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Differential Predictive Power of Self Report and Implicit Measures on Behavioural and Physiological Fear Responses to Spiders.

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Abstract

In this study, we investigated to what extent indirect measures predict behavioural and physiological fear responses towards spiders. Implicit attitudes towards spiders were assessed using an implicit association test and attentional bias towards spiders was assessed using a dot probe task and a disengagement task. Results showed that a self report measure of fear for spiders, but not the indirect measures predicted avoidance behaviour. The indirect measures but not the self report measure predicted changes in heart rate in response to the presentation of a spider. These results suggest that indirect measures may be useful in predicting and understanding fear responses that are not easily voluntarily controlled.

Keywords: attentional bias, implicit attitude, prediction, heart rate, skin conductance, spider fear

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1. Introduction

Over the past decades, evidence has accumulated in support of the idea that automatic processes and cognitions are core features of anxiety disorders (Beck et al., 1985; Eysenck, 1992). Beck and colleagues (1985) postulated that phobia and anxiety disorders are characterized by chronically active danger schemata. These schemata result in the preferential allocation of attention towards threatening stimuli, the interpretation of ambiguous stimuli as threatening, and the prioritized recollection of threatening events or outcomes from memory. These biases in threat processing are considered not to be epiphenomena, but to play a critical role in the *aetiology, maintenance* or *exacerbation* of fear and anxiety (Clark and Wells, 1995; MacLeod et al., 2002; Mogg and Bradley, 1998; Williams et al., 1997). Some studies reported evidence for this assumption. For instance, MacLeod et al. (2002) showed that the manipulation of attentional bias leads to changes in self-reported negative mood in response to a stressor.

If these processes indeed cause fear, it is reasonable to assume that they will also be predictive of fear. More specifically, processing biases are thought to be useful to predict spontaneous, uncontrolled responses (De Houwer, 2006; Egloff and Schmukle, 2002; Fazio and Towles-Schwenn, 1999; but see also Olson and Fazio, 2009). In the present study, we investigated the predictive value of indirect measures of two threat processes, namely biased attention and automatically activated attitudes.

1.1 Biased Attention to Threat

Biased attention towards threatening information is firmly established in fear and anxiety disorders. In their meta-analysis, Bar-Haim et al. (2007) showed that both clinically and non-clinically anxious individuals orient more to threatening stimuli in their environment compared to non-anxious individuals. MacLeod et al. (1986) demonstrated an attentional bias using the dot probe task. In their study, two cue words were presented at two different spatial locations. On most trials, one of these words was threatening, whereas the other word was neutral. A target stimulus appeared either on the same (congruent trials) or the opposite location (incongruent trials) of the threatening word, and participants were required to respond as quickly as possible to the appearance of the target stimulus. Results revealed that anxious participants responded faster to targets on congruent trials compared to incongruent trials, indicating that they preferentially oriented their attention to the threatening word.

Despite the theoretically important role of attentional bias in anxiety, the predictive value of measures of attentional bias on fear related behaviour has not been thoroughly investigated. Only a few prospective studies used measures of attentional bias to predict fear responses. MacLeod and Hagan (1992) used the emotional Stroop task to assess attentional bias. In this paradigm, participants are required to name the colour of threatening and neutral words, while ignoring the meaning of the word. Anxious individuals are typically slower to name the colour of a threatening word compared to the colour of a neutral word (Williams et al., 1996). MacLeod and Hagan found that the degree of emotional Stroop interference predicted the intensity of emotional distress of women who experienced a stressful life event. Three other studies reported similar results (Nay et al., 2004; Van den Hout et al., 1995; Verhaak et al., 2004). However, all these studies used the emotional Stroop task and the interpretation of the emotional Stroop effect has been disputed. Algom and colleagues (2004) argued that the emotional Stroop-effect might assess a threat-based generic slowdown, rather than selective attention. Also, emotional Stroop effects may reflect interference at response selection stages rather than interference at the stage of encoding (e.g., Mogg and Bradley, 1998). Therefore, it is not clear to what extent the effects are related to attentional processes. Furthermore, these predictive studies included only self-report measures of fear as the primary outcome. None included a behavioural or a physiological measure of fear as outcome. It may well be that the results relate only to a small part of what comprises fear. Indeed, Lang (1993) argued that a fear response not only consists of (1) self-reported feelings (e.g., “I am afraid of spiders.”), but also of (2) physiological responses (e.g., increased heart rate), and (3) overt behaviour (e.g., fleeing). Although these response systems may be *expected* to be closely related, covariation between the three systems usually accounts only for a small percentage of the variance (Bradley and Lang, 2000). Therefore, it is important to broaden the scope of research to the prediction of physiological fear responses and overt avoidance behaviour.

To our knowledge, only one study has investigated the predictive value of attentional bias on physiological fear responses. Egloff et al. (2002) showed that attentional bias as measured with the dot probe task outperformed a self-report measure in the prediction of cardiovascular reactivity to a social stressor. This study was the first of its kind to demonstrate that attentional biases predict physiological fear responding. We wanted to extend these studies in two ways. First, we included a measure of disengagement as a predictor (see below), and second, in addition to physiological fear responding, we also assessed overt avoidance behaviour.

