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The Spider Phobia Card Sorting Test: An investigation of phobic fear and executive functioning

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Recent studies indicate that anxious participants show cognitive biases favouring threat-related stimuli. However, most of this evidence comes from Stroop tasks, which are believed to tap a narrow range of executive skills. The current study investigated phobic fear and cognitive biases using tasks designed to tap a wider range of executive processes: the standard Wisconsin Card Sorting Test (WCST; Heaton, 1981), a modified version that included emotionally salient pictorial stimuli; the Spider Phobia Card Sorting Test (SPCST); and an emotionally valenced version of a verbal fluency task (VF). A total of 80 female participants (38 lower and 42 higher scorers on the Spider Phobia Questionnaire; SPQ) drawn from a larger sample of 126 completed either the standard WCST or the SPCST, the VF, and several mood measures. On the card sort, the higher SPQ SPCST group showed a significantly lower proportion of conceptual level responses, required a greater number of trials to complete the first category, and sorted significantly fewer stimulus cards to the spider target card than the lower SPQ SPCST group, or than either of the groups in the WCST condition who sorted to neutral target cards. On the VF, the higher SPQ group generated significantly more exemplars to the category ''spiders'' than the lower SPQ group. Therefore, fearful participants seemed to avoid or neglect the spider cue on the card sort, but performed better in generating ''spiders'' exemplars on the VF, as compared to the nonfearful group. Implications and limitations of these findings are discussed.

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Twenty years of research indicate that, generally, anxious individuals perform more poorly on cognitive tasks that include threat-related stimuli than non-anxious individuals (e.g., Ehlers, Margraf, Davies, & Roth, 1988; Foa, Ilai, McCarthy, Shoyer, & Murdock, 1993; Mogg, Mathews, & Weinman, 1989; Watts, McKenna, Sharrock, & Trezise, 1986). This effect holds across a variety of experimental paradigms (e.g., Stroop, dichotic listening, dot probe, ambiguous cue) using both pictorial and linguistic stimuli (e.g., Bradley, Greenwald, Petry, & Lang, 1992; Kindt & Brosschot, 1997; Lavy & Van den Hout, 1993) in individuals with both clinical and nonclinical levels of anxiety (e.g., Mathews & MacLeod, 1985; Mogg, Bradley, DeBono, & Painter, 1997). One of the most consistent effects found throughout this literature is the selective attention bias toward threat cues which occurs in many anxiety states, including posttraumatic stress disorder (McNally, English, & Lipke, 1993; McNally, Kaspi, Riemann, & Zeitlin, 1990), generalised anxiety disorder (Mathews & MacLeod, 1985), social phobia (Hope, Rapee, Heimberg, & Dombeck, 1990; Mattia, Heimberg, & Hope, 1993), obsessive compulsive disorder (Foa et al., 1993), specific phobia (Watts et al., 1986), and state anxiety (Mogg et al., 1997). Notably, however, there is also a smaller body of evidence of neglect or avoidance of threat-related material (e.g., De Ruiter & Brosschot, 1994; Kindt, 1998; Lavy, Van den Hout, & Arntz, 1993) or negative findings (e.g., Thorpe & Salkovskis, 1998; Tolin et al., 1996; Wenzel & Holt, 1999), despite methodological rigour, particularly in samples with specific phobias.

The vast majority of evidence for these cognitive biases has emerged from studies using modified versions of the Stroop test (1935). The Stroop requires that the subject suppress or inhibit a well-learned response (word reading) and instead implement a more novel response as quickly as possible (text colour naming; Golden, 1976). Stimulus words used in the standard version of the Stroop are colour names either concordant or discordant with text colour (e.g., the word ''red'' written in red vs. blue ink); whereas the modified version includes emotionally valenced words that have special significance to the participant (e.g., ''cobweb'', ''tarantula'' for spider phobic participants; ''embarrass'', ''humiliate'' for social phobic participants). Fearful participants show strong interference effects (i.e., longer text colour naming latencies) when stimuli are fear relevant, which is believed to be due to their difficulty in ignoring the content of fear relevant words. Although the emotional Stroop typically involves linguistic stimuli, evidence from two recent studies revealed that spider phobic participants show comparable degrees of selective attention when pictures of spiders are used as stimuli (Kindt & Brosschot, 1997; Lavy & Van den Hout, 1993).

Selective attention is a cognitive operation governed by the central executive system (e.g., Foster, Eskes, & Stuss, 1994), which is also involved in goal-directed behaviour, the monitoring and regulation of emotion and cognition, and other complex cognitive skills collectively known as executive functions (EF;

Fuster, 1997). Because Stroop and Stroop-like tasks are believed to tap a narrow range of EF (i.e., inhibitory control and attentional set; MacLeod, 1991; Milham et al., 2001; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000), studies using tasks other than the Stroop are needed to clarify our understanding of the impact of fear-relevant cues on the EF spectrum. This issue may be of particular importance in phobic individuals, because of the divergent results from Stroop studies of this population, with some showing selective attention (Lavy et al., 1993; Watts et al., 1986), and some avoidance or neglect (e.g., De Ruiter & Brosschot, 1994; Kindt, 1998; Lavy et al., 1993). Additionally, the small group of rigorous studies which yielded negative findings raise the possibility that the Stroop is somewhat unreliable as a measure of cognitive processing in phobic participants (Thorpe & Salkovskis, 1997; Wenzel & Holt, 1999).

