J. Behav. Ther. & Exp. Psychiat. 43 (2012) 532–539

Contents lists available at ScienceDirect

Journal of Behavior Therapy and Experimental Psychiatry

journal homepage: www.elsevier.com/locate/jbtep

Threat engagement, disengagement, and sensitivity bias in worry-prone individuals as measured by an emotional go/no-go task

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ARTICLE INFO

Article history:
Received 3 January 2011
Received in revised form
27 June 2011
Accepted 5 July 2011

Keywords:
Worry
Generalized anxiety disorder
Emotional go/no-go
Attentional engagement
Attentional disengagement
Sensitivity bias

ABSTRACT

Background and objectives: The goal of the present study was to investigate a threat engagement, disengagement, and sensitivity bias in individuals suffering from pathological worry.
Methods: Twenty participants high in worry proneness and 16 control participants low in worry proneness completed an emotional go/no-go task with worry-related threat words and neutral words.
Results: Shorter reaction times (i.e., threat engagement bias), smaller omission error rates (i.e., threat sensitivity bias), and larger commission error rates (i.e., threat disengagement bias) emerged only in the high worry group when worry-related words constituted the go-stimuli and neutral words the no-go stimuli. Also, smaller omission error rates as well as larger commission error rates were observed in the high worry group relative to the low worry group when worry-related go stimuli and neutral no-go stimuli were used.
Limitations: The obtained results await further replication within a generalized anxiety disorder sample. Also, further samples should include men as well.
Conclusions: Our data suggest that worry-prone individuals are threat-sensitive, engage more rapidly with aversion, and disengage harder.

1. Introduction

Generalized anxiety disorder (GAD) is a highly comorbid (Wittchen, Zhao, Kessler, & Eaton, 1994) and socially impairing anxiety disorder (Olfson & Gameroff, 2007) which is associated with a wide range of medical problems (for a review see Culpepper, 2009). The course of GAD has been described as waxing and waning in its nature (e.g., Ballenger et al., 2001). According to DSM-IV-TR (American Psychiatric Association, 2000), the cardinal feature of GAD is chronic, excessive, and uncontrollable worry. The process of worrying is directed towards future events which are expected to turn out negatively (MacLeod, Williams, & Bekerian, 1991). The goal of the worry process is to prevent these things from happening (Borkovec, Robinson, Pruzinsky, & DePree, 1983). Patients with GAD engage in this process over and over again without actually solving the problem (Mathews, 1990). Worrying is predominantly a linguistic activity and the individual is occupied with verbalizing the worry-related content (e.g., Borkovec & Inz, 1990; Freeston, Dugas, & Ladouceur, 1996).

Directing one's attention in a meaningful and flexible manner is indicative of an intact executive functioning (e.g., Miyake et al., 2000). Thus, impaired attentional control (i.e., engaging and disengaging) might be associated with impaired executive functioning in pathological worrying. There is already data available shedding light on the relationship between worry and executive functioning. Gualtieri and Morgan (2008) showed that GAD patients relative to controls exhibited executive dysfunctions across a wide range of classical neuropsychological tests. Especially problems in memory functioning (Mantella et al., 2007) and set shifting (Dorahy, McCusker, Loewenstein, Colbert, & Mulholland, 2006) were prevalent in GAD samples relative to controls. Such neuropsychological deficits in the classical, non-emotional context have not been replicated by others (Airaksinen, Larsson, & Forsell, 2005; Price & Mohlman, 2007). However, results from studies targeting attentional processes in an *emotional* context deliver a more consistent picture.

A bias towards negative information has consistently been observed in patients suffering from anxiety, ranging from high trait anxiety to full blown anxiety disorders (for a quantitative review see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007, for a qualitative review see Cisler & Koster, 2010; Hayes & Hirsch, 2007; Mathews & MacLeod, 2005; Mogg & Bradley, 2005). Two widely used paradigms have been employed in the examination of attentional

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0005-7916/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jbtep.2011.07.002

biases in anxiety disorders. First, in the *emotional Stroop paradigm*, highly anxious subjects show longer reaction times when naming the color of threat words compared to neutral words. Furthermore, slower reaction times in anxious compared to non-anxious subjects are present. This typical attentional bias towards aversive words has also been observed in GAD patients (Becker, Rinck, Margraf, & Roth, 2001). The emotional Stroop effect has been interpreted to result from an interference of color naming and meaning of the word, because the latter cannot be suppressed in favor of the former.

