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RESEARCH ARTICLE

Trait-anxiety and belief updating: Exploring the role of negativity bias and contrast avoidance

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Abstract

Beliefs play a crucial role in shaping our behaviors and mental health outcomes. Asymmetric belief updating refers to the phenomenon where desirable information is updated more readily than undesirable information. An essential feature of anxiety is threat-overestimation and a tendency to focus on the negative aspects of experience while avoiding sharp negative emotional contrasts. These two characteristics lead to different predictions concerning belief updating. One scenario would suggest a reduction in asymmetric update behavior, indicating negativity bias, whereas the other would indicate an increase in asymmetric update, indicating contrast avoidance. To test these two rival predictions, participants (n = 54) first completed trait-measures and then performed a belief update task. Moreover, memory for the information presented was assessed in the short-term and long-term. Skin conductance response was measured to assess arousal levels. Overall, our findings revealed that higher levels of trait-anxiety predicted a greater integration of desirable information but not undesirable information. Trait-intolerance of uncertainty did not exhibit an association with update behavior. Skin conductance and memory were not associated with trait-measures. We discuss these results in line with the Contrast Avoidance Model of anxiety in terms of avoidance of unexpected negative and positive contrasts induced by relief during belief updating.

Keywords Anxiety · Cognitive bias · Updating · Memory · Avoidance

"*The man who has anticipated the coming of troubles takes away their power when they arrive*." **Seneca, Consolation to Marcia**

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Introduction

Beliefs are "propositional attitudes" that shape our internal worlds and serve decision-making and general well-being (Carver & Scheier, 2014; Carver et al., 2010; Craig et al., 2021). However, our beliefs are not a pure reflection of the world. Instead, our cognitive system biases information processing (Gershman, 2019; Kahneman, 2003).

Positive beliefs about the future or self are associated with better health outcomes (Carver et al., 2010; Sweeny et al., 2006). Conversely, intense negative beliefs are a hallmark of mental disorders (i.e., depression, schizophrenia, etc.) characterized by suboptimal reward-seeking and punishment avoidance (Borkovec et al., 1999; Moutoussis et al., 2015; Watkins

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& Moulds, 2005). Healthy people tend to overestimate the likelihood of positive future events across various domains, such as finance, intelligence, or accidents (Carver et al., 2010; Sweeny et al., 2006; Weinstein, 1980). Besides their epistemic (truthful) aspect, beliefs possess instrumental and hedonic value (Bromberg-Martin & Sharot, 2020; Loewenstein & Molnar, 2018; Sharot et al., 2023). In other words, the value of beliefs could be derived from their ability to predict the environment and guide action selection (instrumental value) and from the affective experience that certain beliefs provide (hedonic value).

Positive beliefs can be rewarding (i.e., being competent, nice, etc.), whereas negative beliefs can produce distress and often are preferred to be avoided. In this sense, beliefs are more readily integrated in response to desirable information ("good news") than undesirable information ("bad news") (Sharot & Garrett, 2016; Sharot et al., 2011). This asymmetric belief updating, known as the "optimistic update bias," suggests that when individuals estimate their risk of experiencing negative outcomes, such as a cardiovascular accident, they tend to update "better than expected" information at a higher rate than "worse than expected" information.

These findings have been replicated and consistently show a positive association between optimism and asymmetrical belief updating (Kuzmanovic et al., 2015; Sharot & Garrett, 2016). Because dysfunctional beliefs are critical in mental disorders and are explicitly targeted during treatment (i.e., cognitive restructuring in Cognitive Behavioral Therapy; Beck & Dozois, 2011), belief updating processes have gained clinical relevance. Previous research has demonstrated that asymmetrical belief updating is influenced by information valence and the specific psychiatric population being studied (Garrett et al., 2014; Korn et al., 2014; Ossola et al., 2020; Schönfelder et al., 2017).

Fear and anxiety are two related human emotions that primarily differ in their relative imminence and uncertainty about threats (Hamm, 2020; Mobbs et al., 2020). Whereas fear corresponds to a defensive response of the organism (fight or flight) in the face of a detectable imminent threat, anxiety is a more persistent negative state in response to distal, uncertain, or potential threats (Barlow, 2004; LeDoux & Pine, 2016).

Much work has been conducted to understand cognitive and behavioral features as well as biases toward threats that initiate and maintain anxiety (Cisler & Koster, 2010; Coles & Heimberg, 2002; Grupe & Nitschke, 2013; Hartley & Phelps, 2012). First, anxiety is associated with threat overestimation (also known as "pessimistic expectations"). Individuals with high anxiety levels tend to exhibit skewed estimates (overestimation) about the probability of negative or uncommon events, perceiving their consequences as more severe (Beck & Dozois, 2011; Grupe & Nitschke, 2013). Second, anxiety implies high levels of intolerance to uncertainty (IU) and increased reactivity to threats. In other words, individuals with high levels of anxiety find uncertain outcomes distressing and tend to respond more negatively (Buhr & Dugas, 2012; Carleton et al., 2007a, 2007b). Third, anxiety is associated with biases toward negative information (negativity bias; Cisler & Koster, 2010; Coles & Heimberg, 2002; MacLeod & Mathews, 2012). This implies that anxious individuals have faster threat detection (attentional bias), infer negative scenarios in ambiguous contexts (interpretative bias), and remember more negative information (memory bias). Finally, anxiety is associated with persistent behavioral and cognitive avoidance of threats. Anxious individuals avoid confronting threatening internal or external experiences or escape from them before their occurrence (Bouton et al., 2001; Buhr & Dugas, 2012; Llera & Newman, 2014). Overall, these anxiety features are thought to maintain symptoms and hinder learning from experience by maintaining skewed negative predictions that are rarely confirmed (Fernández et al., 2017; Grupe & Nitschke, 2013).

To our knowledge, no previous study directly investigated the process of belief updating about future negative events considering individual differences in trait-anxiety and trait-intolerance of uncertainty (trait-IU). Following this hypothesis on the negativity bias of anxiety, it could be hypothesized that when estimating future negative events, high trait-anxious individuals would exhibit a reduced asymmetrical belief updating (unbiased) compared with low trait-anxious individuals. Hence, highly anxious individuals may update to the same extent desirable and undesirable information as information may provide more instrumental value: the opportunity to learn more about threats (risks) regardless of valence, implement control strategies, and avoid those threats in the future. For example, recent work by Garrett et al. (2018) indicated that in the face of an acute threat (Trier Social Stress Test), individuals showed balanced belief updating in the sense that desirable and undesirable information was integrated to an equal extent. However, as previously mentioned, acute and potential threats as imminent or distal threats may involve different processes (Hamm, 2020; Mobbs et al., 2020).

Conversely, a complementary anxiety model predicts a different pattern. The Contrast Avoidance model (CAM; Kim & Newman, 2023; Llera & Newman, 2014; Newman & Llera, 2011; Rashtbari & Saed, 2020) posits that anxious individuals assume a "worst-case scenario" strategy toward threats to avoid an increase in negative affect when expectations are "worse than expected" ("*more threatening than expected*"). This strategy implies that there is a higher likelihood for anxious individuals to experience relief from "better than expected" ("less threatening than expected") experiences, which in turn reinforces worry behavior. Previous work indicated that anxious individuals experience higher relief during avoidance tasks (San Martín et al., 2020; Vervliet et al., 2017). While CAM does not explicitly predict belief updating, we hypothesize that its principles may extend to the way individuals integrate desirable and undesirable information. Specifically, individuals with high trait-anxiety may preferentially update beliefs based on desirable information to avoid sharp negative affective contrasts. This would imply an increased asymmetrical belief updating, because it provides more hedonic value by maximizing relief.