1.2 Implicit Attitudes towards Threatening Stimuli

Anxiety has also been related to automatic activation of threat associations (for reviews see Mathews and MacLeod, 2005; Ouimet et al., 2009). Over the last decade, a wide range of implicit measures of attitudes have been developed, designed to circumvent the limitations of self report measures of attitudes (social desirability and availability of the attitude for introspection; see De Houwer et al., 2009). The most frequently used implicit attitude measure is the Implicit Association Test (IAT: Greenwald et al., 1998). In the IAT, participants are required to categorize stimuli on two dimensions. For instance, in the classical flower-insect IAT by Greenwald and colleagues, participants were shown names of flowers or insects (target dimension) and positive or negative words (attribute dimension). In a first test block, participants responded to both insects and negative words by pressing one button, whereas flowers and positive words were assigned to another response button (compatible mapping). In a next phase, the response buttons for the target dimension were reversed. Participants were required to respond to positive words and insects with one button, and to negative words and flowers with the other (incompatible mapping). The attitude towards insects (relative to flowers) was indexed by calculating the difference in reaction times between the compatible block and the incompatible block. If participants are faster in the compatible block, it is assumed that they have a more negative attitude towards insects compared to flowers (see De Houwer et al. (2009) for a review and Rothermund and Wentura (2004) for an alternative interpretation). Teachman et al. (2001) administered a spider-snake IAT in both spider- and snake-fearful participants. Their results indicated that spider-fearful participants had a more negative attitude towards spiders compared to the snake-fearful participants and vice versa. This result implies that specific phobias are characterized by negative implicit associations with the object of fear.

Several studies have examined the predictive value of implicit measures of attitudes towards feared objects. Using the Extrinsic Affective Simon Task (EAST; De Houwer, 2003a), Huijding and De Jong (2006) showed that implicit attitudes towards spiders predicted physiological fear responses better than a self report measure (Fear of Spiders Questionnaire: FSQ; Szymanski and O’Donohue, 1995). However, the EAST has been criticized because of its relatively poor psychometric properties compared to the IAT (De Houwer and De Bruycker, 2007; Schmukle and Egloff, 2006; Teige et al., 2004). Ellwart et al. (2006) reported evidence that scores on a spider IAT significantly predicted avoidance behaviour. However, they did not report whether the IAT improved the prediction that was based upon the explicit spider fear measure (FSQ) alone. Thus, this study leaves the question on the *incremental* predictive power of the IAT above explicit measures on overt avoidance behaviour unanswered.

In the present study, we investigated to what extent attentional bias towards spider stimuli and implicit attitudes towards spiders predicted physiological fear responses and avoidance of spiders. We were particularly interested in whether these indirect measures predicted scores on outcome variables beyond a self report measure. Biased attention was assessed in two separate tasks. First, a dot probe task was administered as a general measure of attentional bias. Recently, it has been argued that results in this task can rely both on vigilance for threatening information and a difficulty to disengage attention away from threat (Koster et al., 2004). Because there is accumulating evidence that the difficulty to disengage attention might be the driving mechanism of attentional bias (for a review, see Fox, 2004), we also included the disengagement task of Georgiou and colleagues (2005). In their task, a single threatening or neutral cue was presented in the *centre* of the screen, whereas targets were presented on spatially different locations. As a result, participants were on each trial required to disengage attention away from the central cue, and to redirect it to the peripherally presented targets. The time needed to detect the targets was used as an index of how easily participants disengaged their attention away from the stimuli presented in the middle of the screen. Automatically activated associations were assessed with a spider-flower IAT. The distance that participants allowed a spider to approach their hand was used as a measure of avoidance behaviour, and changes in heart rate and Skin Conductance Level (SCL) in response to spiders were used as physiological measures of fear. We hypothesized that, in line with Huijding and De Jong (2006), scores on the FSQ would predict avoidance behaviour, whereas scores on the indirect measures would prove useful to predict physiological responding.

2. Method

2.1 Participants

Fifty-five undergraduates (11 men, *M* age = 21.64, *SD* = 1.99) were paid € 8 for their participation in the experiment. No selection criteria were applied. All participants gave their informed consent and were informed that they could end their participation in the experiment at any moment. The ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University approved the entire procedure of the experiment.

2.2 Apparatus and Materials

The experiment was programmed using the INQUISIT Millisecond 2.0 (2007) software package. The dot probe task, the disengagement task, and the IAT were run on a Dell Optiplex GX520 desktop computer equipped with a 3.2 GHz Pentium D930 processor on a 100Hz 19-inch colour monitor with a resolution of 1024 x 768 pixels. The behavioural avoidance test and the physiological measures were conducted in a separate psychophysiological laboratory. Physiological signals were recorded with a Coulborn Lablinc V, and stored on a PC equipped with a Scientific Solutions Labmaster DMA card, running Psychophysiological Recordings software (PSPHR; 2009). Heart rate was obtained from the photoelectric plethysmography signal from the left index finger (Jennings et al., 1981). The pulse signal was digitized at 500 Hz. Skin conductance was measured using a constant voltage (0.5) and two Ag/AgCL electrodes with a diameter of 8 mm. The electrodes were filled with KY-jelly and were attached on the thenar and hypothenar eminences of the left hand (Stern et al., 2001). Skin conductance was digitized at 10 Hz. The psychophysiological data were analyzed off line using Psychophysiological Analysis (PSPHA; De Clercq et al., 2006).

