Available online at www.sciencedirect.com
ScienceDirect
Behaviour Research and Therapy 46 (2008) 462–476
BEHAVIOUR RESEARCH AND THERAPY
www.elsevier.com/locate/brat

Thought suppression enhances memory bias for threat material

Katharina Kircanski*, Michelle G. Craske, Robert A. Bjork

Department of Psychology, University of California, 1285 Franz Hall, Box 951563, Los Angeles, CA 90095-1563, USA

Received 15 August 2007; received in revised form 23 December 2007; accepted 16 January 2008

Abstract

The current study examined the impact of thought suppression on indices of anxiety, including memory indices (implicit and explicit memory biases) and physiological indices (heart rate). The participants, 81 undergraduates scoring in the top quartile of a self-report measure of trait anxiety, were randomly assigned to one of three experimental groups: thought suppression (TS), thought concentration (TC), and thought wandering (TW). The TC and TW groups were included to control for the effects of effortful processing and exposure to stimuli, respectively. One block of threat words and one block of neutral words were presented under conditions of cognitive load, and participants' physiological responses and memory biases were measured. The thought suppression group exhibited an enhanced overall memory bias for threat words, driven by an elevated explicit memory bias, relative to the other two groups, a result that has implications for ironic processes theory and may inform information-processing models of anxiety.

Keywords: Thought suppression; Memory biases; Anxiety disorders; Heart rate

Introduction

In daily life, virtually all people experience unwanted thoughts (Wegner, 1994). For example, in unselected samples, cognitive intrusions are generally reported by 99% of respondents (Freeston, Ladouceur, Thibodeau, & Gagnon, 1991; Purdon & Clark, 1993). Although the occurrence of such thoughts is commonplace, the various anxiety disorders are characterized by recurrent and persistent intrusive thoughts related to worry, anxiety, and fear (American Psychiatric Association, 2000), and thereby referred to as "threat-related".

Individuals often try to suppress unwanted, aversive, and distressing thoughts (e.g., threat-related thoughts; Hayes, Wilson, Gifford, Follette, & Strosahl, 1996; Wegner & Zanakos, 1994). Thought suppression entails effortful cognitive attempts to not think about or avoid a given thought (Wegner, 1994). However, attempts to use effortful cognitive strategies, such as thought suppression, to manage intrusive thoughts are associated with increased difficulty in eliminating the thoughts as compared with non-effortful responses (Freeston et al., 1991).

*Corresponding author. Tel.: +1 401 487 0580.
E-mail address: kkir@ucla.edu (K. Kircanski).

0005-7967/$ - see front matter
doi:10.1016/j.brat.2008.01.009

Ironic processes theory (Wegner, 1994)

These observations are consistent with an extensive body of research relating to Wegner's ironic processes theory (Wegner, 1994). The theory postulates that thought suppression can generate hyperaccessibility, or enhanced cognitive accessibility of to-be-suppressed thoughts. After a period of attempted suppression, a rebound effect has been observed that takes the form of the suppressed thought being more accessible than it would have been without such suppression (Wenzlaff & Wegner, 2000). The theory was first supported by investigations conducted with unselected college samples, demonstrating that suppression of neutral thoughts leads to elevated subsequent thought rebound using think-aloud paradigms (e.g., Wegner, Schneider, Carter, & White, 1987). Findings also showed that hyperaccessibility is pronounced under conditions of cognitive load, in which participants suppress while performing an additional cognitive task (e.g., rehearsal of a nine-digit number; Wegner & Erber, 1992).

Thought suppression is hypothesized by Wegner to involve dual processes: an effortful operating process that searches for distracter thoughts to promote a desired state, and a non-effortful monitoring process that remains vigilant for unwanted thoughts in order to signal success or failure in suppression and to sustain a preferred state. Cognitive load is believed to enhance ironic effects by creating competing cognitive demands that impair effortful attempts at suppression, while leaving the monitoring process free to search for unwanted thoughts that may then intrude upon conscious awareness (reviewed in Wenzlaff & Wegner, 2000).

Ironic processes theory and anxiety disorders

Several investigations have evaluated ironic processes theory within the context of anxiety disorders. A correlational study by Wegner and colleagues showed an association between the tendency to suppress obsessional thoughts and self-reported occurrence of such thoughts in a sub-clinical college sample (Wegner & Zanakos, 1994). Other studies have examined suppression of threat-related thoughts characteristic of anxiety disorders, generally using self-reported thought occurrence paradigms. For example, Fehm and Margraf (2002) compared groups of participants with agoraphobia, social phobia, or no anxiety disorder, with instructions to suppress three statements: one relevant to fears in agoraphobia, one to fears in social phobia, and one to financial problems. Participants attempted to suppress each topic for 5 min while pressing a button each time the topic came to mind. The agoraphobic group showed a heightened frequency of thoughts related to the agoraphobia topic during attempted suppression, whereas participants with social phobia showed elevated frequency of thoughts across all topics.

Additional studies have employed instructed suppression and thought-monitoring methodology using target thoughts and samples representative of anxiety disorders, such as topics of worry in generalized anxiety disorder (e.g., Becker, Rinck, Roth, & Margraf, 1998; Mathews & Milroy, 1994), traumatic intrusions in posttraumatic stress disorder (e.g., Ehlers & Steil, 1995), feared stimuli in phobias (e.g., Wenzel, Barth, & Holt, 2003; Zeitlin, Netten, & Hodder, 1995), and obsessions in obsessive–compulsive disorder (e.g., Salkovskis & Campbell, 1994; reviewed in Purdon & Clark, 2000). Overall, the findings have been relatively inconsistent across the anxiety disorders, with more support for elevated thought frequency under conditions of suppression in posttraumatic stress disorder and obsessive–compulsive disorder than in specific phobias and generalized anxiety disorder (reviewed in Purdon, 1999).

Differing methodologies may also contribute to the discrepant findings. Certain measures of thought frequency, for example, may be subject to self-reporting biases. More specifically, participants with anxiety disorders or high in trait anxiety may avoid reporting intrusive thoughts on think-aloud or thought recall tasks as such tasks require reproduction of potentially anxiety-provoking stimuli (Gosselin et al., 2007; Hayes et al., 1996). Trait anxiety, as indicated by self-report in the present study, refers to a general propensity to respond fearfully to aversive or threat stimuli (Spielberger, 1985). In the present study, both an implicit memory measure and a recognition memory measure were used, such that participants were never required to reproduce the words presented during the experiment.