This study

To test those two rival hypotheses, we focused on individual differences in trait-anxiety and trait-IU during a belief update task (Fig. 1) compared with trait-optimism, which is proposed to be consistently associated with update behavior (Kuzmanovic et al., 2015; Sharot et al., 2011). After completing psychometric measures, participants were exposed to descriptions of negative events and were asked to provide an initial estimate (P1) of the probability that these events would happen to them in the future. Immediately following this initial estimate, participants were presented with the actual population base rate (PT) for the event for 2 s. In a second session, participants were presented again with the same adverse life events and asked to provide a revised estimate (P2) of their own risk, without being shown the population base rate again. This allowed us to assess how the presented information influenced their initial beliefs. As arousal levels and prediction error responses differ according to trait-anxiety levels (Duits et al., 2015; Xiao et al., 2011), we measure skin conductance response during the updating task. This allowed us to explore the relationship between SCR and various factors, including trait anxiety, the magnitude of the prediction error, and arousal responses during belief updating. We predicted

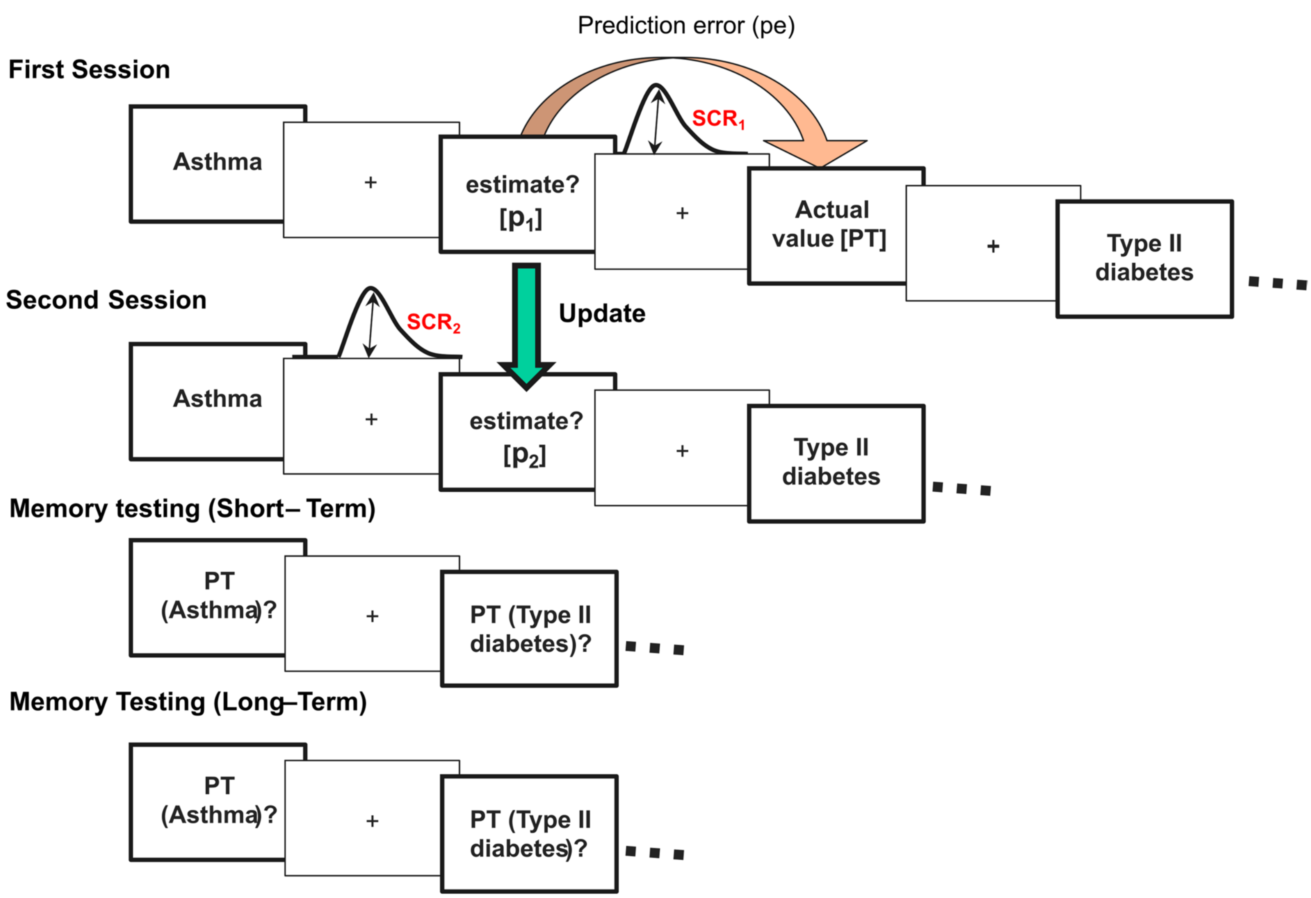

Fig. 1 Belief update task. On each trial, subjects were presented with varying adverse life events and asked to estimate how likely this event was to occur to them in the future (First estimate – P1, First Session). Then, the actual base rate for a person with a similar background (age, gender, and socio-economic status) was presented (True Value – PT). Trials were classified according to their valence. When P1 < PT, it was considered that the subject received desirable information ("good news"). Conversely, when P1 > PT, the trial was classified as undesirable information ("bad news"). SCR picture corresponds to the moment it was measured in the trial. After finishing the 40 trials (events), participants proceeded to the second session, in which they were asked again to re-estimate the likelihood of adverse life events happening to them (P2). The update parameter is calculated as the absolute difference between the participants' estimates in the two sessions (P2-P1) before and after the information (PT) was given. Memory for the actual base rate (PT) was evaluated after the second session (Short-term) and three months later (Long-term)

that if the instrumental value of the information carries more weight during the update process, individuals with higher trait-anxiety would exhibit a reduced asymmetric belief update (balanced), aligning with the negativity hypothesis. Conversely, if the hedonic value carries more weight, individuals with high trait-anxiety would exhibit an increase in the asymmetry (unbalanced), in line with the CAM. Finally, we expected that memory for the actual base rate (PT) would differ according to valence and trait-anxiety levels. Specifically, we hypothesized that memory for undesirable information (PT > P1) would be superior to memory for desirable information (PT < P1) and that this difference would be modulated by trait-anxiety, with more anxious individuals exhibiting a greater memory advantage for undesirable information. This prediction is based on previous research indicating enhanced memory for threat-relevant information in individuals with high anxiety (Cisler & Koster, 2010; Coles & Heimberg, 2002).