2.3 Questionnaires

State and trait anxiety were assessed with the Dutch translations of the State and Trait Anxiety Inventory (STAI-S and STAI-T; Spielberger et al., 1983; van der Ploeg et al., 1980). Both questionnaires consist of 20 statements, scored on a four-point Likert scale (1 = not at all, 4 = very much; sum scores between 20 and 80), assessing the level of anxiety an individual experiences at this moment in time (state version) and a more general susceptibility to experience emotional distress or anxiety (trait version). In the present study the alpha coefficient was .85 for the STAI-S and .90 for the STAI-T.

We used the Dutch translation of the Fear of Spiders Questionnaire (FSQ; Szymanski and O’Donohue, 1995; Muris and Merckelbach, 1996) as a measure of participants’ self reported fear of spiders. This questionnaire consists of 18 items, each scored on an eight-point Likert scale ranging from zero to seven (sum score between 0 and 126). The alpha coefficient in the present study was .98.

2.4 Dot Probe Task

The dot probe task consisted of four different trial types. First, on *congruent* trials, the target appeared at the location previously occupied by a picture of a spider. Second, on *incongruent* trials, the target appeared at the opposite location of the one that was occupied by the spider. Third, on *neutral* trials, the target was preceded by a pair of neutral pictures. Finally, to discourage systematic monitoring of one side of the screen, we also included *digit* trials, randomly intermixed within the task. On these trials, the fixation cross was replaced after 1000 ms by a 100 ms presentation of a digit ranging from one to three. After digit offset, participants were required to indicate which number they had seen using the digit keys on the top left of a standard AZERTY keyboard, and were asked to guess if they had not seen anything. Participants were informed that on these trials, their reaction time was not relevant.

All stimuli in this task were presented on a black background. Each trial started with the presentation of a white fixation cross in the centre of the screen, flanked by two grey rectangles (5.5 cm high by 6.5 cm high, i.e. about 6°20’ by 7°20’) for 1000 ms. The distance between the centre of the rectangles and the fixation cross was 6.7 cm (about 7°40’). Cues and targets were presented at the centre of the grey rectangles. Cue pairs consisted of either two neutral pictures, or of a neutral picture and a spider picture. Eight spider pictures were selected from the internet, and 16 neutral pictures, depicting random household objects, were selected from the IAPS database (Lang et al., 1999).[1] Of the neutral pictures, eight pictures were randomly paired with spider pictures. The remaining eight neutral pictures were paired with each other in a random manner in the neutral trials. The cue pairs were presented for 500 ms, followed by a 30 ms grey rectangle mask. Targets consisted of two small black dots, arranged either horizontally (..) or vertically (:). They remained on the screen until a response was given. Participants were required to respond as quickly and as accurately as possible to the identity of the target by pushing the “2” or the “8” key of the numeric pad of a standard AZERTY keyboard with the index and middle finger of their dominant hand. Targets appeared equally often on the right side as on the left side, and were equally often arranged horizontally as they were arranged vertically. The intertrial interval varied randomly between 250 and 500 ms.

The task consisted of two blocks: a practice block and a test block. The practice block consisted of 18 trials (16 neutral trials and two digit trials), and an error message appeared on incorrect responses. The test block consisted of 104 trials (32 congruent, 32 incongruent, 32 neutral and 8 digit). All trials were presented in a random order. Each spider picture was presented four times on congruent trials and four times on incongruent trials.

2.5 Disengagement Task

In this task, we used the same stimuli as in the dot probe task. Each trial started with the presentation of a white fixation cross on a black background. After 1000 ms, *a single* cue picture was presented in the centre of the screen. This picture was either a spider or a neutral household object. The picture remained on the screen for 500 ms and was masked by a grey rectangle. Thirty ms after the onset of the mask, a target stimulus appeared at 6.7 cm (about 7°40’) to the left or to the right of the centre of the screen. Target stimuli were two white dots, arranged either horizontally (..) or vertically (:). As in the dot probe task, participants were required to respond as quickly and as accurately as possible to the identity of the target by pushing the “2” or the “8” key with the index and middle finger of their dominant hand. Targets appeared equally often to the right as to the left of the fixation cross, and they were as often arranged horizontally as they were arranged vertically. The intertrial interval varied randomly between 250 and 500 ms.

The disengagement task consisted of two blocks: a practice block and a test block. The practice block consisted of 18 trials in which only neutral pictures were presented. An error message appeared on incorrect responses. The test block consisted of 64 trials of which 32 were cued with a spider and 32 were cued with a neutral picture. Trials were presented in a random order. Each picture was shown four times.

2.6 Implicit Association Test

The target categories in the IAT consisted of a new set of eight spider pictures and eight flower pictures (5.5 cm high by 6.5 cm high, i.e. about 6°20’ by 7°20’). The attribute categories consisted of eight positive words (HOLIDAY, SUMMER, PRESENT, GIFT, WARMTH, PARTY, PLEASURE and CHEERFUL) and eight negative words (DEATH, WAR, PAIN, MISFORTUNE, HATE, DISEASE, AVERSION and FUNERAL). Labels were “spider” and “flower” for the target categories, and “positive” and “negative” for the attribute categories. In each block, the relevant labels were shown in the upper left and right corners of the screen. All stimuli were presented in the centre of the screen and remained on the screen until a response was given. Participants were required to respond as quickly and as accurately as possible to the category of each stimulus by pressing the “a” or the “p” key on a standard AZERTY keyboard. The intertrial interval varied randomly between 250 and 500 ms.

