Updating the emotional content of working memory in social anxiety

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ABSTRACT

Background and objectives: Cognitive accounts suggest that information processing biases have an important role in the etiology and maintenance of social anxiety (SA). Empirical evidence support this notion has been established in variety of cognitive domains. Yet, it is still not known how social anxious individuals process emotional content in working memory (WM). Maladaptive WM updating may influence emotion regulation and anxiety during social situations in SA. Thus, the aim of the present study was to explore biases when updating emotional content in SA.

Methods: 31 participants with high SA and 34 control participants performed an emotional 2-back task. Biases were assessed by intrusion cost in reaction times, which reflects the conflict between the inhibition of irrelevant content and the activation of relevant content.

Results: Results revealed a diminished intrusion cost in reaction times for irrelevant positive content in the high, but not in the low SA group. No differences were found for negative or neutral content.

Limitations: In the present study we used an analogue sample of students with high SA rather than a true clinical sample. Further research is needed to examine WM updating in clinical population.

Conclusions: These findings suggest that individuals with SA are better at inhibiting irrelevant positive information, a maladaptive cognitive bias that may prevent positive feedback from entering the cognitive system. This cognitive bias in WM may play a role in the etiology and maintenance of SA.

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1. Introduction

Social anxiety disorder (SAD) is characterized by intense fear or anxiety of situations that involve social interactions, social performance, or evaluation by others (American Psychiatric Association, 2013). SAD is a common anxiety disorder, with lifetime and 12-month prevalence of 12.1% and 7.1%, respectively (Kessler, Berglund, et al., 2005; Kessler, Chiu, Demler, Merikangas, & Walters, 2005). Cognitive accounts suggest that information processing biases constitute one of the main factors underlying social anxiety (SA) symptoms (e.g., Beck, Emery, & Greenberg, 1985; Clark & Wells, 1995; Rapee & Heimberg, 1997; Trower & Gilbert, 1989).

1.1. Information processing in social anxiety

Cognitive models suggest that when processing social information, individuals with SA notice and remember external social cues in an extensively negative fashion, leading them to perceive socially-neutral situations as threatening and hostile. Furthermore, they tend to neglect positive social information, resulting in enhanced anxiety, avoidance and safety behaviors, ultimately perpetuating symptom maintenance. Clark and Wells (1995) suggested that when exposed to social situations, individuals with SA shift their attention to internal markers (such as thoughts, feelings and body sensations) to construct a negative evaluation of how they are perceived by others. This distorted impression contributes to extend and preserve anxiety. The view that cognitive biases affecting processing of internal and external information has been established in a variety of empirical studies in different domains such as attention, interpretation and memory.

1.1.1. Attentional biases in social anxiety

Previous studies have shown that individuals with SA selectively attended toward socially threatening information more than
control participants (e.g., Asmundson & Stein, 1994; Mogg, Philippot, & Bradley, 2004). Moreover, individuals with SA were impaired in disengaging their attention away from socially threatening information to other stimuli (Amir, Elias, Klumpp, & Przeworski, 2003).

In addition, a growing body of research shows that SA is also characterized by a reduced attention to positive social cues. For example, socially anxious individuals recognized positive facial expressions slower than non-anxious individuals (e.g., Perowne & Mansell, 2002; Silvia, Allan, Beauchamp, Maschauer, & Workman, 2006). Similarly, an eye movement study demonstrated that socially anxious individuals disengaged their attention more quickly away from positive stimuli than controls (Chen, Clarke, MacLeod, & Guastella, 2012).

1.1.2. Interpretation biases in social anxiety

After external information captures our attention, it undergoes higher level processing, such as evaluation and interpretation. Studies of interpretation biases demonstrated that individuals with SA tended to interpret ambiguous social cues more negatively and to exaggerate the consequences of mildly negative social events (Amir, Foa, & Mansell, 2002; Silvia, Allan, Beauchamp, Maschauer, & Workman, 2006). In addition, they interpreted positive social outcomes in a negative manner that exacerbates negative predictions for future social interactions (Alden, Taylor, Mellings, & Laposa, 2008).

