Behaviour Research and Therapy 46 (2008) 728–736

Contents lists available at ScienceDirect

Behaviour Research and Therapy

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

Threat processing in obsessive-compulsive disorder: Evidence from a modified negative priming task

Nader Amir[a,*], Michelle Cobb[b], Amanda S. Morrison[a]

[a] *San Diego State University/University of California, Joint Doctoral Program in Clinical Psychology, San Diego, CA 92120, USA*
[b] *Department of Psychology, University of Georgia, Athens, GA 30602, USA*

ARTICLE INFO

Article history:
Received 27 September 2007
Received in revised form
14 February 2008
Accepted 3 March 2008

Keywords:
Obsessive-compulsive disorder
Negative priming
Idiographic
Learning

ABSTRACT

Individuals with obsessive-compulsive disorder (OCD) often experience intrusive thoughts. These intrusions may be due to biases in information processing mechanisms, including attention, memory, and learning. To examine this hypothesis, we presented a modified negative priming (NP) paradigm with idiographically selected words to 19 individuals with OCD (OCs) and 19 matched non-anxious control participants (NACs). The words included OCD-relevant threat, OCD-relevant positive, and neutral words. This paradigm typically elicits positive priming because participants may learn the contingency between the prime and probe that facilitates responding [Frings and Wentura (2006). Strategy effects counteract distractor inhibition: NP with constantly absent probe distractors. *Journal of Experimental Psychology: Human Perception and Performance*, *32*, 854–864]. As predicted, NACs showed facilitation (i.e., positive priming) rather than NP for all word types, whereas OCs exhibited facilitation for only neutral words. For positive words, OCs exhibited no priming and for threat words they exhibited NP. These results suggest that for idiographic, OCD-relevant threat information, individuals with OCD show difficulty learning the contingency between the information in the prime and probe displays relative to the NACs.

Introduction

Obsessive-compulsive disorder (OCD) is characterized by intrusive thoughts that interfere with normal functioning (Swinson, Antony, Rachman, & Richter, 1998; Wilson, 1998). These intrusive thoughts may be the result of a deficient ability to selectively attend to relevant material while simultaneously inhibiting irrelevant competing information (e.g., Clayton, Richards, & Edwards, 1999; Enright & Beech, 1990, 1993b). It is also common for individuals with OCD (OCs) to recall personally relevant, threatening information in specific detail, even several years following the event (Radomsky & Rachman, 2004). Accordingly, researchers have examined attention and memory in OCD (for review, see Muller & Roberts, 2005). One reliable finding is a memory bias favoring threat-related stimuli (e.g., Radomsky & Rachman, 1999; Radomsky, Rachman, & Hammond, 2001; Tolin, Hamlin, & Foa, 2002; Wilhelm, McNally, Baer, & Florin, 1996). In contrast, support for the hypothesis that these individuals display an attentional bias has been less consistent.

Experimental psychopathologists have employed paradigms borrowed from cognitive psychology to study information processing bias in OCD. For example, priming paradigms can be used to examine the nature of threat-relevant semantic networks in OCD. Positive priming, or simply priming, refers to the decrease in the response latency to process an item if

* Corresponding author. Tel.: +1 619 229 3740; fax: +1 619 229 3743.
E-mail address: namir@mail.sdsu.edu (N. Amir).

0005-7967/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.brat.2008.03.001

that same, or a closely related, item was previously processed (e.g., Scarborough, Cortese, & Scarborough, 1977). Negative priming (NP), on the other hand, refers to an increase in the response latency to process a given item if that item was previously ignored (Tipper, 1985). In a typical NP paradigm, participants are asked to process a stimulus (i.e., target) first in a "prime" display and then in a "probe" display, while ignoring any irrelevant stimuli (i.e., distracters). The crucial feature of NP paradigms is the differential relationship between the prime display and the probe display. In control trials, all target and distracter stimuli in the prime display and probe display are unique. Conversely, in ignored repetition trials, the distracter from the prime display becomes the target in the probe display. NP is defined as the increase in response latency to process a target stimulus in an ignored repetition probe display compared to processing the same stimulus as a target in a control probe display.

There is a large body of research establishing the NP effect (Dalrymple-Alford & Budayr, 1966; Neill, 1977; Tipper, 1985; for reviews, see Fox, 1995; Kane, May, Hasher, Rahhal, & Stoltzfus, 1997; May, Kane, & Hasher, 1995; Tipper, 2001). However, disagreements over interpretation of the finding persist (e.g., Frings & Wentura, 2006; MacLeod, Chiappe, & Fox, 2002; Tipper, 2001). Theories attempting to explain NP include: selective inhibition (e.g., Houghton & Tipper, 1994); feature mismatch (Lowe, 1979; Milliken, Tipper, & Weaver, 1994; Park & Kanwisher, 1994); episodic retrieval (Neill & Valdes, 1992; Neill, Valdes, Terry, & Gorfein, 1992; Rothermund, Wentura, & De Houwer, 2005); and temporal discrimination (Milliken, Joordens, Merikle, & Seiffert, 1998). The selective inhibition and episodic retrieval accounts have received the most support. The former account attributes NP to the inhibition of distracting information in the prime display and has been the preferred theory to explain NP findings in clinical research. On the other hand, the episodic retrieval account attributes NP to slowed processing of a probe target that was encoded in the previous processing episode (i.e., prime display) with conflicting response information (e.g., "do-not-respond" tag).