In line with Greenwald et al. (2003), the IAT consisted of 7 blocks, of which the fourth (compatible) and the seventh (incompatible) were critical. Each block started with the presentation of the relevant labels for three seconds. The labels remained on the screen for the entire duration of each block. In the first block, each word was presented twice in order to practice the attribute categorization. The assignment of the response keys to either positive or negative words was counterbalanced across participants. In the second block, each picture was presented twice to practice the target categorization. Spiders were categorized by pressing the key that was paired with the negative words in the first block, whereas flowers were categorized by pressing the other key. In the third block, the compatible category mapping (spider-negative versus flower-positive) was practiced. This block consisted of 32 trials, and each word and each picture was presented once. The fourth block was the compatible test block. This block consisted of 64 trials, in which each word and each picture was presented twice. The fifth block consisted of 32 target categorization trials, presenting each flower and each spider picture twice. However, the response mapping for the target categories was reversed, assigning spider pictures now to the “positive” key and flower pictures to the “negative” key. In the sixth block, the incompatible categorization was practiced (spider-positive versus flower-negative). This block consisted of 32 trials, in which each word and each picture was presented once. The seventh and last block was the incompatible test block. This block consisted of 64 trials, in which each word and each picture was presented twice. In all blocks, trials were presented in a random order.

2.7 Physiological Fear Response Phase and Behavioural Avoidance Task (BAT)

Upon arrival in the psychophysiological laboratory, participants were asked to wash their hands, and the electrodes were attached. Participants were seated at about 50 cm from the computer screen. Their right hand was placed against a thick black line that was drawn on a table. A meter was placed perpendicular to this line. Small black lines were drawn every five cm parallel to the thick black line. Participants were informed that the task instructions would appear on the screen. Then, the experimenter left the room and a three-minute baseline trial started. This trial consisted only of the presentation of a central white fixation cross on a black background. Next, the following instructions appeared on the screen:

In the next phase you will be looking at a spider. First, you will see a picture of a spider, then you will see a real spider under a glass bowl. Later on, the bowl will be removed and the spider will be pushed little by little closer towards your hand until you say stop. The spider is not dangerous, and will be removed the very instant you say stop. It is not necessary to let the spider touch your hand, just say stop when you feel the situation is getting too uncomfortable. This may well be immediately, or not until the spider is very close to your hand. You decide! Try to move as little as possible, and please do not ask questions while the experiment is running.

The text remained on the screen for one minute to be replaced by a picture of a spider (8 cm high by 11.3 cm wide, i.e. about 9°05’ by 12°45’). One minute later, the picture disappeared and the experimenter entered the room, carrying a cardboard box. The box was placed upside down (the lid on the table) at one meter distance from the participant’s right hand. The box was removed, revealing a dead common house spider (*tegenaria domestica*) (body: 0.5 cm wide by 1.5 cm long; legs included: 5 cm wide by 6 cm long) under a glass bowl. Participants were not informed that the spider was dead, and its legs were stretched to make it look alive. Participants looked at the spider for one minute. Finally, the glass bowl was removed, and every five seconds, the lid on which the spider sat was pushed five cm closer to the right hand of the participant. The lid was pushed up against the participants’ hand, unless they indicated that they wanted to stop. Physiological recording ended when the participant indicated to stop or when the lid touched the hand (after approximately 100 seconds).

2.8 Self Report Ratings

Participants rated the threat value of all stimuli used in the experiment. Pictures were presented sequentially in random order in the centre of the screen, and participants were instructed to push the space bar to move on to the assessment of the picture. Upon pressing the space bar, the picture disappeared and participants rated the threat value of the picture on a 10-point Likert scale (1: “not threatening at all” through 10: “very threatening”). Words were rated in the same manner, but in addition to the threat value we also assessed arousal (1: “calm, relaxed” through 10: “very excited”) and valence (1: “positive” through 5: “neutral” and 9:”negative”).

2.9 General Procedure

Upon arrival in the laboratory, participants were informed that the experiment would contain pictures of spiders and they were shown an example of a spider picture. All participants then signed their informed consent. The experiment started by completing the questionnaires in a fixed order (STAI-T, STAI-S and FSQ). Participants were seated at approximately 50 cm from the computer screen. First, they carried out the dot probe task, followed by the disengagement task and the IAT. Upon finishing the IAT, participants were taken to the psychophysiological laboratory. They signed another informed consent form and it was stressed that they could end their participation in the experiment at any time. Then, the physiological measures and the BAT were conducted as described above. After the BAT, the devices were removed and the participants were asked to rate all the stimuli that were used in the experiment.

3. Results

3.1 Scoring and Outliers

For the dot probe task and the disengagement task, trials with errors were excluded from further analyses. Individual scores were excluded from analysis if they deviated more than three *SD*s from the group mean. For the dot probe task, attentional bias scores were calculated by subtracting the median RT on congruent trials from the median RT on incongruent trails (Ratcliff, 1993). The AB-scores of two participants were not taken into account, one because of too many errors on dot probe trials (participant’s score = 23% errors, group mean = 5% errors, *SD* = 4.39), the other because of too many errors on digit trials (participant’s score = 37% errors, group mean = 5% errors, *SD* = 8.50).

For the disengagement task, a disengagement score was calculated by subtracting the median RT on trials with a neutral picture from the median RT on trials with a spider picture. The disengagement score of one participant was not taken into account because of too many errors (participant’s score = 28% errors, group mean = 5% errors, *SD* = 4.52).