Methods

Participants

A total of 54 undergraduates and graduate young participants from Buenos Aires University (Argentina) with a mean age of 23.2 ± 2.1 years participated in the study. Our exclusion criteria were a history of psychiatric disorders. Before the experiment, participants completed self-reported trait-measures: the trait subscale of the State-Trait Anxiety Inventory (Spielberger et al., 1970); the Intolerance of Uncertainty Scale-12 (Carleton et al., 2007a, 2007b); and the Life Orientation Test-Revised (Scheier et al., 1994). All participants signed a written informed consent form approved by the Ethics Committee of the Review Board of the Instituto de Investigaciones Médicas Alfredo Lanari in accordance with the Declaration of Helsinki. The sample size was based on previous studies using similar update tasks and psychometric measures (Garrett et al., 2014, 2018; Kuzmanovic et al., 2015; Ossola et al., 2020; Sharot et al., 2011).

Stimuli

Participants were presented with 40 short descriptions of adverse life events (i.e., having a stroke, being assaulted, etc.). The average probability of each event occurring to someone from Argentina within the same age range and socioeconomic status was estimated from public national sources (https://www.argentina.gob.ar/; https://servicios.registrocivil.gob.ec/cdd/; https://www.indec.gob.ar/). The probabilities of the events ranged between 8 and 70%.

Measures

Self-report measures

Spielberger State and Trait Anxiety Inventory (STAI; Spielberger et al., 1970). We used the Trait subscale to measure Trait anxiety (Cronbach' $\alpha = 0.90$). The STAI consists of a 20-item scale that assesses the level of anxiety as a general stable trait. Our sample scored M = 26.6 ± SEM = 0.14, range = 16–41.

The Intolerance of Uncertainty Scale—12 (IUS-12: Carleton et al., 2007a, 2007b) consists of 12 items (short version, Cronbach' $\alpha = 0.90$) that individuals rate on a 5-point Likert scale, ranging from "Not at all characteristic of me" to "Entirely characteristic of me." This scale assesses the dispositional capacity of individuals to cope with uncertain or unknown outcomes. The mean score was M = 31.9 ± SEM = 0.19, range = 18–50.

The Life Orientation Test-Revised (LOT-R; (Scheier et al., 1994) was used to assess trait-optimism and expectation regarding positive outcomes in life (Cronbach' $\alpha = 0.80$). It consists of 10 items, and respondents rate their level of agreement or disagreement using a Likert scale. Our sample scored M = 18.6 ± SEM = 0.1, range = 12–29.

Electrodermal activity

We used Skin Conductance Response (SCR) to measure physiological arousal and explore its association with prediction error, abs(PT—P1). We used an input device (Psychlab Precision Contact Instruments) with a sine excitation voltage (± 0.5 V) of 50 Hz derived from the main frequency to measure electrodermal activity. The device was connected to two Ag/AgCl electrodes of 20 mm and 16 mm located in the intermediate phalanges of the non-dominant hand. Raw SCR scores were square-root transformed to normalize distributions using MatLab Software. We then used an average moving filter of 5 points (smooth command in Matlab Software) to smooth the raw signal. The time window for signal extraction was set to 0.5 s to 4 s between the subject's first estimate and the presentation of the actual base rate. We used a minimum response criterion of 0.002 micro-Siemens (mS), and all other responses were scored as zero.

Belief update task

Participants performed a belief update task in two sessions (Fig. 1). In the first session, each trial involved a negative life event, and participants were instructed to estimate (First estimate—P1) the likelihood of the event happening to them in the future (i.e., "*What is the probability that you will be mugged?*"). Participants had 5 s to respond, after which the actual population base rate of the event (actual base rate—PT) was presented for 2 s. If participants had previously experienced a specific event, they were instructed to estimate the likelihood of experiencing the same event again. The second session began 5 min after completing the first 40 trials. Participants were presented again with the same adverse life events and asked to reestimate (Second estimate—P2) their own risk. In this session, no population base rate was presented to avoid learning or relearning.

Memory testing at short and long-delay

At the end of the experiment, participants' memory (Short-term) of the actual base rate was assessed. Each of the 40 negative life events was presented again, and participants were instructed to report the actual probability previously seen. Previous studies evaluated memory to test their effects on belief updating and reported no differences between desirable and undesirable information retention (Garrett et al., 2018; Sharot et al., 2011). However, because high anxiety levels were reported to be associated with better memory retention of negative information (Coles & Heimberg, 2002; Fernández et al., 2017), we also tested the memory of the 40 negative life events 3 months after the experiment (Long-term). Memory testing at long delay was conducted online in *Google Forms*. Experimental tasks were designed and presented using MATLAB 2016 (Mathworks Inc., Sherborn, MA) with the Psychtoolbox toolkit.

Data analysis

To model subjects' responses, we performed generalized hierarchical Bayesian regression models. Update was defined as the difference between the subject's first estimate (P1) and second estimate (P2) if P1 is larger than the actual value for that stimulus (PT) (or P2-P1 if P1 is smaller than PT), resulting in a bounded interval of (− 1,1). Prediction error was defined as the absolute difference between P1 and the actual value for that stimulus (PT). The valence of the base rates of negative life events relied on the initial estimate provided by the participants (P1). If the base rate for an adverse event was lower than the participant's initial estimate (P1 > PT), it was considered desirable information "good news"). Conversely, if the base rate was higher, it was seen as undesirable information ("bad news"; P1 < PT). We employed a normal hierarchical model to capture subjects' updated responses. Although the response variable is bounded, we can use the identity link function from the normal model to provide an adequate approximation.

We modeled the updated responses as follows:

$$\begin{aligned} update = \alpha &+ \beta_1\left(News_{desirable}\right) + \beta_2(PredictionError) \\ &+ \beta_3(TrueValue) + \beta_4(Anxiety) + \beta_5(Optimism) \\ &+ \beta_6(Uncertainty) \end{aligned}$$

$$\begin{aligned} &+ \beta_7\left(PredictionError \times News_{desirable}\right) + \beta_8\left(Anxiety \times News_{desirable}\right) \\ &+ \beta_9\left(Optimism \times News_{desirable}\right) + \beta_{10}(Uncertainty \times News_{desirable})+ \end{aligned}$$

$$\begin{aligned} &+ \beta_{11}\left(TrueValue \times News_{desirable}\right) \\ &+ \beta_{12}(Anxiety \times PredictionError) \\ &+ \beta_{13}(Optimism \times PredictionError) \\ &+ \beta_{14}(Uncertainty \times PredictionError)+ \end{aligned}$$

$$\begin{aligned} &+ \beta_{15}\left(PredictionError \times News_{desirable} \times Anxiety\right) \\ &+ \beta_{16}\left(PredictionError \times News_{s_{desirable}} \times Optimism\right) \\ &+ +\beta_{17}(PredictionError \times News_{_{desirable}} \times Uncertainty) \end{aligned}$$

The subject's update was explained by the news valence (desirable/undesirable information), the prediction error, the actual value of the stimuli and the levels of trait-anxiety, trait-IU, and trait-optimism. We included a triple interaction between prediction error and news with trait-anxiety, trait-IU, and trait-optimism. Therefore, the effect of prediction error, news valence, and trait-level measures depended on each other's values. We also included an interaction between the actual value (PT) and the news valence. Because of the bounded nature of the response variable, we established weakly informed priors for all coefficients following a Normal (0,5) distribution and employed default priors for all other parameters (Supplementary material 1). Additionally, we explored the influence of trait anxiety, trait-optimism, and trait-IU on initial (P1) and final (P2) belief estimates. Separate models were fit for P1 and P2. The model for P1 included trait-anxiety and trait-optimism as predictors. The first model for P2 included trait-anxiety, trait-optimism, the true value (PT), the initial estimate (P1), and prediction error (ep) as predictors. The final p2 model added trait-measures, valence, and prediction error (ep) to examine the three-way interaction.

