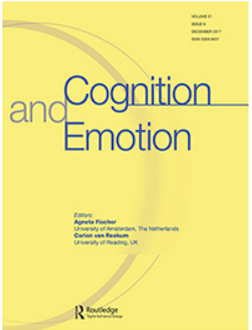

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BRIEF ARTICLE

Working memory in social anxiety disorder: better manipulation of emotional versus neutral material in working memory

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ABSTRACT
Individuals with social anxiety disorder (SAD) engage in post-event processing, a form of perseverative thinking. Given that deficits in working memory might underlie perseverative thinking, we examined working memory in SAD with a particular focus on the effects of stimulus valence. SAD ($n = 31$) and healthy control ($n = 20$) participants either maintained (forward trials) or reversed (backward trials) in working memory the order of four emotional or four neutral pictures, and we examined sorting costs, which reflect the extent to which performance deteriorated on the backward trials compared to the forward trials. Emotionality of stimuli affected performance of the two groups differently. Whereas control participants exhibited higher sorting costs for emotional stimuli compared to neutral stimuli, SAD participants exhibited the opposite pattern. Greater attention to emotional stimuli in SAD might facilitate the processing of emotional (vs. neutral) stimuli in working memory.

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Working memory; executive control; social anxiety disorder; attention

Social anxiety disorder (SAD) is characterised by anticipatory anxiety and post-event processing during which individuals with SAD ruminate about the causes and implications of recent social interactions (Brozovich & Heimberg, 2008). According to attentional control theory (ACT; Eysenck, Derakshan, Santos, & Calvo, 2007), these intrusive, perseverative thoughts consume the limited attentional resources of working memory. Thus, SAD might be associated with deficits in working memory.

Indeed, recent evidence suggests that working memory, which involves the ability to store and manipulate information relevant to current tasks and goals (Baddeley, 2003), is impaired in SAD. For example, the extent to which visual working memory performance suffered in the presence of neutral distractors (compared to the no distractor condition) was significantly correlated with the level of social anxiety in a non-clinical sample (Moriya & Sugiura, 2012). That is, higher levels of social anxiety were associated with greater difficulty filtering out distractors, resulting in difficulties maintaining task-relevant information in working memory. A study examining the effects of stimulus valence (negative and neutral) on working memory in SAD found that non-anxious (vs. SAD) individuals maintained neutral words in working memory significantly better whereas no group differences were found for social threat words (Amir & Bomyea, 2011). In addition, individuals with SAD maintained social threat words in working memory significantly better than neutral words. These findings highlight the importance of utilising emotional stimuli in examining working memory in SAD, but it remains unclear whether SAD is associated with deficits in working memory for all non-threatening stimuli (i.e. both neutral and positive stimuli) or for only non-emotional stimuli (i.e. neutral stimuli).

Previous research focused on the ability to maintain relevant information in working memory. However, for the working memory system to be efficient, it is critical to be able to flexibly manipulate the information in working memory to respond to changes in the

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environment and goals (Joormann, Levens, & Gotlib, 2011). Baddeley (2003) also argued that internal manipulation of stored information is required for higher-order cognitive skills such as problem solving and decision-making. Along this line, the ability to manipulate and update information in working memory has been linked to a range of cognitive processes, including inhibitory control (Minamoto, Osaka, & Osaka, 2010). Furthermore, recent evidence suggests that depression is associated with difficulties *manipulating* information in working memory (Joormann et al., 2011). In this study, participants saw three words presented one at a time. They were then instructed to recall the words in the order in which they were presented or in a reverse order, which requires manipulating the content in working memory. Compared to healthy controls, participants with depression exhibited greater difficulty manipulating words in working memory.