IAT scores were calculated using two different scoring algorithms. First, we calculated the Log IAT as described by Greenwald et al. (1998). For this measure, the first two trials of each block and trials with errors were deleted. Furthermore, response latencies faster than 300 ms and slower than 3000 ms were transformed to 300 ms and 3000 ms respectively. Finally, for each participant, RTs were log-transformed, and the IAT-effect was calculated by subtracting the mean latency in the incompatible test block from the mean latency in the compatible test block. Second, we also calculated the D600 measure as described by Greenwald et al. (2003). Unlike the log measure, the D600 measure includes RTs on practice blocks, an error penalty is applied and for each participant, latencies are corrected for individual variability. The IAT scores of one participant were not taken into account because of too many errors (participant’s score = 22% errors, group mean = 5% errors, *SD* = 4.29). For both measures, negative scores reflect negative associations towards spiders relative to flowers, whereas positive scores reflect a more positive implicit attitude towards flowers relative to spiders.

For the BAT, the minimal distance (in cm) between the participants’ hand and the spider was used as an index of approach/avoidance. High scores reflect strong behavioural avoidance.

Behavioural and physiological data of one participant were not recorded because of excessive fear of being wired to the physiological equipment. For heart rate, we used PSPHA (De Clercq et al., 2006) to detect pulse peaks and artefacts, to correct for these artefacts and to count the number of pulse peaks in one minute for the baseline, the instructions, the picture viewing and the live viewing. For SCL, PSPHA calculated the average skin conductance level in one minute during baseline, instructions, picture viewing and live viewing. SCL data of one participant were not taken into account because of apparatus failure (loose wire). Physiological responses during the approach phase were not taken into consideration because some participants almost immediately stopped the approach (*N* = 4), and for these participants, no data could be collected. Both for SCL and heart rate, difference scores were calculated by subtracting responses in the baseline trial from responses in the three experimental trials. In this manner, outcomes of both physiological measures can be interpreted as increases or decreases relative to participants' physiological responding at rest. For reasons of simplification, we calculated an average change score both for heart rate and SCL by averaging the change scores for the three experimental trials. Separate results for the scores on the three experimental trials were in line with the average change scores, and can be obtained from the first author.

Finally, because extreme scores can produce biased correlations and regressions, scores on variables were not taken into account if they deviated more than three standard deviations from the group mean. This resulted in the loss of data of one participant for log IAT measure, the data of a second participant for the disengagement task and the average heart rate change, and the data of a third participant for the average SCL change. Inclusion of these participants in the analyses did not change the pattern of our results.

3.2 Group Characteristics, Manipulation Checks and Basic Results

3.2.1 Self-report ratings. Average trait anxiety in our sample was 37.67 (*SD* = 7.92), average state anxiety was 31.67 (*SD* = 5.68). Scores on the FSQ ranged between 0 and 114, averaging 34.35 (*SD* = 33.40) (see Table 1). A repeated measures ANOVA on the threat ratings with Picture Type (Spider, Neutral, or Flower) as a within subjects factor revealed a main effect of Picture Type, $F(2, 53) = 64.03$, $p < .001$. Follow-up contrasts showed that spider pictures ($M = 5.58$, $SD = 2.82$) were rated as more threatening than both neutral pictures ($M = 1.27$, $SD = 0.40$), $F(1, 54) = 127.94$, $p < .001$, Cohen's $d = 1.52$, and flower pictures ($M = 1.17$, $SD = 0.77$), $F(1, 54) = 112.02$, $p < .001$, Cohen's $d = 1.43$.[2] For the words used in the IAT, paired sample *t*-tests showed that the negative words were rated as more threatening ($M_{\text{negative}} = 4.56$, $SD = 1.95$ versus $M_{\text{positive}} = 1.48$, $SD = 0.80$), $t(54) = 12.26$, $p < .001$, Cohen's $d = 1.65$, more negative (M_{negative} = 7.43, *SD* = 1.07 versus M_{positive} = 1.96, *SD* = 0.92), *t*(54) = 23.42, *p* < .001, Cohen's *d* = 3.15, and less arousing (M_{negative} = 3.90, *SD* = 1.81 versus M_{positive} = 4.65, *SD* = 2.43), *t*(54) = 2.33, *p* < .05, Cohen's *d* = 0.31, than the positive words.

3.2.2 Reaction time tasks. Descriptive statistics of all crucial variables are listed in Table 1. One-sample *t*-tests were conducted to test whether the attentional bias score, the disengagement score and the IAT measures differed significantly from zero. For the attentional bias score, the test was not significant, *t*(52) < 1, Cohen's *d* = 0.10. For the disengagement score the test was significant, *t*(52) = 2.66, *p* < .05, Cohen's *d* = 0.37, indicating that participants were slower to respond to a target preceded by a picture of a spider compared to targets that were preceded by a neutral picture. For both the log IAT, *t*(52) = 10.90, *p* < .001, Cohen's *d* = 1.55, and the D600, *t*(53) = 17.53, *p* < .001, Cohen's *d* = 2.38, the tests were also significant, indicating that participants had more negative associations towards spiders compared to flowers. Split-half reliabilities (calculated from odd versus even trials) of the dot probe task and the disengagement task were low, *r*(53) = .15, and *r*(54) = -.06, respectively. Split-half reliability of the IAT was high, *r*(54) = .73.

3.2.3 Physiological measures. A one-sample *t*-test showed that the average heart rate change was greater than zero, *t*(52) = 6.40, *p* < .001, Cohen's *d* = 0.88. A one sample *t*-test on the average SCL change scores also proved significant, *t*(50) = 10.05, *p* < .001, Cohen's *d* = 1.37. These results show that participants experienced more physiological arousal during the experimental trials compared to the baseline.

