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Reacting to changing environment: Updating patterns in social anxiety

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1. Introduction

Updating representations, cognitions, and behaviors is essential for adjusting to ever-changing environmental demands (Ionescu, 2012; Kashdan & Rottenberg, 2010). Updating can be conceptualized as the ability to identify external or internal demands, choose the appropriate response from a repertoire of options, and dynamically change it as the demands are changed (Ionescu, 2012; Stange et al., 2017). Classic theories and research focused mainly on the relationships between poor mental health and negative learning and information processing biases (e.g., Beck et al., 1979; Gotlib, 1983). However, a growing body of research suggests that biased updating, and not merely biased learning, may serve as a central mechanism in various psychopathologies, including depression, anxiety, PTSD, and eating disorders (Levens & Gotlib, 2010; Tchanturia et al., 2012; Zabag et al., 2020). However, these updating biases vary across disorders (Haim-Nachum & Levy-Gigi, 2021; Mohlman et al., 2004; Stange et al., 2017). The current study aimed to characterize the profile of updating biases in social anxiety (SA).

SA is a marked and persistent fear of one or more social or performance situations (American Psychiatric Association, 2013; Heimberg et al., 2014). Individuals with high levels of SA report difficulty modulating their beliefs and behaviors (Arlt et al., 2016; O'Toole et al., 2017). Experimentally, the associations between SA and updating of beliefs and behavior, however, revealed mixed results: whereas some studies found negative associations between SA and the ability to update social interpretations (Everaert et al., 2018), behavior (Beltzer et al., 2019) and self-evaluations (Koban et al., 2017), other studies failed to find similar effects even in well-powered clinical samples (Savage et al., 2020; Sutterby & Bedwell, 2012). These inconsistent findings may relate to the nature of the stimuli used in these tasks and the differences between the updating tasks. First, the *content* of the updated information may affect the association between SA and updating. Specifically, studies that focused on updating *non-social associations*, such as geometric shapes or symbols, revealed weak correlations with SA (Sachs et al., 2004; Sutterby & Bedwell, 2012; Topçuoğlu et al., 2009). In contrast, studies that assessed updating of *social* information revealed significant biases in SA (Haker et al., 2014; Mohlman & DeVito, 2017). For example, high but not low-SA individuals displayed updating difficulties in a Wisconsin Card Sorting task when social information (faces) was used but not when non-social information (geometric shapes) was used (Mohlman & DeVito, 2017). Second, the inconsistent pattern of results may be related to the valence of the updating direction: positive updating entails learning that a specific stimulus that was associated with a negative outcome becomes positive, whereas negative updating entails learning that a specific stimulus that was associated with a positive outcome becomes negative (e.g., Levy-Gigi et al., 2015; Sopp et al., 2022). Indeed, studies that used positive updating (i.e., negative-to-positive direction) and negative updating (i.e., positive-to-negative direction) of social scenarios revealed that SA is associated with difficulties only in positive updating (Beltzer et al., 2019; Everaert et al., 2018, 2020).

Taken together, research suggests that SA is related to reduced positive updating of social information. However, to date, no study has tested both the nature of the information and the direction of these updating biases in SA. Characterizing the specifics of such updating patterns can illuminate the processes underlying SA. Moreover, previous studies examining updating in SA did not focus on the comorbid effects of related symptoms of depression and general anxiety (Beltzer et al., 2019; Haker et al., 2014), which are also associated with updating difficulties (Haim-Nachum & Levy-Gigi, 2021; Rosa-Alcázar et al., 2020; Wen et al., 2019). As updating difficulties are related to other psychopathologies, these individual differences, and not SA, may be associated with the updating pattern.

