete the final task (touching the spider), they were instructed to not do so (e.g., "OK, but don't touch the spider"), and received a point simply for stating that they were willing. Participants who reached this task believed that they would have to touch the spider because they had done all of the other tasks. The BAT typically took 3–4 min.

On the second week of the study, participants engaged in the computerized exposure task. They reported a SUDs rating just before beginning this task. The task began with the participant reading the instructions on the computer screen. When she indicated that she understood the task and was ready to begin, the participant pressed the space bar and the stimuli were presented in the same way as the preliminary experiment. The experimenter left the participant alone in the room to experience the computer task so as to be blind to the experimental condition. When the task was finished, a screen appeared indicating that the participant should now call the experimenter back into the room. The experimenter immediately asked the participant for a second SUDs rating upon re-entering the room. After reporting this rating, participants engaged in the BAT once again. Then they were given a brief interview to assess their knowledge of the exposure images. Finally, they were debriefed and paid for their participation.

4.2. Results

A mixed model 2 × 2 × 2 ANOVA was used to test the hypothesis. The first two factors were between-subjects, Type of Exposure (to masked images of either spiders or flowers) and Phobic Status (phobic or non-phobic). The third factor was Time: before and after exposure. In addition, 2 × 2 ANOVAs were used to test the effect of Type of Exposure on the spider-phobic sample and on the non-phobic sample, respectively (the first factor being Type of Exposure, and the second being Time).

4.2.1. Behavioral Avoidance Test (BAT)

As a check of random assignment, the baseline BAT scores of neither the phobic nor the non-phobic groups significantly differed (for the phobic groups, $t\ (33) = .36$, $p = .72$, and for the non-phobic groups, $t\ (33) = 1.32$, $p = .20$). Levene's Test of

Table 1
Behavioral Avoidance Test: Interaction of Very Brief Exposure, Phobic Status and Time.

Phobic status		Very brief exposure: Spiders	Very brief exposure: Flowers
Phobic	Time 1:	6.9 (.40)	6.7 (.39)
	Time 2:	7.5 (.41)	6.8 (.39)
Non-phobic	Time 1:	9.6 (.40)	9.5 (.39)
	Time 2:	9.8 (.41)	9.8 (.39)

Main effect: phobic status: $F\ (1, 66) = 48.5$, $p = .0001$
Main effect: time: $F\ (1, 66) = 24.4$, $p = .0001$
Interaction effects: very brief exposure × phobic status × time: $F\ (1, 66) = 8.99$, $p = .004$
Phobic group: very brief exposure × time: $F(1, 33) = 4.83$, $p = .035$

Note: Values outside of the parentheses represents mean scores on the Behavioral Avoidance Test. A higher number indicates less avoidance of the tarantula, and hence less fear of it. Values within parentheses represent standard error of measurement.

Table 2
Subjective units of distress: interaction of very brief exposure, phobic status and time.

		Very brief exposure	
Phobic status		Spiders	Flowers
Phobic	Time 1:	2.3 (.43)	1.1 (.44)
	Time 2:	2.9 (.48)	1.7 (.49)
Non-phobic	Time 1:	.62 (.45)	.11 (.44)
	Time 2:	.62 (.50)	.33 (.49)
Main effect: phobic status: $F(1, 68) = 13.5$, $p = .0001$			
Main effect: time: $F(1, 68) = 4.27$, $p = .04$			

Note: Values outside of the parentheses represents mean scores on the Subjective Units of Distress (SUDs) Scale. Values within parentheses represent standard error of measurement.

Homogeneity of Variance indicated that the variability of the corresponding groups' baseline BAT scores also did not differ. One outlier in the spider-phobic sample who went up five points on the BAT from Week 1 to Week 2 (>3 SDs) was not included in these analyses.

Table 1 shows the BAT means of the spider-phobic and non-phobic groups. There was a significant main effect of Phobic Status on the BAT, $F(1, 66) = 48.5$, $p = .0001$, indicating that non-phobic participants got closer to the tarantula than phobic ones. There was also a significant main effect of Time, $F(1, 66) = 24.4$, $p = .0001$, indicating that BAT scores increased. The main effect of Type of Exposure was not significant ($F < 1$) because it included both phobic and non-phobic participants. There were no two-way interaction effects. Confirming the main hypothesis, the interaction of Type of Exposure, Phobic Status and Time was significant, $F(1, 66) = 8.99$, $p = .004$, indicating that phobic participants' BAT scores increased more than non-phobic participants' as a result of Type of Exposure. The effect size of this interaction was *Eta* = .35.