3.3 Correlations

Because the data of the FSQ and the BAT were not normally distributed, Spearman correlation coefficients were calculated. As can be seen in Table 1, a positive correlation was found between the FSQ and avoidance behaviour as measured with the BAT. Furthermore, FSQ scores were positively associated with SCL increase and trait anxiety.

Attentional bias scores were positively correlated with increases in heart rate. The results of the log IAT are in line with the results of the attentional bias scores. Stronger negative log IAT scores were associated with a larger increase in heart rate and larger increases in SCL. Interestingly, despite the correlation between the Log IAT and the D600, the D600 did not correlate significantly with any of the physiological measures. The D600 did correlate significantly with the disengagement score and trait anxiety. Finally, difficulties to disengage attention away from spiders were positively correlated with increases in SCL. None of the indirect measures correlated significantly with the BAT.

3.4 Predicting Avoidance Behaviour

The scores on the BAT were not normally distributed because a large number of participants had the maximal score (i.e., approached the spider as closely as possible). We therefore transformed the distance between the hand and the spider to a binary variable. This new variable discriminated between participants who stopped before the end of the approach procedure ($n = 16$) and participants who did not stop ($n = 38$). Because we obtained a different pattern of correlations with the Log IAT compared to the D600, we conducted two separate hierarchical binary logistic regressions, using the Log IAT in the first regression and the D600 in the second. Both regressions were based only on the data of participants for whom we retained valid data on all measures that were included in the analysis ($n = 50$ for the regression with the Log IAT; $n = 51$ for the regression with the D600). Of these participants, 14 had stopped the BAT prematurely.

For the first regression, the FSQ scores were the only predictor in the first step. For this first model, the Hosmer-Lemeshow statistic was not significant, $\chi^2(8) = 6.33$, $p = .61$, indicating that the model fitted the data well. The model was significantly better than the model with no predictors, $\chi^2(1) = 13.75$, $p < .001$. In a second step, the three indirect measures (attentional bias score, disengagement score, and log IAT) were added. The second model was not better than the first model, $\chi^2(3) = 1.08$, $p = .78$. As is shown in Table 2, only the FSQ was a significant predictor of avoidance behaviour in the second model. The values of Exp(β) indicate that an increase of one unit on the FSQ increased the odds of stopping with the BAT (relative to continuing the BAT) with a factor of 1.04 (Field, 2000). Because the value 1 (i.e., the multiplicative identity element) does not fall within the 95% confidence interval, the odds reliably increase for each additional unit on the FSQ. For all three implicit measures, the value 1 does fall within the 95% confidence interval, indicating that an increase on either of the three measures does not reliably affect the odds. The second regression, with the D600 instead of the Log IAT, revealed similar results. The model with only the FSQ as a predictor was better than the model with no predictors, $\chi^2(1) = 14.04$, $p < .001$. The addition of the three indirect measures did not improve the model, $\chi^2(3) = 0.98$, $p = .81$, and only the FSQ was a significant predictor, Exp(β) = 1.04, $p < .005$, all *p*s for the indirect measures > .39.

3.5 Predicting Physiological Fear Responses

Separate hierarchical linear regressions were conducted on the heart rate change and the SCL change. Again, we conducted the same regressions twice, the first time with the Log IAT and the second time with the D600. For all regressions, the FSQ was the only predictor in the first step of the model. In the second step, the attentional bias score, the disengagement score and the respective IAT measure were added as predictors. Due to different numbers of outliers and apparatus failure, the regression on the heart rate change with the Log IAT (D600) is based on data of 50 (51) participants, and the regression on the SCL changes is based on the data of 48 (49) participants.

In the regression analysis with heart rate change as the dependent variable and the FSQ, the attentional bias score, the disengagement score and the Log IAT as predictors, the model with only the FSQ did not reach significance, $F < 1$. After the second step, the second model did reach significance, $F(4, 45) = 5.33$, $p < .005$, and it was significantly better than model with only the FSQ, $F(3, 45) = 7.11$, $p < .005$. Table 3 shows that scores on the FSQ were not predictive of changes in heart rate. The attentional bias score, the disengagement score and the log IAT measure did prove to be significant predictors of increases in heart rate. Higher levels of attentional bias, more difficulties to disengage attention away from spiders and more negative associations towards spiders predicted stronger increases in heart rate. A similar regression with the D600 instead of the Log IAT revealed again that the model with only the FSQ was not significant, $F < 1$. After the second step, the model still failed to reach significance, $F(4, 46) = 1.90$, $p = .13$, but is was marginally better than the model with only the FSQ, $F(3, 46) = 2.53$, $p =.07$. For this regression, the attentional bias score was a significant predictor, $\beta = .33$, $p < .05$. The disengagement score was only marginally significant, $\beta = .27$, $p = .09$, and the D600 did not prove predictive of changes in heart rate, $\beta = -.16$, $p = .27$.

In both regressions with average SCL change as dependent variable, none of the models reached significance, all Fs < 3.33, all ps > .07.