The present study aimed to examine the profile of updating patterns in SA, varying the nature of the information (social vs. non-social) as well as the updating direction (positive-to-negative vs. negative-to-positive). Moreover, we sought to examine whether a biased updating pattern is *specific* to SA. To this end, we applied a dimensional severity

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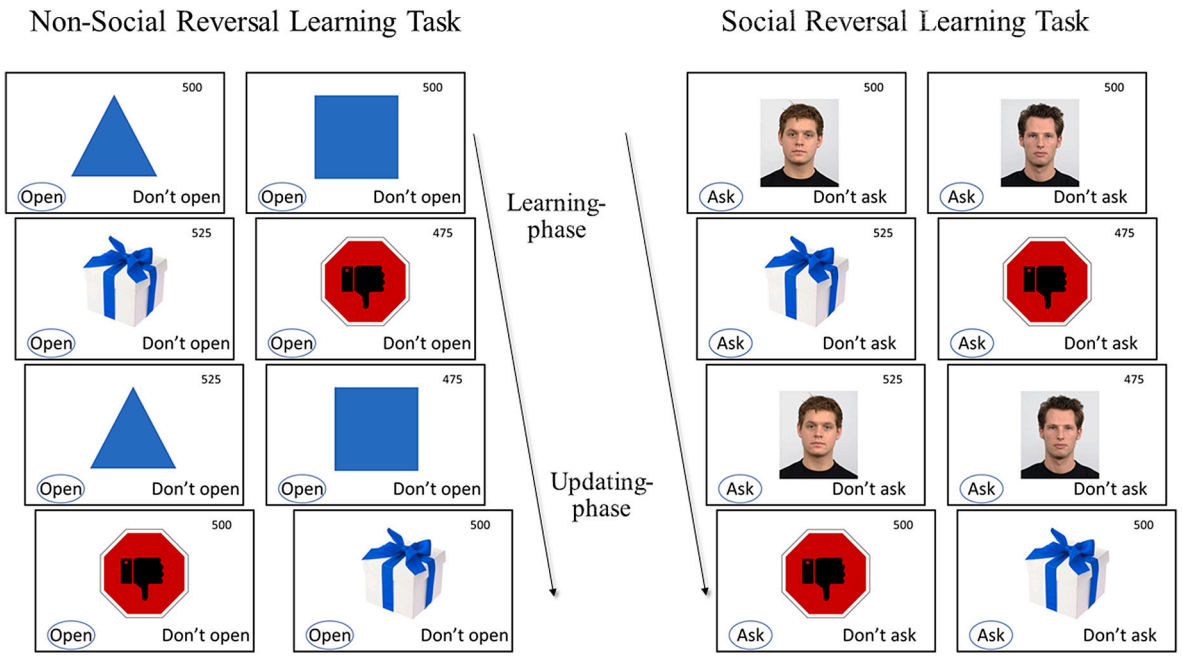


Fig. 1. Non-social and social reversal learning tasks.

approach that controlled for the severity of depression and general anxiety (Haslam et al., 2020; Ruscio, 2010). We utilized a variant of a classic reversal-learning task (Levy-Gigi et al., 2011, 2015). In this two-phase task, the participants' goal was to earn as many points as possible. In the first (learning) phase of the task, participants learned, by trial and error, that certain stimuli are associated with positive (points gained) or negative (points lost) outcomes. In the second (reversal) phase, stimulus-outcome associations were modified (reversed). Hence, a stimulus associated with a negative outcome became associated with a positive outcome and vice versa. Participants were randomly assigned to performing social (using faces as stimuli) or non-social (using geometric shapes as stimuli) reversal learning tasks.

Two hypotheses were examined. First, we expected SA to be associated with *greater* difficulty in the positive updating (i.e., negative-to-positive reversal trials) of social versus not non-social information (*the positive updating bias in social context hypothesis*). Second, we predicted that this updating bias is associated with SA above and beyond the effects of depression and general anxiety (*the disorder specificity hypothesis*). Hypotheses, method, data reduction, and data analysis approach were pre-registered in https://osf.io/9quwc/?view_only=. Given the nature of our sample, we treated SA as a continuous variable (Haslam et al., 2020; Ruscio, 2010).