As previously stated, thought suppression is posited to enhance subsequent cognitive accessibility of to-be-suppressed thoughts. After a period of attempted suppression, a rebound effect has been observed whereby the suppressed thought appears more accessible than it would have been without such suppression (Wenzlaff

& Wegner, 2000). For example, Harvey and Bryant (1999) presented high- and low-trait anxious participants with either a neutral or distressing film, and then instructed participants to either suppress thoughts of the film or think about anything for two 3 min periods, pressing a response button each time they thought about the film. Harvey and Bryant obtained a delayed rebound effect for frequency of film-related thoughts across films during the second 3-min period, mediated by trait anxiety. The evidence for thought rebound effects raises the possibility that suppression may lead to measurable memory biases for previously suppressed thoughts.

Memory biases and anxiety disorders

Memory bias has been operationalized as increased recall of threat-related material relative to non-threat material, and biases may be explicit and consciously retrieved or implicit and tested indirectly (see Coles & Heimberg, 2002, for a review). Memory biases for threat material have generally been studied in anxious populations, as threat-related processing is highly relevant to such groups; however, memory biases for threat have only been obtained in a minority of such studies. As reviewed by Coles and Heimberg (2002), some prior research has obtained evidence of an explicit memory bias in panic disorder, posttraumatic stress disorder, and obsessive–compulsive disorder, and of an implicit memory bias in each of the anxiety disorders, but other studies have found no such effects.

The majority of research has tested memory biases following concentration on threat-related words. Interestingly, in the few studies of memory biases following directed forgetting, an instructional condition similar to thought suppression in which participants are told to either forget or remember words just presented, researchers have found enhanced memory for threat-related words that were instructed to be forgotten (McNally, Metzger, Lasko, Clancy, & Pitman, 1998; Wilhelm, McNally, Baer, & Florin, 1996). However, as yet, memory biases for threat words have not been investigated following instructed thought suppression as operationalized by Wegner and colleagues. Bjork and Bjork (2003) suggested that implicit biases for threat-related thoughts may be particularly susceptible to ironic effects following attempted thought suppression, as suppressed material may remain activated in memory while conscious access to the material may be impaired, although clearly there is a need to evaluate both implicit and explicit memory biases.

Goals of the present research

In addition to exploring memory effects, the present study also explored potential physiological effects of threat-related thought suppression. Several studies have investigated the impact of suppression of negative thoughts on emotion, most using self-report data. For example, Purdon (2001) and Markowitz and Borton (2002) found that instructed suppression of obsessions and negative self-referent thoughts, respectively, led to increases in self-reported anxiety and frustration. Spontaneous suppression of personally relevant intrusive thoughts appears to have a similar impact on emotional distress and discomfort (Freeston et al., 1991; Marcks & Woods, 2005; Salkovskis, Westbrook, Davis, Jeavons, & Gledhill, 1997).

However, only a few studies have examined the effects of thought suppression on physiological indices of emotion. Wegner and Zanakos (1994) demonstrated that individuals who chronically suppress certain thoughts tend to respond to reminders of those thoughts with elevated physiological arousal. Likewise, attempts to suppress expressions of negative emotion elevate physiological activation, measured via cardiovascular activation, skin conductance level, and somatic activity (Gross & Levenson, 1993; Gross & Levenson, 1997). These results provide some support for the predictions of ironic processes theory and align with aforementioned findings regarding self-reported emotion. As yet, however, the effects of suppressing threat-related thoughts on physiological indices of anxiety, such as heart rate, have not been examined directly. As self-report measures may be influenced by factors such as response biases, introspective limits (Nisbett & Wilson, 1977), or demand characteristics (Orne, 1962), physiological data may be particularly useful as a more objective measure as well as a component of anxious processes (Rosen & Schulkin, 1998).

The present study investigated the ways in which threat-related thought suppression may impact memory and physiological indices relevant to anxiety. Instructed thought suppression methodology was adapted from prior research conducted by Wegner and colleagues' (i.e., "try to not think about the word"; reviewed in Wenzlaff & Wegner, 2000) and involved exposure to threat words, stimuli that have been used extensively in previous research (e.g., Mogg et al., 2000; Mogg, Bradley, Millar, & White, 1995). Participants high in trait anxiety, as assessed by a self-report measure, served as a sample. Physiological indices and memory biases were assessed during and following the instruction to suppress, concentrate on, or just notice the words. Building on ironic processes theory and prior information-processing research, it was first hypothesized that an implicit memory bias and explicit recognition memory bias would be most elevated in the thought suppression group compared with the other two groups. Second, it was hypothesized that physiological arousal as assessed via heart rate would be most elevated in the thought suppression group.

Method

Participants

Eighty-one participants (27 per group) enrolled in an Introduction to Psychology course at the University of California, Los Angeles, completed the study. Sample demographics were 75% female, and 42% Caucasian, 26% Asian, 15% Latino/Hispanic, 5% Indian, and 12% Bi-racial. Mean age of participants was 19.12 years (SD = 2.22).

Participants were recruited on the basis of scoring in the top quartile on the Behavioral Inhibition subscale of the Behavioral Inhibition System/Behavioral Activation System Scales (BIS/BAS; Carver & White, 1994). The seven-item Behavioral Inhibition subscale is considered a strong measure of anxiety proneness and demonstrates good psychometric properties (Chronbach's $\alpha = 0.76$; Jorm et al., 1999). Participants' mean score on the subscale was 30.79 (SD = 1.68) at the time of recruitment.

To meet further eligibility requirements, participants did not endorse any of the following: heart, neurological, or respiratory condition; hearing impairment; physician recommendations to stay away from stressful situations; sought or seeking treatment, including medication, for an emotional or psychiatric problem; currently pregnant. Participants seeking treatment were excluded in order to control for effects of current medication or psychotherapy on dependent measures including autonomic state.

Design and independent variables

The experimental manipulation involved exposure to two blocks of words: one block of 30 threat words (e.g., nervous, gasping, emergency), and one block of 30 neutral words (e.g., plastic, curving, secondary), with block order counterbalanced across participants, and word order randomized within each block. Each word was presented for 1 s followed by a 9-s inter-trial interval (blank screen).

Participants were randomly assigned to one of three experimental groups: thought suppression (TS), thought concentration (TC), or thought wandering (TW). The three experimental groups varied in instructions for the 9-s inter-trial intervals; participants were instructed to suppress, concentrate on, or just notice the words and related thoughts. The TC group was included to control for the effects of receiving an instructional set involving effortful processing on physiological and memory measures. The TW group was included to control for mere exposure to stimuli on physiological and memory measures. All participants received the following initial instructions:

> We are interested in your responses to words. You will see a variety of words on the screen in front of you. You will hear the words through the headphones at the same time. Each word will be presented for one second. Then, following each word, the screen will become blank and you will hear nothing through the headphones for nine seconds.