3.6 Supplementary Analyses

Supplementary analyses were conducted in order to investigate the diverging results that we obtained with the Log IAT and the D600. As mentioned earlier, the main differences between the D600 and the Log measure are the error penalty, the inclusion of the practice blocks and the adjustment for individual variability. The pattern of results after the omission of the error penalty from the D600 scoring (but with the inclusion of the practice block and the correction for individual variability) was identical to the pattern of results that we obtained with the error penalty (Spearman's ρ with heart rate = -.05 , p = .73), indicating that it is unlikely that the error penalty caused the differences between the D600 and the Log IAT. Next, we calculated the D600 score without correcting for individual variability, but with the error penalty and the inclusion of the practice blocks. Again, the pattern of results was very similar to the pattern of results that we obtained with the normal D600 (Spearman's ρ with heart rate = -.15 , p = .30). Finally, we calculated separate D600 scores for the practice blocks (D600-practice) and the test blocks (D600-test), but with the error penalty and the correction for individual variability. The D600-practice was not significantly correlated with any of the outcome variables, all Spearman's ρs < .14, all ps > .32. However, the D600-test was – like the Log IAT – significantly correlated with both changes in heart rate (ρ = -.31, p < .05) and changes in SCL (ρ = -.35, p < .05). Hence, these supplementary analyses show that the inclusion of the practice blocks is likely the cause of our diverging results with the Log IAT and the D600.

4. Discussion

In the present study, measures of attentional bias and implicit attitudes towards spiders were used to predict behavioural avoidance of a real spider and changes in heart rate and skin conductance in response to spiders. Self reported fear for spiders significantly predicted avoidance behaviour but not physiological fear responses. None of the indirect measures predicted avoidance behaviour, but both Log IAT and the two attentional bias scores predicted heart rate acceleration in response to spiders. None of our measures proved predictive of changes in SCL.

Our results extend the findings by Egloff and colleagues (2002) and Huijding and De Jong (2006). In general, our results add to a growing body of evidence suggesting that indirect measures and self-report measures have predictive value on different domains (e.g., Asendorpf et al., 2002; Neumann et al., 2004). Our findings suggest that self-report measures outperform indirect measures for the prediction of avoidance behaviour, and that the predictive power of indirect measures is especially apparent for changes in heart rate (but see also Olson and Fazio, 2009).

Our results can to a certain extent be framed within a recently proposed dual-system approach to anxiety (Ouimet et al., 2009). This dual-system approach (see also Back et al., 2009; Hofmann et al., 2009; Strack and Deutsch, 2004) holds that two different systems of information processing can guide behaviour. The impulsive system is theorized to drive impulsive and largely automatic behaviour. This system operates through the automatic spreading of activation between associated concepts in long term memory after stimulus input. For instance, imagine a spider-fearful man who wants to work in the garden and goes to the shed to get a shovel. Upon entering the shed, he suddenly feels sticky threads all over his head. Through spreading of activation, the concepts of sticky threads, cobweb and spider will be activated, and the man is likely to jump back and rub his hair and face franticly. The reflective system, on the other hand, produces behaviours that are more controlled and more deliberate. This system operates through a rational analysis of relations between concepts and knowledge about facts and values, leading to deliberate judgements and higher order mental operations. For instance, returning to the example of the gardener, imagine that he sees the cobweb in front of the shed before entering. He will probably stop, think for a moment, and then take a stick, remove the web and hence chase the spider away. Although it is unlikely that our measures are a pure reflection of either system, it has been argued that explicit measures tap primarily into the reflective system and implicit measures into the impulsive system (Hofmann et al., 2009). The same line of reasoning can be applied to our outcome variables. In the BAT, participants were informed about the task at least three minutes – one for each physiological trial – before the actual approach started. Hence, participants could assess the situation and its possible consequences and they may have used a wide range of strategies that allowed them to cope with this situation. Thus, responses on the BAT are more likely to stem from the reflective system. If responses on the FSQ and the BAT both stem from the same, reflective system, it is plausible that performance on the BAT can be predicted from scores on the FSQ. Although none of the dual-system models to date has explicitly stated that physiological responses stem from the impulsive system, it seems reasonable that physiological responses are the result of more automatic, spontaneous processes rather than the result of deliberate reasoning processes. Hence, if implicit measures and physiological responses both stem from the same, impulsive system, it is plausible that physiological fear responses are best predicted by these implicit measures. Although this dual system approach offers a possible explanation for a part of our results, the results of the SCL changes are hard to fit within this approach.

The distinct nature of implicit and explicit measures may have implications for the treatment of psychopathology. Cognitive behavioural therapies have been shown to be effective for the treatment of anxiety disorders (Hofmann and Smits, 2008). Provided that these therapies are verbal in nature they may be particularly effective in changing the reflective aspects of anxiety. However, as also argued by others (e.g., Öhman and Mineka, 2001), the impulsive system may be left unaffected by purely verbal therapy. Enduring biases in the impulsive system may result in unsuccessful therapy or heightened risk for relapse (see also Huijding and De Jong, 2006). Following this reasoning, specific interventions targeting attentional bias and automatic associations could be a useful addition to traditional therapy (Koster et al., 2009; MacLeod et al., 2009). For instance, the work of Baccus et al. (2004) suggests that implicit attitudes can be changed through an evaluative conditioning procedure. Recently, researchers have started to try and change implicit associations by training participants to approach or avoid certain stimuli. Kawakami et al. (2007) showed that training non-black participants to approach pictures of black individuals reduced racial prejudice (see also Huijding et al., 2009). Following the work of MacLeod and colleagues (2002), research into the malleability of attentional bias has become a hot topic in anxiety research. In these studies, attentional training programs are developed in which participants are encouraged to avoid attending to threatening stimuli, which reduces the attentional bias. MacLeod et al. showed that such attentional avoidance training of threatening stimuli diminished participants' emotional vulnerability in a stressful situation. More recently, attentional training procedures have been proven effective for the reduction of anxiety (e.g., Amir, Beard, Taylor et al., 2009; Amir, Beard, Burns et al. 2009; but see Van Bockstaele et al. 2010).