In the 2×2 ANOVA pertaining to spider-phobic participants, there was a significant main effect of Time, $F(1, 33) = 15.5$, $p = .0001$. The main effect of Type of Exposure was not significant ($F < 1$) because the Week 1 BAT scores of the two groups differed somewhat (though as noted above, not significantly so). The interaction between Type of Exposure and Time was significant, $F(1, 33) = 4.83$, $p = .035$, indicating that phobic participants' BAT scores increased as a result of exposure to very brief spiders. The effect size of this interaction was *Eta* = .36 (between a "medium" and "large" effect, Cohen, 1988). In the 2×2 ANOVA pertaining to non-phobic participants, the only significant effect was Time, $F(1, 33) = 10.2$, $p = .003$.

4.2.2. Subjective units of distress (SUDs)

The SUDs means are shown in Table 2. The baseline SUDs scores of neither the phobic nor the non-phobic groups significantly differed (for the phobic groups, $t(35) = 1.49$, $p = .15$, and for the non-phobic groups, $t(33) = 1.70$, $p = .10$). The main effect of Phobic Status was significant, $F(1, 68) = 13.5$, $p = .0001$, indicating that spider-phobic participants experienced greater distress than non-phobic ones. The main effect of Time was significant, $F(1, 68) = 4.27$, $p = .04$, indicating that SUDs scores increased. The main effect of Type of Exposure was on the border of significance, $F(1, 68) = 3.57$, $p = .06$, wherein participants exposed to spider images reported somewhat more distress than those exposed to flower images (regardless of Phobic Status). This occurred because the baseline SUDs scores of both phobic and non-phobic participants exposed to spiders were somewhat higher than those exposed to flowers (though as noted above, not significantly so). There were no two- or three-way interaction effects. For spider-phobic participants, the effect of Time approached significance, $F(1, 35) = 3.48$, $p = .07$. There were no effects on non-phobic participants ($F < 1$ in all cases).

5. Discussion

This experiment compared the effects of very brief exposure (VBE) to images of spiders or flowers on reducing avoidance of a live tarantula and subjective distress of spider-phobic versus non-phobic participants. The significant interaction between Type of Exposure and Phobic Status confirmed the main hypothesis: exposure to unreportable images of spiders reduced avoidance of a live tarantula in phobic but not non-phobic individuals. While there was no effect of exposure on non-phobic participants' avoidance of the tarantula, this possibility cannot be ruled out because of a possible ceiling effect on the BAT. Regardless, the ANOVA conducted on spider-phobic participants also showed that VBE reduced their avoidance of the tarantula. As developed below, we interpret these findings to mean that avoidance of a feared object can be reduced without conscious awareness during exposure. They build upon the main findings of Siegel and Weinberger (2009; Experiment 2) who showed that VBE promoted approach towards a feared object more than clearly visible exposure to the same stimuli. The findings also build directly on those of Weinberger et al. (2011) who showed that this approach-enhancing effect was specific to those who feared the object. The current experiment constituted a stricter test of VBE because it involved a baseline BAT that could have eradicated the effects of the subsequent exposure manipulation.

Parallel results were not obtained for subjective distress. That is, while VBE to spider images reduced phobic participants' avoidance of the tarantula, they did not report experiencing less fear as a result of such exposure. Indeed, subjective distress increased across participants after exposure, regardless of phobic status or type of exposure. This apparent dissociation between self-report and behavior represents a now common finding in the literature: an *implicit effect* (Greenwald & Banaji, 1995; Kihlstrom, 1987; McClelland, Koestner, & Weinberger, 1989; Schacter, 1992). The bulk of research on implicit phenomena has concerned cognitive processes. This study adds to the literature that extends implicit phenomena to emotion (e.g., Bechara et al., 1995; Dozier & Kobak, 1992; Shedler, Mayman, & Manis, 1993).

A limitation of this study was that it did not include a measure of physiological arousal during VBE. This may have provided an independent corroboration of the effect that was evidenced on phobic behavior, as well as an objective measure of the immediate effect of VBE. Another limitation of this study was that it did not include a group who were exposed to the spider images well within conscious awareness. Without such a group, the possibility that the spider images reduced avoidance of the tarantula only because of their content and not also because of their duration (and hence participants' level of awareness of them) cannot be ruled out. An experiment that includes a group who are exposed to the same clearly visible images of spiders would rule out this alternative explanation.