Second, in the *emotional dot-probe task* (MacLeod, Mathews, & Tata, 1986), two stimuli are shown on the screen, e.g., a pair of words consisting of an aversive and a neutral one, until both words disappear and only one of them is replaced by a probe. The subject's task is to respond as quickly as possible to the probe. It has been shown that GAD patients react faster towards probes replacing threatening stimuli than healthy control subjects (Bradley, Mogg, White, Groom, & de Bono, 1999; Waters, Mogg, Bradley, & Pine, 2008). Moreover, an attentional bias towards threat, evidenced by faster reaction times to probes replacing threatening stimuli relative to probes replacing neutral stimuli, has also been found in highly anxious subjects (Fox, Russo, & Dutton, 2002; Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006; Yiend & Mathews, 2001) as well as in healthy participants (Koster, Crombez, Verschuere, & De Houwer, 2004). This effect is most prominent when highly threatening stimuli are used (Koster et al., 2006).

However, one question in interpreting these findings cited above arises. Why is there an attentional bias towards negative information in the first place? The first possibility to explain the obtained results is by suggesting that individuals solely *attend faster* to aversion. Threatening information 'grabs' the attention quite automatically and thus the color naming interference in the emotional Stroop test as well as the faster detection of probes replacing aversive words takes place. In the same line of reasoning, greater perceptual sensitivity for threat and thereby greater reliability in identifying threat might also plays an important role.

The second possibility states that anxious individuals do not detect aversive information faster, but that they rather have *problems disengaging* from aversion once it has been detected. This explanation is supported by means of an *emotional spatial cueing paradigm* (Fox et al., 2002; Koster et al., 2006; Salemink, van der Hout, & Kindt, 2007; Yiend & Mathews, 2001). Individuals high in trait anxiety exhibited problems in attentional disengagement. This paradigm requires the subject to react to a probe replacing a neutral or an aversive stimulus either on the very same side as the preceding picture (valid trial) or on the other side (invalid trial). The main difference to the emotional dot-probe task consists of the possibility to analyze reaction times not only to probes in valid trials, but also to probes in invalid trials. These studies revealed that anxious subjects had longer reaction times to probes replacing aversive pictures in invalid trials compared to valid trials (Fox et al., 2002; Koster et al., 2006; Salemink et al., 2007; Yiend & Mathews, 2001). This effect was not observed in the control group (see for an exception Fox et al., 2002) and is strongest for highly threatening stimuli (Koster et al., 2006; Yiend & Mathews, 2001).

Verkuil, Brosschot, Putman, and Thayer (2009) used a similar experimental design and showed that the combination of high anxiety *and* worry was able to predict attentional disengagement. Besides the high correlation between worry and anxiety, it has been shown by path-analytic models that worry causally influences anxiety (Gana, Martin, & Canouet, 2001). To further underline the importance of worry for anxiety, it has been proposed that worry might be the component of anxiety that is responsible for the observed problems in disengagement (Eysenck, Derakshan, Santos, & Calvo, 2007). Eysenck et al. (2007) proposed that worrying recruits additional resources from working memory which limits the working memory capacity for concurrent tasks. This point has actually been confirmed empirically by Hayes, Hirsch, and Mathews (2008). They showed that worry restricts working memory capacity. Reduced working memory capacity leads to impaired executive functioning which in turn is connected with dysfunctional attentional control.

Hirsch et al. (2011) investigated the effect of engagement with and disengagement from threat on worry and whether these two processes make a causal contribution. They found that decreasing attentional engagement with threat meanings led in a subsequent worry task to fewer negative thought intrusions than increasing attentional engagement with threat meanings. In contrast, negative thought intrusions in their worry task were independent from a preceding decrease or increase of attentional disengagement from threat meanings. Hence, their results speak in favor of the view that attentional engagement with threat, but not attentional disengagement from threat, causally contribute to worry.

One classical paradigm which involves the need to flexibly shift between categories is the go/no-go task. The classical go/no-go paradigm has been developed by Donders (1868/1969) and has been extensively used to assess behavioral inhibition (e.g., Constantini & Hoving, 1973). Within clinical populations, poor performance on the classical go/no-go task has been associated with, for instance, attention deficit hyperactivity disorder (e.g., Durston et al., 2003). Deficits in inhibitory control are taken to reflect dysregulation in prefrontal activity (see for a review Dillon & Pizzagalli, 2007). In such a task, the participant has to react to frequent go stimuli as fast as possible and has to inhibit responses to infrequent no-go stimuli. This task taps both constructs discussed before, the ability to adequately engage attention and to disengage from prepotent and heavily over-learned responses. It is also suitable to investigate perceptual sensitivity for different experimental conditions (e.g., how reliably go stimuli are identified as such). Although the go/no-go task is traditionally taken to assess behavioral inhibition, we used this task to assess attentional processes. The rationale was that every response inhibition consists of different cognitive processes aimed at controlling behavior such as suppression of prepotent actions (Dillon & Pizzagalli, 2007) and attentional processes.

The performance on a go/no-go task should also vary according to the depth of threat processing. In the present study, this was realized by introducing two different kinds of discrimination conditions between go and no-go stimuli which should either facilitate threat processing or not. First, in the semantic discrimination conditions, participants were required to make a decision solely based on the meanings of the words (aversive vs. neutral) which should enhance threat processing. Second, in the syntactic discrimination condition, participants were required to base their decision solely on the structural properties of the words (capital letter only vs. block letters) which should decrease threat processing.

