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BRIEF REPORT

Working Memory Capacity in Generalized Social Phobia

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Research suggests that understanding complex social cues depends on the availability of cognitive resources (e.g., Phillips, Channon, Tunstall, Hedenstrom, & Lyons, 2008). In spite of evidence suggesting that executive control functioning may impact anxiety (e.g., Eysenck, Derakshan, Santos, & Calvo, 2007), relatively few studies have examined working memory in individuals with generalized social phobia. Moreover, few studies have examined the role of threat-relevant content in working memory performance in clinically anxious populations. To this end, the present study assessed working memory capacity (WMC) in individuals with generalized social phobia and nonanxious controls using an operation span task with threat-relevant and neutral stimuli. Results revealed that nonanxious individuals demonstrated better WMC than individuals with generalized social phobia for neutral words but not for social threat words. Individuals with generalized social phobia demonstrated better WMC performance for threat words relative to neutral words. These results suggest that individuals with generalized social phobia may have relatively enhanced working memory performance for salient, socially relevant information. This enhanced working memory capacity for threat-relevant information may be the result of practice with this information in generalized social phobia.

Keywords: social anxiety, working memory, executive control, anxiety

There is a large body of research suggesting that individuals with generalized social phobia have biased cognitive processes that perhaps maintain and exacerbate their symptoms (e.g., Clark & Wells, 1995; Rapee & Heimberg, 1997). Whereas some social information processing occurs rapidly and automatically (e.g., detecting the presence of threatening faces; Öhman, Lundqvist, & Esteves, 2001), complex forms of social decoding may be dependent on the availability of higher level cognitive resources, such as executive control (e.g., McKinnon & Moscovitch, 2007; Phillips, Channon, Tunstall, Hedenstrom, & Lyons, 2008). Thus, abnormalities in executive control may contribute to incorrect evaluations of social cues. For example, diminished cognitive resources may lead to a bias toward confirmatory information in generalized social phobia (Fischer, Greitemeyer, & Frey, 2008). In spite of research suggesting that individuals with generalized social phobia are characterized by aberrant social information processing, relatively few studies have examined executive control in these individuals. Executive control refers to a set of separate but related processes used to regulate cognitive functioning (e.g., Friedman et al., 2008). Executive control is thought to comprise three functions: (a) inhibiting inappropriate responses or interference from irrelevant information, (b) shifting attention to remain focused on task-relevant information and updating, and (c) maintaining information in working memory for short-term storage (Miyake, Friedman, Emerson, Witzki, & How-Erter, 2000).

In a recent review of executive control in anxiety, Eysenck et al. (2007) suggested that individuals with elevated trait anxiety experience deficits in attention control that lead to poor performance on cognitive tasks. According to Eysenck's attention control theory (Eysenck et al., 2007), anxiety impedes performance on cognitive tasks by increasing stimulus-driven attentional processing at the expense of goal-directed attentional processing. This dysregulation is thought to interfere with inhibition and shifting components of the central executive because these components rely heavily on attention control. The remaining function of executive control (i.e., updating) may also be affected by anxiety under stressful testing conditions. A number of studies conducted with tasks such as verbal reasoning (MacLeod & Donnellan, 1993), spatial reasoning (Markham & Darke, 1991), reading comprehension (Calvo, Eysenck, Ramos, & Jiménez, 1994), verbal working memory (Ikeda, Iwanaga, & Seiwa, 1996), and sustained attention (Elliman, Green, Rogers, & Finch, 1997) support this model. In general, findings from these studies indicate that individuals with elevated anxiety perform worse on tasks measuring executive functioning relative to individuals with low levels of anxiety.

According to this model, anxiety predicts poor performance on cognitive tasks because anxious individuals experience unwanted

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cognitions that consume attentional resources while they attempt to complete the tasks (Eysenck & Calvo, 1992; Eysenck et al., 2007). For example, individuals with generalized social phobia may have recurrent, intrusive, cognitions regarding social performance that are difficult to control (e.g., Hackmann, Surawy, & Clark, 1998). These cognitions are often related to others' perception of their social performance and are frequently associated with a particularly negative autobiographical memory (Hackmann, Clark, & McManus, 2000). Moreover, intrusive cognitions may also occur after social events in the form of postevent processing (for a review, see Brozovitch & Heimberg, 2008) and worry (Cowden, 2005). For example, Rachman, Grüter-Andrew, and Shafran (2000) reported that social anxiety is associated with greater tendencies to engage in negative postevent processing of social situations that are difficult to control. Thus, individuals with generalized social phobia experience recurring anxiety-relevant cognitions during and after social events. Given that these types of cognitions result in relatively diminished attention control, individuals with generalized social phobia may show deficits in performance on working memory tasks.