Definition and brief summary of executive functioning

The term ''executive functioning'' (EF) has been a topic of controversy in the literature of psychology because it refers to a heterogeneous and wide-ranging collection of cognitive operations (e.g., task analysis, governing of future- and goal-oriented behaviours, emotion regulation, metacognition, self-monitoring, set switching; Burgess & Shallice, 1996; Miyake et al., 2000). According to Fuster (1997), the prefrontal cortex associated with EF is connected to limbic structures; most notably the amygdala, the hypothalamus, and the magnocellular portion of the dorsomedial nucleus of the thalamus, and receives information about emotional state directly from the autonomic nervous system. The orbital and medial cortices of the frontal lobe are attuned to emotional behaviour and may be involved in the formation and storage of emotional memories, thus are particularly relevant in studies of threat-related processing. A corresponding output system allows the prefrontal cortex to influence neural systems and viscera such that behaviours can be regulated according to task demands and emotional state. These neural connections have been mechanistically related to the set of cognitive abilities known as EF (Fuster, 1997). Thus, architectural and functional analyses suggest that an individual's ability to solve cognitive tasks can be fatigued by competing emotional demands (Jensen-Campbell et al., 2002).

It is notable that there is not clear consensus on the precise definition of EF. For example, Hayes, Gifford, and Ruckstuhl (1996, p. 279) have argued that the term EF is too often used to delineate ''... whatever function I believe might involve the frontal lobe'', and implies the existence of a homunculus-like entity in the frontal cortex. Accordingly, Stuss and Benson (1986) commented that although the EF represents the most significant frontal lobe accomplishments in humans, the term escapes adequate definition. Thus, although the term EF will be used throughout this paper, it is notable that the existence of a coherent set of executive functions has been, and continues to be, disputed.

The current study

This study sought to clarify whether fear relevant stimuli influence performance on tasks tapping EF in spider-fearful individuals. Performance was assessed in participants scoring lower and higher on the Spider Phobia Questionnaire (SPQ; Klorman, Weerts, Hastings, Melamed, & Lang, 1974) on two cognitive tasks putatively associated with aspects of EF that differed, in part, from the previously characterised Stroop task, and from each other; a card sorting task (Wisconsin Card Sorting Test: WCST; Heaton, 1981); and a verbal fluency task (VF; e.g., Benton & Hamsher, 1976). Critically, for both tasks, we contrasted versions employing neutral stimuli with versions employing emotionally salient stimuli. The standard Wisconsin Card Sorting Test (WCST; Heaton, 1981) uses neutral geometric stimuli, whereas the emotional salient version used modified pictorial stimuli that included neutral, positive, phobic threat, and general threat stimuli. Similarly, the VF task required subjects to generate exemplars of categories that were neutral (''furniture''), positively valenced (''desserts''), or associated with phobic threat (''spiders''). For the VF task, the ''furniture'' and ''desserts'' categories were important as controls to rule out biases based on frequency of priming of categories (i.e., most people encounter furniture and desserts more frequently than spiders), or the effects of emotional valence rather than fear cues per se (i.e., some may show a bias toward emotionally valenced stimuli regardless of whether they are positive or negative).

Although there may be some overlap in skills involved in card sorting and verbal fluency, task analysis suggests that they are not entirely redundant. The WCST requires that participants sort each stimulus card to one of four target cards, based on various attributes that are not made explicit by the tester (i.e., colour, form, or number of stimuli). On a subset of trials, cards sorted correctly match the target on a single attribute (''unambiguously sorted''), whereas on other trials cards sorted correctly will match on more than one attribute (''ambiguously sorted''). Following each sorting attempt, the participant is given feedback indicating whether their attempt to match to the target was correct or incorrect. Thus, achieving even a single category requires the subject to engage in successful hypothesis generation, concept formation, sustained attention, and use of feedback (self-monitoring). After the participant sorts 10 consecutive cards correctly (also called ''completing a category''), the experimenter shifts to a new sorting rule. Thus, participants must spontaneously plan and implement alternative sorting rules once negative feedback is given for the original sort rule. Set-switching requires a considerable degree of cognitive flexibility and inhibitory control (e.g., Jensen-Campbell et al., 2002; Lezak, 1995; Spreen & Strauss, 1998). VF tasks require participants to generate as many exemplars of each target category as possible under time and verbal production constraints that are not found in the card sorting tasks. Thus, VF tasks place greater demands on semantic discrimination, the efficiency and organisation of verbal retrieval and response, initiation and maintenance of word production (Jensen-Campbell et al., 2001; Pihlajamaki et al., 2000; Spreen & Strauss, 1998). As with the card sorting tasks, however, VF tasks also involve some degree of inhibitory control of irrelevant or previously produced responses.

The view that these tasks tap different aspects of EF is supported by correlational and factor analytic data. Burgess, Alderman, Evans, Emslie, and Wilson (1998) studied the external validity of the WCST and VF, and found that the tasks correlated differentially on factors of a behavioural measure of dysexecutive symptoms. The WCST was most strongly associated with an ''executive memory'' factor comprised of temporal sequencing, confabulation, and perseveration, whereas the VF was related primarily to impulsivity, abstract reasoning, and response suppression problems, which comprised an ''inhibition'' factor. Indices from card sorting tasks also load on general cognitive ability factors, such as ''conceptualisation/problem solving'' and ''learning'' (Paolo, Troster, Axelrod, & Koller, 1995). In addition, although in a sample of 250 patients and controls, Boone, Ponton, Gorsuch, Gonzalea, and Miller (1998) found that the WCST, VF, and Stroop all loaded on a higher order EF factor, the WCST loaded on its own unique factor labelled ''cognitive flexibility'', which subsumed all task indices and reflected the ability to shift set, modify behaviour in response to external feedback, and solve problems efficiently. The VF and Stroop, which unlike the WCST require speeded responses, were not associated with this factor. Rather, both of these tasks loaded on a common ''speeded processing'' factor. This was an unexpected finding that contradicts the popular assumption that the VF and Stroop measure different components of EF. Thus, we posit that the current tasks have acceptable external validity, although we acknowledge that the independence of relative task components measured by VF and Stroop is less clear.