Researchers have warned that studies of NP abnormalities in clinical populations have been widely interpreted as reflecting inhibitory difficulties without consideration of the other mechanisms thought to be involved in NP (Fox, 1995; MacDonald, Antony, MacLeod, & Swinson, 1999; Watson & Tipper, 1997). Indeed, many of the researchers of NP in OCD interpreted their results as evidence for OCs ability to inhibit distracting information. This becomes especially problematic because individuals with OCD have been reported to show deficient (Enright & Beech, 1990, 1993a, 1993b), comparable (Enright, Beech, & Claridge, 1995; McNally, Wilhelm, Buhlmann, & Shin, 2001), and enhanced NP (MacDonald et al., 1999).

Seminal studies by Enright and Beech (1990, 1993a, 1993b) suggested reduced NP in individuals with OCD compared to patients with other anxiety disorders. In contrast, Enright et al. (1995) found comparable NP effects for individuals with OCD compared to patients with other anxiety disorders. However, the authors presented their stimuli for longer durations in the latter study (i.e., 250 and 300 ms) than in the former studies (i.e., 100 ms). A study by McNally et al. (2001) extended these findings in comparing individuals with OCD to healthy control participants. These authors found that short prime presentations (i.e., 100 ms) revealed a marginally smaller NP effect for individuals with OCD compared to healthy control participants. When prime displays were presented for a longer duration (i.e., 500 ms), this marginal difference disappeared.

Several explanations have been offered to account for these differences at 100 and 500 ms presentation durations. Enright et al. (1995) concluded that individuals with OCD experience a pre-attentive (i.e., at 100 ms) deficit of cognitive inhibition but no deficit at longer durations (500 ms). MacDonald et al. (1999) speculated that individuals with OCD may have impairments in aspects of visual attention, that result in a disadvantage in this group at short (i.e., 100 ms) but not longer stimulus presentations (e.g., 250 or 500 ms).

In support of the latter hypothesis, MacDonald et al. (1999) administered two different NP tasks to individuals with OCD and healthy controls. One task, a novel paradigm devised by the authors, resulted in comparable NP effects for the OCs compared to the controls, whereas the other more typical color-selection task resulted in a significantly larger NP effect for the OCs compared to the controls. Despite the latter finding of increased NP in the OC group, the authors interpreted their results as suggesting that OCD patients and nonclinical controls perform comparably on NP tasks. However, the novel paradigm devised by the authors may have resulted in artifacts due to unbalanced repetition of the stimuli, resulting in inequalities across conditions (Joordens, Betancourt, & Spalek, 2006; Mackintosh, Mathews, & Holden, 2002).

In summary, NP findings in individuals with OCD have been relatively consistent; for short stimulus presentations, researchers have reported deficient NP abilities in this population (e.g., Enright & Beech, 1990, 1993a, 1993b) and marginally significant reduced NP (i.e., McNally et al., 2001). For longer stimulus presentations, the majority of researchers have reported comparable NP (i.e., Enright et al., 1995; novel task, MacDonald et al., 1999; McNally et al., 2001), although one study found significantly enhanced NP (typical task, MacDonald et al., 1999). Most have interpreted their results in terms of the selective inhibition account. In contrast, MacDonald and colleagues highlighted the importance of considering all possible interpretations of their results in light of the current disagreement in the NP literature.

Given the above results, it is important to use NP paradigms that have an identifiable mechanism. One reliable finding in the NP literature is that the presence of distracter stimuli in the probe display influences whether participants display positive or negative priming. Healthy populations typically exhibit no NP or positive priming in NP paradigms that employ probe displays with no distracter stimuli (i.e., nonconflict displays; Allport, Tipper, & Chmiel, 1985, Experiment 9; Frings & Wentura, 2006, Experiments 1A and 1B; Lowe, 1979; Milliken et al., 1998, Experiment 1B; Moore, 1994; Neill & Westberry, 1987; Tipper, Brehaut, & Driver, 1990, Experiment 5; Tipper & Cranston, 1985, Experiment 3; for review, see Fox, 1995; but see Fox, 1994; Yee 1991). Frings and Wentura (2006) examined the critical feature of NP paradigms with nonconflict probe displays by reducing the extent to which participants could learn the contingency between prime and probe displays. To this end, they tested whether participants would exhibit NP if they were prevented from learning that attending to the distracter in the prime display would enhance performance on the subsequent probe display.

In a series of experiments, Frings and Wentura (2006) presented participants two versions of an NP task without probe distracters in order to manipulate the contingency between the prime and probe. In the prime displays, a red target letter-string was flanked by two green distracter letter-strings. Participants were asked to identify the target and memorize whether it was a word or nonword. Probe displays comprised a solitary target black letter-string that participants were asked to categorize as a word or nonword. Because the task in the probe display was a lexical decision task (i.e., ''Was the stimulus a word or a nonword?''), there were only two possible answers. Frings and Wentura manipulated the typical design of an NP task to reduce the likelihood that the correct response in the probe display could be anticipated in the prime display by attending to the distracter.

In their ''asymmetrical'' design (i.e., Experiments 1A and B) the prime distracter was always a word and the prime target was a word 50% of the time and a nonword 50% of the time. Therefore, on 50% of all trials, both stimuli in the prime display were words and 50% of the time the distracter was a word and the target a nonword. On 2/3 of all trials a stimulus from the prime display, whether target or distracter, was repeated as the target in the probe display. For these trials, in which the participant could recognize that the probe target was a repeated stimulus, the probe target was a word 75% of the time and a nonword 25% of the time. Therefore, by attending to the distracter in the prime, in addition to attending to the probe, the participant could bias his/her decision in favor of responding to the lexical decision task in the probe display as a ''word.'' This resulted in a significant positive priming score (i.e., Experiment 1A) or no NP (i.e., Experiment 1B). Although some participants showed NP—perhaps because they followed the instructions to ignore the prime distracter—this effect was cancelled out by the larger proportion of participants who developed the strategy of using the prime distracter to answer in the probe display. These authors concluded that it is possible to obtain a significant positive priming effect when the majority of participants use the above strategy.