The abovementioned implications lead to interesting challenges for future research. The empirical test of the hypothesis that experimentally induced *changes* in the outcomes of indirect measures predict *changes* in physiological fear responses could provide a crucial extension to the results of the present study because the correlational results of the present study do not allow for a strict causal interpretation. The prospect of the inclusion of procedures that change implicit attitudes and reduce attentional bias in therapy necessitates further basic research into how these initial processes can be changed in the most efficient manner (see also Ouimet et al., 2009).

A remarkable issue in the present study concerns the different results that we obtained with the Log IAT measure compared to the D600. Despite the strong correlation between the outcomes of both algorithms, only the Log IAT measure was a significant predictor of changes in heart rate. Supplementary analyses showed that the inclusion of the practice blocks in the D600 measure is the likely cause of our diverging results with both measures. Indeed, it is plausible that most participants at first have major difficulties linking positive words to spiders and negative words to flowers. After the practice phase, performance of non-fearful subjects is likely to improve, whereas performance of spider fearful individuals is likely to remain the same. Hence, inclusion of the practice blocks in the total score is likely to inflate the effect and reduce inter-individual differences, and thus impede accurate predictions. As argued by Rothermund et al. (2005), the inclusion of practice blocks in analyses is rather unusual in psychological research. Furthermore, the D600 was originally designed to reveal stronger correlations with explicit attitude measures (Greenwald et al., 2003). However, Greenwald and Nosek (2009) argued that there is firm empirical evidence that there is a distinction between implicit and explicit measures of attitudes, indicating that the D600 criterion of high explicit-implicit correlations is somewhat superseded. Although our experiment was not designed to investigate the differences between the two IAT scoring procedures and we want to refrain from favouring one measure over the other, our experiment does point to the need of thorough experimental research to further clarify this issue.

Finally, our study has some limitations. First, the pattern of results of the heart rate changes was remarkably different from the pattern of results of SCL changes. Whereas changes in heart rate could be predicted only by the implicit measures, changes in SCL could not be predicted by either the explicit or the implicit measures, despite the high correlation between changes in heart rate and changes in SCL, and the correlations between SCL and scores on the FSQ, the IAT and the disengagement task. Although we do not have a full explanation for this observation, it has been argued that heart rate is primarily an indicator of affective valence, whereas SCL is primarily an indicator of arousal (Bradley and Lang, 2000). For the IAT, it is possible that the labels that we used (positive/negative) increased the salience of the valence of the pictures, rather than their arousal. Therefore, it is possible that the IAT was a useful predictor of changes in heart rate rather than changes in SCL. Second, although the measures in the present studies are discussed within the framework of implicit and explicit measures, arguably some of the measures do not fully adhere to this distinction and could be improved upon. Third, although the range and *SD* of the FSQ scores show that spider fear varied strongly across participants, a large proportion of participants continued the BAT to the very end. This limited range in scores on the BAT may have limited the accuracy of the prediction of avoidance behaviour. Finally, the pattern of correlations between the implicit measures was rather unexpected. In particular, because attentional bias as measured with the dot-probe task is assumed to be the result of both facilitated engagement towards threat on congruent trials and difficulties to disengage attention away from threat on incongruent trials, we expected a strong positive correlation between the attentional bias score and the disengagement score. The low reliability of both tasks is a likely cause why we failed to find this correlation (see also Schmukle, 2005). Scores on the dot probe task were also not correlated with scores on the IAT, and the disengagement score was only correlated positively to the D600 and not to the Log IAT. Again, the low reliability of the attention tasks is a possible explanation for these results. Also, the tasks differ with regard to the concepts that they are assumed to measure. The IAT is designed to measure attitudes, whereas the dot probe task and the disengagement task are measures of attention. Furthermore, the different task structure underlying the attention tasks on the one hand and the IAT on the other hand can also be a reason why the attention tasks did not correlate with the IAT (see De Houwer, 2003b; 2009 for a detailed structural analysis of indirect measures). That is, on the structural level, the tasks differ in the extent to which the valence of the stimuli (i.e., the threat value) is relevant to the main task. In the attention tasks, the valence of the stimuli is task-irrelevant, as they contain no information for the execution of the participant's main task (classifying dots). In the IAT, however, stimulus valence is task-relevant, as it is related to the execution of the main task (i.e., differentiating spiders from flowers, and positive from negative words).

These limitations notwithstanding, our study provides a direct test of the incremental predictive power of measures of automatic processes on both controllable and uncontrollable fear responses. Our results show that there is a double dissociation in the predictive power of implicit and explicit measures of fear for spiders.

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Footnotes

1. The following neutral IAPS pictures were used in the dot-probe task: 7000, 7002, 7004, 7009, 7010, 7050, 7175, and 7190 on congruent and incongruent trials; 7006, 7020, 7030, 7031, 7034, 7035, 7040, and 7090 on neutral trials. All spider and flower pictures that we used are available from the authors on request.

2. Effect sizes were estimated with Cohen's *d*. According to Cohen (1988), values around 0.20 represent small effects, values around 0.50 represent medium effects and values of 0.80 and larger represent large effects.