1.1.3. Memory biases in social anxiety

Interpretation biases and attentional biases may affect the activation of representations in memory, resulting in biases of encoding, elaboration, and retrieval. However, results of memory biases in SA are inconsistent (see Heinrichs & Hofmann, 2001; Hirsch & Clark, 2004; Musa & Lépine, 2000). Although several studies showed that high socially anxious participants demonstrate bias memory toward negative information (Coles & Heimberg, 2005; Lundh & Ost, 1996), such a bias was not found in most studies in the field (e.g., Becker, Roth, Andrich, & Margraf, 1999; Cloitre, Cancienne, Heimberg, Holt, & Liebowitz, 1995; Rapee, McCallum, Melville, Ravenscroft, & Rodney, 1994; Sanz, 1996; Wenzel & Holt, 2002). One explanation for these mixed results is that selective processing of social information depends on specific memory mechanisms, so the term “memory bias” may be general and misleading. Specifically, explicit and implicit memory processes may affect information processes differentially (Coles & Heimberg, 2002). Additionally, it is important to distinguish between processes of encoding and retrieval that may contribute differently to memory biases. Hence, memory biases should be explored more specifically, considering various memory processes.

Amir et al. (1998) suggest a dual-model account for information processing in SA that reconciles the aforementioned mixed findings. This model separates between automatic and strategic stages of information processing. On the one hand, attention is automatic and effortless, and reflects hypervigilance to threat, resulting in increased activation of negative social representations. On the other hand, high-level processes, such as retrieval from memory, reflect avoidance strategies to threat, resulting in reduced activation of negative social representations. Thus, the vigilance-avoidance model can potentially explain memory biases as reflecting a distinct deficit in SA that is not explained by attentional biases.

1.2. Working memory and social anxiety

In order to understand the specific information-processing deficits in SA, it is important to target the processes that lead to cognitive biases in SA. Keeping this in mind, the present study investigated working memory (WM) as a construct that bridges between perception and attention on the one hand, and long-term memory on the other, as will be elaborated below.

WM is the cognitive system that serves for temporarily maintenance of task-relevant information (Baddeley & Hitch, 1974; Miyake & Shah, 1999). During every conscious moment we are exposed to large amounts of information, including emotional content, but only a limited amount of information is actually accessible for further processing. This problem stems from the severe capacity limitation of WM, being around 3–4 item (Cowan, 2001; Luck & Vogel, 1997). This limitation emphasizes the need for selectively attending relevant information in order to utilize the limited capacity efficiently (Vogel, McCollough, & Machizawa, 2005). The ability to selectively update WM with task-relevant information enables exploiting the most relevant information for high level cognitive functioning, such as goal-directed behavior and problem solving.

Indeed, several studies explored the relationship between WM and SA. For example, Moriya and Sugiuera (2012) examined visual WM capacity in a change detection task with neutral stimuli. WM capacity was positively related to trait SA. Moreover, under inhibition demands, trait SA predicted a decrease in WM capacity. In a different study, Amir and Bomyea (2011) used an operation span task with threat-vs. non-threat-related words. With non-threatening words, SAD individuals demonstrated a lower WM capacity compared to non anxious controls. However, for threat-related words, enhanced WM capacity was observed in SAD individuals. The findings of these two studies are conflicting regarding the effect of neutral stimuli on WM capacity in SA, and more research needs to be carried out toward understanding the phenomenon.

While WM capacity relates to the “static” aspects of WM, namely the amount of maintained information, recent research focused on the dynamic process of WM updating. The ability to selectively update goal-relevant information in WM plays an important role in emotion regulation, as well as in psychopathology (e.g., Levens & Gotlib, 2010). Studying WM updating, rather than capacity per se, is important for at least. First, WM updating plays a key role in goal-directed behavior and high-level cognitive tasks. As such, it might serve to explain between-group differences in these abilities. Second, between-group differences in WM capacity may not reflect a primary etiology, but rather may be the consequence of differences in updating ability. Arguably, deficits in WM capacity may stem from impaired ability to update new information or remove outdated one, rather than from poorer maintenance. To date, no research has examined the processes involved in WM updating with emotional content in socially anxious individuals. This is the goal of the present study.

1.2.1. Working memory updating

WM updating is a complex ability that is composed of several sub-processes that operate in concert to ensure that task-relevant representations enter WM, while irrelevant information is filtered out or discarded (Ecker, Lewandowsky, Oberauer, & Chee, 2010; Kessler & Meiran, 2006, 2008; Kessler & Oberauer, 2014). This is achieved by both input selection, namely focusing on the relevant information while filtering out irrelevant one (Engle, Tuholski, Laughlin, & Conway, 1999; Kane & Engle, 2003), and removing previously-relevant information when it becomes outdated, presumably through inhibitory processes (e.g., Hasher, Zacks, & May, 1999; Oberauer & Kliegl, 2001).