Similar to depression, SAD is associated with high rates of worry and rumination (McEvoy, Watson, Watkins, & Nathan, 2013). Worry (e.g. Stout, Shackman, Johnson, & Larson, 2015) and anxiety in general (see Moran, 2016, for review) have been associated with deficits in working memory capacity. Importantly, detrimental effects of intrusive thoughts in anxiety on working memory are supposed to be pronounced on tasks requiring the use of central executive with its processing-and-storage function (Eysenck et al., 2007). Therefore, SAD might be associated with particular deficits in manipulating (vs. maintaining) information in working memory. Thus, the current study examined the ability to manipulate information in working memory in SAD using emotional stimuli (positive, negative, and neutral). We adapted a task used in a previous study (Joormann et al., 2011) with two changes. First, pictorial stimuli were used in place of words as pictures are more ecologically valid. Second, participants were presented with four stimuli on each trial in the current study, instead of three stimuli. This change was introduced to require manipulation of each and every stimulus on reverse trials.

Regardless of participants' clinical status and the valence of stimuli, we expected the presence of sorting costs that reflect the extent to which participants' performance is hampered on backward trials compared to forward trials. That is, we expected everyone to exhibit greater decrement in their performance on the trials requiring manipulation (i.e. backward trials) compared with the trials requiring pure maintenance (i.e. forward trials) of information. We, however, expected the sorting costs to be higher in the SAD group, suggesting greater difficulties in manipulating content in working memory. Whether the emotional content of the stimuli modulates the performance of individuals with and without SAD differently when it comes to the manipulation aspect of working memory is an open question. Emotional stimuli tend to "grab" attention (e.g. Kensinger & Corkin, 2003). This biasing of attention toward emotional stimuli could interfere with task performance, when an emotional aspect of a stimulus is task-irrelevant as in the case of emotional Stroop task. In the current study, however, contents (and by extension emotional aspects) of stimuli are task-relevant. Thus, attentional biases toward emotional stimuli could lead to an enhanced processing of emotional (vs. neutral) material in working memory (Kensinger & Corkin, 2003). That is, participants were expected to manipulate emotional stimuli better than neutral stimuli (i.e. less sorting cost for emotional than neutral stimuli). Considering the presence of negative attentional biases in SAD (e.g. Schofield, Johnson, Inhoff, & Coles, 2012), holding and manipulating negative information online could be especially facilitated in individuals with SAD. That is, the SAD (vs. control: CTL) group may exhibit lower sorting cost for negative stimuli than neutral stimuli.

Methods

Participants

Participants were recruited through advertisements posted in the community (e.g. Internet bulletin boards, university kiosks) and in a local newspaper. Participants completed a telephone interview, which provided initial selection information. Based on the telephone interview, we excluded participants if they reported severe head trauma or learning disabilities, psychotic symptoms, bipolar disorder, or alcohol or substance abuse within the past 6 months. Participants were also excluded if they were younger than 18 years old, older than 60 years of age, or not fluent in English. Eligible individuals were invited to come to the laboratory for a more extensive interview.

Trained interviewers administered the Structured Clinical Interview for the DSM-IV – Clinical Version (SCID-IV; First, Spitzer, Gibbon, & Williams, 1996) to invited participants during their first visit in the study. All interviewers had extensive training in the use of the SCID and had previous experience in administering structured clinical interviews in a research setting. The

SCID has good reliability for the majority of the disorders covered in the interview (Lobbestael, Leurgans, & Arntz, 2011). For the current study, four independent raters listened to the SCID recordings and achieved perfect agreement with the original interviewers ($\kappa = 1.00$).

Individuals were included in the SAD group if they met the SAD-generalised subtype criteria of the Diagnostic and Statistical Manual of Mental Disorders (4th ed. Text Revised; DSM-IV-TR; American Psychiatric Association [APA], 2000). The never-disordered control (CTL) group consisted of individuals with no current diagnosis and no history of any Axis I disorder. A total of 57 individuals (24 CTL and 33 SAD) participated in this study. Six participants (four participants from the CTL and two participants from the SAD groups) responded correctly on less than a third of the forward trials. These participants were dropped from all analyses because their understanding of the task and/or levels of motivation were questionable. Therefore, there were 20 CTL and 31 SAD participants in the final sample. Participants in the SAD group were allowed to have comorbid conditions. A total of 20 participants had at least one additional diagnosis: 15 with Major Depressive Disorder (MDD), 6 with Generalized Anxiety Disorder, 7 with Specific Phobia, 4 with Panic Disorder, and 1 participant with Obsessive-Compulsive Disorder.