Given that card sort and VF tasks appear to load on different factors of EF, it is possible that the higher SPQ group will evidence different patterns of performance on the emotional variants of these tasks. MacLeod and Mathews (1991) have argued that subjects will allocate more attentional resources to threat cues than to other types of stimuli. Following this logic, we hypothesised that fear-relevant cues would distract higher SPQ participants from higher order conceptual and strategic demands of the card sort tasks, leading to poorer performance on the Spider Phobia Card Sorting Test (SPCST) as compared to the other three groups. Yet, given that higher SPQ individuals appear to have a greater number of associations with ''spiders'' or increased access to such associations (e.g., Dagleish & Watts, 1990; Watts, 1990; Williams, MacLeod, & Mathews, 1996), we would predict that they would generate significantly more exemplars of the ''spiders'' category than the lower SPQ group.

Although a disruption in performance on the SPCST was predicted for higher SPQ individuals, the direction of the effect is difficult to predict due to inconsistencies in prior studies involving spider-fearful participants. On the SPCST, it is possible that higher SPQ participants would attend selectively to the spider target card and sort significantly more cards to the spider target card than the lower SPQ SPCST group, or than the lower and higher SPQ WCST groups, who sorted to a neutral target card depicting two green stars. This effect would be consistent with a selective attention bias (e.g., Lavy et al., 1993; Watts et al., 1986), and would reflect a tendency to fixate on and over-utilise fear cues to solve the task, leading to degraded performance. On the other hand, if participants were avoiding or neglecting fear cues, we would expect to see the higher SPQ SPCST group sort significantly fewer cards to the spider target card than the lower SPQ SPCST group, or than the lower and higher SPQ WCST groups, who sorted to neutral targets. This pattern would be consistent with past research showing that spider phobic participants neglect fear relevant cues, also leading to a disruption in performance (e.g., De Ruiter & Brosschot, 1994; Kindt, 1998; Lavy et al., 1993). Regardless of the direction of the interaction described above, it was expected that degraded performance in higher SPQ SPCST participants would cause them to solve fewer categories, require a significantly greater number of trials to complete the first category, evidence significantly more errors, and achieve a significantly lower proportion of conceptual level responses than the other three groups (lower SPQ WCST and SPCST, higher SPQ WCST).

In summary, we predict that the performance of higher SPQ subjects will differ from lower SPQ subjects on the emotionally salient versions of the card sort and VF tasks, but not on the neutral versions of these tasks. Specifically, the salience of the fear cue in the higher SPQ group may disrupt ‘‘cognitive flexibility’’, and therefore will impair performance on the SPCST, but increase ‘‘speeded processing’’ of fear-relevant information, and therefore, facilitate access to exemplars of the ‘‘spider’’ category in the VF task. More generally, EF skills measured by card sort and VF tasks are of interest because they are likely to be involved in responding to real world threat stimuli (e.g., perceptual and conceptual processing, activation of regulatory arousal systems, planning defence or escape strategies), and thus will extend our understanding of the impact of fear-related cues on complex cognitive skills. They may also approximate skills involved in cognitive behavioural and other psychosocial treatments for anxiety disorders.

METHOD

Participants

A total of 126 female participants were recruited from undergraduate psychology courses at the University of California, Los Angeles and Columbia University, New York, between March 1998 and November 1999. Because most spider-fearful individuals are female, the sample was limited to females to avoid confounding group (lower, higher SPQ) with sex. Ages ranged from 18 to 47 with a mean age of 20. All participants spoke fluent English, had normal colour vision, and were free of known neurological problems. Participants received course credit in return for participating in the study.

Measures

Mood measures. The SPQ (Klorman et al., 1974) was administered to assess specific spider-related fears. The measure consists of 31 true/false items that are summed to produce a total score. Higher SPQ participants' mean scores reported in prior studies range from 17.0 to 24.0 (Antony, Ing, Leeuw, & Swinson, 1998; Klorman et al., 1974). The measure has demonstrated satisfactory internal consistency (.91) and high test-retest correlation across a 3 week period (.94). It has been shown to differentiate phobic from nonphobic participants, correlate in a meaningful way with behavioural indices and other self-reports of spider fear, and is sensitive to treatment effects (Muris & Merckelbach, 1996). The SPQ demonstrated an internal consistency coefficient of .85 in this sample.

The Beck Depression Inventory (BDI; Beck & Steer, 1987) was administered to evaluate and control for the presence and severity of depressive symptoms. Because WCST performance is negatively associated with depression (Martin, Oren, & Boone, 1991), scores on the card sorting tasks might be influenced by depression as well as spider fear. The internal consistency coefficient of the measure was .91 in the current sample.

The State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1983) was administered to control for levels of overall trait anxiety and transient state anxiety at the time of participation in the experiment. Internal consistency coefficients for the state and trait subscales were .87 and .88, respectively, in the current sample.

Measure of verbal intelligence. Scores on the WCST typically show moderate positive correlations with verbal IQ scores (e.g., Spreen & Strauss, 1998). Thus, the Nelson Adult Reading Test-American Version (AMNART; Grober & Sliwinski, 1991) was administered as a gross estimate of verbal intelligence. According to Grober and Sliwinski, the AMNART correlates strongly with intelligence in normal samples, and with other premorbid estimates in clinical samples.

Stimulus rating sheets. A stimulus rating sheet showing each pictorial stimulus in black ink (SPCST) and the names of the stimulus categories (VF) was given to a pilot sample of 96 undergraduate participants at UCLA for the purpose of collecting normative data on task stimuli. As hypothesised, the neutral and positive stimuli were rated as neutral and positive, respectively, and the general threat and phobic threat stimuli were rated as negative.