The goal of the present study was to develop an emotional go/no-go task which allows to test for a threat engagement bias, a threat disengagement bias, and a threat sensitivity bias within one experimental setting. It was expected that worry-prone individuals exhibit a typical bias towards worry-related threat stimuli compared to neutral stimuli. Furthermore, we hypothesized that worriers, once they attend to aversive stimuli, exhibit greater difficulty in disengagement. Also, we predicted that high worriers are more sensitive for worry-related content and that threat is detected more reliably relative to neutral words.

2. Methods

2.1. Subjects

Female college students were recruited via announcement on the campus. The sample was restricted to women only, because sex differences in affective processing have been reported numerously (e.g., Wager, Phan, Liberzon, & Taylor, 2003). They were selected based on their score on the Penn State Worry Questionnaire (PSWQ, Stöber, 1998). According to Behar, Alcaine, Zuellig, and Borkovec (2003), a score of at least 62 on the PSWQ (possible range: from 16 to 80) represents a positive GAD screening, whereas values under 34 characterize individuals with a low worry proneness (Stöber, 1998). Twenty subjects high in trait worry (mean age in years: $M = 20.45$, $SD = 2.24$, education duration in years: $M = 12.40$, $SD = .50$) and 16 subjects low in trait worry (mean age in years: $M = 22.93$, $SD = 3.36$, education duration in years: $M = 13.13$, $SD = 1.41$) participated in the study. Each subject gave written informed consent. The study was approved by a local ethic committee.

2.2. Material

2.2.1. Self-report measures

2.2.1.1. Beck depression inventory (BDI, Hautzinger, Bailer, Worall, & Keller, 1993; English version: Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). The BDI assesses depressive symptoms. Following Beck et al. (1961), a cut-off score of 17 was used to exclude subjects with clinically relevant depression. The BDI shows very good internal consistency ($\alpha = .81$ to .94) and exhibits very good retest reliability ($r = .84$ to .91) as well.

2.2.1.2. Difficulties in emotion regulation scale (English version: DERS, Gratz & Römer, 2004). This scale measures difficulties in emotion regulation by means of 36 items that are rated on a 5-point Likert scale and the German translation was used for the present study. The DERS shows good retest reliability over 4–8 weeks ($r = .88$) and excellent internal consistency ($\alpha = .93$).

2.2.1.3. Penn State Worry Questionnaire (PSWQ, Stöber, 1995; English version: Meyer, Miller, Metzger, & Borkovec, 1990). The PSWQ was used to measure worrying which constitutes the cardinal feature of GAD. This self-report questionnaire is rated on a 5-point Likert scale and consists of 16 items. The German version possesses good internal consistency ($\alpha = .86$ to .89; Stöber, 1995, 1998) as well as good retest reliability over 4 weeks ($r = .87$; Stöber, 1998). Moreover, the PSWQ can be used as a screening instrument for GAD and a cut-off score of 62 (possible range: 16 to 80) in an unselected sample is considered to represent a positive GAD screening (Behar et al., 2003).

2.2.1.4. State-trait anxiety inventory (STAI, Laux, Glanzmann, Schaffner, & Spielberger, 1981; English version: Spielberger, Gorsuch, & Lushene, 1970). The STAI is a widely used instrument to measure anxiety symptoms. The trait version was used in the present study. It consists of 20 items that are rated on a 4-point Likert scale. The STAI shows very good internal consistency ($\alpha = .89$ to .93) and excellent retest reliability ranging from $r = .68$ to .96 depending on the retest interval (i.e., between 1 h and 73 days).

2.2.2. Emotional go/no-go task and stimuli

One hundred aversive and 100 neutral nouns constituted the stimuli used for the emotional go/no-go task. All words were taken from the Berlin Affective Word List (BAWL, Vö, Jacobs, & Conrad, 2006). The list allows the selection of words based on normative ratings for a number of characteristics. For the present study, 100 worry-related threat words (e.g., “scream”, “terror”, “accident”, “virus”, “weapon”) from the BAWL were selected and matched with 100 neutral words (e.g., “meat”, “filter”, “poker”, “circle”, “ladder”) according to their imageability, word length, number per million words, number of orthographic neighbors, and number of higher frequency orthographic neighbors. Based on the normative ratings of the BAWL provided by Vö et al. (2006), worry-related words were rated as more negative than neutral words ($t(174.90) = 45.97$, $p < .001$).

The emotional go/no-go task, (Fig. 1) consisted of four blocks which lasted 225 s each. Each block consisted of 75 go stimuli and 25 no-go stimuli which were shown for 750 ms in the middle of the screen. The order of go and no-go trials was randomized for each block and subjects had to press the left mouse button with their right hand in go trials as fast as possible. After offset of the word, an interstimulus interval (ISI) of 1250, 1500, or 1750 ms followed. The duration of the ISI was randomized to discourage anticipatory processes and a fixation cross replaced the go and no-go stimulus, respectively. Across all four blocks, each word was shown two times during the task.