1.2.2. Working memory updating and psychopathology

Individual differences in WM updating are correlated with intelligence, age, and psychopathology (Friedman et al., 2006; Levens et al., 2004).
1.3. The present study

1.3.1. The emotional N-back paradigm

The N-back paradigm (e.g., Braver et al., 1997; Smith & Jonides, 1997) is extensively used to study WM updating. In this task, participants are required to decide whether or not a given item (e.g., a letter, or − as in the present study − a face showing a certain emotion) is the same as the stimulus that was presented n trials before. The present study used a 2-back task, and focused on performance in intrusion trials to assess the inhibitory components of WM updating (Oberauer, 2005a). Specifically, intrusion trials are trials in which the correct response in trial N is “different”, namely the stimulus that is presented on the screen does not match the one that appeared in trial N−2. However, in these trials the stimulus does match the stimulus that was presented in trial N−1. In other words, these trials involve a conflict between responding “different”, as required by the task demands, and the tendency to respond “same” due to the match between the current trial and the previous one.

Intrusion trials elicit erroneous “same” response tendencies that should be rejected on the basis of their positions. The conflict between maintaining the information in trial N−1 and refraining from responding based on this information until it becomes relevant is resolved by the effort to inhibit irrelevant information while activating relevant information (Oberauer, 2005b). The time needed to overcome the response tendency is reflected in “intrusion costs” on reaction times (RTs) and error rates (e.g., Gray, Chabris, & Braver, 2003; Jonides & Nee, 2006; Kane, Conway, Miura, & Collfesh, 2007; McElree, 2001).

Based on the above reasoning, we used intrusion trials in the “different” condition, as markers for the activation and inhibition of temporarily irrelevant information. We predicted that cognitive biases in WM updating would be demonstrated by differential intrusion costs between high and low socially anxious individuals, which would vary across the specific emotion that has to be maintained. Specifically, in participants with SA symptoms, a bias toward negative content would be reflected in a difficulty to inhibit negative information, thereby leading to a high intrusion cost. On the other hand, a bias away from positive content would be reflected in an efficient inhibition of positive content and, therefore, a diminished intrusion cost.

2. Method

2.1. Participants

189 undergraduate students from Ben-Gurion University of the Negev (age 21–25) were prescreened for SA using the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987). Students whose scores were above 60 on the LSAS were assigned to the high social anxiety (high SA) group (N = 31, 21 females). Students whose scores were lower than 30 on the LSAS were assigned to the low social anxiety (low SA) group (N = 34, 25 females). Cutoffs for SA were made according to previous research (e.g., Mennin et al., 2002; Rytwinski et al., 2005).

Recruitment to the study was done in two parallel ways. Part of the participants included first year students at the Psychology department. The participants were pre-screened using a broad-range questionnaire that was administered at the beginning of the year, and included (among other measures) three items taken from the LSAS. We contacted the students who scored very high or very low in these items, and offered them to participate in the experiment. The rest of the participants were recruited through advertisements in the campus.

All participants filled the LSAS questionnaire at home and those who were found suitable (scores above 60 or lower than 30 in the LSAS) were contacted and invited to participate in the experiment. Participants received course credit or monetary compensation for their participation (about 10 USD).

The higher proportion of females in our sample reflects a higher prevalence of SA in females in the general population (American Psychiatric Association, 2013). The sample size was based on other works in the field, using similar sample sizes (e.g., Coles & Heimberg, 2005; Levens & Gotlib, 2010). One participant from the high group was removed from the analysis due to missing data in some of the cells of the design.

2.2. Self-report measures

Participants were recruited to the study based on their LSAS scores. This scale comprises 24 items, divided into two subscales: fear and avoidance. The scale assesses SAD symptoms related to the fear and avoidance of different social situations experienced in the previous week. Each item is rated on two 4-point Likert-type scales. A total score is calculated by summing all of the fear and avoidance ratings. The Hebrew version of LSAS was administered. This version has demonstrated high test–retest reliability, internal consistency, and discriminate validity (Levin, Marom, Gur, Wechter, & Hermesh, 2002).