Experiments 2 and 3 used the ''symmetrical'' design, such that the number of trials was doubled in order to allow the prime distracter to be a nonword 50% of the time, in contrast to the asymmetrical design (Experiment 1) in which the prime distracters were always words. This resulted in a reduced chance that attending to the distracter in the prime could aid responding in the probe. That is, if the probe stimulus were recognized as having been repeated in the prior display (either as a distracter or a target), then the likelihood that the probe target was a word would be 50% (compared to 75% in the previous asymmetrical design) and a nonword 50% (compared to 25% in the asymmetrical design). This manipulation decreased the probability that the distracter in the prime anticipated the correct response for the probe. In these latter studies the authors obtained a significant NP effect.

By attending to the prime distracter in the asymmetrical design, the participant could bias his/her probe response in favor of ''word'' because there was a greater likelihood that the repeated stimulus in the probe was a word. In the symmetrical design, repeated stimuli in the probe were equally likely to be a word and nonword. Thus, attending to the distracter could not facilitate the correct response in the probe display. Because the participants showed NP under the conditions of the latter two experiments, the authors concluded that NP can be observed in this task with no probe distracters if the contingency-based component is reduced, or equivalently, if the participants do not learn the contingency. These authors concluded that positive priming indicates participants learned the contingency (Experiment 1), whereas an overall NP effect implies participants did not learn the contingency (Experiments 2 and 3).

NP tasks without probe distracters may be useful in studying information processing in OCD because they have an identifiable mechanism in producing priming (i.e., learning the contingency). If individuals with OCD are able to learn the contingency, they should exhibit positive priming. However, if they are unable to learn the contingency, they should show NP. These findings would have implications for attention and learning in OCD. For example, individuals with OCD make more errors than nonanxious individuals when learning associations between neutral words and geometric shapes (Leplow, Murphy, & Nutzinger, 2002; Murphy, Nutzinger, Paul, & Leplow, 2004). A learning deficit in OCD has also been found in other tasks (e.g., Bohne et al., 2005; Veale, Sahakian, Owen, & Marks, 1996), although some studies have found they experience no deficit in their ability to learn (e.g., Rauch et al., 1997).

Finally, this paradigm may also be useful in studying the role of threat meaning in the context of learning the contingency-based component of this NP task. In the conditional associative learning studies by Leplow et al. (2002) and Murphy et al. (2004) mentioned above, the individuals with OCD did not exhibit the same learning deficit when making associations between idiographically selected threatening material and geometric shapes. Because any information processing bias in OCD is likely to be present for OCD-related information, and specifically, personally relevant threat information, we were most interested in functioning involving this type of material. Moreover, there are data suggesting that attention processes in patients with OCD are idiographic. For example, individuals with OCD with contamination concerns, but not individuals with OCD with checking or ordering concerns, exhibit longer latencies to color-name contamination words (e.g., germs) than nonanxious controls (NACs) (Foa, Ilai, McCarthy, Shoyer, & Murdock, 1993). However, there are no group differences in color-naming general threat words (e.g., cancer), neutral words (e.g., apple), or nonwords (e.g., gosp).

To this end, in the current study we employed an NP paradigm with nonconflict probe displays, to examine learning of the contingency between the prime and probe displays, using idiographic stimuli in individuals with OCD.

Table 1
Demographic and psychometric data

Variable	Group	
	OCD M (SD)	NAC M (SD)
% Female	42	37
Age	37 (9.35)	30 (9.35)
ASI	31.3 (11.19)	10.8 (5.22)
BDI	18.4 (8.77)	2.6 (3.37)
STAI-S	46.6 (13.74)	27.2 (9.14
STAI-T	51.7 (13.23)	28.6 (7.93)
OCI	85.3 (24.12)	3.5 (5.68)

Note: OCD = Individuals with obsessive-compulsive disorder; NAC = Non-anxious controls; ASI = Anxiety Sensitivity Index; BDI = Beck Depression Inventory, STAI-S = Spielberger State–Trait Anxiety Inventory-State Form, STAI-T = Spielberger State-Trait Anxiety Inventory-Trait Form, OCI = Obsessive-Compulsive Inventory.

Method

Participants

Nineteen individuals with OCD and 19 NACs participated in this study. The OCD group comprised individuals presenting for evaluation at the Center for Understanding and Treating Anxiety. Participants in the OCD group met DSM-III-R (American Psychiatric Association, 1987) criteria for OCD and were given a primary diagnosis of OCD based on a Structured Clinical Interview for DSM-III-R Axis-I Disorders (SCID; Spitzer, Williams, Gibbon, & First, 1992). The NAC group comprised community and university volunteers who did not meet diagnostic criteria for any Axis-I disorder using the SCID.

Participants completed the Obsessive-Compulsive Inventory (OCI; Foa, Kozak, Salkovskis, Coles, & Amir, 1998), the Beck Depression Inventory (BDI; Beck & Steer, 1987), the Anxiety Sensitivity Index (ASI; Reiss, Peterson, Gursky, & McNally, 1986), and the Spielberger State–Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). As expected, individuals with OCD scored higher than NACs on depression [BDI: $t(34) = 7.26$, $p < .01$], trait anxiety [STAI-Trait: $t(34) = 6.44$, $p < .01$], state anxiety [STAI-State: $t(35) = 5.07$, $p < .01$], anxiety sensitivity [ASI: $t(32) = 7.06$, $p < .01$], and obsessive-compulsive symptoms [OCI: $t(28) = 13.18$, $p < .01$].[1] Groups also differed in age, $t(36) = 2.29$, $p < .05$. Table 1 presents demographic information and means and standard deviations for the above scales.