The TS group received the following additional instructions:

> During these nine seconds, try to not think about the word just presented. Try to not think about the word as best you can. Even if you start thinking about the word, keep trying to not think about it. After nine seconds, a fixation cross will appear on the screen, to indicate that you should stop and prepare for the next word. There are 60 words in total.

The TC group received the following additional instructions:

> During these nine seconds, try to think about the word just presented. Try to think about the word as best you can. Even if you start not thinking about the word, keep trying to think about it. After nine seconds, a fixation cross will appear on the screen, to indicate that you should stop and prepare for the next word. There are 60 words in total.

The TW group received the following additional instructions:

> During these nine seconds, just notice your thoughts and let them wander naturally. After nine seconds, a fixation cross will appear on the screen, to indicate that you should stop and prepare for the next word. There are 60 words in total.

All participants then received instructions for the cognitive load task (Gilbert & Osborne, 1989):

> One last thing; you will also need to remember the following number: 741296835. It is vital that you remember this number, for our study procedures. Do not write this number down, as it is important that you keep it in your head. At the end of the experiment, you will be asked to write this number down.

Participants were given 10 s to look at and rehearse the number.

Last, participants received a reminder screen for each group: for TS, "remember, it is very important that you try to not think about the word as best you can during the nine seconds"; for TC, "remember, it is very important that you try to think about the word as best you can during the nine seconds"; and for TW, "remember, just notice your thoughts and let them wander naturally during the nine seconds."

Materials

During the experimental manipulation, participants were presented with two types of words: threat and neutral. The 30 threat words used in the current study were compiled from previous studies of information processing in anxiety (e.g., Mogg et al., 2000; Mogg et al., 1995). The 30 neutral words selected for the current study were equated with threat words, word-for-word, on mean word length, number of syllables, and frequency of word use in the English language (Carroll, Davies, & Richman, 1971). Similar equating procedures for unrelated neutral words have been used in previous studies of memory bias in anxiety (e.g., Becker, Roth, Andrich, & Margraf, 1999; Mathews & MacLeod, 1985; Rapee, McCallum, Melville, Ravenscroft, & Rodney, 1994; see Coles & Heimberg, 2002, for a review). Words were presented to participants on the computer screen while they were simultaneously played through headphones. All words were presented by either a male or female voice, with gender of speaker counterbalanced across subjects. Each block of threat and neutral words lasted approximately 6 min. A complete list of words used is presented in Table 1.

Self-report measures

Anxiety proneness

At the laboratory visit, participants repeated the Behavioral Inhibition System/Behavioral Activation System Scales (BIS/BAS; Carver & White, 1994). Four participants' scores fell below the top quartile at the time of study completion; as data for these participants did not impact study results, they were retained.[1]

[1] Results excluding the four participants whose BIS subscale scores fell below the top quartile at the time of study completion were as follows: MANOVA for overall group differences in implicit and explicit memory biases, $F\,(4, 146) = 2.625$, $p < 0.05$; ANOVA for implicit memory bias, $F\,(2,74) = 1.903$, $p = 0.15$; ANOVA for explicit memory bias, $F\,(2,73) = 3.422$, $p < 0.05$; ANOVA for HR Group, $F\,(2, 71) = 0.240$, ns; ANOVA for HR Group by Valence interaction, $F\,(2, 71) = 3.071$, $p = 0.05$.

Table 1
Threat and neutral words presented during the experimental manipulation

Threat		Neutral	
Nervous	Humiliated	Plastic	Habitually
Helplessness	Embarrassment	Wastebaskets	Environments
Crazy	Blush	Polar	Flick
Tremble	Stupid	Shading	Traded
Sweat	Isolated	Clerk	Variable
Tense	Fail	Moist	Dive
Panicky	Mistake	Sundial	Passage
Worry	Inferior	Arrow	Casually
Disease	Criticism	Shorter	Inhabited
Injury	Trapped	Sodium	Matched
Disaster	Dizzy	Longitude	Abide
Attack	Dying	Papers	Meter
Emergency	Faint	Secondary	Ruled
Accident	Gasping	Becoming	Curving
Nightmare	Danger	Springing	Proper

Thought suppression

Participants were instructed to complete the White Bear Suppression Inventory (WBSI; Wegner & Zanakos, 1994), established as a reliable and valid measure of the tendency to experience and suppress unwanted, intrusive thoughts in everyday life (Chronbach's $\alpha = 0.87$–0.89; Wegner & Zanakos, 1994). This measure was used as a potential covariate in the event of group differences.

State emotion

The 20-item Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988) was completed prior to the experimental manipulation. The PANAS has been shown to be highly internally consistent and demonstrates good discriminant and convergent validity (Chronbach's $\alpha = 0.84$–0.90; Watson et al., 1988). This measure was used as a potential covariate in the event of group differences.

Manipulation check

Participants completed a four-item manipulation check questionnaire that inquired, on a 1–5 Likert scale, how easy or difficult it was to follow task instructions, how hard they tried to follow task instructions, how successful they were at following task instructions, and how frequently they thought about the words presented. All three experimental groups received the same wording of items.

Memory measures

A new set of additional threat words for the implicit and explicit memory tasks was compiled from previous studies of information processing in anxiety (e.g., Mogg et al., 2000; Mogg et al., 1995). A new set of additional neutral words was equated with new threat words, word-for-word, on mean word length, number of syllables, and frequency of use in the English language (Carroll et al., 1971). Memory bias data were recorded using the E-prime computer program.[2]

Implicit memory

Implicit memory for words was tested using a white-noise judgment paradigm, which has been established as a reliable and valid indirect measure of memory in previous research (e.g., Amir, McNally, & Wiegartz,

[2]Heart rate and heart rate variability data were missing for two participants when event markers indicating the start of the experimental blocks failed to be recorded or were improperly recorded. Movement and ectopic beat analyses were performed prior to statistical analyses for all physiological variables.

1996; Jacoby, Allan, Collins, & Larwill, 1988). A total of 60 words were presented to each participant over headphones, one word at a time and in a clearly audible range. The 60 words were comprised of 30 previously presented words, 15 threat words and 15 neutral words, intermixed with 30 non-presented words, 15 new threat words and 15 new neutral words, and the order of presentation was randomized within and across participants. The gender of the speaker of words during the memory tasks was switched from gender of speaker during the experimental manipulation, in order to reduce aspects of perceptual memory for words that might influence the results. Simultaneous with the presentation of each word, one of three volume levels of white noise were presented in randomized order. All participants received the following instructions:

> You will hear a variety of words through the headphones. You will hear each word along with some static noise. For each item, your task will be to rate the volume level of the static noise, by pressing any key from 1 (very quiet) to 7 (very loud).

