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Review

Biased information-seeking and information-integration in social anxiety

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Social anxiety is associated with an intense fear of social evaluation and rejection, often leading to avoidance behaviors and distress. In this review, we summarize the current understanding of how various cognitive biases may lead to the development and maintenance of social anxiety. While early models of social anxiety have focused on negative biases in perception, attention, memory and emotion regulation, more recent literature has started to characterize biases in information-seeking and information-integration, especially in the context of self-referential information and social feedback. We also highlight directions for future work, including characterizing how different biases in social anxiety relate to each other, and how they may help dissociate social anxiety symptoms from co-occurring conditions such as generalized anxiety and depression.

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Background

Social anxiety (SA) is characterized by an intense fear of being judged in social situations [1]. While it may involve fear of both positive and negative evaluation, SA has traditionally been associated with a fear of negative evaluation (FNE) and rejection. When this fear severely impairs daily functioning, it can lead to a clinical diagnosis of Social Anxiety Disorder (SAD) or Social Phobia. DSM-5 criteria for the disorder include FNE persisting for over six months, provoking anxiety and/or panic attacks, as well as avoidance of the feared social situations, and such avoidance being recognized as unreasonable [2]. Lifetime prevalence of SAD was around 12% when it was last established almost 20 years ago [3] but is estimated to have risen dramatically since then, especially in young adults [4], due to factors such as changes in socio-cultural norms, technology/social media, as well as the COVID-19 pandemic [5]. Thus, understanding the cognitive mechanisms underlying social anxiety has become even more crucial. This review provides an overview of the cognitive biases associated with symptoms of social anxiety, thus contributing to the emergence and persistence of the disorder. We focus on biases in information-seeking and information-integration, recently emphasized in the domain of computational psychiatry in hopes of a better trans-diagnostic characterization of symptoms.

Biases in perception, attention, emotion and memory

Early cognitive models of social anxiety [6–9] have focused on biases in perception (especially self-perception), attention and emotion regulation (for a detailed review, see Ref. [1]).

Perception biases usually stem from past negative social encounters and distorted (negative) self-perception [10]. This leads socially anxious individuals to believe that others view them unfavorably and would disapprove of their behavior, while simultaneously thinking that others hold very high, often unattainable standards for their social performance. This mismatch between self-perception and perceived social expectations is the source of anxiety. In terms of attentional biases, social phobics also divert their attention away from what is happening in a social situation and toward themselves, worrying about what impressions they might be conveying to others [11]. Here, the negative self-perception makes matters worse, distorting their self-

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image to reflect the negative, feared social outcomes rather than the objective reality [12].

Biases in attention paid towards others are also observed in social anxiety, with heightened focus on negative (and away from positive) social information [13,14], thus reinforcing the belief of social disapproval. Interpretation bias - the tendency to interpret ambiguous or neutral social experiences as negative/threatening - is another characteristic feature of social anxiety [15,16]. Increased interpretation bias in SA was found to carry a large effect size in a recent meta-analysis [17], while the association with attentional bias towards threatening faces appeared less definitive [16]. Interestingly, socially anxious individuals tend to interpret even positive social events negatively and find it hard to believe and accept others' positive reactions [18,19]. Similarly, they also exhibit dissociable affective forecasting biases for themselves and for others, overestimating self and others' negative affect, and underestimating others' positive affect [20].

Besides FNE, individuals with SA paradoxically experience a fear of positive evaluation (FPE). It has been proposed that FPE might stem from delayed FNE [21], as positive evaluation would raise others' expectations of them in subsequent interactions, thus increasing the chances of negative evaluation in the future, and perpetuating a mismatch between expectations and (perceived) social outcome [22]. Despite this potential overlap, recent work suggests that FPE and FNE are distinct constructs and one does not necessarily arise from the other [23]; instead, both work in tandem to maintain one's position in the social hierarchy [24]. While FNE works to prevent downward mobility, FPE intends to avoid an upward shift and potential social competition or conflict arising from it [23,25,26]. Biases in emotion regulation also emerge in social anxiety, and consistent with FPE, individuals with SA exhibit a fear of positive emotions. While most people try to sustain positive emotional states, people with SA downregulate these states instead, exhibiting difficulty decoding and savoring positive emotions [27], leading to low self-positive affect [28,29].

A more recent review integrates the role of memory with other cognitive biases in social anxiety [30]. Specifically, threat-related attentional biases interact with working memory, which becomes more likely to capture and retain threat-related information, further biasing attentional control in a loop-like manner. Additionally, autobiographical, long-term memory biases in social anxiety were only observed in recollections of being inadequate in social situations. Related to social feedback specifically, SA individuals exhibit stronger response bias and recall bias for negative versus positive social feedback, but no bias in their recognition memory [31].