The blocks differed with respect to the discrimination condition between go and no-go stimuli. In block A and B, the discrimination condition was a semantic one, because solely the meaning of the word (i.e., aversive or neutral) discriminated between go stimuli and no-go stimuli. In these two blocks, subjects had to specifically attend to the meanings of the words to decide whether a button press is appropriate or not. For example, in block A subjects were instructed as follows (*mutatis mutandis* for block B):

> "When you see a negative word, e.g. "Danger", please press the left mouse button. Do not press any key when you see a neutral word, e.g. "Table". Complete the task as fast and accurately as possible! Please press the left mouse button to start."

During worrying, the worry-related content is verbalized and thus the meanings of the words become the focus for the individual. In order to capture this process adequately, this semantic discrimination condition was introduced. When semantics becomes the attention grabbing feature, processing of threat gets facilitated through exposure to aversive words. More resources are needed, due to a greater emotional load, to deal with the concurrent task. In *block A,* 75 aversive words (e.g., “Death”) were used as go stimuli and 25 neutral words (e.g., “Table”) were used as no-go stimuli. These stimuli where chosen randomly from the respective stimulus set. In *block B,* the remaining 75 neutral words of the neutral stimulus set served as go stimuli and the remaining 25 aversive words of the aversive stimulus set served as no-go stimuli.

A syntactic discrimination condition was used in blocks C and D and solely the appearance of the word (i.e., capital letter or block letters) discriminated between go and no-go stimuli. Here, subjects had to specifically attend to syntactical features of the words which makes it easier to decide whether pressing a button is appropriate or not. For instance, in block C subjects were instructed as follows (*mutatis mutandis* for block D):

> "When you see a neutral word with a capital letter, e.g. "Chair", please press the left mouse button. Do not press any key when you see a neutral word with block letters, e.g. "TABLE". Complete the task as fast and accurately as possible! Please press the left mouse button to start."

When syntax becomes the attention grabbing feature, no processing of threat gets facilitated. This is true for neutral and aversive words. In these syntactic discrimination conditions, the emotional load is smaller and fewer resources are needed to deal with the concurrent task. In *block C,* all 100 neutral words constituting the neutral stimulus set and in *block D,* all 100 aversive words constituting the aversive stimulus set were used as go and no-go stimuli. In these two blocks, go stimuli were written with a capital letter (e.g., “Flower” for block C and “Pain” for block D, respectively) and