Prior research using this paradigm has demonstrated that implicit memory for words previously presented is associated with lower ratings of accompanying static-noise volume (e.g., Amir, McNally, Riemann, & Clements, 1996; Amir et al., 1996; Jacoby et al., 1988; Jacoby, Toth, Lindsay, & Debner, 1992).

Explicit memory

Following the implicit measure, an explicit measure of recognition memory was used. Participants were presented with a series of 30 old threat words, 30 old neutral words, 30 new threat words, and 30 new neutral words, on a computer screen and through the headphones, in randomized order within and across participants. Half of the old and new words of each type had also been presented on the implicit memory task and half had not. Words varied in font, size, color, and gender of speaker from words originally presented, in order to reduce aspects of perceptual memory for words that might influence the results. All participants received the following instructions:

> You will see a variety of words on the screen in front of you. You will hear the words through the headphones at the same time. For each word, think back to the first two parts of the experiment, in which you were similarly presented with a variety of words. Press the key labeled Y to indicate that you were presented with the word previously, during those first two parts of the experiment. Press the key labeled N to indicate that you were not presented with the word previously, during those first two parts of the experiment. If you do not know, please guess.

Physiological measures

Heart rate

Heart rate data were monitored continuously using the LifeShirt (VivoMetrics; Wilhelm, Roth, & Sackner, 2003), an ambulatory monitoring system that records cardiovascular and respiratory responses. The LifeShirt has been used in a wide variety of experimental studies to investigate physiological processes such as heart rate, breathing rate, skin conductance, and motor-behavioral responses (Wilhelm, Pfaltz, & Grossman, 2006). Heart rate data were analyzed by VivoLogic 2.8.[3] Throughout each block, mean heart rate (beats per minute; HRT) was analyzed as averages over two blocks of 30 words each (6 min per block). Heart rate variability (respiratory sinus arrhythmia magnitude; RSA) was also derived from this measure and analyzed as averages over the two blocks. RSA is an index of vagally mediated cardiac control (Berntson, Cacioppo, & Quigley, 1993), and lower cardiac vagal control evidenced by shorter inter-beat-intervals has been shown to negatively correlate with degree of emotional arousal (Frazier, Strauss, & Steinhauer, 2004).

Procedure

Participants were recruited through telephone calls made to students who scored in the top quartile of the BIS subscale of the BIS/BAS. They were informed of their potential eligibility, provided information about the

[3]Memory bias data were missing for one participant who failed to complete the explicit memory task.

study, asked a series of further eligibility questions, and if eligible, provided the option to participate for course credit.

Participants who attended the laboratory session provided informed consent before experimenters fitted them with the LifeShirt heart rate recording system. For the remainder of the experiment, participants were seated at a desk approximately 2 ft away from a Dell desktop computer used to present the words, with a $12 \times 16\,\text{inch}^2$ computer monitor placed at eye level, and headphones attached at medium volume level for all participants. Following a 3-min period in which baseline measures of HRT and RSA were obtained, participants completed the BIS/BAS and PANAS.

Next, participants received instructions for the experimental manipulation. Experimenters then asked participants if they had any questions, placed headphones on participants, recorded an event marker on the physiological equipment to indicate the start of the first block of the task, and left the room. When the first block was finished, participants received instructions on the computer screen to contact the experimenter. Experimenters re-entered the room and all participants received the same reminder screen that they had received prior to beginning the first block. Experimenters asked participants if they had any questions, placed headphones on participants, recorded an event marker on the physiological equipment to indicate the start of the second block of the task, and left the room.

Upon completion of the second block, participants again received instructions on the computer screen to contact the experimenter. Experimenters re-entered the room and participants were administered a one-item cognitive load questionnaire, with instructions to write down the number that they were asked to remember during the course of the manipulation. Participants were then administered the manipulation check questionnaire.

Next, participants received instructions for the implicit memory task. Memory tasks were unexpected for all participants. Experimenters asked participants if they had any questions, placed headphones on participants, recorded an event marker on the physiological equipment to indicate the start of the implicit memory task, and left the room. The implicit memory task lasted approximately 3–5 min; duration depended on how long participants took to respond to the items.

When the implicit memory task was finished, participants received instructions on the computer screen to contact the experimenter. Experimenters re-entered the room and participants then received instructions for the explicit memory task. Experimenters asked participants if they had any questions, placed headphones on participants, recorded an event marker on the physiological equipment to indicate the start of the explicit memory task, and left the room. The explicit memory task lasted approximately 7–10 min, depending on how long participants took to respond to the items.

Following completion of the explicit memory task, participants received instructions on the computer screen to contact the experimenter. Experimenters re-entered the room, removed the recording device from the LifeShirt, and left the room while participants changed out of the LifeShirt. Experimenters re-entered the room and instructed participants to complete the WBSI. Lastly, participants underwent debriefing.

Results

All analyses were conducted in SPSS Version 14.0. An α level of 0.05 was used for all statistical tests. Statistical power was estimated using standard formulas, and was in the range of 67% for the predicted memory bias results but only 10% for the predicted heart rate result.

Preexisting and baseline differences

A χ^2 test revealed no group differences in proportion of females, χ^2 $(2) = 0.033$, ns, proportion of each ethnicity, χ^2 $(6) = 0.664$, ns, mean age, $F\,(2, 78) = 0.539$, ns, or mean income, $F\,(2, 78) = 1.738$, ns. Likewise, one-way ANOVAs revealed no significant differences in BIS subscale scores across groups at the time of recruitment, $F\,(2, 78) = 1.970$, ns, or at the time of participating in the study, $F\,(2, 78) = 1.497$, ns.

One-way ANOVAs revealed no significant differences across groups in HRT, $F\,(2, 77) = 0.754$, ns, or RSA, $F\,(2, 77) = 0.257$, ns, during the baseline recording period prior to the start of the experimental manipulation. One-way ANOVAs revealed no significant differences across groups for PANAS-positive

Table 2
Means (and standard deviations) of bias scores and raw values for implicit memory and explicit memory for experimental groups

	Experimental group		
	Thought suppression	Thought concentration	Thought wandering
Implicit memory			
Bias score	−0.01 (0.39)	−0.09 (0.27)	−0.17 (0.41)
Threat words	4.09 (0.87)	4.07 (0.68)	4.24 (0.57)
Neutral words	4.08 (0.86)	3.98 (0.74)	4.07 (0.56)
Explicit memory			
Bias score	0.15 (0.16)	0.04 (0.10)	0.10 (0.16)
Threat words	0.88 (0.09)	0.89 (0.10)	0.86 (0.11)
Neutral words	0.73 (0.19)	0.85 (0.11)	0.76 (0.18)

Note: Bias scores for implicit memory were calculated by subtracting the average static noise volume rating for threat items from the average static noise volume rating for neutral items for each group. Bias scores for explicit memory were calculated by subtracting the average hit rate for neutral words from the average hit rate for threat words. For both implicit and explicit memory, higher bias scores equate to greater memory for threat words relative to neutral words.

emotion, $F\ (2, 78) = 2.213$, ns, or PANAS-negative emotion, $F\ (2, 78) = 0.513$, ns, prior to the experimental manipulation, and no significant differences in WBSI scores across groups, $F\ (2, 78) = 2.495$, ns. Since no group differences were observed for these variables, they were not used as covariates in subsequent analyses.