Materials

A total of 18 words were used for each participant in this experiment (6: OCD-Threat (e.g., contaminated, unlocked), 6: OCD-Positive (e.g., purified, secure), and 6: Neutral-Household items (e.g., kettle, flowerpot). These words were selected from a list of 163 words, pre-selected from a study of OCD (Foa et al., 1993) and measures of OCD (e.g., Foa et al., 1998). Participants rated each word on a −3 (negative) to +3 (positive) emotionality scale. These ratings were then used to compile a set of 18 words for each participant that was relevant to his/her specific concerns. That is, ratings of −3 indicated Threat, ratings of 0 indicated Neutral, and ratings of +3 indicated Positive. If these cutoffs did not yield at least six words for each word type, they were extended to −2 for Threat and +2 for Positive. Each individual in the OCD group was yoked to a NAC participant. Thus the NAC participant saw the same words as those selected by his/her OCD counterpart.

Each set of 18 words was further divided into six triplets (i.e., one Threat, one Positive, one Neutral). Following a practice block of 24 trials consisting of neutral words (e.g., apple) as prime distracters and probe targets, participants were presented with 144 randomized, experimental trials: 6 word sets $\times 2$ prime target types (odd or even digit) $\times 4$ prime distracter types (i.e., OCD-Threat, OCD-Positive, or Neutral word, or X's) $\times 3$ probe target word types (i.e., OCD-Threat, OCD-Positive, Neutral).

Design and procedure

Each trial began with a fixation cross-presented for 500 ms. Next, participants saw a digit, surrounded on the top and bottom by either a row of X's or a Neutral, OCD-Positive, or OCD-Threat word. X's served as the distracters in control trials (Enright & Beech, 1993a, 1993b; Enright et al., 1995; McNally et al., 2001; Maki, O'Neill, & O'Neill, 1994). Participants then indicated whether the digit was odd or even by pressing the left or right mouse button, respectively. Prime stimuli remained on the screen until participants responded. After an 800 ms delay, participants saw a word and were asked to

[1] Degrees of freedom differ because some participants did not complete all of the measures.

Table 2
Mean reaction times and standard deviations (in ms) for digit classification in each prime trial type

Prime distracter	Group	
	OCD M (SD)	NAC M (SD)
Control (XXXX)	528 (219)	498 (112)
OCD-related threat	585 (267)	536 (144)
OCD-related positive	574 (250)	543 (152)
Neutral	586 (252)	537 (142)

Note: Control trials are prime trials where the digit is flanked by X's. OCD-related threat, OCD-related positive, and Neutral are prime trials where the digit is flanked by a word of the indicated valence.

read the word aloud. This probe stimulus remained on the screen until participants responded. A voice relay measured response latency to initiate word reading. Thus, we used a modified version of the procedure used by Fox (1994, Experiment 3). The only difference between our procedure and hers was that participants read the words on the probe trial rather than performing a lexical decision. We asked participants to read the words because the majority of NP tasks employ word reading or color-naming rather than lexical decision (e.g., Enright et al., 1993, 1995; May et al., 1995, MacDonald et al., 1999; McNally et al., 2001).

NP scores were calculated by subtracting the latency to name the target word when primed by X's (i.e., control trials) from the response latency to name the same target word when primed by itself (i.e., ignored repetition trials). Reaction times less than 400 ms and greater than 2000 ms were eliminated from the word reading (i.e., probe) trials. Reaction times less than 200 ms and greater than 2000 ms were eliminated from the digit classification (i.e., prime) trials. Trials in which the digit was classified incorrectly were also removed from analysis. A total of 3% of the trials were eliminated.

Results

Digit classification (prime) displays

Table 2 presents mean response latencies for the digit classification (i.e., prime) displays. In order to determine whether digit classification differed across the four types of prime distracters, we submitted response latencies for all prime displays to a 2 Group (OCD, NAC) $\times$ 4 Prime Distracter Type (Control-X's, OCD-Positive, OCD-Threat, Neutral) analysis of variance with repeated measurement on the second factor. This analysis revealed a significant main effect of Prime Distracter Type, $F(3, 105) = 9.14$, $p < .001$. Response latencies did not vary across Group, $F(1, 35) = .44$, $p > .50$, nor was there a significant interaction of Group $\times$ Prime Type, $F(3, 105) = .36$, $p > .50$. To follow up the significant main effect of Prime Distracter Type, we conducted paired-samples t-tests. Digit classification response latencies did not differ between any two word types, $ps > .05$. However, participants were quicker to classify digits that were surrounded by X's than digits that were surrounded by OCD-Positive words, $t(36) = 3.39$, $p < .005$, OCD-Threat words, $t(36) = 3.88$, $p < .001$, or Neutral words, $t(36) = 4.52$, $p < .001$. Thus, participants took longer to classify the digits when the digits were surrounded by words than when the digits were surrounded by X's.

Priming scores

Table 3 presents mean response latencies for the control and ignored repetition probe trials. Consistent with the literature, we calculated priming scores by subtracting mean response latencies for control probe trials from mean response latencies for ignored repetition probe trials. These scores were then submitted to a 2 Group (OCD, NAC) $\times$ 3 Word Type (OCD-Positive, OCD-Threat, Neutral) analysis of variance with repeated measurement on the second factor.[2] This analysis revealed a main effect of Group, $F(1, 36) = 5.70$, $p < .05$, that was modified by an interaction of Group $\times$ Word Type, $F(2, 72) = 3.79$, $p < .05$. The main effect of Word Type was not significant, $F(2, 72) = .313$, $p > .70$. To follow up the significant interaction we conducted a simple effects analysis.