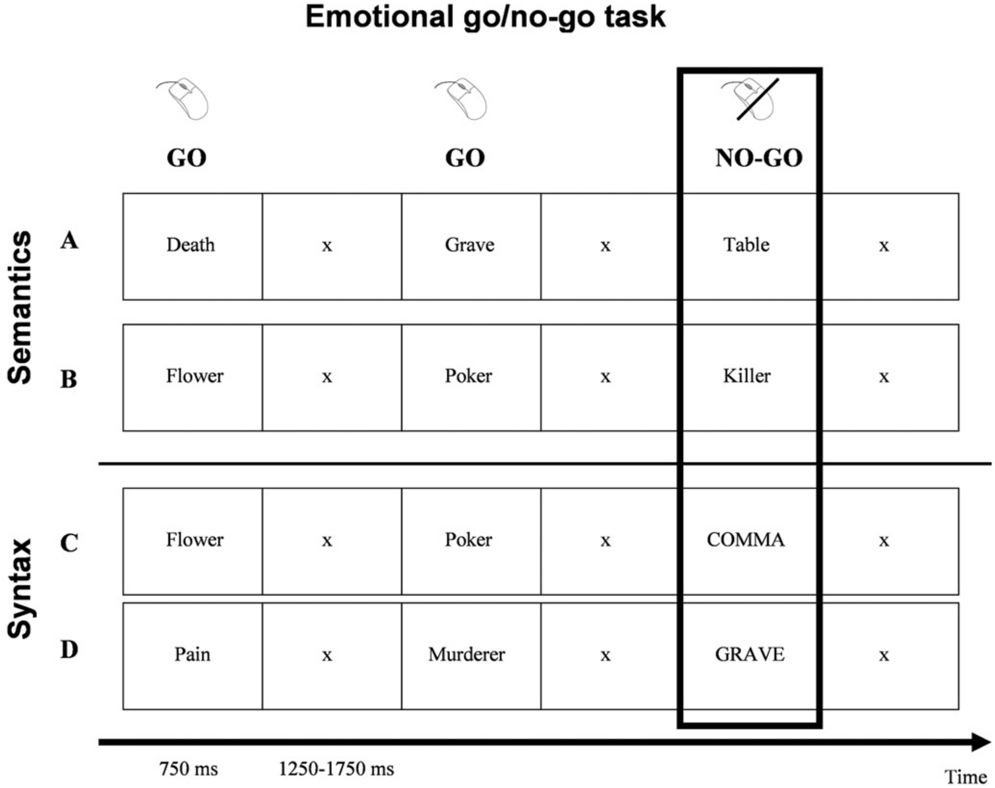

Fig. 1. Schematic illustration of the emotional go/no-go task and the four experimental conditions. All go as well as no-go stimuli were shown for 750 ms and the interstimulus interval varied between 1250 and 1750 ms. In block A, aversive words served as go stimuli whereas in block B, neutral words served as go stimuli. A semantic discrimination condition between go and no-go stimuli was used in both blocks. That is, the meanings of the words were relevant. Block C consisted of neutral go stimuli, whereas block D consisted of aversive go stimuli. Here, a syntactic discrimination criterion was used and structural properties of the words were relevant.

no-go stimuli were written with block letters (e.g., “COMMA” for block C and “GRAVE” in block D, respectively).

The order of the four blocks was pseudorandomized for the purpose of adding a further set-shifting component to the task. In particular, block A got never separated from block B (i.e., A-B or B-A). Similarly, block C and block D were not separated as well (i.e., C-D or D-C) resulting in a total of eight possible block orders (A-B-C-D, B-A-C-D, A-B-D-C, B-A-D-C, C-D-A-B, D-C-A-B, C-D-A-B, C-D-B-A). Before each block, subjects were instructed to the task. After each block, participants had the option to make a short break and go on with the task and the next block when they felt ready to do so by pressing a mouse button.

2.3. Procedure

At the beginning of the session, participants gave written informed consent and it was made sure that they understood the nature of the study. Then, the participants underwent an interview in order to assess demographic variables. Also, they answered screening questions about their current somatic and mental status. Subjects were excluded from the study if they reported any current mental or neurological disorder (besides GAD) as well as current anxiolytic or antidepressant medication. Afterwards, participants filled out the BDI and all those with a score of at least 17 points got excluded. Before the start of the actual paradigm, participants completed six practice trials for each block in order to get acquainted with the task. Then, subjects completed the first session of the emotional go/no-go task consisting of all four blocks. After that, subjects filled out the remaining questionnaires (i.e., DERS and STAI). Subsequently, subjects completed the second session of the emotional go/no-go task consisting of all four blocks. Following this part, participants rated the words on the valence and arousal dimension by means of the Self-Assessment Manikin (SAM; Bradley & Lang, 1994). The SAM consisted of a 9-point Likert scale and the valence rating ranged from “1” (negative) to “9” (positive), whereas the arousal rating ranged from “1” (not arousing) to “9” (highly arousing).

2.4. Data analysis

In go trials, subjects had to react as fast as possible to the stimuli whereas in no-go trials, subjects were not allowed to make any response at all. However, if subjects pushed falsely the mouse button in no-go trials, reaction times to no-go stimuli could be obtained. Hence, for the performance measures, mean reaction times to go stimuli, mean reaction times to no-go stimuli, mean commission errors for no-go stimuli (i.e., subjects pushed falsely the mouse button), and mean omission errors for go stimuli (i.e., subjects missed to push the mouse button) across the experiment were used for statistical analysis. Commission errors are the *via regis* to determine deficits in disengagement by measuring deficits in inhibiting reactions to over-learned responses. The gold standard for attentional engagement is the analysis of the reaction times. Omission errors tap similar processes as attentional engagement measures do. However, the difference is that lower rates of omission errors primarily indicate greater sensitivity for the respective experimental condition. Because of the full factorial design of the go/no-go task, ANOVAs were used for statistical analysis.

The three performance measures (reaction times to go stimuli, commission error rates, and omission error rates) were submitted separately to a univariate $2 \times 2 \times 2$ repeated measures ANOVA with the factors *group* (high worry, low worry), *valence* of the go stimulus (aversive, neutral), and *discrimination condition* (semantic, syntactic). For the reaction times to no-go stimuli, the factor *valence* of the no-go stimulus (aversive, neutral) was used as an independent variable. In order to decompose expected interactions between variables, post-hoc ANOVAs separately for the two discrimination conditions were used. Follow-up *t*-tests were used as post-tests. Because we had specific expectations about the directionality of the comparisons, one-tailed *t*-tests within and between groups were used.

Questionnaire data were submitted separately to independent *t*-tests. Moreover, univariate 2×2 repeated measures ANOVAs, separately for valence and arousal ratings, were carried out with the factors *group* (high worry, low worry) and *category* (aversive, neutral).

3. Results

3.1. Self-report data

3.1.1. Questionnaire data

The high worry group obtained higher scores on all questionnaire measures than the low worry group (see Table 1). They had higher BDI scores ($t(34) = 2.77$, $p = .009$), exhibited more difficulties regulating their emotions (DERS, $t(34) = 5.51$, $p < .001$), and showed higher levels of trait anxiety (STAI, $t(34) = 7.88$, $p < .001$). By design, the high worry group exhibited higher worry levels compared to the low worry group (PSWQ, $t(34) = 20.22$, $p < .001$).