In summary this literature points towards social anxiety being associated with a combination of cognitive biases related to self-perception in social situations together with threat-related and/or negative biases in attention, interpretation and memory related to social information.

Biases in information-seeking

The cognitive and computational processes by which people actively decide to seek or avoid information have only recently started to be characterized [32–36], specifically via three main motives that drive information-seeking: instrumental, hedonic, and cognitive. The instrumental value of information refers to its utility in helping people maximize extrinsic rewards and minimize losses [32,33,37]. The hedonic value of a piece of information is determined by the affective outcome associated with it: people prefer information that generates a positive emotional response and avoid information that generates negative affect, even if that information has no instrumental value (i.e. cannot be used to improve extrinsic outcomes) [37,38]. Finally, the cognitive value reflects how information contributes to one's own "mental model" of the world, including satisfying curiosity and reducing uncertainty about a topic or a future event.

People differ in how much weight they assign to the three above-mentioned motives while seeking information, and these weights can also be indicative of underlying psychopathology [32,39]. For example, individuals who report higher general psychopathology symptoms exhibit a negative effect of cognitive utility on information-seeking, suggesting that information that reduces uncertainty is less valuable to them [39]. This might constitute a bias given that cognitive utility typically drives information-seeking in the other direction. Given this finding, the question of whether socially anxious individuals exhibit biases in how they seek information is intriguing. This is particularly relevant to the symptoms of fear of social evaluation (information about oneself coming from another person) and avoidance of social situations (information about social situations may be avoided more). Recent research focusing on symptoms of generalized or trait anxiety, which are known to exhibit high comorbidity with social anxiety [40,41], suggest that anxious individuals seek more information specifically in response to large changes in the environment, rather than seeking more information in general, or more positively- or negatively-valenced information [42]. This may reflect heightened motivation to reduce uncertainty, consistent with increased intolerance to uncertainty in anxiety [43].

While these studies did not establish specific information-seeking biases in social anxiety, it may be that seeking 'social' information more specifically - that is, information from or about others - is more biased in

SA than general drivers of information-seeking. For instance, seeking information about others before making judgments of social rank was found to be reduced in SA [44]. Given the associated fear of evaluation, most empirical work so far has focused on feedback-seeking, the process of seeking information about oneself from others. Seeking social feedback is a natural part of social interactions and communication, helps people learn about themselves, and can involve seeking validation, clarification, or reassurance. Fear of evaluation as a core symptom may lead socially anxious individuals to avoid feedback to a greater extent, while on the other hand may result in increased feedback-seeking to achieve various social goals or actions (e.g. feeling understood, engaging in a social situation, etc). Evidence does indeed suggest that socially anxious individuals exhibit distorted patterns of social feedback-seeking. Seeking reassuring, safety-related information, can become excessive and maladaptive in SA, leading to excessive reassurance-seeking (ERS) [45,46]. In fact, ERS constitutes one of the safety behaviors in SAD, which can help alleviate anxiety in the short term, but can also aggravate the underlying and unresolved fears in the long term [8,47]. Paradoxically, while ERS is intended at seeking positive feedback, individuals with SAD also seek negative feedback [46]. This might serve as a self-verification process [48,49], whereby feedback is sought to reinforce negative self-perceptions. Despite this apparent heightened tendency to excessively seek social feedback, socially anxious individuals have also been found to seek less social feedback, for example by exerting less effort to seek social media likes from high-status peers [50].

These findings suggest that social anxiety may be specifically associated with how individuals perceive and weigh the hedonic value of social feedback, such that socially anxious individuals may be uniquely characterized by increased preference for both positive and negative feedback from close others, but reduced preference for feedback from strangers, compared to non-socially anxious individuals. Whether such opposite preferences are observed in different situations within the same individual or in different individuals with different symptoms, or both, and whether they directly map onto FNE and FPE symptoms, remains unknown.

Beyond feedback-seeking, other factors may drive information seeking or information avoidance in social anxiety, though we note that empirical evidence for those is currently lacking. For example, socially anxious individuals could exhibit differences not only in feedback-seeking, which is inherently self-referential and evaluative, but also in seeking other types of social information such as advice, gossip, or information about others' preferences and attitudes (e.g. see Ref. [44]). The source of social information may also matter, with socially anxious individuals potentially exhibiting heightened preferences to seek information from close/safe sources, rather than from strangers. Avoidance of social situations may limit active information gathering and reduce opportunities to encounter more accurate representations of reality, further reinforcing avoidance behaviors [51]. Research into the cognitive mechanisms of information-seeking is still in its infancy, so future investigations are needed to establish how they might vary with social anxiety.