To model the impact of skin conductance response (SCR), we again used the identity link function for the generalized hierarchical Bayesian regression model using Normal (0,2) priors for all parameters. We employed a modified version of the original model for the update response and included the SCR value as a predictor variable alongside a triple interaction with the prediction error and the news valence.

Finally, the subject's short-term memory was defined as the absolute difference between the actual value (PT) and the subject's response at the end of the experiment (short-term memory) for each event. Therefore, it was naturally bounded between the (0,1) interval. To model the subject's memory of the actual base rate (PT), we employed a zero-inflated beta hierarchical Bayesian model owing to the bounded nature of the response variable and the presence of a (relatively) small amount of 0 values, forcing us to include the zero-generating component. In this model, we employed Normal (0,2) priors for all fixed coefficients including the intercept. We also defined a Normal (0,1) prior for the random effects and a Gamma (1,0.01) prior for the Φ component of the regression. Lastly, we defined a Normal (−3,1) prior for the zero-generating component to accommodate the small number of zero cases. We employed the same model as in the case of the update response and included a time-interval (Short / Long) parameter, which is a categorical variable defining whether the response variable came from an immediate or a delayed test. In addition, we included the triple interaction between this parameter, the prediction error, and the news valence.

We computed posterior estimates for all models using four Markov chain Monte Carlo (MCMC) chains of 10,000 iterations each (5,000 were used as warm-up). We visually inspected trace plots, density plots of the posterior, and autocorrelation plots for each parameter. We also assessed adequate convergence using R-hat values for each parameter and examined the effective sample size (ESS) to determine the posterior estimation stability. Lastly, we checked the model adequacy using prior posterior predictive checks and posterior predictive checks.

Owing to nonlinearities arising from interactions or nonlinear link functions, we computed average marginal effects to examine the impact of specific covariates. In this report, we present the coefficients (β) extracted from the model and the average marginal effects (M) to test the effects of interest. All posterior reports use the mean as the posterior point estimate and the 95% highest density interval (HDI) as a measure of uncertainty. The HDI conveys the range of most probable values in the posterior. Parameter estimates can be interpreted as statistically meaningful (akin to statistical significance in the frequentist approach) if zero is outside the HDI. All analyses were performed in R version 4.3.0. The *brms* package was used to fit and estimate generalized hierarchical Bayesian models. The *tidybayes* package was employed for general posterior manipulation and plotting, and *the marginal effects* package was used to compute all marginal effects.

Results

Belief update task

The hierarchical Bayesian analysis showed the expected asymmetry in belief updating (Fig. 2; News Valence $\beta = -0.37$ [−0.71, −0.03]). Subjects updated to a greater extent while receiving desirable information ($M = 0.152$ [0.13, 0.17]; Supplementary material 2) compared with undesirable information ($M = 0.085$ [0.06, 0.09], $M_{\text{difference}} = 0.069$ [0.052, 0.81]). In addition, we found an association between the Prediction Error level, the True Value (PT), and subsequent update (Prediction Error $\beta = 1.35$ [0.51, 2.47], True Value (PT) $\beta = -0.19$ [−0.28, −0.09]). There was also a noticeable difference in the slope of the Prediction Error ($M_{\textit{difference}} = 0.332$ [0.193, 0.465]) between undesirable information ($M = 0.396$ [0.278, 0.513]) and desirable information ($M = 0.729$ [0.662, 0.795]), suggesting that although both were in the same direction, the latter showed a higher prediction error-dependent update than the former.

In accordance with the CAM, we found that higher levels of trait-anxiety were associated with increased asymmetry in the integration of information (Fig. 3A, Main

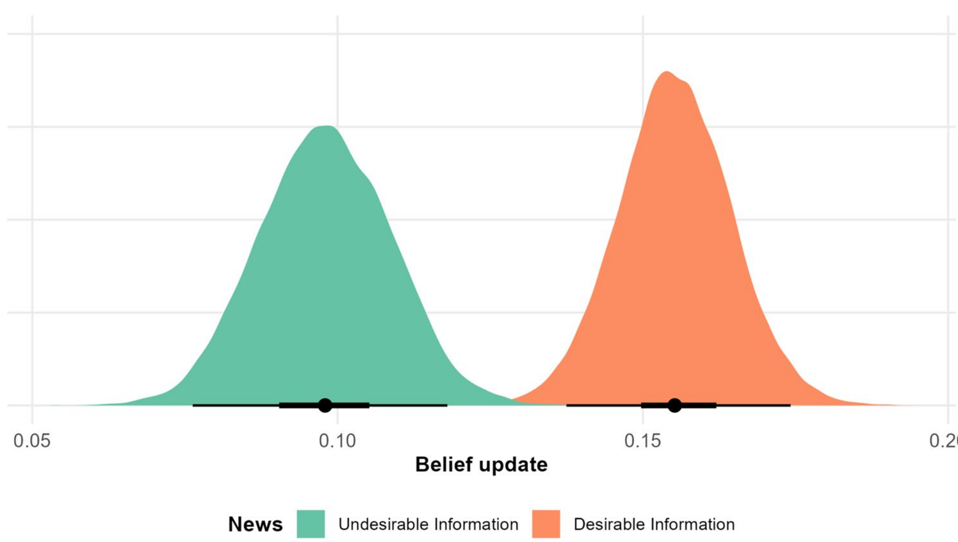

Fig. 2 Belief update results. Posterior marginal effect of news valence (desirable/undesirable information). Subjects updated their estimations to a greater extent after receiving desirable information than undesirable information (asymmetrical belief updating)

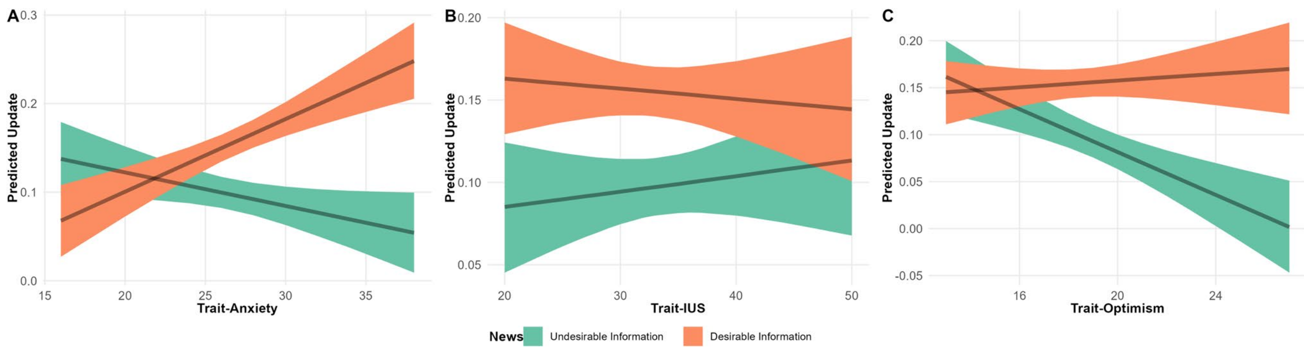

Fig. 3 Belief updating as a function of trait-measures and news valence (desirable/undesirable information). Predicted marginal effect of Trait-measures on update behavior. (**A**) Trait-anxiety; (**B**) Trait-IU; (**C**) Trait-Optimism