3.1.2. SAM ratings

The ANOVA for valence ratings showed a significant main effect of *category* ($F(1, 34) = 91.56$, $p < .001$, $\eta_p^2 = .73$) indicating that aversive words were rated as more negative than neutral words. The ANOVA for arousal ratings yielded the same results ($F(1, 34) = 44.67$, $p < .001$, $\eta_p^2 = .57$), meaning that aversive words were rated as more arousing compared to neutral ones (Table 1).

3.2. Performance measures

All mean reaction times, commission error rates, and omission error rates with corresponding standard deviations can be seen in Table 2.

3.2.1. Reaction times to go stimuli

The three-way ANOVA with the factors *group* (high worry, low worry), *valence* of the go stimulus (aversive, neutral), and *discrimination condition* (semantic, syntactic) revealed a significant effect of *discrimination condition* ($F(1, 34) = 610.21$, $p < .001$, $\eta_p^2 = .95$). Subjects, independent of their group status, had faster reaction times during blocks with a syntactic discrimination condition relative to a semantic discrimination condition. In addition, a significant three-way interaction *valence* × *discrimination condition* × *group* ($F(1, 34) = 5.16$, $p = .030$, $\eta_p^2 = .13$) emerged.

Follow-up ANOVAs within the syntactic discrimination condition did not show a significant *valence* × *group* interaction ($p = .98$), but within the semantic discrimination condition a significant interaction *valence* × *group* ($F(1, 34) = 5.88$, $p = .021$, $\eta_p^2 = .15$) was revealed. Within the high worry group, faster reaction times to aversive words than neutral words were observed ($t(19) = -2.25$, $p = .018$). This effect was not present in the low worry group ($p = .121$). *T*-tests between the groups showed that the reaction times towards aversive and neutral words did not differ between high worry and low worry subjects (all ps > .11).

3.2.2. Commission errors

The three-way ANOVA with the factors *group* (high worry, low worry), *valence* of the go stimulus (aversive, neutral), and *discrimination condition* (semantic, syntactic) revealed a significant effect of *discrimination condition* ($F(1, 34) = 192.98$, $p < .001$, $\eta_p^2 = .85$). Participants made fewer commission errors during blocks with a syntactic discrimination condition relative to a semantic discrimination condition. Also, the three-way ANOVA yielded a significant interaction *valence* × *group* ($F(1, 34) = 5.56$, $p = .024$, $\eta_p^2 = .14$) which can be subsumed under the three-way interaction *valence* × *discrimination condition* × *group* ($F(1, 34) = 23.00$, $p = .002$, $\eta_p^2 = .26$).

Follow-up ANOVAs within the syntactic discrimination condition did not show a significant *valence* × *group* interaction ($p = .26$). However, within the semantic discrimination condition, the interaction *valence* × *group* emerged as significant ($F(1, 34) = 9.15$, $p = .005$, $\eta_p^2 = .21$). Within the high worry group, more commission errors were present when neutral words relative to aversive words constituted the no-go stimulus ($t(19) = 3.31$, $p = .002$). No such effect emerged in the low worry group ($p = .114$). In addition, differences between the groups were such that high worry subjects committed more commission errors when neutral words were used as no-go stimuli than low worry subjects ($t(34) = 1.98$, $p = .028$).

3.2.3. Omission errors

The three-way ANOVA with the factors *group* (high worry, low worry), *valence* of the go stimulus (aversive, neutral), and *discrimination condition* (semantic, syntactic) revealed a significant effect of *discrimination condition* ($F(1, 34) = 445.25$, $p < .001$, $\eta_p^2 = .93$). Subjects made fewer omission errors during blocks with a syntactic discrimination condition relative to a semantic discrimination condition. Moreover, the ANOVA revealed a significant *valence* × *group* interaction ($F(1, 34) = 34.00$, $p = 001$, $\eta_p^2 = .30$) which can be subsumed under the three-way interaction *valence* × *discrimination condition* × *group* ($F(1, 34) = 5.00$, $p = 032$, $\eta_p^2 = .13$).

Follow-up ANOVAs within the syntactic discrimination condition did not show a significant *valence* × *group* interaction ($p = .93$). Within the semantic discrimination condition, a significant *valence* × *group* interaction ($F(1, 34) = 15.26$, $p < .001$, $\eta_p^2 = .31$) could be observed. Further *t*-tests revealed that high worry subjects committed less omission errors when aversive words relative to neutral words served as go stimuli ($t(19) = -5.01$, $p < .001$). This was not the case with low worry subjects ($p = .148$). In addition, fewer omission errors were present during aversive go stimuli in the high worry group compared to the low worry group ($t(34) = -2.98$, $p = .003$).