The stimuli were also rated on emotional valence by the current sample. Participants rated each dimension on a 0 to 6 Likert-type scale where 0 meant ‘‘strongly negative’’ and 6 meant ’strongly positive’’. Ratings are displayed in Table 1.

Experimental groups and design

In the current sample, SPQ scores ranged from 0 to 26. The top and bottom scoring 35% of participants were split into lower SPQ and higher SPQ groups. The middle scoring 30% of the sample was not included in the analysis so that between group differences based on spider fear would be maximised. The anxiety disorder modules of the Structured Clinical Interview Diagnostic for DSM-IV (SCID; First, Gibbon, Spitzer, & Williams, 1995) were administered to determine each participant’s phobic status and the presence of comorbid anxiety disorders.

Repeated administrations of the WCST have been known to produce strong practice effects, because once the participant discovers the sort and shift principle, she is unlikely to show poor performance on subsequent attempts (Lezak, 1995). Therefore, a 2 (Group; lower SPQ, higher SPQ) × 2 (Condition; WCST, SPCST) between-subjects design was used, with 38 participants in the WCST condition (18 lower SPQ, 20 higher SPQ) and 42 in the SPCST condition (20 lower SPQ, 22 higher SPQ). Within the higher SPQ group, 8 participants in the SPCST condition and 10 participants in the WCST condition met DSM-IV criteria for spider phobia, a difference that was not statistically significant according to a chi-square test.

Materials

WCST. Stimuli in the WCST condition consisted of two standard decks of 64 3 × 3 inch cards depicting one, two, three, and four triangles, stars, circles, and plus signs. Each was presented in each of four colours (red, blue, green, yellow). The target cards of the WCST depicted one red triangle, two green stars, three yellow plus signs, and four blue circles. For the purposes of the current study, two full decks were used (128 total stimulus cards) because completion of the task (solving six categories) typically requires more than the 64 trials allowed with a single deck.

SPCST. The SPCST was developed for use in this study by the first author, and is identical to the WCST in administration. Stimuli in the SPCST condition consisted of 128 3 × 3 inch cards depicting one, two, three, or four apples (positive), paw prints (neutral), skulls (general threat), or spiders (phobic threat). Each was presented in each of four colours (red, blue, green, yellow). The target cards of the SPCST depicted one red paw print, two green spiders, three yellow apples, and four blue skulls. The SPCST deck was designed to control for the attributes of colour and number of stimuli so that the effect of the form attribute could be isolated; therefore, the target cards from the SPCST corresponded to those in the WCST on colour and number, but not on form (e.g., one red triangle in the WCST vs. one red paw print in the SPCST; two green stars in the WCST vs. two green spiders in the SPCST, etc.).

Dependent measures: Card sorting tasks. As mentioned earlier, we were interested in the impact of fear cues on a number of cognitive skills tapped by the card sorting tasks. These include concept formation, hypothesis generation, set switching, appropriate use of feedback, and sustained attention. We were also interested in broader indices of task performance, such as the total number of trials required to complete the task and the number of categories completed.

Dependent variables derived from the card sorting tasks were: (a) the number of categories completed (runs of 10 correctly sorted cards) out of a possible total of six, which reflects concept formulation and sustained attention; (b) total number of cards sorted to the each of the four target cards, a broad index of performance; (c) total number of failures to maintain set, which indicate lapses in attention; (d) total number of perseverative errors, which reflect an inability to switch set and formulate appropriate responses based on feedback; (e) total number of other errors, reflecting random sorting; (f) proportion of conceptual level responses, reflecting nonrandom sorting and concept formation; (g) proportion of cards sorted to each attribute of each target card (colour, form, number), which indicates biases based on a specific feature of the stimuli (e.g., form); and (h) number of trials needed to complete the first correct category, reflecting hypothesis generation skills. Failures to maintain set are defined as incorrect responses that interrupt runs of at least five correctly sorted cards. Perseverative errors are scored when a participant repeats an incorrect sorting attempt despite feedback from the experimenter on the prior trial that the response was incorrect. Conceptual level responses are defined as runs of three or more correctly sorted cards, summed over all trials, and reflect the participant's tendency to formulate and test discrete hypothetical categories of card attributes, rather than implement a random sorting strategy (Heaton, 1981; Heaton, Chelune, Talley, Kay, & Curtiss, 1993; Spreen & Strauss, 1998). These variables are typically reported in studies of the WCST.

Dependent measures: VF. We were interested in studying several cognitive skills tapped by VF: verbal fluency, efficiency and organisation of verbal responses, inhibitory control, and semantic discrimination. Therefore, we chose to analyse the number of admissible and inadmissible exemplars on each of the categories between the lower and higher SPQ groups. Scores on the VF were sums of all admissible exemplars for each of the three target categories (''furniture'', ''desserts'', ''spiders''). Inadmissible exemplars were excluded from total scores and included phrases, proper names, words beginning with capital letters, multiple exemplars using the same word stem with different endings, or variants of the same exemplar (Guilford & Guilford, 1980); for example, if the category was ‘‘spiders’’, ‘‘black widow’’ was admissible but ‘‘widow’’ and ‘‘widow spider’’ were subsequently inadmissible. If an exemplar was repeated (e.g., ‘‘black widow’’ generated twice), the second exemplar was inadmissible.

Procedure

Participants were informed that the study was an investigation of how different groups of people solve complex problems. After reading and signing the consent form, participants completed the anxiety disorder modules of the Structured Clinical Interview for DSM-IV (SCID-IV; First et al., 1995) to determine diagnostic status. Then each participant completed the questionnaires detailed above and a stimulus rating sheet. These tasks were given in the same order to all participants.