Stimuli

We selected positive, neutral, and negative pictures (128 pictures each) from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008), which provides arousal and valence ratings on a 9-point scale. The mean (SD) valence ratings were 7.14 (.54) for the positive pictures, 2.89 (.69) for the negative pictures, and 5.25 (.45) for the neutral pictures. The mean arousal ratings were 4.99 (.97) for the positive pictures, 5.47 (.88) for the negative pictures, and 3.58 (.72) for the neutral pictures.

WM-manipulation task

On each trial, participants viewed four pictures on a computer screen. The pictures were presented one at a time for 750 ms each with a 250 ms fixation point preceding each picture (Crone, Wendleken, Donohue, van Leijenhorst, & Bunge, 2006). All four pictures within a trial were of the same valence. After the presentation of the four pictures, a fixation cross was presented for 750 ms. This was followed by a cue, either the word "Backward" or the word "Forward", presented for 2500 ms. If the cue was "Forward", participants were instructed to remember the pictures in the order in which they were presented. If the cue was "Backward", participants had to reverse the order and re-sort them in working memory. The cue was followed by a 4000 ms delay period to allow participants to rehearse the pictures in a forward order (the maintenance trials) or re-sort the pictures (the manipulation trials). Finally, a probe picture (one of the four pictures) was presented until the participant responded. Participants were asked to press an appropriate key to indicate as quickly and as accurately as possible whether the probe was the first, second, third, or fourth picture in the set according to the cue. Participants' responses and response latencies were recorded.

There were six different conditions, which were created by varying the valence of the pictures (i.e. positive, negative, neutral) and the cue (forward, backward). Whether the first, second, third, or fourth picture was the correct response was counterbalanced. The task consisted of four blocks, and each condition was presented four times in each block, resulting in a total of 96 trials. The sequence of trials was randomised between participants.

Questionnaires

Participants completed the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987), which was originally developed as an interviewer rated measure. In this study, it was administered as a self-report measure. Participants also completed the Beck-Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996). In the current study, Cronbach's alpha was .98 for the LSAS and .95 for the BDI.

Procedure

All participants provided written informed consent and were paid $15/hour. They were tested individually within 2 weeks following their initial diagnostic interview. Participants completed the WM-manipulation task followed by the questionnaires described earlier along with a demographic form.

Data processing

We restricted our analyses of decision latencies to trials on which participants made correct responses. On average 35% of the trials were inaccurate, and there were no group differences regarding the percentage

of data removed due to inaccuracy, $t(49) = -.23$, *ns*. To eliminate outliers, we treated RTs less than 100 ms or greater than 2.5 SD above an individual's mean as missing values. This affected 2.1% of all RTs, and there were no group differences regarding the percentage of data deleted due to outliers, $t(49) = .18$, *ns*.

Results

Participant characteristics

Not everyone responded to all items, which is reflected by different dfs associated with different analyses. The CTL (5 F and 11 M) and the SAD (15 F and 16 M) groups did not significantly differ in gender composition, $\chi^2(N = 47) = 1.27$, $p = .26$. The two groups significantly differed in age, $t(39) = 2.01$, $p = .052$, with the CTL group ($M = 34.73$, $SD = 8.34$) being significantly older than the SAD group ($M = 29.12$, $SD = 8.81$). However, including age as a covariate did not alter the findings presented below. As expected, the SAD group ($M = 91.53$, $SD = 30.60$) scored significantly higher than the CTL group ($M = 30.59$, $SD = 17.44$) on the LSAS, $t(45) = -7.53$, $p < .001$. Similarly, the SAD group ($M = 26.30$, $SD = 14.93$) scored significantly higher than the CTL group ($M = 6.06$, $SD = 5.18$) on the BDI, $t(45) = -5.39$, $p < .001$.