Working memory capacity (WMC) tasks require concurrent processing of dual tasks and have been used to measure attention control (e.g., Engle, 2002). For example, in the Operation Span paradigm (OSPAN; Turner, & Engle, 1989), participants try to remember sequentially presented words while simultaneously solving simple math equations. The primary dependent measure is the number of words the participant can recall in correct serial order. Performance on this task predicts performance on tasks tapping complex cognitive processes such as fluid ability (e.g., Engle, Tuholski, Laughlin, & Conway, 1999) and emotion regulation (Schmeichel, Volokhov, & Demaree, 2008). However, research evaluating WMC in anxious individuals has produced mixed findings. Studies evaluating WMC in high- and low-anxious individuals have failed to find group differences in WMC (e.g., Calvo & Eysenck, 1996; Calvo et al., 1994) or that high-anxious individuals perform better than low-anxious individuals (Sorg & Whitney, 1992). When a stressor is added (e.g., a video game competition), one study failed to find differences between high- and low-anxious individuals on WMC (Sorg & Whitney, 1992), whereas another study found worse performance in high-anxious individuals relative to low-anxious individuals (e.g., Darke, 1988). These mixed findings may be due to methodological differences, such as materials used and level of anxiety of participants. Moreover, these studies cannot speak to WMC performance in individuals with clinical levels of anxiety nor to how stimuli valence influences WMC abilities.

The goal of the present study was to evaluate WMC performance in clinically anxious individuals with generalized social phobia using neutral and social threat stimuli. To our knowledge, no studies have compared the ability to maintain neutral and threat-relevant stimuli in working memory in clinically anxious populations. To do so, we asked each participant to complete the OSPAN task with both neutral and social-threat word stimuli. Previous research has demonstrated that threat-relevant information impairs information processing in anxious individuals when processing this information is task incongruent (e.g., emotional Stroop task, Williams, Mathews, & MacLeod, 1996). Conversely, emotional information has been shown to capture attentional and memory resources better than neutral information (Calvo & Lang, 2004; Nummenmaa, Hyönä, & Calvo, 2006) and may have a working memory advantage in anxious individuals because accessing this type of information is well practiced (Hayes, Hirsch, & Mathews, 2008). Moreover, according to attention control theory, threat-relevant information is likely to capture attention in individuals who are anxious as a result of the reliance on bottom-up information processing (Eysenck et al., 2007). Consistent with this theory, studies using probe detection tasks indicate that individuals with social anxiety show attentional vigilance for threat information (e.g., Mogg, Philippot, & Bradley, 2004). Thus, when threatening information is task relevant, performance may be facilitated in anxious individuals. Given that threat information was task relevant in the present study, we hypothesized that individuals with generalized social phobia would likely demonstrate better WMC when test stimuli were threat relevant than when the stimuli were neutral.

Method

Participants

Individuals in the generalized social phobia group comprised 36 patients meeting primary *Diagnostic and Statistical Manual of Mental Disorders* (*DSM–IV* ; American Psychiatric Association, 2000) criteria for current generalized social phobia as determined by a Structured Clinical Interview for DSM–IV (SCID; Spitzer, Williams, Gibbon, & First, 1990) diagnostic interview and scoring above 60 on the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987). These participants were recruited from an ongoing clinical treatment trial conducted at the Center for Understanding and Treating Anxiety at San Diego State University; all participants completed the task prior to beginning treatment. All interviews were videotaped for reliability assessment, and the randomly selected portion (20%) of the interviews was rated by an independent clinician during weekly team meetings. Interrater reliability was high ($\kappa = 0.89$).

The nonanxious control group comprised 35 individuals who did not meet criteria for any past or present Axis I disorder based on a SCID screening completed by clinic staff. These participants were recruited from the community and scored 29 or lower on the self-report version of the LSAS (LSAS–SR; Liebowitz, 1987; Mennin et al., 2002). All participants were paid $20 for their participation.