After completing the interview and self-report measures, each participant was given the AMNART (Grober & Sliwinski, 1991) according to standard administration instructions. Next, each participant completed the VF, in which she was asked to name as many exemplars as possible from each of three categories in a 60 second period. The categories were ‘‘furniture’’, ‘‘spiders’’, and ‘‘desserts’’, presented in the same order across all participants.

Participants were then randomly assigned to either the WCST or SPCST condition stratified on lower-SPQ versus higher-SPQ status. Regardless of condition, the experimenter read the instructions for the card sorting task as they appear in the WCST manual (Heaton et al., 1993) before administering the test. Participants heard the following instructions:

> The next test is a little unusual because I am not allowed to tell you very much about how to do it. You will be asked to match each of the cards in theses decks to one of the four key cards. I am going to hand you cards one-at-a-time and I want you to place each card below the target card you think it matches. I can’t tell you how to match the cards, but I will tell you each time whether you are correct or incorrect. If you are incorrect, leave the card where you’ve placed it, and try to get the next card correct. Here is the first card.

During the test, the experimenter recorded the sorting strategy used on each trial on a response sheet as detailed in the WCST manual.

RESULTS

Participant characteristics

A 2 (Group; lower SPQ, higher SPQ) $\times$ 2 (Condition; WCST, SPCST) multivariate analysis of variance (MANOVA) was conducted to test for differences on demographic and self-report measures. Both the main effect of condition and the interaction were nonsignificant. There was a significant main effect of group,

$F(1, 28) = 34.17$, $p < .001$, $\eta^2 = .84$, which was accounted for by differences on the SPQ, $F(1, 76) = 13.43$, $p < .001$, $\eta^2 = .67$, and verbal IQ, $F(1, 76) = 12.95$, $p < .05$, $\eta^2 = .16$. Thus, means were collapsed over condition for display in Table 1. The lower SPQ and higher SPQ groups did not differ significantly on any other demographic variable or mood measure. Stimulus ratings collected from the sample are shown in Table 1 (0 = very negative; 3 = neutral; 6 = very positive). The higher SPQ participants showed significantly lower ratings of the spider stimulus on valence, indicating that subsequent effects were not driven by a general bias toward emotional or negative stimuli, but rather a more specific bias toward spider-relevant cues.

Verbal fluency task

Because predictions on the VF were independent of card sort condition, the analysis of VF data consisted of a 2 (Group; lower SPQ, higher SPQ) × 3 (Stimulus; positive-dessert, neutral-furniture, phobic threat-spiders) MANCOVA with verbal IQ covaried. The higher SPQ group generated a significantly greater number of exemplars when the target category was ''spiders'' than the lower SPQ group, $F(1, 28) = 20.48$, $p < .001$, $\eta^2 = .23$. However, the higher SPQ group did not generate significantly more ''furniture'' or ''desserts'' words than the lower SPQ group. There were no significant between-group differences on the number of errors made on the VF, and the overall number of inadmissible exemplars was very low (mean < 0.50 in each group for each category). Means and standard deviations of admissible responses are displayed in Table 2. The participants in the higher SPQ group rated the spider stimulus as significantly more negative than the lower SPQ group, again indicating a difference on spider-relevant cues per se, rather than a more general bias.

Card sorting tasks

Because there were considerable (although nonsignificant) between-group differences on the total number of sorting trials needed to complete the task, verbal IQ and trials were used as covariates in the main analysis. The number of cards participants sorted to each of the four target cards was standardised, then entered along with the number of completed categories, trials required to complete the first category, failures to maintain set, perseverative errors, other errors, and proportion of conceptual level responses as dependent variables into a 2 (Group: lower SPQ, higher SPQ) × 2 (Condition: WCST, SPCST) MANCOVA. We did not conduct a three-way factorial analysis because we were not interested in all possible comparisons between groups, conditions, and stimuli; rather we tested only those cells relevant to our hypotheses in a set of planned comparisons (higher vs. lower SPQ group on number of cards sorted to spider target card in SPCST condition, higher SPQ SPCST vs. higher SPQ, and lower SPQ WCST groups on number of cards sorted to spider or star target card).

TABLE 1
Characteristics of the sample

	Lower SPQ (n = 38)	Higher SPQ (n = 42)
	Mean (*SD*)	*Mean* (*SD*)
Age	20.46 (6.82)	19.29 (1.88)
Education (years)	13.51 (1.31)	13.08 (1.30)
Marital status		
Single	99%	100%
Married	1%	0
Employed	52%	60%
Ethnicity		
Caucasian	53%	47%
Asian American	29%	32%
African American	9%	13%
Hispanic/Latino	9%	8%
Other anxiety disorders		
Panic attacks	32%	30%
Generalised anxiety	9%	8%
Social phobia	23%	23%
No. of additional fears	0.63 (0.77)	0.89 (0.98)
SPQ	3.06 (0.98)	16.61 (4.40)*
BDI	7.23 (5.50)	6.94 (4.89)
STAI-State	35.87 (9.49)	37.20 (10.57)
STAI-Trait	39.30 (10.06)	40.60 (9.45)
Verbal IQ	117.84 (5.03)	114.38 (3.65)*
Stimulus valence ratings: SPCST		
Paw print	3.76 (1.17)	4.02 (1.18)
Spider	2.10 (1.12)	1.11 (0.93)*
Apple	4.16 (1.10)	4.23 (1.33)
Skull	1.50 (1.07)	1.37 (1.30)
Stimulus valence ratings: VF		
Furniture	3.04 (0.89)	3.09 (1.01)
Desserts	5.13 (1.24)	5.24 (1.12)
Spiders	2.00 (1.43)	0.97 (0.86)**

SPQ = Spider Phobia Questionnaire, BDI = Beck Depression Inventory. Stimulus valence rating scale: 0 = very negative, 3 = neutral, 6 = very positive. *$p < .05$; **$p < .001$.