Table 1
Mean questionnaire scores (standard deviations) and mean valence and arousal ratings (standard deviations) for the high worry group and low worry group.

	High worry group, M (SD)	Low worry group, M (SD)
Questionnaires		
BDI	9.13 (4.40)	4.94 (4.65)
DERS	89.35 (12.50)	66.69 (12.00)
PSWQ	64.20 (5.41)	32.50 (3.54)
STAI	47.55 (8.91)	28.06 (4.77)
Aversive words		
Valence	2.85 (1.69)	3.00 (1.37)
Arousal	5.60 (1.79)	3.63 (2.22)
Neutral words		
Valence	6.05 (1.47)	5.50 (1.03)
Arousal	2.85 (1.57)	2.00 (1.32)

Note: BDI = Beck Depression Inventory, DERS = Difficulties in Emotion Regulation Scale, PSWQ = Penn State Worry Questionnaire, STAI = State-Trait Anxiety Inventory.

Table 2
Mean reaction times to go and no-go stimuli in ms (standard deviations), mean commission error rates in percent (standard deviations), and mean omission error rates in percent (standard deviations) for the high worry group and low worry group for the four blocks in the emotional go/no-go task: semantic discrimination condition with block A (aversive go stimuli) and block B (neutral go stimuli) and syntactic discrimination condition with block C (aversive go stimuli) and block D (neutral go stimuli).

	Semantic discrimination condition		Syntactic discrimination condition	
	Go – aversiv, M (SD)	Go – neutral, M (SD)	Go – aversiv, M (SD)	Go – neutral, M (SD)
High worry group				
Reaction time to go stimuli (ms)	563 (67)	580 (72)	434 (57)	426 (52)
Reaction time to no-go stimuli (ms)	538 (93)	549 (89)	243 (145)	267 (128)
Commission error (%)	33.50 (14.48)	25.70 (10.43)	6.20 (4.40)	5.20 (3.58)
Omission error (%)	4.29 (2.29)	9.87 (4.19)	0.47 (0.95)	0.10 (0.24)
Low worry group				
Reaction time to go stimuli (ms)	564 (43)	556 (39)	435 (49)	427 (41)
Reaction time to no-go stimuli (ms)	570 (63)	538 (54)	251 (156)	225 (128)
Commission error (%)	24.13 (13.65)	28.25 (9.29)	4.00 (4.90)	4.63 (3.48)
Omission error (%)	6.96 (3.07)	8.62 (4.11)	0.42 (1.17)	0.08 (0.33)

3.2.4. Reaction times to no-go stimuli

The three-way ANOVA with the factors *group* (high worry, low worry), *valence* of the no-go stimulus (aversive, neutral), and *discrimination condition* (semantic, syntactic) revealed a significant effect of *discrimination condition* ($F(1, 34) = 192.41$, $p < .001$, $\eta_p^2 = .85$). Subjects, independent of their group status, had faster reaction times during blocks with a syntactic discrimination condition compared to a semantic discrimination condition. No further significant effects could be observed.

4. Discussion

Attentional control is one facet of the central executive (Miyake et al., 2000). Previous findings point towards an impaired executive functioning in individuals with GAD, predominantly within an emotional context (Becker et al., 2001; Bradley et al., 1999; Waters et al., 2008). The main goal of the present study was to develop an emotional go/no-go task which allows to test for a threat engagement, a threat disengagement, and a threat sensitivity bias within one experimental setting. We expected to find these three threat biases in high worriers.

Regarding the threat engagement bias, the main finding was that only the high worry group exhibited shorter latencies to aversive relative to neutral go stimuli when a semantic discrimination condition was present. Attending explicitly to the meanings of the words has a greater impact only on individuals high in trait worry. This finding stands in line with the results by others (Bradley et al., 1999). But, both groups had comparable latencies to aversive go stimuli. This means that low worry subjects reacted as fast as high worry subjects to negative stimuli. This makes sense from the point of view of evolution. The early detection of threat is important for the survival of individuals high in worry and individuals low in worry alike. Detection of threat occurs very early and quite automatic in information processing and awareness does not have to enter the picture (Ellenbogen & Schwartzman, 2009). However, the lack of faster reaction times towards threat words in high worriers compared to low worriers stands in contrast with the results by Bradley et al. (1999) in a GAD sample. The reasons might be methodological ones. First, we used simple reaction time data for our analysis, whereas Bradley et al. (1999) used the difference in reaction times for different experimental conditions. Second, the present study employed a go/no-go paradigm, but Bradley et al. (1999) used a dot probe paradigm. Third, we used subjects high in trait worry and not patients with a full-blown GAD. Fourth, we instructed the subjects to respond as quickly as possible to the go stimuli. Therefore, maximal performance was required and a ceiling effect might have taken place when reacting to worry-related words. Reacting as quickly as possible to aversive stimuli might not have captured the *typical performance* of the subjects. So, different results are possible depending on the instruction and the distinction of maximal performance and typical performance.