WM-manipulation task

Manipulation – decision latencies

Mean RTs for the CTL and the SAD groups in the different conditions are presented in Table 1. A group (CTL, SAD) × valence (neutral, negative, positive) × trial type (forward, backward) repeated measures ANOVA was conducted on RTs. The main effect of valence was significant, $F(2, 98) = 3.54$, $p = .03$, $\eta_p^2 = .07$, with participants being faster on neutral trials than on negative trials. As expected, the main effect of trial type was also significant, $F(1, 49) = 74.92$, $p = <.001$, $\eta_p^2 = .61$, with participants being significantly slower on the backward (vs. forward) trials, suggesting greater difficulty manipulating (vs. maintaining) stimuli in working memory. None of the other effects were significant, including all the main and interaction effects involving group, all Fs < 1.

Manipulation – response accuracy

Mean percentages of correct responses for the CTL and the SAD groups in the different conditions are presented in Table 1. A group × valence × trial type repeated measures ANOVA on response accuracy revealed a significant main effect of trial type, $F(1, 49) = 18.80$, $p < .001$, $\eta_p^2 = .28$, again suggesting greater difficulty manipulating (vs. maintaining) stimuli in working memory. This main effect was qualified by a significant group × valence × trial type interaction, $F(2, 98) = 5.83$, $p = .004$, $\eta_p^2 = .11$. None of the other effects were significant, including all the main and interaction effects involving group, all Fs < 1.

To examine the significant 3-way interaction further, we followed previous studies (Crone et al., 2006; Joormann et al., 2011) and computed sorting costs for each participant by subtracting the number of accurate backward trials from the number of accurate forward trials. Participants' performance on the forward trials represents their ability to maintain information in working memory, whereas performance on the backward trials represents their ability to both maintain and manipulate information in working memory. Thus, subtracting performance on backward trials from performance on forward trials is crucial to control for differences in participants' ability to maintain information in working memory. Higher sorting costs indicate difficulties manipulating information in working memory while controlling for individual differences in pure maintenance (Crone et al., 2006). As expected, there was a significant group × valence interaction, $F(2, 98) = 5.83$, $p = .004$, $\eta_p^2 = .11$. Group differences approached significance for the sorting costs for neutral stimuli, $t(49) = -1.92$, $p = .06$, $d = -0.55$, but sorting costs for positive and negative stimuli did not differ significantly between the two groups, both ts(49) < 1.19, ps > .24, ds < 0.34. Within-group follow-up analyses revealed that the CTL group exhibited less sorting costs for neutral, compared to positive, stimuli ($F(1, 19) = 11.75$, $p = .003$, $\eta_p^2 = .38$), whereas the SAD group exhibited greater sorting costs for neutral (vs. negative) stimuli, $F(1, 30) = 6.46$, $p = .016$, $\eta_p^2 = .18$. No other comparison was significant, all ts<|1.78|, all ps < .09.[1] Almost half the participants in the SAD group had comorbid MDD. It is worth noting that separating the SAD group into two groups (i.e. SAD without MDD and SAD with MDD) still yielded a significant group × valence interaction, $F(4, 96) = 3.15$, $p = .018$, $\eta_p^2 = .12$, with the same pattern of results.[2] Figure 1 depicts the mean sorting costs for the three types of stimuli in each group.

Maintenance in working memory

Previous research on maintenance of the content in working memory has yielded mixed results. Although

Table 1. Response latencies and percentage of correct responses in the two groups.