2. Method

2.1. Participants

Participants were recruited via Amazon's Mechanical Turk (MTurk), an online labor market. MTurk was found to be useful for studying clinical and subclinical populations and may provide high-quality data when adequate cleaning procedures are applied (Chandler et al., 2020; Chandler & Shapiro, 2016). Demographically, MTurk samples tend to be more representative and diverse of the U.S. population than undergraduates and other internet samples (Buhrmester et al., 2011; Redmiles et al., 2019). Based on the work of Chandler and colleagues (Chandler et al., 2020), participants (n = 1057) were excluded if they (a) used IP addresses located outside the United States or associated with U.S.-based virtual private servers; n = 61; (b) answered questions very quickly (more than one item per second; n = 332) (c) endorsed having unlikely experiences (e.g., having been abducted by aliens; n = 58); and (d) filled the questionnaires in a non-conscientious manner (i.e., had no variability in responding to all the questionnaires; n = 16). The final sample consisted of 590 participants (51.19% women; Mage = 40.93, sd = 12.11). This sample size provides sufficient power for identifying an anticipated small effect size found in previous online studies (Beltzer et al., 2019).

2.2. Procedure

Participants were invited to participate in a study investigating how people make decisions. They provided informed consent and were randomly assigned to social (n = 294) or non-social (n = 296) versions of the reversal learning task. After performing the task, participants completed symptoms and demographic measures and were debriefed and thanked for their participation. The duration of the study was approximately 30 min. Participants got a remuneration of $2.5 and were also reimbursed based on their success in the reversal learning task (up to $2). The study was approved by the ethics committee of the Psychology Department at Bar-Ilan University.

2.3. Measurements

2.3.1. Reversal learning task

During the learning-phase, four stimuli were associated with a positive outcome (i.e., point gain, gift icon) and four with a negative outcome (points loss, stop-sign icon; see Levy-Gigi et al., 2015). Participants learned the positive and negative stimulus-outcome associations by trial and error. They gained points when they engaged with stimuli associated with positive outcomes and lost points when they engaged with stimuli associated with negative outcomes. A disengagement decision (avoidance of a stimulus) did not lead to gain or loss or the opportunity to learn anything about the outcome associated with this stimulus. The learning-phase consisted of 12 blocks (96 trials). A subsequent updating-phase immediately followed the learning-phase without any cue or delay. In the updating-phase, three of the four faces associated with negative outcomes became associated with

Table 1
Means and Standard Deviations (in parentheses) or Frequencies of Demographic Characteristics, Psychopathology Severity, and Performance Parameters by Task Type.

	Non- Social task	Social task
Demographic characteristics		
Gender (% females)	52.4	50
Age	40.7 (12.20)	41.17 (12.04)
Education	15.31 (2.48)	15.25 (2.47)
Shipley (estimated IQ)	33.06 (4.45)	33.38 (4.15)
Ethnicity (%)		
Caucasians	75.7	78.6
African Americans	14.5	9.5
Hispanics	4.4	4.4
Asians	4.4	5.1
Native Americans	0.3	1.4
Marital status (%)		
Single	27.6	27.4
Romantic relationship	61.6	61.8
Divorced	9.5	10.1
Widowed	1.4	0.7
Sexual orientation (%)		
Heterosexual	89.2	86.1
Homosexual	6.1	8.8
Bisexual	3.7	3.7
Refused to answer	1	1.4
Psychopathology severity		
LSAS	52.39 (28.83)	51.00 (27.82)
SPIN	23.10 (15.85)	21.42 (15.02)
BDI-II	11.81 (10.97)	11.18 (10.42)
STAI-T	42.70 (13.85)	42.20 (14.15)
Performance parameters (%)		
Engagement decisions	47.62 (12.15)	47.63 (15.22)
Overall accuracy in negative-outcome associations learning	84.89 (15.78) *	74.98 (16.77) *
Overall accuracy in positive-outcome associations learning	75.59 (23.92) *	67.56 (23.07) *
Overall accuracy in the last eight trials of the learning-phase	87.33 (16.34) *	80.57 (16.40) *
Overall accuracy in positive-to-negative updating	81.53 (17.92)	79.14 (18.97)
Overall accuracy in negative-to-positive updating	72.33 (34.89)	68.21 (36.11)

Note. All measures were compared in a *t*-test or Chi-Square. Measures that were significantly different from each other are marked with *.
*p < .001.