Memory biases

Descriptive statistics for implicit memory bias and explicit memory bias across groups are presented in Table 2. Bias scores for implicit memory were calculated by subtracting the average rating for threat items from the average rating for neutral items for each group. Higher bias scores (i.e., lower volume ratings for static accompanying threat words relative to neutral words) equated to greater implicit memory for threat words relative to neutral words. Bias scores for explicit memory were calculated by subtracting the average hit rate (proportion correctly recognized) for old neutral words from the average hit rate for threat words. Higher bias scores (i.e., higher hit rates for threat words than neutral words) equated to greater explicit memory for threat words relative to neutral words. Hit rates rather than false alarm rates were used in order to examine memory bias specific to those stimuli that were instructed to be suppressed, similar to Wegner and colleagues' and previous memory bias research, rather than utilizing false alarm rates that may indicate a more generalized response bias subsequent to attempted thought suppression (Dowens & Calvo, 2003). Further, subsequent analyses utilized false alarm rates in order to evaluate the possibility of response bias.

A multivariate ANOVA (MANOVA) was used to examine overall group differences in implicit and explicit memory bias. As hypothesized, analyses revealed a main effect for Group, $F\ (4, 154) = 2.378$, $p = 0.05$. Thus, univariate effects were analyzed.

Implicit memory bias

Contrary to expectation, a one-way ANOVA revealed no significant group differences, $F\ (2, 78) = 1.443$, $p = 0.2$. However, a trend for group differences was in the predicted direction; the TS group exhibited a slightly greater bias than the TC group and the TW group; d for largest mean difference between TS and TW group $= 0.45$, which represents a small to medium effect size.

A series of one-sample t-tests indicated that the TS group showed no memory bias, $t\ (26) = -0.090$, ns, whereas a trend toward a bias away from threat words was shown in the TC group, $t\ (26) = -1.686$, $p = 0.1$, and a significant bias away from threat words was shown in the TW group, $t\ (26) = -2.179$, $p < 0.05$.

Explicit memory bias

As hypothesized, a one-way ANOVA revealed significant group differences, $F\ (2, 77) = 3.444$, $p < 0.05$. Using a planned contrast, the quadratic effect was significant, $t\ (77) = 2.205$, $p < 0.05$, whereby the TS group

Table 3
Means (and standard deviations) of raw values for heart rate for experimental groups

Measurement period	Experimental group		
	Thought suppression	Thought concentration	Thought wandering
Baseline	81.0 (11.1)	77.0 (10.8)	79.2 (12.8)
Threat block	76.0 (9.5)	72.6 (8.9)	75.8 (13.0)
Neutral block	77.3 (10.6)	73.0 (8.9)	75.1 (12.1)

Note: Heart rate was measured in beats per minute (bpm).

showed a greater explicit memory bias than both the TC and TW groups; d for largest mean difference between TS and TC group = 0.70, which represents a medium to large effect size. The linear effect was not significant, t (77) = 1.211, ns.

A series of one-sample t-tests indicated that the TS group, t (25) = 4.651, $p = 0.000$, TC group, t (26) = 2.404, $p<0.05$, and TW group, t (26) = 3.120, $p<0.01$, all showed an explicit memory bias toward threat words, though as indicated by the planned contrast, the explicit memory bias observed in the TS group was significantly larger than that observed in the TC and TW groups.

False alarm rates (new words incorrectly identified as old) for response bias scores for each group were calculated by subtracting the average false alarm rate for neutral words from the average false alarm rate for threat-related words. Analyses revealed no significant group differences, F (2, 77) = 0.347, ns. Thus, the significantly elevated explicit memory bias shown in the TS group was not related to a general response bias for threat words.

Physiology

Heart rate

Descriptive statistics for HRT across groups are presented in Table 3. A 3 (Group) $\times$ 2 (Valence) repeated measures ANOVA was used to examine group differences in HRT (change from baseline to the two blocks of the task). The square of baseline heart rate was entered as a covariate to control for under-adjustment of analyses (LIV; Wilder, 1958; Cacioppo & Petty, 1982). Contrary to expectation, analyses revealed no main effects for Group, F (2, 75) = 0.174, ns, or Valence, F (1, 75) = 3.275, ns. However, an interaction effect for Group $\times$ Valence was observed, F (2, 75) = 3.970, $p<0.05$. Paired-samples t-tests indicated higher HRT during the neutral block than during the threat block for the TS group, t (26) = 2.243, $p<0.05$, but not the TC group, t (25) = 1.161, ns, or the TC group, t (26) = -1.441, ns. RSA data were also derived and analyzed, but no group differences were observed.

Manipulation check

One-way ANOVAs were conducted to examine whether groups differed in reported difficulty of the task, effort during the task, and success in the task. Analyses revealed no significant group differences in self-reported task difficulty, F (2, 78) = 0.010, ns, or success in the task, F (2, 78) = 0.956, ns. However, group differences in self-reported effort during the task were observed, F (2, 78) = 5.062, $p<0.01$. Independent samples t-tests indicated that the TW group reported less effort ($M = 3.52$, SD = 0.94) than the TS group ($M = 4.22$, SD = 0.75), t (52) = -3.048, $p<0.01$, and the TC group ($M = 4.07$, SD = 0.87), t (52) = -2.255, $p<0.05$, that did not differ from each other, t (52) = 0.668, ns. Group differences in self-reported thought frequency were observed, F (2, 78) = 16.309, $p<0.001$. Independent samples t-tests indicated that the TS group reported less frequent thought occurrence during the task, ($M = 2.52$, SD = 0.85) than the TC group ($M = 3.93$, SD = 0.87), t (52) = -6.003, $p = 0.000$, and the TW group ($M = 3.37$, SD = 1.00), t (52) = $-$ 3.363, $p = 0.001$, and the TW group also reported less frequent thought occurrence than the TC group, t (52) = 2.167, $p<0.05$.

Discussion

The present results for memory bias generally support and extend the postulates of ironic processes theory, with particular implications for understanding of cognitive processing of threat material. Conversely, results for heart rate failed to support study hypotheses. In the comments below, limitations for both sets of data are discussed along with possible directions for future research.