The participants that took part in the study completed questionnaires in the following order: Beck Depression Inventory-II (BDI; Beck, Steer, & Brown, 1996); The BDI is a 21-item, self-reports measure of the severity of depressive symptoms. The sum of the scores obtained in each item results in a total score ranging from 0 to 63.

The State-Trait Anxiety Inventory-State Form (STAI-S), and Trait Form (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983); The STAI-S measures state anxiety as a transitory emotional state characterized by subjective, consciously perceived feelings of
tension, while the STAI-T measures trait anxiety as a relatively stable personality trait. Each questionnaire comprises 20 items measured by a 4-point Likert scale.

2.3. Stimuli and apparatus

The experiments were run on PC computers with 17″ screens and were programmed using E-Prime (Schneider, Eschman, & Zuccolotto, 2002). For the emotional 2-back task, a total of 120 images of individual faces (one face per image) from the KDEF database were used (Lundqvist, Flikt, & Ohman, 1998). The 120 images comprised sets of three expressions each of 40 people, such that there were 40 pictures each of social threat-related (disgust), of positive (happy), and of neutral expressions. Among the people photographed for each expression, the sexes were equally represented. Male and female pictures were presented in different experimental blocks. Emotional valence was varied randomly within each block.

2.4. Procedure

All participants first filled in the LSAS to assess eligibility for participation. Subsequently, eligible participants (≥60, <30 for the high and low SA groups respectively) read and signed an informed consent form which included participation in the 2-back task and filling-in questionnaires. Prior to performing the emotional 2-back task, participants completed the questionnaires in the following order: BDI, STAI-S and STAI-T and underwent a training phase that comprised a 2-back task with numerical stimuli (55 trials) to familiarize themselves with the 2-back task.

The emotional 2-back task included 330 trials separated into six blocks of 55 trials each. A single stimulus (i.e., facial expression) was presented in each trial until a response was indicated, or for a maximum of 2 s. The inter-trial interval was 2.5 s. In each trial, participants had to indicate whether the emotion expressed in the photograph was the same as that of two trials earlier. Specifically, they were instructed to ignore the identity of the face and only respond according to the emotional expression (see Fig. 1). The keys “P” and “Q” on a standard QWERTY keyboard were used to indicate “same” and “different”, respectively. Reaction time (RT) and accuracy (ACC) were recorded. The condition in each trial, namely “same” or “different”, was randomly selected with equal probabilities. Accordingly, “Different no-intrusion” trials were about twice more frequent than “Different intrusion” (on average, 21.91 vs. 10.29 trials, respectively, for each of the emotion).

3. Results

3.1. Clinical characteristics

Scores on STAI-S and STAI-T were significantly higher in the high, compared to the low group (see Table 1). The between-group difference in BDI scores, reflecting higher score for the high SA group, was marginally significant. Nevertheless, mean BDI scores were well within the normal range (0–25) for both groups.

3.2. Emotional 2-back task

3.2.1. RT

Mean RT was calculated for each trial type. RTs shorter than 100 ms were discarded as outliers. In addition, RTs from error trials or from trials following an error were removed from the analysis. Intrusion cost was calculated as the difference between “Different-intrusion” and “Different no-intrusion” trials, separately for each emotion in trial N. An ANOVA was conducted with Group (high, low) as a between-subject variable, Emotion in Trial N (negative, neutral, positive) and Intrusion (intrusion, no-intrusion) as within-subject variables, only for the “different” trials (see Table 2 for descriptive statistics). The main effect for Intrusion, reflecting a cost of 6 ms, was significant, \( F(1,62) = 53.99, \eta^2_p = 0.46, p < .0001 \), replicating earlier findings in the literature (e.g., Oberauer, 2005a). Additionally, the main effect for Emotion in Trial N was significant, \( F(2,124) = 79.6, \eta^2_p = 0.11, p < .001 \). Finally, as predicted, the three-way interaction between Group, Emotion in Trial N and Intrusion was significant, \( F(2,124) = 3.83, \eta^2_p = 0.06, p < .05 \). This finding sets the stage for the subsequent analysis (see Fig. 2).
3.2.1. Intrusion cost. We continued by examining the effects of Group and Emotion in Trial N on the Intrusion cost. Planned contrasts were conducted on intrusion costs in order to simplify the picture. Importantly, intrusion costs did not differ between the groups for neutral and negative items (both Fs <1). For positive items, in contrast, the intrusion cost was smaller for the high group compared to the low group, F(1,62) = 11.97, ηp² = 0.16, p < .001. Moreover, for the high group, intrusion cost did not differ significantly from zero, t(29) = 8.7, p = .39. These findings demonstrate differential inhibition of positive information in individuals with high SA scores.