Table 2
Pearson correlations between psychopathology severity and accuracies during updating-phase by tasks.

Variable	1	2	3	4	5
1. SA	–	.549***	.657***	−.132*	.061
2. BDI-II	.576***	–	.831***	−.092	.030
3. STAI-T	.653***	.832***	–	−.098	.075
4. Positive-to-negative updating	.157*	.188**	.184**	–	−.052
5. Negative-to-positive updating	−.119*	−.080	−.073	−.088	–

Note. The results for the non-social task are presented above the diagonal. The results for the social task are presented below the diagonal.
SA = social anxiety, BDI-II = depression, STAI-T = general anxiety.
*p < .05. **p < .01. ***p < .001.

positive outcomes and vice versa. Two stimuli remained associated with their initial outcomes. The updating-phase consisted of 8 blocks (64 trials).

In the social version of the task, eight male faces with neutral facial expressions were used. Faces were selected from the Radboud Faces Database (Langner et al., 2010). Male faces were found to be more impactful than female faces in the context of approach or avoidance tasks (i.e., elicited shorter response time and more extreme rating in women and men responders; see Seidel et al., 2010). The social version can be found at the following link: https://barilanpsychology.qualtrics.com/jfe/form/SV_796KjwjKLwSpVfn).

In the task's non-social version, the stimuli included eight different geometric shapes (square, triangle, star, circle, arrows, semicircle, hourglass, and rhombus). The non-social version can be found at the following link: https://barilanpsychology.qualtrics.com/jfe/form/SV_9plt6StDyMfhgSV.

Importantly, we used identical feedback both in the social and the non-social tasks, controlling for the possibility that the negative or positive feedback impaired the performance (Fig. 1 presents the tasks).

2.3.2. Self-report measures

The Liebowitz Social Anxiety Scale - Self-Report version (LSAS-SR; Liebowitz, 1987). The LSAS-SR comprises 24 items that assess levels of anxiety and avoidance in social or performance situations using a 0–3 Likert-type scale. An alpha Cronbach of 0.969 was obtained in the current study.

Social Phobia Inventory (SPIN; Connor et al., 2000). A 17-item self-report was designed to assess fear, avoidance, and physiological discomfort in social situations. Each item is rated on a 0–4 Likert-type scale. An alpha Cronbach of 0.947 was obtained in this study.

The Beck Depression Inventory (BDI-II; Beck et al., 1996). A 20-item measure of the severity of depression symptoms in the preceding two weeks. The suicide item (question number 9) was not presented in the online sample. An alpha Cronbach of 0.943 was obtained in this study.

The Trait Anxiety Inventory (STAI; Spielberger & Gorsuch, 1983). A 20-item questionnaire designed to measure general trait anxiety. An alpha Cronbach of 0.960 was obtained in this study.

The Shipley Vocabulary Test (Shipley, 1940). A 40-item measure of crystallized intelligence. Participants were instructed to decide which of