effect of trait-anxiety $\beta = -0.001$ [-0.006, 0.004], trait-anxiety x News Valence x Prediction Error interaction $\beta = 0.04$ [0.01, 0.06], desirable and undesirable information $M_{\text{difference}} = 0.011$ [0.007, 0.016]). Moreover, higher scores of trait-anxiety exhibited an increase in update behavior for desirable information ($M = 0.009$ [0.004, 0.013]) but not for undesirable information ($M = -0.003$ [-0.007, 0.001]). In contrast, we did not find evidence that trait-IU was associated with the integration of information (Fig. 3B, Main effect of trait-IU $\beta = 0.001$ [-0.001,0.001], trait-IU x News Valence x Prediction Error interaction $\beta = 0.001$ [-0.02, 0.02]). Regarding trait-optimism, marginal effect analysis revealed a difference in update behavior while receiving desirable compared to undesirable information (Fig. 3C, Main effect of trait-optimism $\beta = -0.001$ [-0.01, 0.007], trait-optimism x News Valence x Prediction Error interaction $\beta = 0.02$ [0.01, 0.06], $M_{\text{difference}} = 0.012$, HDI [0.005, 0.019]). Undesirable information showed a negative slope of $M = -0.010$ [-0.016, -0.003], indicating that higher levels of trait-optimism lead to lower levels of update, whereas the slope for good news was not different from 0 ($M = 0.001$ [-0.004, 0.008]). Whereas first estimates (P1) may differ in desirable and undesirable trials and as a function of anxiety, controlling for these factors as in the model below does not alter the main results presented in Fig. 3 (Supplementary Material 6). We also tested a simplified version of the model to reduce the chance of collinearity. Results from this model, in which trait-IUS and trait-optimism were removed as covariates, were also similar to the results presented in Fig. 3 (see Supplementary Material 7 for more details).

Finally, we explored the influence of trait-anxiety and trait-optimism on both initial beliefs (P1) and final beliefs (P2) after receiving new information, allowing us to disentangle the effects of these traits on the starting point of belief formation and the subsequent updating process. Analysis of P1 revealed a small negative association between trait-optimism and initial estimates of negative event likelihood ($\beta = -0.01$, 95% HDI [-0.03, -0.00]). However, there was no credible association between trait-anxiety and P1 ($\beta = -0.0001$, 95% HDI [-0.01, 0.01]) nor with trait-IU ($\beta = -0.003$, 95% HDI [-0.01, 0.01]).

The model of P2, including P1 as a predictor, showed evidence of positive associations with the true value (pT; $\beta = 0.31$, 95% HDI [0.26, 0.36]), initial belief (P1; $\beta = 0.43$, 95% HDI [0.39, 0.47]), and a credible negative association with prediction error (ep; $\beta = -0.15$, 95% HDI [-0.21, -0.10]). While negative associations were observed between both trait-measures with P2, their 95% HDIs included zero (trait-anxiety: $\beta = -0.01$, 95% HDI [-0.01, 0.00]; trait-optimism: $\beta = -0.01$, 95% HDI [-0.01, 0.00]); trait-IU $\beta = -0.001$, 95% HDI [-0.001, 0.001]), suggesting these effects are likely weak or negligible.

To further investigate the role of trait-measures in final belief estimates (P2), we fit models including the three-way interactions of trait-anxiety and trait-optimism with valence and prediction error on P2, controlling for P1. The three-way interaction with trait-anxiety was credible ($\beta = -0.03$, 95% HDI [-0.06, -0.01]), suggesting that the relationship between trait-anxiety and P2 depends on both the valence and the magnitude of the prediction error. Similarly, we found evidence for a three-way interaction with trait-optimism ($\beta = 0.07$, 95% HDI [0.03, 0.10]), indicating that the relationship between optimism and P2 also depends on both valence and prediction error. Analysis of the trait-IU indicated no evidence for an interaction ($\beta = -0.02$, 95% HDI [v0.03, 0.01]).

Analysis of average marginal effects clarified these interactions. For trait-anxiety, the average marginal effect of trait-anxiety on P2 for desirable information was -0.008 (95% CI [-0.013, -0.002]), while the effect for undesirable information was negligible (estimate $= -0.001$, 95% CI [-0.006, 0.005]). This suggests that higher trait-anxiety is associated with lower P2 for desirable information but not for undesirable. For trait-optimism, the average marginal effect of optimism on P2 for desirable (estimate $= 0.005$, 95% CI [-0.004, 0.014]) and undesirable (estimate $= -0.007$ (95%

CI [−0.016, 0.002]) were negligible. These findings suggest that trait-anxiety primarily modulates P2 in response to positive information.

Skin Conductance Response (SCR) and update behavior

When replicating the original statistical model including SCR as a predictor, we did not find evidence for an association between SCR and update behavior (Main effect β = 0.034 [−0.016, 0.088], SCR x News Valence x Prediction Error, β = 0.36 [−0.52, 1.04]). However, model comparison based on Pareto Smoothed importance sampling Leave-One-Out Cross-Validation indicated that a simpler model without trait-measures interactions provided a better model fit (Winning model: *News x SCR x Prediction Error + News x True Value + Trait Measures*; Supplementary material 3). Overall, we found results similar to those of the original model (Supplementary material 4). Interaction analysis of the winning model provided evidence that SCR levels in the time interval between the subject's first estimate (P1) and the presentation of the actual base rate (PT) predicted subsequent update behavior (Fig. 4A, Main effect SCR, β = −0.03 [−0.15, 0.09], SCR x News Valence x Prediction Error (β = 0.75 [0.16, 1.35]). Moreover, SCR levels were higher during the presentation of desirable information (M = 0.15 [0.13, 0.178] compared with undesirable information (M = 0.09 [0.07, 0.12], $M_{\text{difference}} = -0.06$ [−0.08, −0.03].

Short-term and long-term memory of the presented base rate (PT)

After completing the belief updating task (short-delay) and after 3 months (long-delay) memory for the current base rate (PT) presented was evaluated. As depicted in Fig. 4B, memory errors were higher at long-term testing compared with short-term testing (interval β = −0.23 [−0.34, −0.12], short-term M = 0.02 [−0.02, 0.07], long-term M = 0.2 [0.14, 0.25], $M_{\text{difference}} = -0.06$ [−0.07, −0.05]). Moreover, Prediction Error during the belief update task (β = 0.022 [0.13, 0.31] and the actual base rate (PT, β = 0.15 [0.09, 0.21]) predicted memory performance. Notably, we found no effect of news valence on memory retention (β = 0.01 [−0.29, 0.31]. Finally, trait-anxiety (β = −0.001 [−00002, 0.00001]), trait-IU (β = 0.001 [−00001, 0.00001]), and trait-optimism (β = 0.001 [−00001, 0.00001]) were not associated with memory errors at testing (see Supplementary material 5 for details).