Materials

The WMC assessment was a computer-based OSPAN task (Unsworth, Heitz, Schrock, & Engle, 2005). We presented stimuli in the center of the computer screen. Participants were seated approximately 30 cm from the computer monitor. Each trial began with a fixation cross (+) presented in the center of the screen for 500 ms. This was followed by a blank screen for 500 ms. A word then appeared for 800 ms, followed by a solved equation (e.g., $2 + 3 = 4$). Participants were asked to indicate whether the answer was correct by pressing a corresponding mouse button. The set of completed math equations was chosen from prior research on WMC tasks (e.g., Unsworth et al., 2005) and was presented with an equal number of solutions that were correct and incorrect.

After the participant made his or her decision, the next fixation cross appeared, followed by the next word. This word then disappeared, and the next equation was presented in the same manner. This repeated two to six times (reflecting WMC spans from two to six; Engle et al., 1999) such that the participants saw two to six to-be-remembered words on a particular trial. After the words and equations for a particular set were presented, the participant saw a screen listing 12 words. The participants were asked to indicate which words had been presented and in what order they occurred. After the participant indicated that he or she had completed his or her answers, the next trial block began. Each participant saw a different random order of WMC span and word type.

In order to test the effect of socially threatening information on WMC span, we included both neutral (e.g., chair) and social threat (e.g., stupid) words. For each word type, we created 10 sets of 12 words. Sets were matched on word length and word frequency (Francis & Kučera, 1982). Depending on the WMC span being tested, two to six words were presented to be remembered. The remaining six to 10 words in each set were presented during the recognition phase as distracters. In total, participants completed 20 trials (2 word types × 5 memory spans [2, 3, 4, 5, 6] × 2 trials per span).

Procedure

Each participant read and signed a consent form after entering the laboratory. Participants also completed self-report assessments (State–Trait Anxiety Inventory [STAI]; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983, and Beck Depression Inventory [BDI]; Beck, Steer, & Brown, 1996). Patients were administered the LSAS during the clinical interview; nonanxious control participants completed the LSAS–SR with the other self-report measures. The two versions of the LSAS have been shown to have similar psychometric properties and are highly correlated (Fresco et al., 2001).

The session began with a practice block of trials using neutral stimuli different from those used during the experimental session. Participants were instructed to remember words presented on the screen in the order they appeared. They were told that they should also try to solve the interspersed math problems as quickly and accurately as possible. After completing the practice, the participant completed the experimental WMC task.

Results

Self-Report Measures

Consistent with prior studies, we eliminated participants whose math accuracy was of less than 85% (e.g., Conway et al., 2005). This resulted in the removal of three participants from the generalized social phobia group and five from the nonanxious control group. In addition, one participant in the generalized social phobia group had reaction times greater than three standard deviations above the mean reaction times for the sample while solving the math problems and was removed from data analysis. Groups did not differ on age, $t(60) = 0.82$, $p = .41$; education, $t(60) = 0.77$, $p = .50$; or gender, $\chi^2(1) = 3.1$, $p > .07$. Table 1 presents clinical characteristics of the sample.

Table 1
Demographics, Questionnaire, and Math Performance Data

	Group	
Variable	Generalized social phobia (n = 32)	Nonanxious control group (n = 30)
% Female	72	50
Age in years	31.3 (9.3)	29.2 (11.4)
Education	15 (5)	15 (2)
LSAS	84.0 (11.3)	12.2 (7.2)
STAI–T	61.9 (12.9)	28.9 (7.1)
STAI–S	49.2 (9.2)	26.7 (4.7)
BDI	24.8 (10.6)	4.7 (6.0)
Reaction time (social) in ms	3,172 (1,422)	2,793 (1,321)
Reaction time (neutral) in ms	3,309 (1,531)	2,767 (1,035)
Accuracy (social)	95%	96%
Accuracy (neutral)	95%	97%
Words correctly recalled (social)	63%	68%
Words correctly recalled (neutral)	59%	70%

Note. Standard deviations are presented in parentheses. LSAS = Liebowitz Social Anxiety Scale (Liebowitz, 1987); STAI–T = Spielberger State–Trait Anxiety Inventory—Trait; STAI–S = Spielberger State–Trait Anxiety Inventory—State (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983); BDI = Beck Depression Inventory (Beck, Steer, & Brown, 1996).

Math Reaction Times

We examined reaction times for completing the math equations in the two groups. Consistent with Unsworth et al. (2005), we calculated median response latencies for each participant's math completion and then averaged across the groups (see Table 1 for descriptive statistics). The generalized social phobia group did not differ significantly from the nonanxious control group on reaction times to solve math problems for social threat, $t(60) = 1.10$, $p = .28$ or neutral words, $t(60) = 1.60$, $p = .11$.