TABLE 2
Standardised mean values of cards sorted to each target card and VF scores by group and condition

	Lower SPQ (n = 38)	*Higher SPQ* (n = 42)
Target card stimulus	*Mean* (*SD*)	*Mean* (*SD*)
WCST condition		
One red triangle (WCST)	0.250 (0.71)	0.004 (0.94)
Two green stars (WCST)	0.480 (0.58)	0.452 (1.32)
Three yellow pluses (WCST)	0.464 (0.56)	0.662 (1.48)
Four blue circles (WCST)	0.179 (0.48)	0.504 (1.57)
SPCST condition		
One red paw print (SPCST)	0.216 (0.70)	0.208 (0.76)
Two green spiders (SPCST)	0.205 (0.78)	−0.813 (0.79)*
Three yellow apples (SPCST)	0.144 (0.81)	0.077 (1.21)
Four blue skulls (SPCST)	−0.094 (0.87)	0.100 (1.28)
Verbal fluency task		
Furniture	12.71 (3.02)	13.02 (4.08)
Spiders	8.83 (3.38)	12.56 (3.55)**
Desserts	12.31 (3.72)	13.00 (2.95)

Note: * Significantly different from lower SPQ WCST, SPCST, and higher SPQ WCST group, $p < .05$. ** Lower and higher SPQ groups significantly different, $p < .05$.

The analysis yielded significant main effects of group, $F(3, 76) = 6.97$, $p < .01$, $\eta^2 = .57$, and condition, $F(3, 76) = 10.89$, $p < .01$, $\eta^2 = .45$. These effects were qualified by a significant group by condition interaction, $F(3, 76) = 5.14$, $p < .01$, $\eta^2 = .68$. Follow-up univariate analyses of variance (ANOVAs) indicated a significant difference between the groups on the proportion of conceptual level responses, $F(1, 76) = 4.48$, $p < .05$, $\eta^2 = .26$, the number of trials needed to complete the first category, $F(1, 76) = 4.30$, $p < .05$, $\eta^2 = .22$, and on the number of cards sorted to the target card that depicted a star (WCST condition) or a spider (SPCST condition), $F(1, 64) = 6.93$, $p < .01$, $\eta^2 = .33$. There were no differences between the groups on the three types of errors (failures to maintain set, perseverative errors, other errors) or the number of categories completed on the task.

Proportions of conceptual level responses, the number of trials needed to complete the first category, and the number of cards sorted to the target card depicting a star or spider were further compared with pairwise comparisons. The higher SPQ SPCST group sorted a significantly lower number of cards to the target card that depicted a spider than the lower SPQ SPCST group, $F(1, 76) = 7.42$, $p < .005$, $\eta^2 = .26$, the lower SPQ WCST group, $F(1, 76) = 9.74$, $p < .01$,

$\eta^2 = .39$, and the higher SPQ WCST group, $F(1, 76) = 12.71$, $p < .01$, $\eta^2 = .41$. Standardised mean values of the number of cards sorted to each of the target cards are displayed in Table 2.

The higher SPQ SPCST group also evidenced a lower proportion of conceptual level responses than the lower SPQ SPCST group, $F(1, 76) = 7.11$, $p < .01$, $\eta^2 = .13$, the lower SPQ WCST group, $F(1, 76) = 8.01$, $p < .01$, $\eta^2 = .19$, and the higher SPQ WCST group, $F(1, 76) = 9.69$, $p < .005$, $\eta^2 = .14$. There were no significant differences on proportion of conceptual level responses between the two lower SPQ groups, or between either of the lower SPQ groups and the higher SPQ WCST group, as displayed in Table 3.

The higher SPQ SPCST group also required a significantly greater number of trials to complete the first category than the higher SPQ WCST group, $F(1, 76) = 6.81$, $p < .005$, $\eta^2 = .32$, the lower SPQ SPCST group, $F(1, 76) = 13.02$, $p < .005$, $\eta^2 = .48$, or the lower SPQ WCST group, $F(1, 76) = 15.15$, $p < .005$, $\eta^2 = .46$. Means and standard deviations are shown in Table 3.

Attribute-level analyses

The data was also tested for attribute-level sorting biases (colour, form, number) by comparing the proportions of cards sorted ambiguously and unambiguously to attributes of each target card. No biases were found when all 24 attributes (colour, form, and number for all eight target cards) were entered into a Group × Condition MANOVA. Additionally, no biases were found in an isolated test of the form dimension across participant groups and in both conditions.

TABLE 3
Adjusted mean scores (and standard deviations) on card sorting tasks by group and condition

	Lower SPQ		*Higher SPQ*	
	WCST (n = 18)	*SPCST* (n = 20)	*WCST* (n = 20)	*SPCST* (n = 22)
Raw scores	*Mean* (*SD*)	*Mean* (*SD*)	*Mean* (*SD*)	*Mean* (*SD*)
Trials	76.20 (7.90)	78.65 (10.35)	91.00 (10.05)	85.95 (9.59)
Categories	6.00 (0.00)	5.98 (0.15)	5.81 (0.54)	5.65 (1.18)
Trials to complete first category	12.13 (1.12)	10.94 (2.35)	11.75 (1.18)	14.95 (1.70)*
Failures to maintain set	0.27 (0.46)	0.95 (2.70)	0.69 (1.14)	0.85 (1.50)
Perseverative errors	8.40 (4.81)	8.45 (4.53)	9.81 (4.14)	12.25 (3.53)
Other errors	3.86 (3.02)	9.15 (5.42)	5.35 (4.04)	9.63 (2.41)
Conceptual level responses	0.84 (0.26)	0.81 (0.24)	0.79 (0.11)	0.64 (0.09)*

Note: * Significantly different from lower SPQ WCST, SPCST, and higher SPQ WCST groups, $p < .05$.