	CTL		SAD	
Condition	Response latency (ms)	Correct responses (%)	Response latency (ms)	Correct responses (%)
Forward				
Negative	2316 (622)	70.63 (18.04)	2418 (607)	68.55 (19.33)
Positive	2390 (846)	71.88 (21.70)	2179 (649)	66.73 (21.55)
Neutral	2074 (477)	69.38 (23.73)	2227 (745)	73.19 (15.83)
Backward				
Negative	3543 (2247)	60.94 (24.66)	3360 (1045)	62.10 (24.74)
Positive	3126 (1164)	57.81 (21.73)	3158 (1146)	59.27 (21.88)
Neutral	3157 (1249)	65.31 (21.11)	3092 (1094)	58.87 (24.73)

CTL = control group; SAD = social anxiety disorder group.

this was not our main interest, we also looked at the forward trials separately to examine the maintenance aspect of working memory. The group by valence repeated-measure ANOVA on RTs yielded no significant effects. Similarly, the ANOVA on response accuracy on the forward trials yielded no significant results. Thus, the SAD group did not differ significantly from the CTL group in their ability to *maintain* information in working memory.

Discussion

Despite theories positing that anxiety is associated with deficits in working memory (Eysenck et al., 2007), relatively few studies have empirically examined working memory in SAD. Furthermore, to the best of our knowledge, no study has examined the manipulation of emotional content in working memory in SAD. We demonstrated that emotionality of stimuli differentially affected the SAD and the CTL groups' sorting costs. Specifically, control participants exhibited a greater performance decrement on the trials requiring manipulation of emotional information compared with neutral information. In contrast, individuals with SAD exhibited better manipulation of emotional information, negative in particular, than neutral information.

Previous research investigating socially anxious individuals' *maintenance* of information in working memory has yielded mixed findings. For example, healthy controls maintained neutral information significantly better than the SAD group, while no significant group differences were observed for maintenance of negative information (Amir & Bomyea, 2011), suggesting that the ability to maintain neutral information was hampered in individuals with SAD. However, another study demonstrated that socially anxious individuals were better able to maintain neutral stimuli than their less anxious counterparts when no distractors were present, but group differences disappeared when distractors were introduced (Moriya & Sugiura, 2012). Our current finding suggests that individuals with SAD do not differ from the CTLs in terms of maintaining information in working memory. The differences in tasks, sample characteristics (clinical vs. analogue), and stimulus characteristics (e.g. words, complex pictures, array of squares) might be responsible for inconsistent findings. For example, Amir and Bomyea (2011) used the ospan task, in which participants are required to complete additional task (i.e. indicate whether easy math problems are solved correctly or not) while maintaining information. In contrast, forward trials in the current study require participants to simply maintain information without any additional cognitive load.

While forward trials only require simple maintenance of information, backward trials require goal-directed rearrangement of this information, and, thus, involve both maintenance and manipulation of information in working memory (Oberauer & Bialkova, 2009). As would therefore be expected, both SAD and CTL participants' performance suffered on the backward (i.e. manipulation) condition compared with the forward (i.e. maintenance) condition, resulting in positive sorting costs. More importantly, participants' diagnostic status affected sorting costs for emotional and neutral stimuli in a different manner. In the CTL group, sorting costs were higher for emotional (negative and positive) than neutral stimuli, which might be due to arousal-based competition (ABC; Mather & Sutherland, 2011). ABC theory argues that when all of the stimuli are arousing (either positive or negative), there will be an overall suppression of performance due to competitions among multiple high priority representations. Considering that manipulation of content requires greater resources than pure maintenance, the competition among emotional items can be especially costly for backward (vs. forward) trials leading to a greater sorting cost for emotional information than