Working Memory Span Scores

We calculated WMC scores using the sum of correctly recalled items across sets (partial-credit load scoring; Conway et al., 2005). Thus, for each trial, participants received one point for each word that was recalled in correct serial position. Means and standard errors for WMC scores are presented in Figure 1. Values for the WMC scores expressed as a percentage are also presented in Table 1. These values are consistent with prior research examining automated OSPAN performance (e.g, 70% for neutral words and 68% for threat words in nonanxious control participants compared with 74% in unselected individuals; Unsworth et al., 2005).

We submitted the WMC scores to a 2 (group: generalized social phobia, nonanxious controls) × 2 (word type: social threat, neutral) mixed-design analysis of variance (ANOVA) with repeated measurement on the second variable. These analyses did not reveal a main effect of group, $F(1, 60) = 2.40$, $p = .13$, or word type, $F(1, 60) = 0.90$, $p = .36$. There was a significant interaction of Group × Word type, $F(1, 60) = 4.80$, $p = .033$, $\eta_p^2 = .07$. Follow-up t tests revealed that groups did not differ on WMC performance for social words, $t(60) = 0.88$, $p = .38$. However, the generalized social phobia group demonstrated significantly worse WMC performance than did the nonanxious control group for

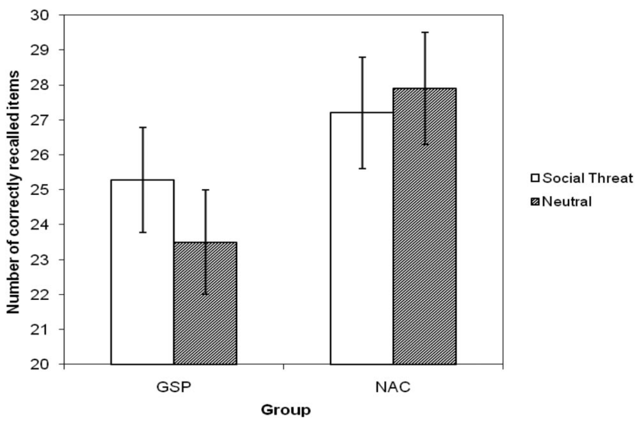

Figure 1. Working memory capacity scores for generalized social phobia (GSP) and nonanxious control (NAC) groups (error bars represent standard errors).

neutral words, $t(60) = 2.10$, $p = .042$. The nonanxious control group did not differ in WMC performance between the two word types, $t(29) = 0.85$, $p = .41$. The generalized social phobia group remembered significantly more social threat words than neutral words, $t(31) = 2.30$, $p = .028$.

Discussion

Our findings suggest that individuals with generalized social phobia differ from nonanxious controls in their WMC performance when processing stimuli with different valence (i.e., neutral vs. threat). As hypothesized, when WMC performance was tested with neutral stimuli, individuals in the nonanxious control group performed better than individuals in the generalized social phobia group. Results from the present study are consistent with prior studies suggesting that anxiety disrupts working memory performance when remembering neutral information (e.g., Darke, 1988; Sorg & Whitney, 1992) and models of working memory performance suggesting deficient WMC abilities in anxious individuals (e.g., Eysenck et al., 2007), For social threat words, however, the performance of the socially anxious and nonanxious individuals did not differ. Individuals with generalized social phobia also demonstrated better WMC when presented with social threat stimuli relative to neutral stimuli. Including threat-relevant stimuli in the task allowed us to delineate one factor that may influence basic information processing functioning in this population.

Why might socially anxious individuals demonstrate relative deficiencies on WMC functioning when the task contains neutral information? Eysenck and Calvo (1992) theorized that relatively diminished working memory in anxious individuals may be the result of concurrent cognitive processes during the task, such as worry and rumination. These cognitive processes are proposed to consume working memory resources and thus negatively impact performance. Consistent with this hypothesis, research suggests that worry explains additional variance in WMC performance beyond anxious mood (Crowe, Matthews, & Walkenhorst, 2007) and that worry specifically decreases WMC in anxious individuals (Hayes et al., 2008). A growing body of evidence suggests that social anxiety is characterized by recurrent, intrusive cognitions, including negative self images (Hackmann et al., 2000), rumination (Rachman et al., 2000), and worry (Cowden, 2005). These specific types of anxiety-relevant cognitions may impact WMC functioning of these individuals, leading to poorer performance on the task. Future research is needed to evaluate further the relationship between WMC performance and specific forms of anxiety-relevant cognitions.