Simple effect of Word Type revealed that the two groups differed in their relative priming scores for OCD-related threat words, $t(36) = 2.89$, $p < .01$. Groups did not differ in their relative priming scores for neutral, $t(36) = 1.15$, $p > .25$, or OCD-related positive words, $t(36) = .84$, $p > .40$.

Simple effect of group revealed that NACs did not differentiate among word types, $F(2, 36) = 1.43$, $p > .25$, whereas OCs exhibited a trend for word type differentiation, $F(2, 36) = 2.58$, $p = .09$. To investigate the hypothesis that NP in the OCD

[2] We also conducted the 2 Group $\times$ 3 Word Type $\times$ 2 Condition (Control versus Ignored Repetition) ANOVA with repeated measurement on the last two factors. There was a main effect of Condition, $F(1,72) = 15.925$, $p < .05$, and a interaction of Group by Condition, $F(2,72) = 3.78$, $p < .05$. These effects were moderated by a 3-way interaction, $F(2,72) = 3.78$, $p < .05$. No other effects were significant.

Table 3
Mean reaction times and standard deviations (in ms) to probe trial types

Probe trial type	Group	
	OCD M (SD)	OCD M (SD)
OCD-related threat		
Ignored repetition	617 (107)	611 (113)
Control	607 (85)	669 (145)
OCD-related positive		
Ignored repetition	586 (119)	612 (102)
Control	604 (92)	645 (119)
Neutral		
Ignored repetition	599 (120)	605 (101)
Control	624 (109)	645 (121)

Note: Ignored repetition trials are probe trials where the target word is identical to the distracter word on the prime trial. Control trials are probe trials where the prime included only rows of X's as distracters.

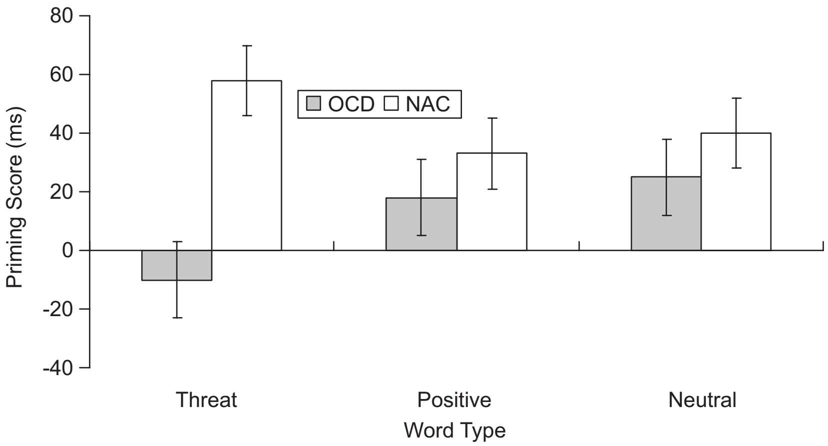

Fig. 1. Priming scores.

group would vary based on threat relevance, pairwise comparisons were conducted. Among individuals with OCD, priming scores were relatively greater (i.e., more positive) for neutral than for threat words, $t(18) = 2.08$, $p = .05$, but priming scores did not differ between threat and positive, $t(18) = 1.35$, $p > .15$, or positive and neutral words, $t(18) = .76$, $p > .45$.

To remain consistent with the analysis of Frings and Wentura (2006), we also conducted chi-squared tests on the proportion of individuals displaying a negatively- versus a positively-signed priming effect. This analysis was conducted in order to: (1) determine what proportion of individuals in each group learned the contingency and (2) ensure significant group differences were not a reflection of extreme negative or positive priming values. For the OCD-related threat words, a larger proportion of OCs (42.1%) than NACs (5.3%) displayed a negatively-signed rather than positively-signed priming effect, $\chi^2 = 7.13$, $p < .01$. For both the neutral, $\chi^2 = .23$, $p > .50$, and OCD-related positive words, $\chi^2 = .13$, $p > .50$, groups did not differ in the proportion of individuals showing negatively- versus positively-signed priming values.

Finally, we tested the difference of each of the six priming scores of the 2×2 design from absolute zero to remain consistent with the NP literature (e.g., Fox, 1994). One sample t-tests revealed priming scores for NACs for all three word types were significantly greater than absolute zero, $ps < .05$. For the OCs, priming values for threat and positive words did not differ significantly from absolute zero, $ps > .05$, but priming scores for neutral words were significantly greater than zero, $p < .05$. (Fig. 1).

Discussion

Using an NP paradigm with no selection conflict on the probe trials and idiographic stimuli, we found that individuals with OCD exhibit less priming than NACs for OCD-related, idiographic threat information. In contrast, groups did not differ in their priming scores for neutral words or for OCD-related, idiographic positive words. Previous studies have shown nonanxious individuals exhibit either no priming or positive priming in NP paradigms that employ nonconflict probe displays (e.g., Milliken et al., 1998; see Fox, 1995 for a review; Frings & Wentura, 2006, Experiments 1A and 1B). Frings and Wentura (2006) examined NP in this paradigm in a series of experiments in order to identify the mechanism responsible for this lack of NP. The authors found that in typical NP paradigms with nonconflict probe displays, such as in the present study, participants learn the contingency between the prime and probe display. These authors concluded that participants learn, implicitly or explicitly, to attend to the distracters in the prime display in order to enhance their performance in the subsequent probe display.