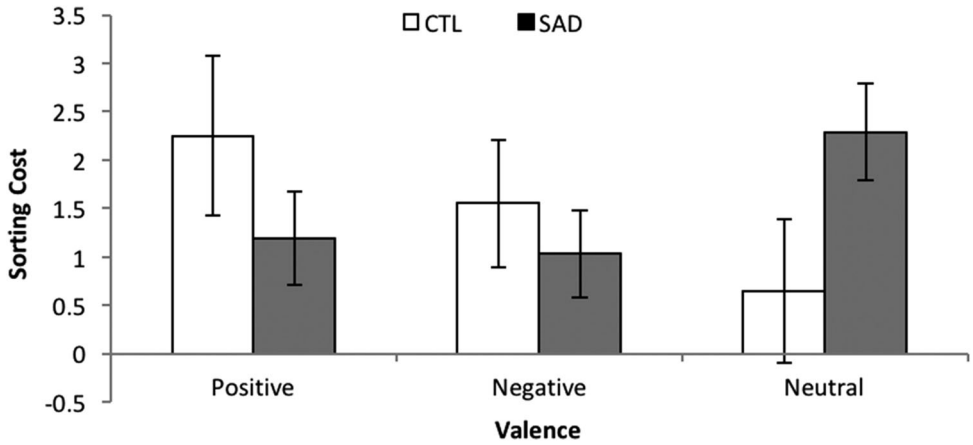

Figure 1. Mean sorting cost as a function of picture valence for control and socially anxious participants. Sorting costs were calculated by subtracting the number of accurate responses on the backward trials in which participants were instructed to remember pictures in the reverse order from the number of accurate responses on the forward trials in which participants were instructed to remember pictures in the order in which they were presented. CTL = control group; SAD = social anxiety disorder group. Error bars represent one standard error.

neutral information in the CTL group. ABC theory, however, cannot explain performance of individuals with SAD who exhibited more difficulties manipulating neutral information compared with emotional information, negative information in particular.

It is important to keep in mind that valence of stimuli in the current study was *not* task-irrelevant, distracting information. Therefore, socially anxious individuals' tendencies to attend to negative material (e.g. Schofield et al., 2012) could in fact enhance the processing of negative stimuli that are better remembered and elicit larger ERP markers of visual working memory maintenance (Sessa, Luria, Gotler, Jolicœur, & Dell'acqua, 2011). Enhanced processing of negative stimuli, in turn, could have led individuals with SAD to exhibit reduced sorting costs for negative (vs. neutral) information. Although the differences in sorting costs for neutral and positive stimuli did not differ significantly, the SAD group exhibited greater sorting costs for neutral (vs. positive) information, similar to the pattern observed for neutral vs. negative information. Individuals with SAD might find any emotional information potentially relevant and important. Along this line, fMRI studies have demonstrated that SAD is associated with heightened amygdala activity to emotionally salient stimuli, including positive stimuli (e.g. Yoon, Fitzgerald, Angstadt, McCarron, & Phan, 2007). Therefore, individuals with SAD might devote attentional resources to both positive and negative information, which in turn enhance the processing of emotional stimuli in general in working memory (Kensinger & Corkin, 2003). It is of note that the SAD group did not exhibit significantly better maintenance of negative stimuli, albeit exhibiting non-significantly better maintenance of negative (vs. positive) pictures. A pure maintenance does not require as much attention and effort as manipulation of information in working memory, and, thus, effects of attention might not be as pronounced due to the ceiling effect. We, however, acknowledge that this is pure speculation.

Being able to maintain and manipulate information in working memory should certainly be advantageous. However, if individuals focus on the wrong information for a solution or consider irrelevant information as relevant, the ability to control one's executive attention could backfire (Ricks, Turley-Ames, & Wiley, 2007). This is especially the case in real life situations where relevancy of information (or whether certain information is a distractor or not) is frequently ambiguous. If socially anxious individuals are already focused on the emotional, often negative, aspects of a situation, their ability to manipulate negative information might make other negative information more easily accessible while filtering out other (in their minds) irrelevant neutral information. Difficulty manipulating neutral information (or their need for greater cognitive control to process neutral information) could lead to difficulty problem solving in social situations. Future studies should investigate whether relative difficulties manipulating neutral (vs. negative) content in working memory are associated with functional impairment in SAD.