This account of diminished WMC does not explain the relatively improved performance on social threat trials relative to neutral trials in the generalized social phobia group. One explanation for enhanced WMC for social threat words in individuals with generalized social phobia may pertain to attention control. Engle (2002) posited that performance on WMC tasks reflects one's ability to allocate attentional resources to the stimuli being input, maintained, and discarded in the working memory store. Poor control over these processes leads to poor WMC performance, whereas greater attention control results in the opposite effect. Because social threat words are particularly salient for individuals with generalized social phobia relative to neutral words, processing these words likely requires fewer attentional resources for socially anxious individuals (Eysenck et al., 2007). That is, less attention control may be needed because attention is partially controlled by stimulus salience, which relies on automatic processing based on prior experience. As a result, actively manipulating and storing threat words in memory while simultaneously performing the math task would be less challenging than neutral words. This explanation is consistent with research demonstrating that socially anxious individuals are characterized by attention bias for threatening stimuli relative to nonanxious individuals (e.g., Mogg, Philippot, & Bradley, 2004; Pishyar, Harris, & Menzies, 2004) while nonanxious individuals demonstrate an attentional avoidance of social threat information (Mogg et al., 2000). Although in other cognitive paradigms such as the emotional Stroop task such attentional biases may be detrimental to anxious individuals' performance because they interfere with the primary task, in the case of WMC tasks, these biases are congruent with task goals. Thus, the observed pattern of relatively better performance on social threat trials compared with neutral trials in socially anxious individuals may reflect greater allocation of attentional resources to stimuli that are threatening.

The present results suggest that biases in WMC may be one factor that influences performance in social situations for individuals with social anxiety. As noted in the introduction, processing of complex social cues requires available cognitive resources. Because not all stimuli in the environment can be simultaneously processed and maintained as active representations at any one time, multiple stimuli in the environment compete for cognitive resources. The current study indicates that compared with nonanxious individuals, threat stimuli may be retained in working memory relatively more efficiently than neutral information for individuals with generalized social phobia. Because working memory influences processes such as attention (Huang & Pashler, 2007) and long–term memory formation (Ranganath, Cohen, & Brozinsky, 2005) biases, retention of threat information in working memory may play a particularly crucial role in the information-processing biases theorized to be involved in the maintenance of social anxiety. As such, programs designed to improve or train working memory for nonthreat information may be a useful method for enhancing processing of benign information in individuals with social anxiety.

From a clinical perspective, implementing effective treatments for social anxiety may also benefit from considering the parameters of WMC functioning. Components of most cognitive–behavioral therapy programs require strategically implementing learned principles under conditions of stress (e.g., identifying negative thoughts and generating alternatives when approaching anxiety-provoking situations). These tasks require cognitive resources to overcome automatic tendencies at a time when these resources may be most taxed by hypervigilance to potential threat. Given that cognitive resources available for processing benign or neutral information are relatively diminished for these individuals, implementing certain therapy components (e.g., attending to and evaluating disconfirming evidence for negative beliefs) may be particularly challenging. Future research is needed to better understand the relationship between WMC functioning and implementation and efficacy of cognitive behavioral interventions.

Our study has limitations. First, because the patient group was also more depressed and anxious than the nonanxious group, it is not possible to rule out potential effects of general anxiety or depression on our results. Future studies should include a group of individuals with depression or high trait anxiety and low social anxiety to examine the effect of word content and social anxiety in this paradigm. Moreover, although participants reported high levels of depression on the BDI, only one individual in the generalized social phobia group met *DSM–IV* criteria for major depressive disorder. Although this bolsters the argument that the observed findings are specific to social anxiety, the present sample may not be representative of all individuals with generalized social phobia. Moreover, we only used one type of emotional information in the WMC task. Therefore, it is not possible to rule out the possibility that emotional salience (and not social relevance) or general arousal level accounted for the results. Finally, viewing social threat stimuli on half of the trials may have influenced performance on neutral trials. Further research is needed to examine the mechanisms relating WMC to intrusive cognitions in generalized social phobia (e.g., imagery and rumination).

In summary, the present results support the conclusion that socially anxious individuals demonstrate differential patterns of WMC performance relative to nonanxious individuals, depending on the type of information that is being processed. This pattern may be the result of differential allocation of attentional resources to social threat information in individuals with social anxiety relative to nonanxious individuals. Thus, deficits in this cognitive capacity may partially account for cognitive biases characteristic of this disorder.

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