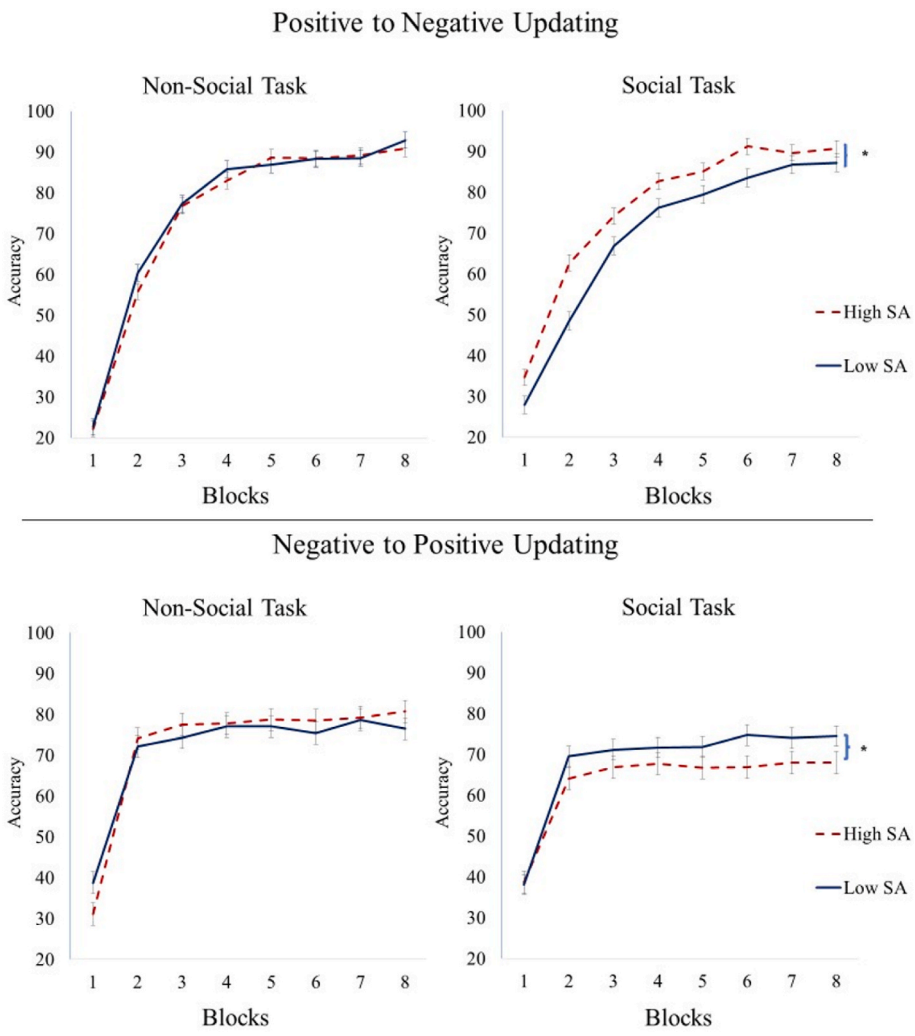


Fig. 2. *Accuracy Patterns during the Updating-Phase by Direction, Task Type (Social vs. Non-Social), and SA-group (High vs. Low).*

four words is most similar to a prompted word for each item. The Shipley correlates with other measures of crystallized intelligence (r = 0.66; Matthews et al., 2011) and can represent an estimated IQ measure. Because intelligence is correlated with measures of cognitive flexibility (Colzato et al., 2006), the Shipley was used to control for intelligence levels.