There are a few limitations to the current study. First, the SAD group consisted of participants with other comorbid conditions, including MDD. When the SAD group in the current study was divided into individuals with and without MDD, we found no significant differences between the two groups. However, analyses comparing two SAD groups might be underpowered due to small sample sizes. Future studies should directly compare pure MDD, pure SAD, and comorbid SAD and MDD groups in their ability to manipulate content in working memory. Only studies that directly compare these groups could clarify the similarities and differences in working memory functioning in these groups. Second, the stimuli used in the study are not social in content. Though some images were related to the concerns of SAD, most images were not. Future studies should use social stimuli to examine any biases in working memory in SAD. The use of pictorial stimuli, instead of words, might have had unexpected effects on participants' performance. That said, we believe participants' performance on the current task relied on the phonological loop (Baddeley, 2003) as would be the case if stimuli were words. Each picture on a trial was distinct from each other and could be named relatively easily. Thus, participants likely have relied on names/descriptions of pictures rather than actual images of the pictures to maintain and manipulate pictures in working memory. Considering the purported role of attention in working memory (e.g. Posner & Rothbart, 2007), it would also be important to examine the relation between attention and working memory in SAD. Lastly, error rates were high in the current study. Unlike Joormann et al. (2011) that had three words per trial, we asked participants to maintain or reverse the order of four items in each trial. This particular change likely increased task difficulty, which in turn adversely affected participants' performance. As a result, reliability of the current findings, RT results in particular, might not be at an ideal level, and thus the current findings require replication.

Despite these limitations, the current study is the first to demonstrate that differences between individuals with SAD and healthy controls in manipulating content in working memory are dependent on emotionality of content. Whereas healthy controls exhibited greater sorting costs for emotional (vs. neutral) information, individuals with SAD exhibited greater sorting costs for neutral vs. emotional information. More studies are needed to fully understand the effects of content valence on working memory in SAD and the effects of working memory biases on their functioning.

Notes

1. We also conducted analyses collapsing positive and negative stimuli together and compared sorting costs for neutral vs. emotional stimuli. Sorting costs for neutral stimuli was higher than for emotional stimuli in the SAD group, $t(30) = 2.43$, $p = .02$. In contrast, the CTL group exhibited the opposite pattern of higher sorting costs for emotional vs. neutral stimuli, $t(19) = -2.83$, $p = .01$.
2. We also conducted alternative analyses to examine whether our findings are due to high levels of depressive symptoms in the SAD group. To this effect, we conducted three separate hierarchical linear regression analyses, in which we predicted sorting costs from the LSAS scores, controlling for group, BDI scores, and the two remaining sorting costs. That is, for example, when we predicted sorting costs for negative stimuli, sorting costs for neutral and positive were included. For positive sorting costs, the LSAS scores was not a significant predictor, $\beta = -0.15$, $p = .53$. The LSAS scores were significant and unique predictors for negative, $\beta = -0.44$, $p = .04$, and neutral, $\beta = 0.40$, $p = .05$, sorting costs, suggesting that the current findings cannot be fully accounted for by high levels of depressive symptoms in the SAD group. The BDI scores did not emerge as significant predictors in the final models for positive, $\beta = -0.30$, $p = .81$, negative, $\beta = 0.08$, $p = .67$, and neutral, $\beta = -0.08$, $p = .63$.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual for mental disorders* (4th ed. TR). Washington, DC: Author.

Amir, N., & Bomyea, J. (2011). Working memory capacity in generalized social phobia. *Journal of Abnormal Psychology*, *120*(2), 504–509.

Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Reviews Neuroscience*, *4*, 829–839.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for the beck depression inventory-II*. San Antonio, TX: Psychological Corporation.

Brozovich, F., & Heimberg, R. G. (2008). An analysis of post-event processing in social anxiety disorder. *Clinical Psychology Review*, *28*(6), 891–903. doi:10.1016/j.cpr.2008.01.002

Crone, E. A., Wendleken, C., Donohue, S., van Leijenhorst, L., & Bunge, S. A. (2006). Neurocognitive development of the ability to manipulate information in working memory. *Proceedings of the National Academy of Sciences*, *103*, 9315–9320.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, *7*(2), 336–353. doi:10.1037/1528-3542.7.2.336

First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. W. (1996). *Structured clinical interview for DSM-IV axis I disorders – clinician version (SCID-CV)*. Washington, DC: American Psychiatric Press.

Joormann, J., Levens, S. M., & Gotlib, I. H. (2011). Sticky thoughts: Depression and rumination are associated with difficulties manipulating emotional material in working memory. *Psychological Science*, *22*, 979–983.

