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Andrew Wei April 6, 2022

Receptiveness and Affective Responses to Counterfactual Information in Anxiety

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An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
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Abstract

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The current study focuses on understanding how anxiety influences counterfactual decision-making, receptiveness to counterfactual outcomes, and affective responses. Anxiety has been associated with aberrant decision-making and risk-aversion. During economic decision-making, individuals with anxiety exhibit persistent biases towards low-risk, low-reward options. There is evidence that suboptimal decision-making in people with anxiety may be mediated by both intolerance of uncertainty and regret sensitivity. These two manifestations of anxiety are potentially in competition to determine whether to receive or avoid information regarding the outcome of an unchosen option (i.e., counterfactual information). However, little is known about how intolerance of uncertainty and regret sensitivity influence decisions, affective responses, and receptiveness to counterfactual information. Here, we recruited 125 undergraduates to complete a modified Counterfactual Gambling Task (CGT) and self-report assessments of anxiety, intolerance of uncertainty, and regret sensitivity. One component of the CGT assesses gambling decisions and affective responses to received outcomes. A second component of the CGT included a novel experimental manipulation assessing preferences to receive or avoid counterfactual outcomes before measuring subsequent affective responses to counterfactual information. We found that higher anxiety is associated with more intense negative affective responses to negative feedback. In addition, higher intolerance of uncertainty is associated with increased willingness to view counterfactual information, and surprisingly, regret sensitivity is also associated with increased willingness to view counterfactual information. These findings help clarify how anxiety manifests in counterfactual decision-making, offering new insights into the processes underlying aberrant decision-making observed in individuals with anxiety.

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Abstract

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also associated with increased willingness to view counterfactual information. These findings help clarify how anxiety manifests in counterfactual decision-making, offering new insights into the processes underlying aberrant decision-making observed in individuals with anxiety.

Introduction

People often consider what their lives would look like if they had made a past choice differently. For example, perhaps if someone chose a different romantic partner, they would have significantly greater life satisfaction. Would this person want to find out or avoid information about what their life would look like if they chose differently? Counterfactual information is information regarding potential alternatives to past events (Epstude & Roese, 2008; Byrne, 2016). When one thinks about counterfactual information (i.e., "what might have been"), they are engaging in counterfactual thinking (CT).

CT is central to human cognition and emotion, as every day, people make important decisions between options. Given that people can only experience the outcome of what they choose, counterfactual information, which involves mental simulations of outcome states differing from experienced reality, offers valuable insights into what might have happened if they chose another path (Epstude & Roese, 2008; Byrne, 2016). Thus, CT serves a primary adaptive function of improving behavior by comparing one's experienced reality with potential counterfactual information to motivate behavioral change and better decision-making (e.g., If I studied more instead of watching TV, I would have gotten a better grade on the test) (Epstude & Roese, 2008). On the other hand, CT can become maladaptive when it overwhelmingly generates negative emotions like regret, fear, and worry, and the actor has limited agency to change their behavior and circumstances based on perceived counterfactual information (e.g., If I studied

more in high school and got into college and applied to medical school, I could have been a doctor) (Epstude & Roese, 2008; Byrne, 2016).

Maladaptive CT might be especially prominent in individuals high in anxiety. Anxiety is associated with negative attentional (Cisler et al., 2010) and perceptual biases (Hartley & Phelps, 2012), maximizing personality (Iyengar et al., 2006), rumination (Nolen-Hoeksema, 2000), and intensified negative emotional responses (Hartley & Phelps, 2012), all of which might heighten painful thoughts and emotions involved in maladaptive upward CT (Epstude & Roese, 2008; Byrne, 2016). Furthermore, anxiety is associated with behavioral risk aversion biases, where individuals who are anxious tend to choose low-risk, low-reward options over high-risk, high reward options (Maner et al., 2007) (Figure 1). Two independent features of anxiety might mediate receptiveness to counterfactual information: intolerance of uncertainty (IU) (Carleton, 2012) and regret sensitivity (RS) (Roese et al. 2009). IU embodies fear of the unknown. Individuals high in IU experience negative affect in response to uncertainty (Carleton, 2012) and might seek counterfactual information to reduce uncertainty. On the other hand, RS represents fear of knowing how different past actions might have achieved better outcomes. Individuals high in RS experience negative affect from discovering regretful information (Roese et al. 2009) and might avoid counterfactual information to reduce regret. These mechanisms, while both prevalent in anxiety, are potentially in competition to determine whether an individual will choose to seek or avoid counterfactual information.