3. Results

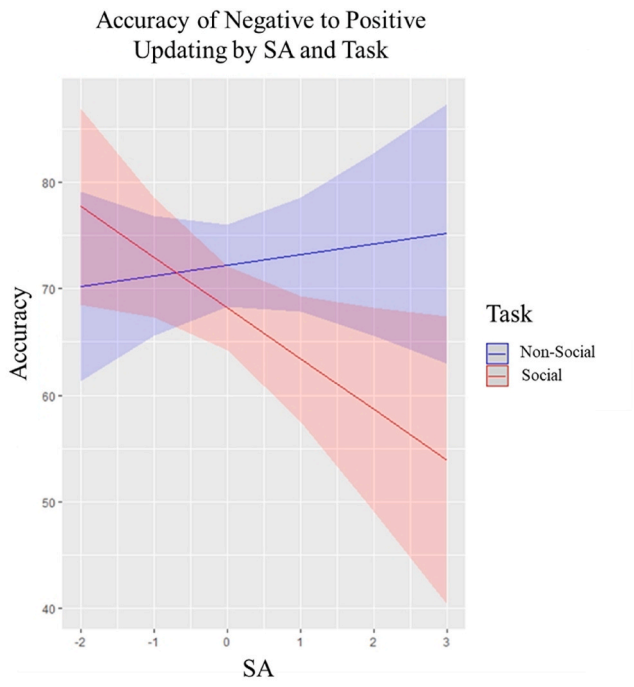
Table 1 presents demographic characteristics, psychopathology severity, and performance parameters by task type (social or non-social). Accuracy levels were calculated as the percentage of correct responses (i.e., decisions increasing the total gain in the task): engagement with positive-outcome stimuli and disengagement from negative-outcome stimuli. As can be seen from the Table, demographic characteristics and psychopathology severity did not differ between the tasks. With respect to performance parameters, the percentage of engagement decisions did not differ by task type. In the learning-phase, participants performed better in the non-social as compared to the social task. However, in the updating-phase, accuracy levels did not differ across tasks.

Table 2 presents zero-order correlations between SA (computed as averaged standardized scores of LSAS and SPIN), depression, general anxiety, positive-to-negative updating, and negative-to-positive updating in the social and the non-social tasks. As can be seen from this Table, all measures of psychopathology are positively correlated with positive-to-negative updating, and SA is negatively correlated with negative-to-positive updating.

To examine the positive updating bias in the social context hypothesis, a repeated measures GLM was conducted on decision accuracy (i.e., the percentage of correct responses) in the updating-phase. Direction (positive-to-negative vs. negative-to-positive) and Block (1–8) were within-subject variables; SA (continuous) and Task (social, non-social) were between-subject variables. Overall decision accuracy during the learning-phase was used as a covariate to control the differential accuracy effects in the learning-phase.

In line with our prediction, results revealed a significant three-way interaction between SA, Direction, and Task (F (1, 585) = 12.45, p < .001, η^2 = 0.021). A pictorial depiction of the findings appears in Fig. 2 (for simplicity, results are presented based on a median split of SA). The complete analysis is presented in the supplementary materials (Table S6). To examine the source of the interaction, we conducted an identical GLM repeated measures analysis separately on the non-social and the social task. Results revealed that in the case of the non-social task, SA was not associated with updating bias (ps > 0.15). However, in the case of the social task, interaction of Direction and SA was found (F (1, 291) = 9.29, p = .003, η^2 = 0.031). In line with our pre-registered hypothesis, SA was associated with a *reduced* negative-to-positive updating (F (1, 291) = 5.73, p = .017, η^2 = 0.019). Fig. 3 presents the association between decision accuracy of negative-to-positive updating and SA as a function of task (social vs. non-social).

To examine the disorder specificity hypothesis in the positive social



Note. SA = social anxiety, standardized.

Fig. 3. *Associations between Accuracy of Negative-to-positive Updating and SA by Task Type*
Note. SA = social anxiety, standardized.

Table 3a
Hierarchical multiple regression analysis predicting accuracy during negative-to-positive updating in the social task.

Variables	*B*	*SE B*	β	R^2	ΔR^2	VIF
Step 1				.11	.11***	
Constant	7.83*	3.50				
Age	−0.18***	0.04	−.29***			1.07
Shipley	0.42***	0.11	.23***			1.07
Step 2				.12	.02	
Constant	11.79**	3.86				
Age	−0.20***	0.04	−.32***			1.12
Shipley	0.43***	0.10	.24***			1.08
BDI-II	0.06	0.07	.08			3.11
STAI-T	−0.10	0.05	−.19			3.19
Step 3				.13	.01	
Constant	11.39**	3.87				
Age	−0.20***	0.04	−.32***			1.12
Shipley	−0.41***	0.11	.22***			1.12
BDI-II	0.06	0.07	.08			3.12
STAI-T	−0.07	0.06	−.13			3.87
SA	−0.79	0.60	−.10			1.84

Note. Shipley = estimated IQ, BDI-II = depression, STAI-T = general anxiety, SA = social anxiety.
*p < .05. **p < .01. ***p < .001.

updating, we conducted a pre-registered hierarchical multiple linear regression on negative-to-positive updating in the social task (see Table 3a). Results did not support our disorder specificity hypothesis. After controlling for age, estimated IQ, depression, and general anxiety, SA was not associated with a bias in negative-to-positive updating of social information.