An additional analysis was carried out in order to examine whether the differential intrusion effect in the positive condition in Trial N depends on the emotion presented in Trial N − 2. An ANOVA was conducted with Emotion in Trial N − 2 and Group as independent variables, and Intrusion cost as dependent variable. The main effect of Group was significant, F(1,62) = 12.51, ηp² = 0.16, p < .001. Additionally, the two-way interaction between Emotion in Trial N − 2 and Group, and the main effect of Emotion in Trial N − 2 were all not significant (F < 1), indicating that our findings do not depend on the specific emotion presented in Trial N − 2.

Given the difference between the groups in STAI-S, STAI-T and BDI scores, it is important to confirm that the effects were attributed to SA, measured by the LSAS scores, rather than depression or anxiety in general. To this end, we conducted a two-step regression analysis with intrusion cost for positive content as dependent variable. In step 1, STAI-T, STAI-S and BDI were entered as predictors. The model with STAI-S, STAI-T and BDI did not significantly predict the positive content, R² = .07, F(3,60) = 1.59, p = .20. However, adding the SA factor in step 2 improved the prediction significantly, R² change = .12, F(1,59) = 9.10, p < .005. Therefore, differences in the intrusion effect for positive emotions are exclusively explained by SA, and not by individual differences in state and trait anxiety or depression.

3.2.1.2. Repetition effect. Our results show that the intrusion effect is diminished in SA when confronted with positive content. This effect may reflect two different mechanisms. According to the first possibility, individuals with high SA inhibit irrelevant positive contents more strongly and effectively than controls. For this reason, irrelevant positive information (such as the emotion in trial N − 1) leads minimal or no interference. The second possibility is that positive information is less activated and potent in SA, and therefore leads to smaller interference. This possibility suggests that the group differences do not reflect differential control processes, but rather the strength of positive representations and the degree to which they are activated. We analyzed performance in the “same” condition to decide among these possibilities. In this condition, the intrusion cost in trial N − 1 is still irrelevant to performance in trial N. However, situations in which the emotion in trials N and N − 1 are repeated may benefit from facilitation. This priming effect reflects the automatic activation of the information in trial N − 1. However, no group differences are expected if our findings on intrusion costs reflect inhibition.

An ANOVA was conducted with Emotion in Trial N (negative, neutral, positive) and Repetition (repetition, no-repetition) as within-subject variables, for the “Same” trials. The main effect for Repetition was significant, F(1,62) = 68.89, ηp² = 0.53, p < .00001, as well as the main effect for Emotion in Trial N, F(2,124) = 36.95, ηp² = 0.37, p < .00001. Additionally, the two-way interaction between Emotion in Trial N and Repetition was significant, F(2,124) = 4.49, ηp² = 0.07, p < .02, indicating that the repetition effect for negative and positive stimuli was significantly smaller than that of neutral stimuli, F(1,62) = 10.91, ηp² = 0.15, p < .005, but there was no significant difference in intrusion cost for negative and positive, F(1,62) = 0.02, ηp² = 0.0002, p = .91. Following this, we suggest that the emotional content modulates the repetition effect. Emotional faces contain meaningful social and personal information (Ekman, 1993). For this reason, they might facilitate processing, even that of irrelevant information. For example, the informative emotional expression may facilitate encoding of irrelevant aspects of the task, such as the identity of the face (Schweinberger, Burton, 1992).
This may result in distraction and hence in a modulation of the repetition effect. It should be noted that this result was not predicted, and hence should be taken with caution. Finally and most importantly, the three-way interaction was not significant, $F(2, 124) = .99$, $p = .37$, therefore, there is no evidence for group differences in the facilitation effect. These results suggest that the absence of intrusion cost for positive emotions in high SA reflects a higher degree of control over irrelevant positive information. In other words, the SA group is more effective in inhibiting distracting information, but only when its valence is positive.