Discussion

The formation and updating of our belief system do not accurately or impartially represent the external world or even our inner world. Belief changes involve biased motivations, preferences, values, expectations, and other cognitive processes that alter our "objective rationality" (Kahneman, 2003; Loewenstein & Molnar, 2018). Thus, a robust finding is that individuals are more prone to update their beliefs when confronted with desirable information ("good news") rather than undesirable information ("bad news") regarding potential negative life events (Sharot & Garrett, 2016; Sharot et al., 2011). Given this scenario, differences in individual traits are expected to be associated with different information integration (updating) patterns. Our results provide evidence that trait-anxiety is strongly associated with the level of information integration of possible future negative events. More specifically, we found that the higher the levels of trait-anxiety, the greater the updating of desirable information but not undesirable information. Conversely, the

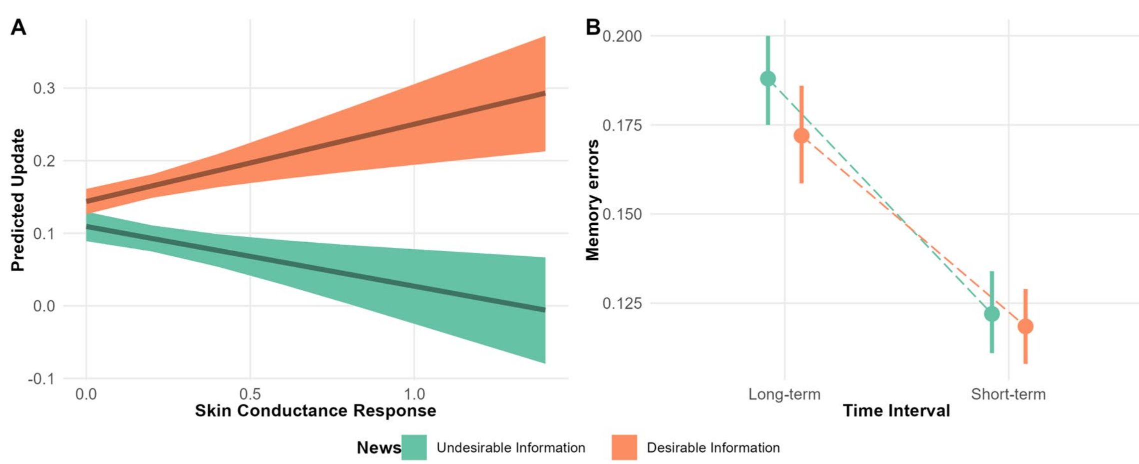

Fig. 4 Skin Conductance Response (SCR) and Memory error results. (**A**) Predicted marginal effect of SCR during belief update task. (**B**) Posterior marginal means of memory errors at the short-term (immediate) and long-term intervals (3 months)

trait-intolerance of uncertainty (IU) was not associated with the update behavior. These results are aligned with the idea that the Intolerance of Uncertainty Scale (IUS) overlaps with more cognitive aspects of anxiety, such as the need for controllability and fear of the unknown, whereas the State-Trait Anxiety Inventory (STAI) captures more affective aspects of dispositional anxiety, such as the tendency to experience negative affect (Chen et al., 2018; Llera & Newman, 2023; Wroblewski et al., 2022). While anxiety is characterized by overestimating the probability of threats, optimism is characterized by underestimating them (Sweeny & Dooley, 2017; Sweeny et al., 2006). Accordingly, trait-optimism was also associated with asymmetrical belief updating. However, we found an interesting dissociation between how trait anxiety and trait optimism contribute to biased belief updating. Our results suggest that trait-anxiety mainly affects desirable information integration, whereas trait-optimism alters how undesirable information is incorporated.

Consistent with previous findings (Garrett et al., 2018; Kuzmanovic et al., 2015; Sharot et al., 2011), update behavior was not explained by memory, because short-term and long-term retention of the actual base rate of negative events was similar for desirable and undesirable information and was not associated with trait-measures. Thus, our results did not support the memory bias hypothesis for negative information in highly anxious individuals. Electrodermal data indicated that changes in skin conductance between the first estimation (P1) and the presentation of the actual base rate (PT) predicted subsequent update behavior. However, this effect was not found to be associated with trait-measures. As a result, further investigation is required to explore the potential application of electrodermal activity as a marker of update behavior.

Contrary to the hypothesis that could be derived from the negativity bias in anxiety (Cisler & Koster, 2010; Coles & Heimberg, 2002; Grupe & Nitschke, 2013; MacLeod & Mathews, 2012), which suggests that highly anxious individuals would exhibit unbiased belief updating, our findings indicate that individuals with high trait-anxiety tend to update desirable information to a greater extent than undesirable information. These findings are consistent with the CAM, which aims to explain the etiology and maintenance of anxiety and worry (Llera & Newman, 2014; Newman & Llera, 2011; Rashtbari & Saed, 2020). More specifically, the model proposes that individuals with generalized anxiety mainly avoid unexpected negative changes (contrasts) in their emotional state. Therefore, by generating sustained mild negative emotional states, such as worry (expecting the worst-case scenario), highly anxious individuals prevent strong negative emotional contrasts. Consequently, because the worst-case scenario rarely occurs, highly anxious individuals experience relief and an increase in the likelihood of positive emotional contrast. Thus, threat-overestimation and worry are reinforced and maintained. For example, Kim and Newman (2023) found that participants with Generalized Anxiety Disorder who engaged in worrying before watching a positive film clip experienced a greater increase in positive affect compared with those who had relaxed before the clip. A recent finding supported this result using momentary assessment and worry induction (Newman et al., 2019). In other paradigms, it was also found that the emotional impact of individuals receiving bad grades or discovering that they had tested positive for a fictitious disease was better when they had predicted the worst scenario than the best one (Sweeny & Dooley, 2017). These ideas resemble the ancient Stoic practice of "negative visualization," which suggests exercising our imagination to envision the worst-case scenario to prepare ourselves to face it and subsequently experience gratitude.

In addition, while we observed the predicted negative relationship between optimism and initial risk estimates, the relationship between anxiety and initial risk estimates was negligible. This suggests that optimistic individuals tend to underestimate the likelihood of negative events, while anxious individuals do not necessarily overestimate them. Furthermore, we found a complex association between trait anxiety, trait optimism, and final belief estimates (P2). Optimistic individuals showed reduced changes in final belief estimates (P2) for undesirable information but not for desirable information. Conversely, anxious individuals exhibited greater reductions in final belief estimates (P2) for desirable information than less anxious individuals, consistent with a desire to embrace information that reduces potential threat. However, the absence of a strong effect for undesirable information suggests that anxious individuals might not necessarily avoid updating their beliefs in the face of negative information but rather show a selective sensitivity to positive information. These findings refine our understanding of how anxiety and optimism influence initial and final belief estimates. Rather than a simple overestimation or underestimation of threat, these traits appear to modulate sensitivity to different types of information, with anxiety increasing sensitivity to good news and optimism decreasing sensitivity to bad news. The observed pattern of updating aligns with the Contrast Avoidance Model (CAM) in a nuanced way. The CAM posits that anxious individuals worry to minimize the negative contrast experienced from unexpected negative events. Our findings suggest that a similar process may be at play with belief updating; anxious individuals may be more sensitive to desirable information, incorporating it more readily to reduce the potential negative contrast of a worse-than-expected outcome. This focus on minimizing negative contrast, rather than simply maintaining negative beliefs, offers a refined perspective on the role of anxiety in belief updating. This nuanced perspective highlights the importance of considering both the valence and the predictive value of information when examining the influence of trait-measures on belief updating.