The aforementioned GLM repeated measures analysis on the social task revealed that SA was also associated with *enhanced* positive-to-negative updating (F (1, 291) = 5.47, p = .006, η^2 = 0.026). To explore this association, we conducted an (unplanned) identical hierarchical multiple linear regression on positive-to-negative updating in the social task (see Table 3b). SA was not associated with an enhanced updating of social information from positive-to-negative, above and beyond age, and estimated IQ, depression, and general anxiety.

Table 3b
Hierarchical multiple regression analysis predicting accuracy during positive-to-negative updating in the social task.

Variables	*B*	*SE B*	β	R^2	ΔR^2	VIF
Step 1				.03	.03*	
Constant	18.02***	1.90				
Age	−0.06**	0.02	−0.17**			1.07
Shipley	0.03	0.06	0.03			1.07
Step 2				.06	.03**	
Constant	16.60***	2.10				
Age	−0.05*	0.02	−0.15*			1.12
Shipley	0.03	0.06	0.03			1.08
BDI-II	0.06	0.04	0.15			3.11
STAI-T	0.01	0.03	0.04			3.19
Step 3				.06	.00	
Constant	16.72***	2.11				
Age	−0.05*	0.02	−0.15*			1.12
Shipley	0.04	0.06	0.04			1.12
BDI-II	0.06	0.04	0.14			3.12
STAI-T	0.00	0.03	0.01			3.87
SA	0.24	0.33	0.06			1.84

Note. SA = social anxiety, Shipley = estimated IQ, BDI-II = depression, STAI-T = general anxiety.
*p < .05. **p < .01. ***p < .001.

Supplementary materials present the results of the learning-phase (see Tables S1–S5) as well as updating across tasks and in the non-social task (Tables S7–S10).

4. Discussion

The current study aimed to examine the pattern of updating biases in SA. First, we found that updating biases in SA were specific to social information. This selective social updating bias in SA is consistent with other findings showing that distressed individuals tend to exhibit biases when processing stimuli associated with their diagnoses. For instance, it was found that individuals with high levels of specific phobia experience selective difficulties in updating the outcome of phobic-related stimuli (Mohlman et al., 2004). Similarly, depression was selectively associated with biased updating of emotional stimuli (de Lissnyder et al., 2010; Stange et al., 2017). Finally, individuals with PTSD show a selective deficit in updating the outcome of *aversive* contextual information (Levy-Gigi et al., 2015; Sopp et al., 2022). Indeed, the pattern we found in SA is consistent with this disorder's focus on social information (Mohlman & DeVito, 2017; Haker et al., 2014).

Contextualizing and refining these findings and consistent with our initial predictions, SA was found to be related to reduced positive updating of social (but not non-social) stimulus-outcome associations. These results extend previous findings of updating biases in the context of self-related information (Everaert et al., 2018, 2020), suggesting that reduced positive updating in SA also manifests in *other-related* information (Zabag et al., 2022). Thus, SA is associated with *resistance to positive change* in intrapersonal and interpersonal contexts. In an interpersonal context, a real-life example might be a failure to notice that a colleague initially seen as unpleasant is becoming friendlier and signaling an interest in a closer relationship.