Correlational analysis

A post-hoc correlational analysis was conducted to clarify the relation between the percentage conceptual level responses, the number of cards sorted to the spider target card, and number of trials to complete the first category among higher SPQ participants in the SPCST condition. The number of cards sorted to the spider target card correlated significantly and positively with proportion of conceptual level responses ($r = .35$, $p < .01$) and significantly and negatively with the number of cards required to complete the first category ($r = -.46$, $p < .001$). In contrast, the lower SPQ group showed a significant negative correlation between conceptual level responses and the number of cards sorted to the spider target card ($r = -.48$, $p < .001$), with no relation between the number of trials required to solve the first category and the number sorted to the spider target card.

DISCUSSION

Many previous studies of executive functioning (EF) in phobic individuals using Stroop and Stroop-like tasks report selective attention biases toward fear cues. We found evidence of this type of selective bias on the verbal fluency task (VF) but not necessarily on card sorting tasks. Although we cannot build a strong argument for why the current pattern of results differed across tasks, task characteristics (timed vs. untimed), stimulus characteristics (pictorial vs. linguistic; self-generated vs. prefabricated; unitary vs. multidimensional), or type of memory system involved (working vs. long-term) are possible contributors.

As predicted, results of the VF task revealed that the higher SPQ group generated significantly more exemplars of the category ''spiders'' than the lower SPQ group. Possible explanations of this effect are that fearful individuals have more associated cues in memory pertaining to threat stimuli than less fearful individuals, or that such cues are more easily accessible in fearful individuals, perhaps due to selective attention, memory biases, or more frequent activation and subsequent strengthening of information in semantic networks (e.g., Dagleish & Watts, 1990; Watts, 1990; Williams et al., 1996). Any of these phenomena would give fearful individuals special expertise on tasks involving long term memory for spider-related cues.

This evidence is consistent with the cognitive biases toward threat cues reported in prior Stroop, dot probe, and dichotic listening studies in various groups of anxiety patients (e.g., Ehlers et al., 1988; Foa et al., 1993; MacLeod, 1991; MacLeod & Mathews, 1991; Mogg et al., 1989; Watts et al., 1986). VF results are also consistent with studies of enhanced autobiographical recall of phobic material (Burke & Mathews, 1992; Richards & Whitaker, 1990), but diverge from prior investigations of poor recall and recognition memory for previously learned fear-relevant words in spider-fearful individuals (Watts, 1986; Watts & Dagleish, 1991) and other anxiety disorders (Foa, McNally, & Murdock, 1989; Mogg, Mathews, & Weinman, 1987). The higher SPQ group did not perform differently from the lower SPQ group on ''furniture'' or ''desserts'' exemplars, which allows the ruling out of a bias based on emotional valence rather than phobic fear per se.

On the card sort, it was expected that the higher SPQ SPCST group would perform significantly worse than the other three groups on categories, trials required to complete the first category, errors, and conceptual level responses. These predictions were based on the notion that the presence of a fear-relevant stimulus would lead to selective attention to, or avoidance or neglect of, fear cues. Either of these biases would interfere with the cognitive operations necessary for solving the card sorting task. Therefore, we also predicted that the higher SPQ SPCST group would sort either significantly more or significantly fewer cards to the spider target card than the lower SPQ SPCST group, or than the lower and higher SPQ groups in the WCST condition, who sorted to the star target card. The groups in the WCST condition and the lower SPQ SPCST group were not expected to differ significantly on any of these measures.

The analysis yielded significant effects on the number of cards sorted to the spider (SPCST condition) or star (WCST condition) target card, proportion of conceptual level responses, and the number of trials required to complete the first category, with the higher SPQ SPCST group demonstrating the worst performance; however, there were no significant differences found on categories or errors.

The higher SPQ SPCST group showed the lowest proportion of conceptual level responses, defined as runs of three or more consecutive cards sorted correctly. This suggests that the higher SPQ SPCST group was least successful at formulating and testing hypothetical categories during the task than the other three groups. According to Heaton (1981) and Spreen and Strauss (1998), a lower proportion of conceptual level responses indicates difficulty with inferring sorting rules, as reflected by a tendency to achieve one or two correct responses, then make an error. This effect could have resulted from avoidance of the spider target card, leading to a sorting strategy that was more random.

Furthermore, correlational data suggest that difficulty with testing hypothetical categories was likely to have occurred during attempts to complete the first category of the task, because the higher SPQ SPCST group required significantly more trials than the other groups to do so. Overall, it appears that processing fear-relevant information interfered with the ability of the higher SPQ (and to a lesser degree, the lower SPQ) SPCST groups to formulate and test hypothetical categories of card attributes on the sorting task, with a higher number of errors occurring early in the task as compared to the other groups. To summarise, the higher SPQ SPCST group took slightly longer to ''catch on'' to the sorting principles, indicating a less systematic approach to solving the task. Alternatively, as noted by Basso, Schefft, Ris, and Dember (1996), anxiety is associated with a bias toward the processing of details rather than global components of visual cues. Perhaps the form and number dimensions on stimulus cards were more salient to the higher SPQ group than the colour dimension which led to an increased number of trials to complete the first category, within which the correct sorting rule was colour.