In our experiment, it could be considered that anxious individuals experience relief and a positive emotional contrast when they overestimate the threat of a negative event (first estimate) and receive desirable information (actual base rate < subjective estimate). This implies a greater integration of "better than expected" information, which may function as a reassurance-seeking strategy. Conversely, when anxious individuals underestimate the probability of a negative event (undesirable information), they could experience an aversive negative contrast, leading to decreased belief updating to avoid a greater negative emotional state. This suggests that in individuals with higher trait-anxiety levels, the hedonic value of a belief, namely, the expected relief, carries greater weight than its instrumental value in accurately predicting events (Bromberg-Martin & Sharot, 2020; Sharot et al., 2023). This perspective also clarifies the robust association between update behavior trait-anxiety but not trait-IU, because the former is more closely related to the affective experience of anxiety while the latter is to the cognitive one. Future experiments on belief updating could incorporate trial-by-trial online measures of positive and negative affect after presenting the actual base rate (PT) to clarify the CAM hypothesis of anxiety. Several limitations of this study should be acknowledged. First, our sample consisted of nonclinical participants. Therefore, generalizing these findings to individuals diagnosed with anxiety disorders requires caution. Future research should investigate belief updating processes in clinical samples to determine whether the observed relationships between trait anxiety and belief updating hold in the context of clinically significant anxiety. Second, it is important to acknowledge that the psychometric properties of the specific belief updating task used in this study have not been formally assessed. While the task draws upon established paradigms in belief updating research, future studies should prioritize investigating the reliability and validity of this measure. Establishing these properties would strengthen the interpretation of findings, facilitate comparisons across studies, and improve its potential clinical application.

Previous research has provided important insights into how individuals update their beliefs in response to new information and how these processes might differ among individuals with certain psychiatric conditions or traits. For example, studies have shown that patients with mood disorders tend to update their beliefs in an unbiased manner (Garrett et al., 2014; Korn et al., 2014), whereas individuals at risk of mania show an exaggerated integration of positive information (Schönfelder et al., 2017). Surprisingly, that performance on this task could predict future relapse in bipolar patients (Ossola et al., 2020). Our study focused on individuals with different levels of trait-anxiety and found that highly anxious individuals tend to integrate desirable information more strongly than undesirable information about negative future events. In line with the Contrast Avoidance Model, we propose that this phenomenon could occur because of the avoidance of unexpected negative emotional contrast, as well as positive contrast induced by relief. Our beliefs significantly impact our lives, public policy, and mental health. The study of beliefs holds promise for better understanding psychiatric disorders and developing new interventions in the field of psychotherapy.

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Data availability The datasets obtained in the current study are available from the corresponding author upon request.

Code availability The code created in the current study are available from the corresponding author upon request.

Declarations

Conflict of interest / Competing interests All authors declare to have no conflict of interest related to the presented work.

Ethics approval All participants signed a written informed consent form approved by the Ethics Committee of the Review Board of the Instituto de Investigaciones Médicas Alfredo Lanari in accordance with the Declaration of Helsinki.

Consent to participate All participants voluntarily agreed to participate in the study.

Consent for publication Not applicable.

References

Barlow, D. H. (2004). *Anxiety and its disorders: The nature and treatment of anxiety and panic*. Guilford press. https://books.google.com.ar/books?hl=es&lr=&id=Lx9hf-3ZJCQC&oi=fnd&pg=PA1&dq=barlow+anxiety+chronic&ots=WgxkEufM9g&sig=fFJ6I1JP32alufcnHDIX4gD39dg

Beck, A. T., & Dozois, D. J. (2011). Cognitive therapy: Current status and future directions. *Annual Review of Medicine, 62*, 397–409.

Borkovec, T. D., Hazlett-Stevens, H., & Diaz, M. L. (1999). The role of positive beliefs about worry in generalized anxiety disorder and its treatment. *Clinical Psychology & Psychotherapy, 6*(2), 126–138.

Bouton, M. E., Mineka, S., & Barlow, D. H. (2001). A modern learning theory perspective on the etiology of panic disorder. *Psychological Review, 108*(1), 4–32. https://doi.org/10.1037/0033-295X.108.1.4

Bromberg-Martin, E. S., & Sharot, T. (2020). The value of beliefs. *Neuron, 106*(4), 561–565.

Buhr, K., & Dugas, M. J. (2012). Fear of emotions, experiential avoidance, and intolerance of uncertainty in worry and generalized anxiety disorder. *International Journal of Cognitive Therapy, 5*(1), 1–17.

Carleton, R. N., Norton, M. P. J., & Asmundson, G. J. (2007a). Fearing the unknown: A short version of the Intolerance of Uncertainty Scale. *Journal of Anxiety Disorders, 21*(1), 105–117.

Carleton, R. N., Sharpe, D., & Asmundson, G. J. (2007b). Anxiety sensitivity and intolerance of uncertainty: Requisites of the fundamental fears? *Behaviour Research and Therapy, 45*(10), 2307–2316.

Carver, C. S., & Scheier, M. F. (2014). Dispositional optimism. *Trends in Cognitive Sciences, 18*(6), 293–299.

Carver, C. S., Scheier, M. F., & Segerstrom, S. C. (2010). Optimism. *Clinical Psychology Review, 30*(7), 879–889. https://doi.org/10.1016/j.cpr.2010.01.006

Chen, S., Yao, N., & Qian, M. (2018). The influence of uncertainty and intolerance of uncertainty on anxiety. *Journal of Behavior Therapy and Experimental Psychiatry, 61*, 60–65.

Cisler, J. M., & Koster, E. H. (2010). Mechanisms of attentional biases towards threat in anxiety disorders: An integrative review. *Clinical Psychology Review, 30*(2), 203–216.

Coles, M. E., & Heimberg, R. G. (2002). Memory biases in the anxiety disorders: Current status. *Clinical Psychology Review, 22*(4), 587–627. https://doi.org/10.1016/S0272-7358(01)00113-1

Craig, H., Freak-Poli, R., Phyo, A. Z. Z., Ryan, J., & Gasevic, D. (2021). The association of optimism and pessimism and all-cause mortality: A systematic review. *Personality and Individual Differences, 177*, 110788. https://doi.org/10.1016/j.paid.2021.110788

Duits, P., Cath, D. C., Lissek, S., Hox, J. J., Hamm, A. O., Engelhard, I. M., van den Hout, M. A., & Baas, J. M. P. (2015). Updated meta-analysis of classical fear conditioning in the anxiety disorders. *Depression and Anxiety, 32*(4), 239–253. https://doi.org/10.1002/da.22353

Fernández, R. S., Pedreira, M. E., & Boccia, M. M. (2017). Does reconsolidation occur in natural settings? Memory reconsolidation and anxiety disorders. *Clinical Psychology Review, 57*, 45–58.

Garrett, N., González-Garzón, A. M., Foulkes, L., Levita, L., & Sharot, T. (2018). Updating beliefs under perceived threat. *Journal of Neuroscience, 38*(36), 7901–7911.

Garrett, N., Sharot, T., Faulkner, P., Korn, C. W., Roiser, J. P., & Dolan, R. J. (2014). Losing the rose tinted glasses: Neural substrates of unbiased belief updating in depression. *Frontiers in Human Neuroscience*, *8*. https://www.frontiersin.org/articles/https://doi.org/10.3389/fnhum.2014.00639

Gershman, S. J. (2019). How to never be wrong. *Psychonomic Bulletin & Review, 26*, 13–28.