Biases in information integration

Some earlier theories of anxiety (see Ref. [1] for a review) report that post-event processing (PEP) — a thought process involving reviewing one's own actions and the reactions of others in anticipation or following a social situation — is distorted in SA. PEP is often negatively self-focused and ruminative, maintains negative self-impressions, and leads to biased retrieval of negative memories, thus perpetuating the anxiety [52]. This suggests that learning in general, or updating beliefs about the self or the social world in response to information, may also be biased in social anxiety.

Recent literature has delved into this question. Besides biases in social feedback-seeking mentioned above, individuals wih SA also exhibit biases in how they integrate social feedback to update their self-beliefs. For example, following a public speaking task, socially anxious individuals updated their self-evaluation and self-esteem to a greater extent after negative compared to positive social feedback [53] or failed to show a positivity bias during affective updating, contrary to controls [54]. In a more iterative social evaluation task combined with a computational model of reinforcement learning, such tendency to learn more easily from negative social feedback increased with self-reported FNE levels and with reduced positive beliefs about the self [55,56]. This negative information integration bias appears supported by biased neural responses to social feedback, including more negative EEG signals to the anticipation of feedback [57], and stronger brain responses to the delivery of negative versus positive feedback [53,58]. Interestingly, positive social feedback has been associated with stronger error responses [59], consistent with it being more unexpected than negative feedback. It's possible that socially anxious individuals give more weight to negative outcomes and learn more from them than positive ones, as negative feedback may feel more salient and threat-related attention and memory biases are at play. It could also be partially because the value of positive feedback might be reduced by their desire to avoid conflict or competition, or by fear of not being able to meet others' expectations. These ideas align with explanations for FPE [22,26].

Furthermore, increased learning in negative contexts may be specific to or exacerbated in social situations: in a modified trust game involving only negative and neutral

outcomes, FNE was associated with elevated learning rates [60]. Additionally, individuals with higher FNE showed more behavioral reactivity in the social version of the task, where outcomes come from other people, relative to a non-social control task [60]. This negativity bias in reinforcement learning was not found when the outcome was about the valence of a facial expression, that is learning rates did not vary with social anxiety when learning the probability that a neutral face turns into a happy or angry face [61]. These findings suggest that increased learning of negative information in SA may only occur when the information is self-relevant, such as feedback about oneself from others, or changes in one's own outcomes because of another person's actions.

Besides the negative information integration bias described above, other learning differences are observed in social anxiety. First, socially anxious individuals exhibit difficulties adapting their learning rate to the volatility in the environment, specifically in threatening contexts [62]. This mirrors a similar deficit observed in trait anxiety [63], raising the question of whether the difficulty to adjust learning in volatile environments is related to trait anxiety, social anxiety, or to a more general anxiety dimension that would encompass both. A recent study aiming to disentangle these hypotheses found inconclusive results, such that volatility did not overall influence learning nor were volatility changes in learning rates related to anxiety or FNE specifically [60]. In a competitive social learning context, those with high SA exhibited increased learning from situations in which taking a different action would have led to a better outcome [64]. So, instead of updating their beliefs more strongly after losing (negative outcome), biased learning occurred specifically in response to the counterfactuals, focusing on what would have been better even if they won. This focus may contribute to cycles of negative self-perception and rumination even in the context of positive events. In the context of competing for social influence, individuals with SA learn to blend in by matching what their rivals do, rather than by trying to gain and assert influence [65], shedding light on how decisions to share information - here, advising others - are altered in social anxiety. Finally, biased information integration was also found to occur in the context of avoiding social situations. Avoidance of social situations results in a lack of information available to be integrated and to appropriately update beliefs, and thus can reinforce and perpetuate avoidance behaviors [51]. Interestingly, in a recent study [66] where participants were presented with counterfactual positive outcomes from avoided social situations (i.e. cases where approaching a person would have been beneficial), those with high SA exhibited difficulty updating their beliefs in response to the positive information, suggesting that even when the information is available, it may not be enough to break or mitigate the circle of perpetuating social avoidance.

Conclusions and future directions

In summary, cognitive biases involving increased processing of negative versus positive information in social anxiety apply to a wide range of processes, including attention, working memory, self-perception, interpretation, information-seeking and reinforcement learning. While these biases appear to underlie the main symptom of social anxiety - the fear of negative evaluation - biases in how positive information is valued and processed may carry a lot of relevance in further characterizing individual differences in social anxiety symptoms, particularly when it comes to the fear of positive evaluation.