Thought suppression enhances memory bias

Results from the current study provide support for the hypothesis that attempts at suppression of threat words generates an enhanced memory bias for these words, compared with the effects of concentrating on or just noticing the words. As demonstrated by significant results for the MANOVA, between-group effects for implicit memory bias coupled with between-group effects for explicit memory bias indicate an overall elevation of memory biases in the TS group relative to the TC and TW groups. Results for univariate analyses suggest that this enhancing effect of thought suppression is driven by a significantly elevated bias in explicit recognition memory. Although group differences in implicit memory bias were not statistically significant, the relative ordering of the TS group compared with the other experimental groups was consistent with findings for explicit memory bias.

Findings for memory bias support and extend the postulates of Wegner's ironic processes theory (1994) in several ways. First, findings suggest that threat-related thought suppression may paradoxically enhance subsequent memory for this material as assessed through explicit modalities, in addition to its ironic effects on attention (i.e., hyperaccessibility and rebound) that have been investigated more extensively in previous studies. Theoretical links between thought suppression and memory have been discussed in prior research (e.g., Bjork & Bjork, 2003), but have not been empirically investigated. Additionally, results were suggestive of a genuine memory bias rather than a more general response bias, given that the thought suppression group was not more likely than the other two groups to show a recognition bias for new threat words relative to new neutral words.

Interestingly, results for explicit memory bias showed a larger effect size and attained statistical significance, whereas results for implicit memory showed a smaller effect size and did not reach significance. This result was relatively surprising, given that the majority of prior research on memory bias in the anxiety disorders has found greater evidence for an implicit rather than explicit memory bias (reviewed in Coles & Heimberg, 2002) and Bjork and Bjork (2003) similarly suggested that thought suppression may generate stronger effects on implicit rather than explicit memory. Differing methodologies across studies may account for this discrepancy. In the present study, participants were never required to reproduce the words presented during the experiment, in either the explicit or the implicit memory tasks. Consequently, response avoidance biases are less likely to have influenced the current set of results than might occur in tasks in which reproduction of threat material is required, such as word stem completion and recall tasks. This is also suggested by the finding that all three groups in the present study demonstrated an explicit memory bias for threat words, though the TS group exhibited a significantly stronger bias. It is also possible that the sensitivity of the implicit measure used in the current study was weakened by changes in the gender of speaker of words from the experimental manipulation to the memory task, as the effect of changes in speaker characteristics has not been thoroughly investigated in previous white-noise judgment research (Jacoby, personal communication), or by low reliability of difference scores in general (Lord, 1956).

Results for implicit and explicit memory biases also differed in the direction of effects across groups. While all groups showed a degree of explicit bias toward threat, the groups varied in implicit bias, with TS group showing no bias, the TC group showing a trend toward bias away from threat, and the TW group showing a significant bias away from threat. Differing perceptual processing modalities may also be involved in this discrepancy. The implicit task involved primarily auditory perception while the explicit task also involved visual perception, and prior experimental research has suggested that anxious processes may be enhanced by visual or imagery processing (e.g., Holmes & Mathews, 2005). The visual nature of the explicit memory task may have more strongly elicited imagery processing that helped to activate the threat-related associative network in memory and generate a greater bias across the groups.

The explicit memory bias findings suggest that the ironic effects of thought suppression appear to privilege threat material over neutral material. That is, the enhanced explicit memory bias in the TS group was characterized by a similar level of recognition for threat words and a decreased level of recognition for neutral words compared with the TC and TW groups. Results did not suggest a relative increase in recognition for threat words in the TS group. This finding may be influenced by possible ceiling effects on hit rate for threat words, as all groups showed notably high hit rates and limited between-group variability in hit rates for threat words (0.86–0.88). Lower hit rates and increased between-group variability in hit rates for neutral words (0.73–0.85) suggests that recognition for neutral words may not have been as susceptible to ceiling effects. Future studies might increase duration of time between the experimental manipulation and memory tasks in order to lessen potential ceiling effects.

Potential limitations for memory bias data

The primary limitation of the current study is the lack of a low trait anxious group to which results for the high trait anxious sample may be compared. Also, due to the selection criteria for the current sample, it remains unclear whether similar results might be obtained in an unselected sample. Though high trait anxious groups tend to report increased effortful thought suppression relative to low trait anxious groups (Freeston et al., 1991; Freeston, Ladouceur, Thibodeau, & Gagnon, 1992) it is possible that the association between thought suppression and enhanced memory bias for threat material may represent a more general phenomenon. This would be consistent with findings that memory for emotionally valenced material is typically heightened relative to neutral material (e.g., Bower, 1992; Guy & Cahill, 1999), but could indicate ways in which such mechanisms may become maladaptive following efforts at thought suppression. The next step is to compare memory bias for threat words following instructed thought suppression in a low trait anxious or unselected sample, an important question in and of itself.

It should also be noted that the semantic relatedness of threat words in the current study may have partially contributed to their enhanced recognition across groups, as memory for each threat word may have enhanced the cognitive accessibility of other threat words (Bower & Forgas, 2000). This contrasted with the neutral words that were not semantically related. However, other previous information-processing studies using semantically related threat words and unrelated neutral words have not shown significant effects for memory bias (e.g., Becker et al., 1999; Mathews & MacLeod, 1985; Rapee et al., 1994; see Coles & Heimberg, 2002, for a review). Last, as past thought suppression studies (e.g., Purdon, 2001) have suggested that participants in control groups may attempt to spontaneously suppress aversive material, it may have been informative to assess suppression effort across all three groups using the manipulation check questionnaire.

Thought suppression and physiology

Results for the heart rate data did not support the hypothesis that thought suppression is associated with increased physiological arousal compared with thought concentration and thought wandering. Rather, an interaction effect was observed, whereby the TS group showed significantly elevated arousal during the neutral block compared with the threat block, while the TC and TW groups did not exhibit differences in arousal during the neutral block relative to the threat block. This finding seems to suggest that the instruction to engage in thought suppression may actually decrease arousal for threat-related words relative to neutral words. In accord, recent neurobiological research proposes that there may be short-term reductions in physiological arousal when emotional experience is processed in a controlled linguistic manner, as verbal processing of threat stimuli may partially inhibit amygdala activation (e.g., Lieberman et al., 2007). Alternatively, participants may be more accustomed to suppressing threat words than neutral words in everyday life, such that participants found suppression during the threat block more natural and habitual, and thus less arousing. It is also possible that the increased arousal for neutral words relative to threat words shown in the TS group may index more effortful attempts at thought suppression, the success of which may be indicated by the decrease in recognition for neutral words. A limitation of the design of the study was that effort involved in compliance with instructions, including suppression effort, was not completed separately after each block. Lastly, despite the possible success of thought suppression on physiological arousal in the short term, a rebound effect for physiological arousal may be observed once suppression attempts have ended. The design of the current study only allowed for evaluation of the immediate effects of thought suppression on physiological arousal, and future studies may evaluate longer-term effects.