In light of this second limitation, the question arises as to whether the participants were aware of the stimuli. In preliminary experiments, measures of subjective and objective awareness showed that independent samples of participants failed to recognize the target stimuli that were used in the main experiment. However, more significant than the limitations of these measures described earlier is that participants were not exposed to a live tarantula prior to viewing the images in the preliminary experiments. Thus, unlike participants in the main experiment, they were not primed to expect to see spiders when viewing the target stimuli. Demonstrating this priming effect in the main experiment, the number of phobic participants exposed to flowers who reported that they saw spiders was the same as the number exposed to spiders who reported the same thing ($n = 3$). Similarly, the SUDs rating of both phobic groups – those exposed to flowers as well as those exposed to spiders – increased by the same amount (.6). Regardless, two phobic participants exposed to spiders reported that they were able to make out one image, one reported that they saw two images, and one reported that he saw four. It seems unlikely that the effect of the masked spider images on reducing phobic avoidance of a live tarantula could reflect such minimal awareness. If participants were more aware of these stimuli than they reported, it presumably would have differentially influenced their SUDs ratings. Taken together, these effects of VBE on behavior versus conscious experience are consistent with the interpretation that they occurred outside of awareness.

Thus, the current findings appear to be consistent with the body of research attesting to the primacy of non-conscious processes on fear (e.g., Carlsson et al., 2004; LeDoux, 1996; Öhman & Mineka, 2001; Öhman & Soares, 1993, 1994, 1998; Morris et al., 1998, 1999; Phelps, 2005; Ruys & Stapel, 2008). Just as fear responses can be activated, conditioned, and experientially evoked without conscious knowledge, the current findings suggest that avoidance of a feared object can be similarly influenced. It has long been maintained that in order to reduce fear of an object or situation, one must directly confront it with full conscious awareness. It was once similarly maintained that awareness of stimulus contingencies is a requirement of Pavlovian conditioning. This long-standing belief was refuted when it was shown that fear responses can be conditioned by masked stimuli (Esteves, Dimberg, & Ohman, 1994; Öhman & Soares, 1998). The current findings suggest that just as conscious awareness is not a requirement of conditioning by fear-relevant stimuli, nor is it necessary to reduce avoidance of a feared object that was likely previously conditioned.

5.1. Theoretical implications

The implicit effect of VBE suggests that phobic behavior was altered without attending changes in conscious cognition. As developed in the introduction, this argues against cognitive models of fear learning, such as new learning theory (e.g., Bouton et al., 2001; Foa, 1997; Schiller et al., 2010) and disconfirmation of catastrophic beliefs (Beck & Clark, 1997; Cavanagh & Davey, 2004; Eysenck, 1992; Menzies & Clarke, 1995). Recall that from the latter point of view, phobic behavior is attributable to consciously maintained beliefs about the certain danger of feared stimuli. Thus, changes in phobic behavior cannot occur in the absence of concomitant changes in such beliefs. However, changes in catastrophic beliefs may not, in fact, cause reduction of phobic behavior as the therapeutic effects of exposure do not depend on such changes (Emmelkamp, 2004). Our findings are consistent with this latter view. While we did not assess changes in irrational beliefs about spiders, phobic participants who were exposed to very brief spiders presumably did not get closer to the tarantula because of changes in such beliefs. After all, their distress increased as much as those exposed to flowers. This finding is consistent with the aforementioned reports that phobic participants gave during the funneled debriefing interview (an equal number in the two experimental conditions reported that they saw spiders).

These effects of VBE on subjective distress versus behavior have implications for the relationship between conscious cognition and emotion. Flowers, like spiders, are living things with a central body and multiple protrusions; unlike spiders, however, they are not fear-inducing. Yet the main effect of Time on SUDs (and its near-significant effect on the phobic sample) showed that distress increased as a result of VBE, regardless of whether it was to spiders or flowers. At the same time, only the phobic behavior of the former group was affected. Taken together, these data suggest that under conditions that allow minimal awareness of fear-inducing stimuli, ''quick and dirty'' processing mechanisms that involve less cognitive evaluation mediate behavioral responses and the subjective experience of emotion. LeDoux (1996) first developed this notion in his ''low-road'' theory of fear, as did Öhman and Mineka (2001) in their theory of the fear module. As developed in the introduction, numerous studies have shown that the amygdala is rapidly activated and that physiological responses are initiated by subliminal, fear-relevant stimuli – much faster than conscious, cognitive appraisal of them would require. The meaning of threatening stimuli is evaluated directly and outside of awareness, with minimal conscious knowledge of it.