Despite these recent advances, our suggestions for future directions involve:

1) Further delineating the specificity of these biases. Recent studies employing a transdiagnostic approach suggest some specificity and dissociation from other psychopathology dimensions [67] or from depression specifically [56]; however it remains unclear whether most of the biases described in this review are specific to social anxiety symptoms, or could be driven by other correlated dimensions, such as general or trait anxiety.
2) Characterizing how these biases relate to one another. It is possible that some of these biases arise from the same versus distinct psychological constructs, but this remains hard to establish given that most studies tested a single construct or bias within their experiment. Future studies might leverage computational modeling to shed light on unique, interpretable mechanisms, together with big data and machine learning approaches to better parse unique versus shared variance between these biases, as well as their predictive power of social anxiety symptoms and/or subtype groups.
3) Establishing the causal and potentially bidirectional relationship between information-seeking and integration biases and social anxiety symptoms.
4) Understanding whether the association between cognitive biases and social anxiety differs between individual levels of social anxiety in the general population and clinical levels of social anxiety in social anxiety disorder.
5) Examining whether social anxiety, especially in the general population, can be adaptive, such as hypervigilance and more efficient perceptual learning [67]. Cognitive biases are generally interpreted as detrimental or maladaptive, especially in the context of psychiatric symptoms along which they may be exacerbated. However, biases (e.g. knowledge avoidance, resource rationality, availability bias,

optimism bias, confirmation bias, etc) can be adaptive, not only in one's daily life but also in surviving evolutionary pressures [68]. Further characterizing these more adaptive processes could shed light on coping mechanisms and interventions targets if or when they become maladaptive.

Credit author statement

Yukta Thyagaraj: Conceptualization, Writing - Original Draft, Writing - Review & Editing.

Selin Topel: Writing - Review & Editing.

Caroline Charpentier: Conceptualization, Writing - Original Draft, Writing - Review & Editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

No data was used for the research described in the article.

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* of special interest
** of outstanding interest

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Further information on references of particular interest

16. ** In this study, the authors used cluster analyses to shed light on well-known biases associated with social anxiety in the general population. They identified two groups: one with adaptive cognitive patterns (low biases, high executive functioning) and one with more maladaptive patterns (high interpretation bias, good alerting but poor executive functioning), with higher levels of social anxiety found in the second group. Their findings suggest that social anxiety symptoms are primarily associated with interpretation bias, rather than an attention bias towards threatening stimuli.

46. * One of the first and only studies that quantified both positive and negative feedback-seeking behavior in clinical groups, including social anxiety disorder and generalized anxiety disorders. Through diary data, there were no differences in feedback-seeking behavior between the groups, but through self-report questionnaires, both clinical anxiety groups reported more feedback-seeking from close others.

50. ** In this study, active feedback-seeking behavior was measured through the amount of physical effort expended. In a social media simulation, both adolescents and young adults with and without social anxiety symptoms created social media posts and expended effort to show their post to others in order to receive feedback. Individuals with social anxiety symptoms were found to exert less effort to seek social feedback specifically from high status peers.

55. ** In a computational model of feedback learning, individuals with high fear of negative evaluation were found to learn more easily from negative feedback about themselves, as shown through greater self-negative learning rates. Additionally, this bias was associated with a reduced overall belief that others would choose a positive (vs negative) attribute to describe them. This study is also of interest from a methodological standpoint, using a novel approach that integrates clinical symptoms within the computational model-fitting.

64. ** In a socially framed reinforcement learning task, social anxiety was found to be associated with increased evaluative deliberation - in particular through increased learning from 'upward counterfactuals', that is from situations where taking a different action would have led to a better outcome. In a replicated computational psychiatry approach, the authors also show that this effect appears specific to social anxiety, rather than anxious-depression, obsessive-compulsive thoughts, or cognitive reasoning.

65. ** In this study, the authors assess two competing goals that can drive the decision to share information (here, advice) with other people, specifically competing to gain influence versus blending in with the group. They find that socially anxious individuals share information in an attempt not to gain influence, by giving advice that was similar to that of rival advisers, and that they exhibit more negative social comparisons with rivals.

66. ** This work presents an interesting account of altered counterfactual learning in social anxiety. In an online social approach-avoidance task, participants had to learn from trial-and-error which partner to approach or avoid, then after initial learning, the contingencies are reversed, such that the previously avoided partner should now be approached (positive updating) and vice versa for the other partner (negative updating). Socially anxious individuals exhibited a specific impairment in learning in the positive updating condition, even though they were being informed of the counterfactual (i.e. that a positive outcome would have occurred had they approached the partner). This suggests a difficulty in updating beliefs about previously avoided social situations that should no longer be avoided, possibly contributing to the maintenance of avoidance behavior in social anxiety.