Measures other than heart rate may serve as stronger or more appropriate indices of the physiological effects of threat-related thought suppression. In studying the suppression of emotion expression, Gross and Levenson (1993, 1997) found that measures such as skin conductance, respiratory activation, and sympathetic activation of the cardiovascular system were stronger markers of physiological arousal than heart rate. Heart rate was isolated for the present study in order to evaluate autonomic activity in general and to accommodate the use of the various other dependent measures.

Implications for anxiety disorders

Individuals with anxiety disorders are prone to attempts at thought suppression, but they often find that despite their best efforts, they continue to experience intrusive and persistent threat-related thoughts. Ironic processes theory proposes an explanation for this phenomenon and the conditions under which memory biases are most likely to be observed. To date, less evidence has been accrued for memory biases in the anxiety disorders relative to attentional biases (Coles & Heimberg, 2002). Empirical investigation of threat-related thought suppression represents a critical step in informing scientific understanding of both the magnitude and limitations of thought suppression in its effects on cognitive and physiological indices of anxiety. The present study is one of the first to suggest that attempts at thought suppression generate an enhanced memory bias for threat material. Further research is needed to examine whether this elevated memory bias may generate other and perhaps longer-term memory-related and physiological consequences for individuals across a variety of populations.

Acknowledgments

We would like to acknowledge contributions made by Steven Smith, Ph.D., to early phases of study design.

References

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders*, fourth ed., text revision. Washington, DC: American Psychiatric Association.

Amir, N., McNally, R. J., Riemann, B. C., & Clements, C. (1996). Implicit memory bias for threat in panic disorder: Application of the white noise paradigm. *Behaviour Research and Therapy*, *34*, 157–162.

Amir, N., McNally, R. J., & Wiegartz, P. S. (1996). Implicit memory bias for threat in posttraumatic stress disorder. *Cognitive Therapy and Research*, *20*, 625–635.

Becker, E., Rinck, M., Roth, W. T., & Margraf, J. (1998). Don't worry and beware of white bears: Thought suppression in anxiety patients. *Journal of Anxiety Disorders*, *12*, 39–55.

Becker, E. S., Roth, W. T., Andrich, M., & Margraf, J. (1999). Explicit memory in anxiety disorders. *Journal of Abnormal Psychology*, *108*, 153–163.

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Respiratory sinus arrhythmia: Autonomic origins, physiological mechanisms, and psychophysiological implications. *Psychophysiology*, *30*, 183–196.

Bjork, E. L., & Bjork, R. A. (2003). Intentional forgetting can increase, not decrease, residual influences of to-be-forgotten information. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*, 524–531.

Bower, G. H. (1992). How might emotions affect learning? In S. Christianson (Ed.), *The handbook of emotion and memory: Research and theory* (pp. 3–31). Hillsdale, NJ, England: Lawrence Erlbaum Associates.

Bower, G. H., & Forgas, J. P. (2000). Affect, memory, and social cognition. In E. Eich, J. F. Kihlstrom, G. H. Bower, J. P. Forgas, & P. M. Niedenthal (Eds.), *Cognition and emotion* (pp. 87–168). New York: Oxford University Press.

Cacioppo, J. T., & Petty, R. E. (Eds.). (1982). *Perspectives in cardiovascular physiology*. New York: Guilford Press.

Carroll, J. B., Davies, P., & Richman, B. (1971). *The American heritage word frequency book*. Boston, MA: Houghton Mifflin.

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of Personality & Social Psychology*, *67*, 319–333.

Coles, M. E., & Heimberg, R. G. (2002). Memory biases in the anxiety disorders: Current status. *Clinical Psychology Review*, *22*, 587–627.

Dowens, M. G., & Calvo, M. G. (2003). Genuine memory bias versus response bias in anxiety. *Cognition and Emotion*, *17*, 843–857.

Ehlers, A., & Steil, R. (1995). Maintenance of intrusive memories in posttraumatic stress disorder: A cognitive approach. *Behavioural and Cognitive Psychotherapy*, *23*, 217–249.

Fehm, L., & Margraf, J. (2002). Thought suppression: Specificity in agoraphobia versus broad impairment in social phobia? *Behaviour Research and Therapy*, *40*, 57–66.

Frazier, T. W., Strauss, M. E., & Steinhauer, S. R. (2004). Respiratory sinus arrhythmia as a measure of emotional response in young adults. *Psychophysiology*, *41*, 75–83.

Freeston, M. H., Ladouceur, R., Thibodeau, N., & Gagnon, F. (1991). Cognitive intrusions in a non-clinical population: I. Response style, subjective experience, and appraisal. *Behaviour Research and Therapy*, *29*, 585–597.

Freeston, M. H., Ladouceur, R., Thibodeau, N., & Gagnon, F. (1992). Cognitive intrusions in a non-clinical population: II. Associations with depressive, anxious and compulsive systems. *Behaviour Research and Therapy*, *30*, 263–271.

Gilbert, T. T., & Osborne, R. E. (1989). Thinking backward: Some curable and incurable consequences of cognitive busyness. *Journal of Personality and Social Psychology*, *57*, 940–949.

Gosselin, P., Langlois, F., Freeston, M. H., Ladouceur, R., Laberge, M., & Lemay, D. (2007). Cognitive variables related to worry among adolescents: Avoidance strategies and faulty beliefs about worry. *Behaviour Research and Therapy*, *45*, 225–233.

Gross, J. J., & Levenson, R. W. (1993). Emotional suppression: Physiology, self-report, and expressive behavior. *Journal of Personality and Social Psychology*, *64*, 970–986.

Gross, J. J., & Levenson, R. W. (1997). Hiding feelings: The acute effects of inhibiting negative and positive emotion. *Journal of Abnormal Psychology*, *106*, 95–103.

Guy, S. C., & Cahill, L. (1999). The role of overt rehearsal in enhanced conscious memory for emotional events. *Consciousness and Cognition*, *8*, 114–122.

Harvey, A. G., & Bryant, R. A. (1999). The role of anxiety in attempted thought suppression following exposure to distressing or neutral stimuli. *Cognitive Therapy and Research*, *23*, 39–52.

Hayes, S. C., Wilson, K. G., Gifford, E. V., Follette, V. M., & Strosahl, K. (1996). Experiential avoidance and behavioral disorders: A functional dimensional approach to diagnosis and treatment. *Journal of Consulting and Clinical Psychology*, *64*, 1152–1168.

Holmes, E. A., & Mathews, A. (2005). Mental imagery and emotion: A special relationship? *Emotion*, *5*, 489–497.