Grupe, D. W., & Nitschke, J. B. (2013). Uncertainty and anticipation in anxiety: An integrated neurobiological and psychological perspective. *Nature Reviews Neuroscience, 14*(7), 488–501.

Hamm, A. O. (2020). Fear, anxiety, and their disorders from the perspective of psychophysiology. *Psychophysiology, 57*(2), e13474.

Hartley, C. A., & Phelps, E. A. (2012). Anxiety and decision-making. *Biological Psychiatry, 72*(2), 113–118.

Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist, 58*, 697–720. https://doi.org/10.1037/0003-066X.58.9.697

Kim, H., & Newman, M. G. (2023). Worry and rumination enhance a positive emotional contrast based on the framework of the contrast avoidance model. *Journal of Anxiety Disorders, 94*, 102671. https://doi.org/10.1016/j.janxdis.2023.102671

Korn, C. W., Sharot, T., Walter, H., Heekeren, H. R., & Dolan, R. J. (2014). Depression is related to an absence of optimistically biased belief updating about future life events. *Psychological Medicine, 44*(3), 579–592. https://doi.org/10.1017/S0033291713001074

Kuzmanovic, B., Jefferson, A., & Vogeley, K. (2015). Self-specific optimism bias in belief updating is associated with high trait optimism. *Journal of Behavioral Decision Making, 28*(3), 281–293.

LeDoux, J. E., & Pine, D. S. (2016). Using neuroscience to help understand fear and anxiety: A two-system framework. *American Journal of Psychiatry, 173*(11), 1083–1093.

Llera, S. J., & Newman, M. G. (2014). Rethinking the role of worry in generalized anxiety disorder: Evidence supporting a model of emotional contrast avoidance. *Behavior Therapy, 45*(3), 283–299.

Llera, S. J., & Newman, M. G. (2023). Incremental validity of the contrast avoidance model: A comparison with intolerance of uncertainty and negative problem orientation. *Journal of Anxiety Disorders, 95*, 102699. https://doi.org/10.1016/j.janxdis.2023.102699

Loewenstein, G., & Molnar, A. (2018). The renaissance of belief-based utility in economics. *Nature Human Behaviour, 2*(3), 166–167.

MacLeod, C., & Mathews, A. (2012). Cognitive bias modification approaches to anxiety. *Annual Review of Clinical Psychology, 8*, 189–217.

Mobbs, D., Headley, D. B., Ding, W., & Dayan, P. (2020). Space, time, and fear: Survival computations along defensive circuits. *Trends in Cognitive Sciences, 24*(3), 228–241.

Moutoussis, M., Story, G. W., & Dolan, R. J. (2015). The computational psychiatry of reward: Broken brains or misguided minds? *Frontiers in Psychology*, 6. https://doi.org/10.3389/fpsyg.2015.01445

Newman, M. G., Jacobson, N. C., Zainal, N. H., Shin, K. E., Szkodny, L. E., & Sliwinski, M. J. (2019). The effects of worry in daily life: An ecological momentary assessment study supporting the tenets of the contrast avoidance model. *Clinical Psychological Science, 7*(4), 794–810. https://doi.org/10.1177/2167702619827019

Newman, M. G., & Llera, S. J. (2011). A novel theory of experiential avoidance in generalized anxiety disorder: A review and synthesis of research supporting a contrast avoidance model of worry. *Clinical Psychology Review, 31*(3), 371–382.

Ossola, P., Garrett, N., Sharot, T., & Marchesi, C. (2020). Belief updating in bipolar disorder predicts time of recurrence. *eLife, 9*, e58891. https://doi.org/10.7554/eLife.58891

Rashtbari, A., & Saed, O. (2020). Contrast avoidance model of worry and generalized anxiety disorder: A theoretical perspective. *Cogent Psychology, 7*(1), 1800262.

San Martín, C., Jacobs, B., & Vervliet, B. (2020). Further characterization of relief dynamics in the conditioning and generalization of avoidance: Effects of distress tolerance and intolerance of uncertainty. *Behaviour Research and Therapy, 124*, 103526.

Scheier, M. F., Carver, C. S., & Bridges, M. W. (1994). Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): A reevaluation of the life orientation test. *Journal of Personality and Social Psychology, 67*(6), 1063.

Schönfelder, S., Langer, J., Schneider, E. E., & Wessa, M. (2017). Mania risk is characterized by an aberrant optimistic update bias for positive life events. *Journal of Affective Disorders, 218*, 313–321. https://doi.org/10.1016/j.jad.2017.04.073

Sharot, T., & Garrett, N. (2016). Forming beliefs: Why valence matters. *Trends in Cognitive Sciences, 20*(1), 25–33.

Sharot, T., Korn, C. W., & Dolan, R. J. (2011). How unrealistic optimism is maintained in the face of reality. *Nature Neuroscience, 14*(11), 1475–1479.

Sharot, T., Rollwage, M., Sunstein, C. R., & Fleming, S. M. (2023). Why and when beliefs change. *Perspectives on Psychological Science, 18*(1), 142–151.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *Manual for the state-trait anxiety inventory*. http://ubir.buffalo.edu/xmlui/handle/10477/2895

Sweeny, K., Carroll, P. J., & Shepperd, J. A. (2006). Is optimism always best?: Future outlooks and preparedness. *Current Directions in Psychological Science, 15*(6), 302–306. https://doi.org/10.1111/j.1467-8721.2006.00457.x

Sweeny, K., & Dooley, M. D. (2017). The surprising upsides of worry. *Social and Personality Psychology Compass, 11*(4), e12311.

Vervliet, B., Lange, I., & Milad, M. R. (2017). Temporal dynamics of relief in avoidance conditioning and fear extinction: Experimental validation and clinical relevance. *Behaviour Research and Therapy, 96*, 66–78.

Watkins, E., & Moulds, M. (2005). Positive beliefs about rumination in depression—A replication and extension. *Personality and Individual Differences, 39*(1), 73–82. https://doi.org/10.1016/j.paid.2004.12.006

Weinstein, N. D. (1980). Unrealistic optimism about future life events. *Journal of Personality and Social Psychology, 39*(5), 806.

Wroblewski, A., Hollandt, M., Yang, Y., Ridderbusch, I. C., Pietzner, A., Szeska, C., Lotze, M., Wittchen, H.-U., Heinig, I., Pittig, A., Arolt, V., Koelkebeck, K., Rothkopf, C. A., Adolph, D., Margraf, J., Lueken, U., Pauli, P., Herrmann, M. J., Winkler, M. H., … Richter, J. (2022). Sometimes I feel the fear of uncertainty: How intolerance of uncertainty and trait anxiety impact fear acquisition, extinction and the return of fear. *International Journal of Psychophysiology*, 181, 125–140. https://doi.org/10.1016/j.ijpsycho.2022.09.001

Xiao, Z., Wang, J., Zhang, M., Li, H., Tang, Y., Wang, Y., Fan, Q., & Fromson, J. A. (2011). Error-related negativity abnormalities in generalized anxiety disorder and obsessive–compulsive disorder. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 35*(1), 265–272. https://doi.org/10.1016/j.pnpbp.2010.11.022