In our study, individuals with OCD did not use the contingency-based component to the same extent as the nonanxious participants when processing idiographic threat-relevant information. However, OCs did not differ from the NACs when processing neutral and idiographic positive stimuli, suggesting OCs are capable of learning the contingency between the displays. Previous research on learning involving neutral and threat information in individuals with OCD compared to nonanxious individuals has shown OCs experience deficits in learning neutral stimuli but not threat stimuli (Leplow et al., 2002; Murphy et al., 2004). The authors of these two studies attribute this finding to an attentional bias that compensates for the general learning deficit. The discrepancy between our results and these studies may be due to the lack of explicit instructions for learning in the present paradigm. Rather, learning the contingency between the prime and probe was not necessary to complete the trials but only an advantage if the participant made the association. Moreover, the contingency-learning aspect of the task was secondary to the response tasks of the prime and probe displays (i.e., digit classification and word reading). It is also possible, however, that the individuals with OCD learned the contingency for all of the trials, but simply failed to use the heuristic in the trials involving threat. One explanation for this finding may be that when individuals with OCD process threatening information, semantic representations of their corresponding compulsion become active. Subsequently, these compulsive associations may function as distracters on the probe trials, thus enabling an NP effect in the absence of external distracting stimuli. Future studies should determine the nature of activation of compulsions in relation to obsessions.

Our findings of an information processing bias in OCD might also be closely related to inhibitory or retrieval mechanisms typically inferred from NP paradigms. Although several models have been used to explain NP findings, the selective inhibition (for review, see Tipper, 2001) and episodic retrieval (Neill & Valdes, 1992; Neill et al., 1992; Rothermund et al., 2005) accounts have received the most support. In the absence of probe selection conflict, the formal selective inhibition model attributes the finding of no NP or positive priming to facilitation of the prime distracters compared to baseline (i.e., their level of activation if they had not been in the prime trial at all), even though they are inhibited relative to the prime target. The episodic retrieval account attributes this finding to the dissimilarity between the prime and probe displays. Specifically, retrieval of response information from the previous processing episode, in which the probe target received a "do-not-respond" tag, is limited (e.g., Neill et al., 1992; Moore, 1994). Because OCs exhibited significantly less priming in this paradigm for the idiographic threat information relative to the NACs, according to these two accounts, they either: (1) suppressed threatening distracters below baseline, implying an enhanced inhibitory process or (2) preferentially retrieved processing episodes with threatening distracters, implying a positive memory bias. Although we cannot differentiate these two accounts based on our current results, there is some evidence that idiographic, OCD-related threat information is particularly salient in individuals with OCD, producing enhanced memory for this information (e.g., Radomsky & Rachman, 1999; Radomsky et al., 2001; Tolin et al., 2002; Wilhelm et al., 1996). Therefore, our finding that these individuals may be more likely than NACs to retrieve the "do-not-respond" tag is consistent with this body of research.

To our knowledge none of the other studies of NP in individuals with OCD have used idiographically selected OCD-related information. Therefore, it is difficult to compare our results to previous research. However, our neutral word category was similar to other studies examining NP in OCD. Our finding for neutral words is inconsistent with findings that individuals with OCD exhibit reduced NP compared to controls (Enright & Beech, 1990, 1993a, 1993b). However, these studies presented stimuli for very short durations (i.e., 100 ms), perhaps tapping pre-attentive mechanisms (Enright et al., 1995). Indeed, other studies of NP in OCD employed longer stimulus durations, observing similar NP in individuals with OCD compared to NAC participants (MacDonald et al., 1999, novel task; McNally et al., 2001) and individuals with other anxiety disorders (but only compared to OCD noncheckers; Enright et al., 1995). However, one NP task resulted in enhanced NP effects in OCD compared to NACs (MacDonald et al., 1999, typical task). In the current study, we presented stimuli until participants responded. This resulted in comparable priming effects for the OCD and NAC groups for neutral words. Thus, our results are consistent with the majority of studies of NP in individuals with OCD for the processing of neutral information.

Our study has limitations. We did not use an anxious control group; therefore, it is possible that our results were not specific to OCD. Moreover, we did not assess for comorbidity within our OCD group. This may be important because researchers have suggested comorbidity plays a role in information processing biases in OCD (e.g., Muller & Roberts, 2005). Future research would benefit from employing categories of threatening OCD-related stimuli corresponding to each of the OC subtypes (e.g., washers: germs, checkers: unlocked, orderers: messy, etc.). These stimuli might determine whether enhanced NP effects for threat in OCD are specific to idiographic stimuli or if it extends to more general OC subtype-related concerns. Similarly, categorizing the OCD group into subtypes may reveal differential processing within OCD. For example, Enright et al. (1995) found OCD checkers, but not OCD noncheckers, display deficits in NP compared to anxious controls even at longer stimulus presentation durations (i.e., 250 and 300 ms). Finally, our groups differed in age. However, when we repeated our analyses of group on priming scores with age as a covariate, we still obtained significant ($p<.05$) group differences for threat words and not for positive or neutral words. Thus, although the age difference is statistically significant, it is unlikely to be clinically significant.

In summary, this study addressed the need for clarification of former research investigating NP effects in OCD. We focused on choice of stimuli and isolation of the mechanism of interest. We found evidence for increased NP magnitude in this population, but only for OCD-related, idiographic threat information. Interpretation of this finding may be premature due to persistent disagreement in NP findings. However, a recent study on NP paradigms with no selection conflict on the probe display has suggested the mechanism underlying this design may be learning of a contingency between the prime and probe display. Thus, we conclude that OCs exhibit deficient learning of contingencies compared to NACs, but only for OCD-related, idiographic threat information.