Furthermore, SA was associated with an enhanced *negative* updating of social information. Indeed, in previous studies, individuals with SA disorder, as compared to healthy controls, displayed enhanced updating of positive impressions of others when presented with new negative information (Haker et al., 2014). Moreover, high-SAs also demonstrated *faster* detection of the offset in changes from negative facial expressions to positive ones (Azoulay et al., 2020). Taken together, the current study provides additional support for the link between SA and ease of

transitioning to a negative view of social reality. This enhanced negative updating in the social context is likely to be associated with heightened social reactivity - frequent and possibly significant adjustments to perceived shifts in the behavior of others.

The disorder specificity hypothesis was not supported. Biased updating of social information may characterize not only SA but also depression (Everaert et al., 2018) and other anxiety disorders (Wen et al., 2019). Indeed, depression vulnerability was also associated with biased updating of social stimuli rather than non-social stimuli (Stange et al., 2017). The results may suggest that transdiagnostic personality characteristics, such as rejection sensitivity, are associated with updating biases (Cohen et al., 2016). Future studies may compare SA disorder to other anxiety disorders (generalized anxiety disorder, PTSD) as well as depression to further delineate the common and unique updating patterns in these conditions. Utilizing disorder-related social and emotional content may help create a more detailed and nuanced understanding of these patterns.

Theoretically, our results highlight that the efficacy of updating depends on the nature of information and the direction of updating. Moreover, our findings suggest that SA is associated with *biased* updating of information about others. These updating biases may combine with other information processing biases to contribute to the maintenance of SA. Indeed, our results suggest a way by which updating biases may maintain SA. For example, a reluctance to notice that a colleague initially seen as unpleasant is becoming friendlier and signaling an interest in a closer relationship (reduced positive updating) combined with a quick revision of positive beliefs about a long-term relationship based on an unfriendly gesture (enhanced negative updating) is likely to lead to social withdrawal. Clinically, enhancing positive updating and reducing negative updating of social information may assist in ameliorating SA. Indeed, training focused on improving updating was found to reduce repetitive negative thinking (Roberts et al., 2021).

In closing, several limitations of our study should be mentioned. First, in our task, as in many everyday encounters, participants received feedback about the nature of the stimulus only when an engagement but not avoidant (disengagement) response was chosen. Thus, it is possible that reduced positive updating of social information is partially due to the asymmetry in feedback provision. Importantly, no significant difficulty was evident in positive updating of non-social information, even though no feedback was provided in this condition as well. However, a definitive resolution of this issue entails examining tasks with symmetric feedback. Second, SA was also associated with enhanced negative learning (see supplementary materials). Even though we controlled for the effect of accuracy during initial learning, the association between SA and positive updating could be partly due to stronger negative stimulus-outcome associations formed during the initial learning-phase. Third, the cross-sectional design of our study precludes conclusions regarding the causal nature of the updating patterns. Hence, we cannot determine whether reduced or enhanced updating leads to SA or vice versa. Fourth, the current study is based on an analog sample. Although a full range of severity was evident in our sample, it is important to test our hypotheses, especially the disorder specificity hypothesis, in samples with clinically distressed groups. Fifth, our social stimuli included only male Caucasian faces. Future studies may use male and female faces from different backgrounds to assess their impact on SA-related biases. Increasing construct validity by using diverse social stimuli (e.g., female faces, crowds, faces expressing rejection or discontent) is imperative.

In sum, we found that in the context of social, but not non-social, information, SA is related to biased updating - reduced positive updating and enhanced negative updating of other-related information. These updating patterns were not specific to SA and might be common to related psychopathology (depression and general anxiety). The current research extends and refines current cognitive theories by highlighting the possible role of updating patterns as contributing to the maintenance of SA.

Declaration of competing interest

The dataset reported here is not part of any published or currently in press works. The authors have no competing interests to declare.

CRediT authorship contribution statement

Reut Zabag: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing – original draft. **Eva Gilboa-Schechtman:** Conceptualization, Methodology, Supervision, Writing – review & editing, Funding acquisition. **Einat Levy-Gigi:** Conceptualization, Methodology, Supervision, Writing – review & editing, Funding acquisition.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.brat.2022.104159.

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