Furthermore, this is the first study that revealed a sensitivity bias towards threat in worry-prone individuals. This was only the case when subjects had to specifically attend to the meanings of the words. Pathological worriers made fewer omission errors when they had to react to aversive go stimuli relative to neutral go stimuli and compared to low worry subjects. This is very likely the case, because high worriers are more vigilant for threat and are drawn to aversion relatively fast leading to an earlier start of the information processing. Hence, threat is identified as such faster and more reliably. In addition, fewer omission errors suggest that high worriers do not only identify threat more reliably, but they also react more accurately.

With respect to the threat disengagement bias, this is the first study that revealed this bias within high worry subjects. Once threat has captured the attention of the subjects, it is harder for individuals high in worry to detach from aversive stimuli. The high worry group committed more inhibition errors during blocks with aversive go and neutral no-go stimuli relative to blocks with neutral go and aversive no-go stimuli and compared to low worry subjects. The present study thus expands previous findings gathered in high anxious individuals (Fox et al., 2002; Koster et al., 2006; Salemink et al., 2007; Yiend & Mathews, 2001) to pathological worriers. Problems in set shifting (Dorahy et al., 2006) as well as executive dysfunction in a composite score over a variety of neuropsychological tests (Gualtieri & Morgan, 2008) have already been reported for GAD patients relative to controls. The importance of worry for disengagement from threat stimuli has only been underscored empirically by one study. Verkuil et al. (2009) showed by means of a regression analysis that problems in disengaging from aversive stimuli were best predicted by the interaction of trait worry and trait anxiety. In the somewhat other direction go the results by Hirsch et al. (2011) who did not find a causal influence of disengagement from threat meanings on a subsequent worry task.

The present study stresses the view that both, engagement with as well as disengagement from aversive stimuli play a more important role for pathological worry than any of these processes alone. In addition, greater sensitivity for threat was also shown to be associated with trait worry. The present results also support the beneficial role of allocating attention away from the threatening meaning of the aversive stimuli. Faster reaction times to go stimuli and less errors of any kind were present when subjects had to specifically attend solely to the syntactical information of words for both valence categories. Thus, from a clinical perspective, instructing pathological worriers to attend to non-threatening properties of otherwise worry-related stimuli give some relief in negative consequences of the worry process.

Notwithstanding the overwhelming recent data supporting the usefulness of attentional retraining in high worriers to reduce the threat engagement bias and GAD symptoms (Amir, Beard, Burns, & Bomyea, 2009; Hayes, Hirsch, Krebs, & Mathews, 2010a,b; Hazen, Vasey, & Schmidt, 2009; Hirsch, Hayes, & Mathews, 2009, 2011; see also Krebs, Hirsch, & Mathews, 2010), the threat disengagement bias was a robust finding in the present study and deficits in inhibitory control within an emotion context is thus part of worrying. It has been shown in a pilot study that improvements in GAD symptoms following cognitive-behavioral therapy were greater in GAD patients with intact and improved executive functioning from pre- to post-treatment compared to GAD patients with sustained executive dysfunction (Mohlman & Gorman, 2005). That is, executive functioning serves as a mediator in therapy outcome. From a clinical perspective, training cognitive flexibility and disengagement from threat might also serve as a useful intervention in high worriers. In the same line of thought, Koster et al. (2006) raised the same issue for highly anxious individuals.

With this at hand, we interpret the main findings of the present study such that pathological worriers are more sensitive to threat, engage more rapidly with aversion, and disengage harder which in turn leads to deficits in inhibitory control. All three processes, threat sensitivity for, threat engagement with, and threat disengagement from aversion, contribute to the detrimental effects of pathological worry. Our novel emotional go/no-go task is an excellent way of measuring these constructs within one experimental design. This interpretation should be handled with caution, because no difference between groups was present regarding the threat engagement bias.

The emotional version of a go/no-go task has been shown to measure the same basic principles of engagement, disengagement, and sensitivity as the non-emotional, classical version (Schulz et al., 2007). Our emotional go/no-go task introduced a further distinction of semantic and syntactic features which allow to discriminate between go and no-go stimuli. For all experimental conditions with a syntactic discrimination criterion, shorter reaction times to go as well as no-go stimuli, fewer inhibition errors, and fewer omission errors could be observed compared to conditions with a semantic discrimination criterion. These results support the modulating effect of attending towards the meaning of the words and different processing styles depending on the discrimination condition.

The present study is not free of limitations. Further samples should include men as well to make sure that the obtained conclusions are not restrained to women only. Moreover, although the mean PSWQ score in the high worry group was comparable to those of a group of GAD patients, the present results await further replication within a clinical GAD sample.

Acknowledgments

The authors would like to thank Lina Gorenc, Bianca Gschaidbauer, and Elisabeth Treichler for assistance in data collection.

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