3.2.2. Accuracy

A three-way ANOVA with Group, Emotion in Trial N and Intrusion as independent variables was conducted on the accuracy data. The main effect of Intrusion was significant, $F(1,63) = 13.35$, $\eta^2_p = 0.17$, $p < .001$, reflecting an effect of intrusion cost, replicated earlier findings in the literature (e.g., Oberauer, 2005a). Furthermore, the interaction between Intrusion and Emotion in Trial N was significant, $F(2,126) = 3.51$, $\eta^2_p = 0.05$, $p < .05$, indicating that the intrusion cost was significant for the emotional conditions, for negative $F(1,63) = 16.1$, $\eta^2_p = 0.2$, $p < .001$, and for positive, $F(1,63) = 10.14$, $\eta^2_p = 0.14$, $p < .005$, but was non-significant in the neutral condition, $F(1,63) = 0.34$, $\eta^2_p = 0.005$, $p = .55$. This means that emotional content that is irrelevant to the task is difficult to inhibit. Emotional content is important to our perception and judgments of the surrounding (e.g., Lemerise & Arsenio, 2000), thus it is likely that it will be hard to inhibit. Future research should further explore these findings. However, this result was not predicted, and hence should be taken with caution. In addition, the main effect of Group and the higher-order interactions involving Group were non-significant (all $p > .24$). Accordingly, speed-accuracy trade-off does not account for the RT results.

4. Discussion

The present study aimed at examining WM updating in SA. While the literature on SA shows clear evidence for attentional biases towards negative information and away from positive information, the role of WM in SA is poorly understood. Although attention and WM are intimately related (e.g., Cowan, 1988), it is important to make a distinction between these concepts. Specifically, selecting and focusing on information in the external environment involves visual or auditory attention. Attentional biases in SA therefore reflect the maladaptive tendency to process information in the external world and to act on it as part of the task requirements. In contrast, WM reflects the ability to focus on temporarily maintained internal representations. It is therefore conceived as involving later processing stages. This distinction maps nicely to cognitive theories of SA (Clark & Wells, 1995), that propose deficits in both domains. First, biases in attentional processes lead to biases in selecting and focusing on external information. Second, when the information gets into WM, it continues to be processed in a maladaptive biased fashion. Importantly, since these two stages rely on distinctive cognitive processes and capacities, the nature of biases and deficits observed in them are not necessarily similar.

We capitalized on the intrusion effect in the 2-back, and examined whether it is modulated by the specific emotion presented in Trial N, and whether it differs between high- and low-socially anxious individuals. Equivalent intrusion costs for negative and neutral stimuli were observed for both groups. However, intrusion was diminished for positive stimuli in the high SA group.

In general, intrusion costs reflect the effect of residual activation in trial N−1 on performance in trial N (Oberauer, 2005a). This effect stems from the competition between two processes, namely familiarity and recollection. Familiarity is not context-specific, and merely relies on the identity and activation of a representation in memory, regardless of its associated context. In contrast, recollection is the product of an analytic search process that involves the context to which an item was previously associated. In intrusion trials, the two processes are in conflict: a familiarity signal will fire a “same” response, whereas recollection provides evidence for responding “different”. The ability to respond correctly, even in intrusion trials that present a large familiarity signal, reflects cognitive control over memory retrieval, namely recollection over familiarity. A diminished intrusion cost (as being found in the high SA group for positive condition) could be therefore caused by a weak signal of familiarity or by a strong signal of recollection.

Following this, an analysis of repetition effect was conducted in order to give priority to one option over the other. A differentiation of repetition effect between group and emotion conditions will reflect differences in familiarity signal. Our analysis of “same” trials demonstrates that the repetition benefit in all emotions is comparable between the groups. Accordingly, the diminished intrusion effect in positive emotions reflects a more efficient recollection process in the high SA group, rather than a weaker familiarity signal. This finding possibly implies that individuals with high SA tend to process positive information as being context-specific rather than generalized. This tendency leads to linking positive information to a specific temporal and spatial context, rather than allowing it to generalize and influence them more broadly. The limited and context-dependent influence of positive information, in turn, might lead to greater dominance of negative information, resulting in a tendency to interpret situations as being negative and hostile.