Higher SPQ participants sorted fewer cards to the spider target card, which is more consistent with an avoidance bias than selective attention. However, it is possible that selective attention occurred as an early-emerging bias, and avoidance or distraction as a later occurring bias (e.g., Lavy et al., 1993; Mogg et al., 1989), leading to a net effect of neglect of the spider target card. Although it cannot be concluded that this specific two-part response occurred here (i.e., selective attention followed by distraction, attentional, or motoric avoidance), this possibility warrants careful study in future investigations. Because a subset of EF studies have indicated a tendency for anxious individuals to neglect fear relevant material, a theory that accounts for both favouring and neglecting biases is needed to augment the often discussed selective attention hypothesis. Because the Stroop and VF are timed tasks, it may not tap later emerging responses, such as strategic avoidance. This would explain the abundance of data supporting selective attention in anxious individuals, based on the frequent use of the Stroop and similar timed tasks.

We can conclude that this neglect or avoidance bias was not driven by differences in state anxiety, which could have functioned as a distractor that interfered with task performance but was not directly related to our hypotheses. State anxiety scores were not significantly different across lower and higher SPQ groups, or between higher SPQ groups in either condition.

A greater number of perseverative errors were made by the higher SPQ group in the SPCST condition, although this effect fell short of statistical significance. Unfortunately, the scoring system used in the study did not allow for a detailed analysis of exactly when perseverative errors occurred. However, we can deduce that higher SPQ SPCST participants were not showing perseveration in sorting to the spider target card because the overall number of cards sorted to the spider target card was lower than in the other groups. The higher SPQ group in the SPCST condition did not appear to have trouble switching or maintaining set, as revealed by their overall performance and relatively low frequencies of failures to maintain set.

Limitations of the study and future directions

Although the study revealed important differences between higher and lower SPQ groups of these tests of EF, there are some limitations to the generalisability of results. Our testing was conducted on an all-female undergraduate sample, thus it is unknown whether males and nonstudents show similar deficits. It is also possible that cognitive tasks are more familiar to a college population than to the population at large, making task familiarity a possible confound. Future studies should include mixed sex and nonstudent samples of participants to provide results with better external validity than in this investigation. Replication in a truly phobic, rather than higher SPQ, sample might yield stronger or otherwise different effects.

It has been hypothesised that degrees of attentional bias may correlate with severity or type of anxiety symptoms (e.g., McNally et al., 1993; Wenzel & Holt, 1999). It is also unclear whether the biases found here would also occur in generally anxious individuals or those with anxiety disorders other than phobias. Because spider phobia involves a focal and concrete feared stimulus, it is possible that we found a stronger bias to neglect or avoid fearful pictorial cues than would be found in individuals with more abstract fears (e.g., claustrophobia, fear of heights). In most studies of biases in subjects with anxiety disorders, experimental cues are typically symbolic (e.g., words representing feared circumstances, such as ''embarrass'', used with social phobic individuals) and may not be immediately potent enough to elicit avoidance or neglect. Additionally, because symbolic cues require deeper semantic processing than pictorial cues, we speculate that selective attention may occur most often when linguistic stimuli are used with nonfocal phobias, as this pairing would require semantic interpretation.

It has also been hypothesised that those with anxiety disorders may respond more fearfully to both symbolic and pictorial stimuli, but analogue samples such as the current spider fearful individuals respond only to pictorial threat cues (Thorpe & Salkovskis, 1998). Therefore, selective attention could have come into play on the card sort, but not on the VF, accounting for the divergent patterns of results by the higher SPQ group.

Although pictorial stimuli are assumed to have enhanced ecological validity as compared to linguistic stimuli (e.g., Kindt & Brosschot, 1997; Lavy & Van den Hout, 1993), the stimuli used in the SPCST were simple images that were somewhat unrealistic, especially the stimuli depicting skulls. This may have influenced the extent to which participants attended to task demands versus the emotional salience of the stimuli. Future studies could include realistic, detailed photographic images that would elicit more fear and stronger response biases (e.g., Foa & Kozak, 1986).

CONCLUSION

This study sought to provide data from tests tapping a range of executive function (EF) skills to extend what is known about cognitive biases in phobic participants. Results indicated that fear-relevant cues caused degraded performance on the card sorting task; namely, higher SPQ SPCST participants evidenced the lowest proportion of conceptual level responses and required a greater number of trials to complete the first category of the task. This suggests that they initially adopted more of a random sorting strategy to solve the task and did not use the experimenter's feedback as constructively as the other participants. The higher SPQ participants also sorted fewer cards to the spider target card than the lower SPQ group in the either condition or the higher SPQ group in the WCST condition. However, on the VF they showed an opposite pattern, generating a greater number of exemplars for the category ''spiders'' than the lower SPQ group.

It is difficult to argue strongly for any single cause of the effects found herein. Investigations of cognitive performance have demonstrated that temporal and other task-specific factors play a role in determining which cognitive operations will be used to solve tasks (e.g., Chiarello, Church, & Hoyer, 1997; Johnson, Kounios, & Reeder, 1994; Ober, Vinogradov, & Shenaut, 1997). Therefore, it is possible that the effects found on the VF and SPCST were driven by stimulus type (self-generated vs. prefabricated; linguistic VF vs. pictorial card sort; unitary VF vs. multidimensional card sort), temporal factors (timed VF vs. untimed card sort), type of memory system involved (VF tapping long-term memory, card sort tapping working memory) or by an interaction of several task characteristics.

We can conclude, however, that these biases appear to be highly prone to task demands, which implicate different cognitive operations and neural systems. Differences in cognitive biases may also be found across anxiety states, with less consistency in spider phobic as compared to other samples. It is clear that biases found on Stroop tasks (which formed the basis for the selective attention hypothesis) will not necessarily be replicated on tasks with different characteristics. Tasks that tap a wider range of EF (such as card sorting tasks) may yield avoidance or neglect of threat cues, or possibly, selective attention that interferes with performance, leading to a net effect of avoidance or neglect. Further studies should seek to clarify exactly which cognitive operations and task demands drive the effects found herein to increase our understanding of how anxious individuals solve EF tasks involving fear cues.

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