Acknowledgements

This study was supported grants from the National Institutes of Health (R34 MH073004-01 and R34 MH077129) awarded to the first author.

References

Allport, D. A., Tipper, S. P., & Chmiel, N. R. J. (1985). Perceptual integration and postcategorial filtering. In M. I. Posner, & O. S. M. Marin (Eds.), *Attention and performance XI* (pp. 107–132). Hillsdale, NJ: Erlbaum.

American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders* (3rd ed., Rev). Washington, DC: American Psychiatric Association.

Beck, A. T., & Steer, R. A. (1987). *Beck depression inventory manual*. San Antonio, TX: The Psychological Corporation.

Bohne, A., Savage, C. R., Deckersbach, T., Keuthen, N. J., Jenike, M. A., Tuschen-Caffier, B., et al. (2005). Visuospatial abilities, memory, and executive functioning in trichotillomania and obsessive-compulsive disorder. *Journal of Clinical and Experimental Neuropsychology*, *27*, 385–399.

Clayton, I. C., Richards, J. C., & Edwards, C. J. (1999). Selective attention in obsessive-compulsive disorder. *Journal of Abnormal Psychology*, *108*, 171–175.

Dalrymple-Alford, E. C., & Budayr, B. (1966). Examination of some aspects of the stroop color-word test. *Perceptual and Motor Skills*, *23*, 1211–1214.

Enright, S. J., & Beech, A. R. (1990). Obsessional states: Anxiety disorders or schizotypes? An information processing and personality assessment. *Psychological Medicine*, *20*, 621–627.

Enright, S. J., & Beech, A. R. (1993a). Further evidence of reduced cognitive inhibition in obsessive-compulsive disorder. *Personality and Individual Differences*, *14*, 387–395.

Enright, S. J., & Beech, A. R. (1993b). Reduced cognitive inhibition in obsessive-compulsive disorder. *British Journal of Clinical Psychology*, *32*, 67–74.

Enright, S. J., Beech, A. R., & Claridge, G. S. (1995). A further investigation of cognitive inhibition in obsessive-compulsive disorder and other anxiety disorders. *Personality and Individual Differences*, *19*, 535–542.

Foa, E. B., Ilai, D., McCarthy, P. R., Shoyer, B., & Murdock, T. (1993). Information processing in obsessive-compulsive disorder. *Cognitive Therapy and Research*, *17*(2), 173–189.

Foa, E. B., Kozak, M. J., Salkovskis, P. M., Coles, M., & Amir, N. (1998). The validation of a new obsessive-compulsive disorder scale: The obsessive-compulsive inventory. *Psychological Assessment*, *3*, 206–214.

Fox, E. (1994). Attentional bias in anxiety: A defective inhibition hypothesis. *Cognition and Emotion*, *8*, 165–195.

Fox, E. (1995). Negative priming from ignored distractors in visual selection: A review. *Psychonomic Bulletin and Review*, *2*, 145–173.

Frings, C., & Wentura, D. (2006). Strategy effects counteract distractor inhibition: Negative priming with constantly absent probe distractors. *Journal of Experimental Psychology: Human Perception and Performance*, *32*, 854–864.

Houghton, G., & Tipper, S. P. (1994). A model of inhibitory mechanisms in selective attention. In D. Dagenbach, & T. Carr (Eds.), *Inhibitory mechanisms in attention, memory and language* (pp. 53–112). San Diego, CA: Academic Press.

Joordens, S., Betancourt, I., & Spalek, T. M. (2006). Selective attention versus selection for action: Negative priming is not the result of distractors being unattended. *Perception and Psychophysics*, *68*, 890–896.

Kane, M. J., May, C. P., Hasher, L., Rahhal, T., & Stoltzfus, E. R. (1997). Dual mechanisms of negative priming. *Journal of Experimental Psychology: Human Perception and Performance*, *23*, 632–650.

Lowe, D. G. (1979). Strategies, context, and the mechanism of response inhibition. *Memory and Cognition*, *7*, 382–389.

Leplow, B., Murphy, R., & Nutzinger, D. O. (2002). Specificity of conditional-associative learning deficits in obsessive-compulsive disorder (OCD) and non-OCD anxiety disorders. *Journal of Clinical and Experimental Neuropsychology*, *24*, 792–805.

MacDonald, P. A., Antony, M. M., MacLeod, C. M., & Swinson, R. P. (1999). Negative priming for obsessive-compulsive checkers and noncheckers. *Journal of Abnormal Psychology*, *108*, 679–686.

Mackintosh, B., Mathews, A., & Holden, E. (2002). Bigger than a breadbox? Attention to distractors may not enhance negative priming. *Journal of Experimental Psychology: Human Perception and Performance*, *28*, 1323–1329.

MacLeod, C. M., Chiappe, D. L., & Fox, E. (2002). The crucial roles of stimulus matching and stimulus identity in negative priming. *Psychonomic Bulletin and Review*, *9*, 521–528.

Maki, W. S., O'Neill, H. K., & O'Neill, G. W. (1994). Do nonclinical checkers exhibit deficits in cognitive control? Tests of an inhibitory control hypothesis. *Behaviour Research and Therapy*, *32*, 183–192.

May, C. P., Kane, M. J., & Hasher, L. (1995). Determinants of negative priming. *Psychological Bulletin*, *118*, 35–54.

McNally, R. J., Wilhelm, S., Buhlmann, U., & Shin, L. M. (2001). Cognitive inhibition in obsessive-compulsive disorder: Application of a valence-based negative priming paradigm. *Behavioural and Cognitive Psychotherapy*, *29*, 103–106.