Kensinger, E. A., & Corkin, S. (2003). Effect of negative emotional content on working memory and long-term memory. *Emotion*, *3*(4), 378–393. doi:10.1037/1528-3542.3.4.378

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International affective picture system (IAPS): Affective ratings of pictures and instruction manual*. (Technical Report A-8). Gainesville: University of Florida.

Liebowitz, M. R. (1987). Social phobia. *Modern Problems in Pharmacopsychiatry*, *22*, 141–173.

Lobbestael, J., Leurgans, M., & Arntz, A. (2011). Inter-rater reliability of the structured clinical interview for DSM-IV axis I disorders (SCID I) and axis II disorders (SCID II). *Clinical Psychology & Psychotherapy*, *18*(1), 75–79. doi:10.1002/cpp.693

Mather, M., & Sutherland, M. R. (2011). Arousal-biased competition in perception and memory. *Perspectives on Psychological Science*, *6*(2), 114–133. doi:10.1177/1745691611400234

McEvoy, P. M., Watson, H., Watkins, E. R., & Nathan, P. (2013). The relationship between worry, rumination, and comorbidity: Evidence for repetitive negative thinking as a transdiagnostic construct. *Journal of Affective Disorders*, *151*(1), 313–320. doi:10.1016/j.jad.2013.06.014

Minamoto, T., Osaka, M., & Osaka, N. (2010). Individual differences in working memory capacity and distractor processing: Possible contribution of top–down inhibitory control. *Brain Research*, 1335, 63–73. doi:10.1016/j.brainres.2010.03.088

Moran, T. P. (2016). Anxiety and working memory capacity: A meta-analysis and narrative review. *Psychological Bulletin*, *142*(8), 831–864. doi:10.1037/bul0000051

Moriya, J., & Sugiura, Y. (2012). High visual working memory capacity in trait social anxiety. *Plos One*, *7*(4). doi:10.1371/journal.pone.0034244

Oberauer, K., & Bialkova, S. (2009). Accessing information in working memory: Can the focus of attention grasp two elements at the same time?. *Journal of Experimental Psychology-General*, *138*(1), 64–87. doi:10.1037/a0014738

Posner, M. I., & Rothbart, M. K. (2007). Research on attention networks as a model for the integration of psychological science. *Annual Review of Psychology*, *58*(1), 1–23. doi:10.1146/annurev.psych.58.110405.085516

Ricks, T. R., Turley-Ames, K. J., & Wiley, J. (2007). Effects of working memory capacity on mental set due to domain knowledge. *Memory & Cognition*, *35*(6), 1456–1462. Retrieved from http://dx.doi.org.proxy.library.nd.edu/10.3758/BF03193615

Schofield, C. A., Johnson, A. L., Inhoff, A. W., & Coles, M. E. (2012). Social anxiety and difficulty disengaging threat: Evidence from eye-tracking. *Cognition & Emotion*, *26*(2), 300–311. doi:10.1080/02699931.2011.602050

Sessa, P., Luria, R., Gotler, A., Jolicœur, P., & Dell'acqua, R. (2011). Interhemispheric ERP asymmetries over inferior parietal cortex reveal differential visual working memory maintenance for fearful versus neutral facial identities. *Psychophysiology*, *48*(2), 187–197. doi:10.1111/j.1469-8986.2010.01046.x

Stout, D. M., Shackman, A. J., Johnson, J. S., & Larson, C. L. (2015). Worry is associated with impaired gating of threat from working memory. *Emotion*, *15*(1), 6–11. doi:10.1037/emo0000015

Yoon, K. L., Fitzgerald, D. A., Angstadt, M., McCarron, R. A., & Phan, K. L. (2007). Amygdala reactivity to emotional faces at high and low intensity in generalized social phobia: A 4-tesla functional MRI study. *Psychiatry Research: Neuroimaging*, *154*(1), 93–98. doi:10.1016/j.pscychresns.2006.05.004