The implicit effect of VBE is also consistent with the prevailing view that fear learning occurs on two related but independent levels: a conscious, cognitive level, and an automatic, emotional level (Öhman & Mineka, 2001). For example, in a systematic case study, Bechara et al. (1995) found that a patient with bilateral lesions of the amygdala could not acquire fear responses as a result of both visual and auditory aversive conditioning. Nonetheless, he acquired factual knowledge of the conditioned stimulus (CS) – aversive unconditioned stimulus (UCS) contingency. (LaBar et al. (1995) reported the same finding in a sample of such patients.) Another patient with a bilaterally damaged hippocampus showed precisely the opposite pattern, acquiring the conditioned fear response in the absence of factual knowledge of the CS-aversive UCS contingency. These data suggest that in fear conditioning, we independently encode a cognitive, CS-UCS contingency as well as an emotional response – a CS-conditioned response (CR) contingency. Cognitive models of fear conditioning and extinction tend to emphasize the encoding and revision of the CS-aversive UCS contingency (e.g., Foa & Kozak, 1986; Schiller et al., 2010). The current findings suggest that just as this cognitive contingency can be weakened by direct confrontation of feared stimuli, it is possible to weaken the emotional CS-CR contingency without conscious knowledge that this has occurred.

How might this happen as a result of VBE? In his aforementioned model, LeDoux (1996) proposed that fear reactions occur in two stages. First, the amygdala receives stimulation directly from the thalamus, generating an immediate, autonomic response based on processing of gross stimulus features. A second, slower response based on visual perception and semantic processing of threatening stimuli involves activation of the amygdala by the cortex. This second boost of activation by the cortex likely strengthens the CS-CR contingency encoded in the amygdala. Backwards masking can be viewed as a way of short-circuiting cortical processing (Wiens, 2006; Öhman & Mineka, 2001), so that this second boost of activation is minimized. Thus, in VBE, repeated presentations of a masked, fear-relevant stimulus may result in the first but not the second response of the amygdala, weakening the CS-CR emotional contingency encoded therein. With repeated exposure to the same seemingly threatening stimulus in the absence of unpleasant consequences, it would be adaptive to not continue to waste resources on false positive responses (i.e., to a stimulus that actually is not dangerous, such as a picture of a spider). This should eventually result in decreased responding or non-conscious habituation (Dijksterhuis & Smith, 2002) of the amygdala. Habituation of a non-conscious fear circuit could be manifested implicitly, as in the current study: reducing avoidance of the feared object, without affecting subjective distress.

5.2. Future studies

A non-conscious habituation theory could be tested by coupling VBE with suitable technology, like skin conductance responses or fMRI. If for example the latter measure found that amygdalar nuclei are first activated by and then habituate during VBE, it would support the theory. Another obvious direction for future research is to test effects on clinical populations and other fears. VBE raises the possibility of initially bypassing direct confrontation of a feared object in treatment. The majority of individuals with phobias do not seek treatment presumably because of the distress associated with exposure (Garcia-Palacious et al., 2002; Magee et al., 1996). In this study, VBE reduced phobic avoidance without placing participants under significant distress. However, these participants were not seeking help for their fears. The effects of a single, VBE session reported here – a change of less than one unit on a BAT in a non-clinical sample – do not represent clinically meaningful changes. If the current findings are replicated, the effects of multiple very exposure sessions and on clinical samples should be investigated.

Appendix A

A.1. Funneled Interview

(1) *When you were watching the computer screen, what do you remember happening?*

If this question did not elicit information about the stimuli, the participant was asked:

(2) *In between the X and the capital letters presented on the screen, did you see something?*

If the participant indicated that he saw something but did not say what it was, he was asked: *What did you see?* If the participant said that he saw "a flash" (i.e., the masked target stimulus), he was asked:

(3) *If you had to guess what the flash was, what would you say it was?*

If the participant denied that he saw anything between the X and the capital letters, he was told:

(4) *Something was flashed on the screen between the X and the capital letters. If you had to guess what the flash was, what would you say it was?*

If a participant said that he saw a spider(s)/flower(s) in response to any of the above questions, he was next asked:

(5) *How many times did you see a spider/flower?*

A.2. Behavioral Avoidance Test

(0) Will not enter room.
(1) Enters the room but approaches no further.
(2) Comes within 5 ft of the tank but no further.
(3) Stands next to tank.
(4) Removes blanket covering tank.
(5) Places hands on two sides of tank closest to spider.
(6) Removes top cover of tank, and puts it back.
(7) Removes top cover of tank, puts face over open tank, and replaces cover.
(8) Removes top cover of tank, puts face over open tank and describes spider in detail.
(9) Removes top cover of tank, and places entire hand inside of tank horizontally.
(10) Reports willingness to touch spider (asked but never allowed, as explained below).

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