The results of the present study suggest that socially anxious individuals inhibit positive social content when updating WM. This finding is in line with the results of earlier empirical studies (e.g., Garner, Mogg, & Bradley, 2006; Hirsch & Mathews, 2000; Liang, Hsu, Hung, Wang, & Lin, 2011), showing a deficit in attending to positive stimuli and in interpreting and encoding them as needed. While cognitive models have traditionally focused on a bias toward threatening information, a more comprehensive view can be obtained by evaluating how positive information is processed. As noted, Clark and Wells (1995) suggested that individuals with SA ignore positive feedback from the external environment, therefore eliminate the potential of contradicting their self-negative evaluations in social situations. Failure to perceive positive feedback, in turn, may contribute to aroused anxiety and to distorted perception of social situations.

Taylor, Bomyea, and Amir (2010) argued that such a positive bias mediates the link between SA and vulnerability to social stressors. Moreover, Kashdan et al. (Kashdan, 2007; Kashdan & Collins, 2010; Kashdan, Weeks, & Savostyanova, 2011) have claimed that individuals with SA are characterized by a flat positive affect and the absence of a normative bias toward positive information in social situations, findings that cannot be explained by the co-occurrence or severity of depression. In contrast, for individuals without SA, a bias toward positive information was found to reduce one’s negative cognitive-emotional reactivity to stress (Wadlinger & Isacowitz, 2008).

When presented with negative or neutral contents, the intrusion cost in the high SA group was comparable to the low SA group. One explanation for this finding can be extracted from the results of earlier research in the field of attention control. In the presence of a cognitive conflict, the emotional system is down-regulated, thereby decreasing the disruptive effects of negative stimuli (Cohen, Henik, & Mor, 2011). During WM updating, the presence of a conflict may lead to down-regulate the irrelevant negative stimuli that are
expected to be salient. This claim is consistent with the vigilance-avoidance model, which was mentioned earlier (Amir et al., 1998). When dealing with a conflict in WM, inhibition-controlled strategies are used by individuals with SA, leading to decreased threat meanings. Accordingly, both groups show similar intrusion cost to negative content. Future studies are needed to examine the precise nature of dealing with a conflict that contains emotional content in SA.

Our study has several limitations. First, we used an analogue sample of students with high SA rather than a true clinical sample. Although Stopa and Clark (2001) have argued that such analogue samples are informative and parallel clinical groups and although mean LSAS score in the high anxiety group in our study was above the clinical cutoff, more research is needed to examine WM updating in a clinical population. Second, the high SA group was generally high in anxiety measurements relative to the low SA group. Therefore we cannot rule out the potential effects of general anxiety on our results. Third, attentional biases, which occur at an earlier stage of processing, may be linked to biases in WM updating. Biases in these two stages may be different in nature, however it is still a possibility that they interact or even reflect a common cause. The present study did not examine attentional biases, and hence it is still unclear whether and how they affect WM updating. Future studies should address this important issue.

This finding may suggest some important clinical implications for the treatment of SAD patients. Possibly, it may be beneficial to add interventions aimed at encouraging the processing of positive information, particularly while patients are confronted with stressful social situations. By keeping positive information highly active, even if it is not relevant to the task, coping with stressful situation may be enhanced. This suggestion corresponds with a growing body of research demonstrating benefits of positive psychology interventions on affective disorders (e.g., Seligman, Steen, Park, & Peterson, 2005). One such effective intervention for the reduction of depressive symptoms is called “three good things” and entails listing three things that went well on that day and why they happened. Monitoring positive social exchanges either in neutral or socially stressful situations may enhance treatment effects. A second clinical implication involves attention bias modification training (ABMT) which showed promise as an intervention for SAD (Amir et al., 2009; Schmidt, Richey, Buckner, & Timpano, 2009). Such training regimens have always utilized threatening vs. neutral stimuli to date. The present findings suggest that adding sessions with positive vs. neutral training may enhance ABMT for SAD and raises the possibility of using the emotional n-back paradigm to alternate a positive WM bias in SAD.

5. Conclusions

In summary, the present study is the first to show that a cognitive bias exists in WM updating in SA. Relative to controls, socially anxious individuals exhibited superior inhibition of positive information in WM when it was not relevant. This possibly counterproductive ability may contribute to their hyper-arousal, to the maintenance of their anxiety symptoms, and to the facilitation of avoidant behavior.

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