Milliken, B., Joordens, S., Merikle, P. M., & Seiffert, A. E. (1998). Selective attention: A reevaluation of the implications of negative priming. *Psychological Review*, *105*, 203–229.

Milliken, B., Tipper, S. P., & Weaver, B. (1994). Negative priming in a spatial localization task: Feature mismatching and distractor inhibition. *Journal of Experimental Psychology: Human Perception and Performance*, *20*, 624–646.

Moore, C. M. (1994). Negative priming depends on probe-trial conflict: Where has all the inhibition gone? *Perception and Psychophysics*, *56*, 133–147.

Muller, J., & Roberts, J. E. (2005). Memory and attention in obsessive-compulsive disorder: A review. *Journal of Anxiety Disorders*, *19*, 1–28.

Murphy, R., Nutzinger, D. O., Paul, T., & Leplow, B. (2004). Conditional-associative learning in eating disorders: A comparison with OCD. *Journal of Clinical and Experimental Neuropsychology*, *26*, 190–199.

Neill, W. T. (1977). Inhibitory and facilitatory processes in selective attention. *Journal of Experimental Psychology: Human Perception and Performance*, *3*, 444–450.

Neill, W. T., & Valdes, L. A. (1992). Persistence of negative priming: Steady state or decay? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *18*, 565–576.

Neill, W. T., Valdes, L. A., Terry, K. M., & Gorfein, D. S. (1992). Persistence of negative priming: II. Evidence for episodic trace retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *18*, 993–1000.

Neill, W. T., & Westberry, R. L. (1987). Selective attention and the suppression of cognitive noise. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *13*, 327–334.

Park, J., & Kanwisher, N. (1994). Negative priming for spatial locations: Identity mismatching, not distractor inhibition. *Journal of Experimental Psychology: Human Perception and Performance*, *20*, 613–623.

Radomsky, A. S., & Rachman, S. (1999). Memory bias in obsessive-compulsive disorder (OCD). *Behaviour Research and Therapy*, *37*, 605–618.

Radomsky, A. S., & Rachman, S. (2004). The importance of importance in OCD memory research. *Journal of Behavior Therapy and Experimental Psychiatry*, *35*, 137–151.

Radomsky, A. S., Rachman, S., & Hammond, D. (2001). Memory bias, confidence and responsibility in compulsive checking. *Behaviour Research and Therapy*, *39*, 813–822.

Rauch, S. L., Savage, C. R., Alpert, N. M., Dougherty, D., Kendrick, A., Curran, T., et al. (1997). Probing striatal function in obsessive-compulsive disorder: A PET study of implicit sequence learning. *Journal of Neuropsychiatry and Clinical Neurosciences*, *9*, 568–573.

Reiss, S., Peterson, R. A., Gursky, D. M., & McNally, R. J. (1986). Anxiety sensitivity, anxiety frequency, and the prediction of fearfulness. *Behaviour Research and Therapy*, *24*, 1–8.

Rothermund, K., Wentura, D., & De Houwer, J. (2005). Retrieval of incidental stimulus-response associations as a source of negative priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*, 482–495.

Scarborough, D. L., Cortese, C., & Scarborough, H. S. (1977). Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance*, *3*, 1–17.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the state– trait anxiety inventory*. Palo Alto, CA: Consulting Psychological Press.

Spitzer, R. L., Williams, J. B. W., Gibbon, M., & First, M. B. (1992). The structured clinical interview for DSM-III-R (SCID): I. History, rationale, and description. *Archives of General Psychiatry*, *49*, 624–629.

Swinson, R. P., Antony, M. M., Rachman, S., & Richter, M. A. (Eds.). (1998). *Obsessive-compulsive disorder: Theory, research, and treatment*. New York: Guilford Press.

Tipper, S. P. (1985). The negative priming effect: Inhibitory effects of ignored primes. *Quarterly Journal of Experimental Psychology*, *37A*, 571–590.

Tipper, S. P. (2001). Does negative priming reflect inhibitory mechanisms? A review and integration of conflicting views. *Quarterly Journal of Experimental Psychology A: Human Experimental Psychology*, *54A*, 321–343.

Tipper, S. P., Brehaut, J. C., & Driver, J. (1990). Selection of moving and static objects for the control of spatially directed action. *Journal of Experimental Psychology: Human Perception and Performance*, *16*, 492–504.

Tipper, S. P., & Cranston, M. (1985). Selective attention and priming: Inhibitory and facilitatory effects of ignored primes. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology*, *37A*, 591–611.

Tolin, D. F., Hamlin, C., & Foa, E. B. (2002). Directed forgetting in obsessive-compulsive disorder: Replication and extension. *Behaviour Research and Therapy*, *40*, 792–803.

Watson, F. L., & Tipper, S. P. (1997). Reduced negative priming in schizotypal subjects does reflect reduced cognitive inhibition. *Cognitive Neuropsychiatry*, *2*, 67–79.

Wilhelm, S., McNally, R. J., Baer, L., & Florin, I. (1996). Directed forgetting in obsessive-compulsive disorder. *Behaviour Research and Therapy*, *34*, 633–641.

Wilson, K. D. (1998). Issues surrounding the cognitive neuroscience of obsessive-compulsive disorder. *Psychonomic Bulletin and Review*, *5*, 161–172.

Veale, D. M., Sahakian, B. J., Owen, A. M., & Marks, I. M. (1996). Specific cognitive deficits in tests sensitive to frontal lobe dysfunction in obsessive-compulsive disorder. *Psychological Medicine*, *26*, 1261–1269.

Yee, P. L. (1991). Semantic inhibition of ignored words during a figure classification task. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology*, *43*, 127–153.