Jacoby, L. L., Allan, L. G., Collins, J. C., & Larwill, L. K. (1988). Memory influences subjective experience: Noise judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *14*, 240–247.

Jacoby, L. L., Toth, J. P., Lindsay, D. S., & Debner, J. A. (1992). Lectures for a layperson: Methods for revealing unconscious processes. In R. F. Bornstein, & T. S. Pittman (Eds.), *Perception without awareness: Cognitive, clinical, and social perspectives* (pp. 81–120). New York: Guilford Press.

Jorm, A. F., Christensen, H., Henderson, A. S., Jacomb, P. A., Korten, A. E., & Rodgers, B. (1999). Using the BIS/BAS scales to measure behavioural inhibition and behavioural activation: Factor structure, validity and norms in a large community sample. *Personality and Individual Differences*, *26*, 49–58.

Lieberman, M. D., Eisenberger, N. I., Crockett, M. J., Tom, S. M., Pfeifer, J. H., & Way, B. M. (2007). Putting feelings into words: Affect labeling disrupts amygdala activity to affective stimuli. *Psychological Science*, *18*, 421–428.

Lord, F. M. (1956). The measurement of growth. *Educational and Psychological Measurement*, *16*, 421–437.

Marcks, B. A., & Woods, D. W. (2005). A comparison of thought suppression to an acceptance-based technique in the management of personal intrusive thoughts: A controlled evaluation. *Behaviour Research and Therapy*, *43*, 433–445.

Markowitz, L. J., & Borton, J. L. S. (2002). Suppression of negative self-referent and neutral thoughts: A preliminary investigation. *Behavioural and Cognitive Psychotherapy*, *30*, 271–277.

Mathews, A., & MacLeod, C. (1985). Selective processing of threat cues in anxiety states. *Behaviour Research and Therapy*, *23*, 563–569.

Mathews, A., & Milroy, R. (1994). Effects of priming and suppression of worry. *Behaviour Research and Therapy*, *32*, 843–850.

McNally, R. J., Metzger, L. J., Lasko, N. B., Clancy, S. A., & Pitman, R. K. (1998). Directed forgetting of trauma cues in adult survivors of sexual abuse with and without posttraumatic stress disorder. *Journal of Abnormal Psychology*, *107*, 596–601.

Mogg, K., Bradley, B. P., Dixon, C., Fisher, S., Twelftree, H., & McWilliams, A. (2000). Trait anxiety, defensiveness and selective processing of threat: An investigation using two measures of attentional bias. *Personality and Individual Differences*, *28*, 1063–1077.

Mogg, K., Bradley, B. P., Millar, N., & White, J. (1995). A follow-up study of cognitive bias in generalized anxiety disorder. *Behaviour Research and Therapy*, *33*, 927–935.

Nisbett, R., & Wilson, T. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review*, *84*, 231–259.

Orne, M. T. (1962). On the social psychology of the psychological experiment: With particular reference to demand characteristics and their implications. *American Psychologist*, *17*, 776–783.

Purdon, C. (1999). Thought suppression and psychopathology. *Behaviour Research and Therapy*, *37*, 1029–1054.

Purdon, C. (2001). Appraisal of obsessional thought recurrences: Impact on anxiety and mood state. *Behavior Therapy*, *32*, 47–64.

Purdon, C., & Clark, D. A. (1993). Obsessive intrusive thoughts in nonclinical subjects, Part 1. Content and relation with depressive, anxious, and obsessional symptoms. *Behaviour Research and Therapy*, *31*, 713–720.

Purdon, C., & Clark, D. A. (2000). White bears and other elusive intrusions: Assessing the relevance of thought suppression for obsessional phenomena. *Behavior Modification*, *24*, 425–453.

Rapee, R. M., McCallum, S. L., Melville, L. F., Ravenscroft, H., & Rodney, J. M. (1994). Memory bias in social phobia. *Behaviour Research and Therapy*, *32*, 89–99.

Rosen, J. B., & Schulkin, J. (1998). From normal fear to pathological anxiety. *Psychological Review*, *105*, 325–350.

Salkovskis, P. M., & Campbell, P. (1994). Thought suppression induces intrusion in naturally occurring negative intrusive thoughts. *Behaviour Research and Therapy*, *32*, 1–8.

Salkovskis, P. M., Westbrook, D., Davis, J., Jeavons, A., & Gledhill, A. (1997). Effects of neutralizing on intrusive thoughts: An experiment investigating the etiology of obsessive–compulsive disorder. *Behaviour Research and Therapy*, *35*, 211–219.

Spielberger, C. D. (1985). Anxiety, cognition, and affect: A state-trait perspective. In A. H. Tuma, & J. D. Maser (Eds.), *Anxiety and the anxiety disorders* (pp. 171–182). Hillsdale, NJ: Erlbaum.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*, 1063–1070.

Wegner, D. M. (1994). Ironic processes of mental control. *Psychological Review*, *101*, 34–52.

Wegner, D. M., & Erber, R. (1992). The hyperaccessibility of suppressed thoughts. *Journal of Personality and Social Psychology*, *63*, 903–912.

Wegner, D. M., Schneider, D. J., Carter, S. R., & White, T. L. (1987). Paradoxical effects of thought suppression. *Journal of Personality and Social Psychology*, *53*, 5–13.

Wegner, D. M., & Zanakos, S. (1994). Chronic thought suppression. *Journal of Personality*, *62*, 615–640.

Wenzel, A., Barth, T. C., & Holt, C. S. (2002). Thought suppression in spider-fearful and nonfearful individuals. *Journal of General Psychology*, *130*, 191–205.

Wenzlaff, R. M., & Wegner, D. M. (2000). Thought suppression. In S. T. Fiske (Ed.), *Annual review of psychology*, Vol. 51 (pp. 59–91). Palo Alto, CA: Annual Reviews.

Wilder, J. (1958). Modern psychophysiology and the law of initial value. *American Journal of Psychotherapy*, *12*, 1958.

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

Wilhelm, F. H., Pfaltz, M. C., & Grossman, P. (2006). Continuous electronic data capture of physiology, behavior and experience in real life: Towards ecological momentary assessment of emotion. *Interacting with Computers*, *18*, 171–186.

Wilhelm, F. H., Roth, W. T., & Sackner, M. A. (2003). The LifeShirt: An advanced system for ambulatory measurement of respiratory and cardiac function. *Behavior Modification. Special Issue: Respiratory Psychophysiology*, *27*, 671–691.

Zeitlin, S. B., Netten, K. A., & Hodder, S. L. (1995). Thought suppression: An experimental investigation of spider phobics. *Behaviour Research and Therapy*, *33*, 407–413.