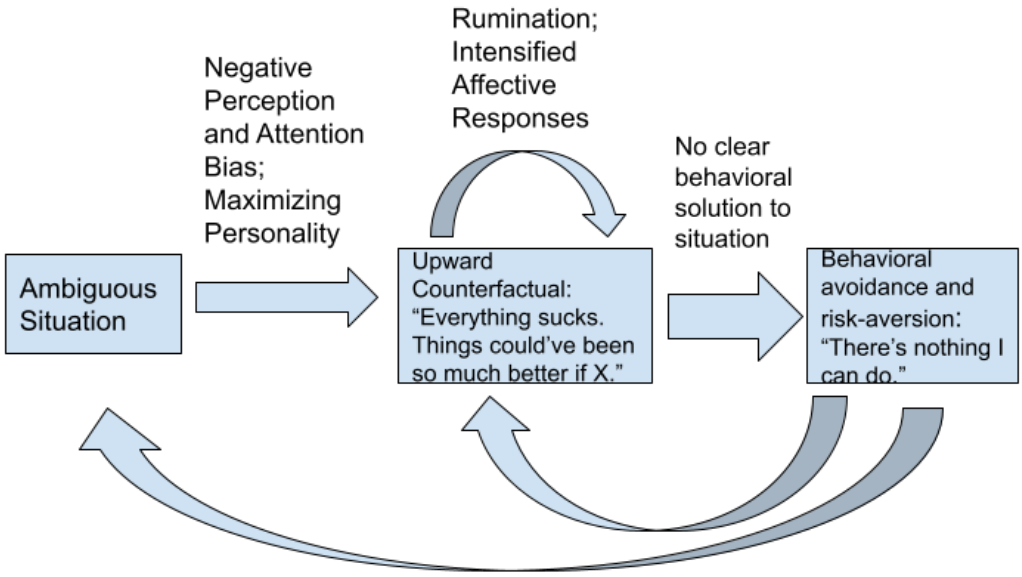


Figure 1: Proposed Model of Maladaptive Counterfactual Thinking in Anxiety. Individuals with anxiety tend to interpret ambiguous situations through a lens of negative perception and attentional biases. Due to maximizing personality biases, high anxiety might perceive a situation in a more negative way, generating an upward counterfactual cognition. The upward counterfactual might compound with negative emotions through rumination and intensified affective responses common in anxiety. If there is no clear behavioral solution to the situation, the person might begin to engage in avoidance and risk-averse behavior as they believe there is no way to solve their problems. This avoidance may lead to future suboptimal outcomes which further trigger ambiguous situations and upward counterfactual thinking.

While anxiety affects numerous cognitive, emotional, and behavioral components involved in CT, little research has directly studied the relationship between anxiety and CT (Epstude & Roese, 2008). It remains unclear how anxiety influences counterfactual decision-making, emotional responsiveness to counterfactual information, and willingness to seek out counterfactual information. Furthermore, to date, no research has sought to understand what factors influence an individual's receptiveness to counterfactual information. To address these gaps, the current study investigates how people high in anxiety differ from those low in anxiety in counterfactual decision-making, emotional responsiveness, and willingness to discover counterfactual information. This study also further explores what aspects of personality and psychopathology are associated with varying degrees of willingness to obtain counterfactual information.

To examine the relationships between CT and anxiety, we administered a Counterfactual Gambling Task (CGT) to an undergraduate sample to assess decision-making, willingness to view counterfactual information, and subsequent affect to received and counterfactual outcomes. Furthermore, we administered a battery of self-reports measuring anxiety, IU, and RS to explore individual differences in behavior in the CGT. In the CGT, participants choose between two wheels that vary in expected value and potential to evoke regret and relief. The outcome of the chosen wheel is revealed while the outcome of unchosen wheel is hidden, prompting the participant to indicate whether they would prefer to seek or avoid the counterfactual information from the unchosen wheel. Participants provide affective responses to received and counterfactual outcomes, respectively. By using this paradigm, we could assess differences in individual differences in economic decision-making, emotional responses, and willingness to seek or avoid counterfactual information.

We hypothesize that those high in anxiety will exhibit intensified affective responses to both positive and negative feedback. Furthermore, individual differences in RS and IU will determine willingness to avoid or seek counterfactual outcomes- higher RS is associated with greater avoidance of counterfactuals whereas higher IU is associated with greater seeking of counterfactual information. We also predict a Win/Loss valence of obtained outcomes x Anxiety level interaction, where, relative to low anxiety, higher anxiety will predict avoidance of counterfactual information in trials where they obtained worse outcomes, but seeking of counterfactual information when they obtain better possible outcomes.

Methods

Participants

Participants included 154 undergraduate students at Emory University in Atlanta, Georgia. Participants were recruited through SONA, an online research participant management platform, and they were compensated for their participation via credit in an introductory Psychology course. To ensure quality completion of the behavioral task, participants were excluded from analysis if their individual score was 2.5 standard deviations away from the sample mean on the following behavioral measures: overall response time at initial choice, overall partial affect response time, overall partial affect rating standard deviation, frequency of providing partial affect response without any change from the default rating, frequency of time out from responding too slowly, response time to a regular attention check, and combined proportion of avoid and seek trials. This exclusion process removed 29 participants and yielded datasets from 125 participants (65 Female, M_{age} = 20.2, SD_{age} =1.2). Two separate samples were collected- one

in-person (n=43, after exclusion) and one online (n=82, after exclusion). All procedures were reviewed and approved by the Emory University Institutional Review Board, and written informed consent was obtained from all participants.

Measures

Self-Reports: A battery of self-reports are collected to identify individual differences in 3 main cognitive targets: anxiety/psychopathology levels, intolerance of uncertainty, and regret sensitivity.

Anxiety/Psychopathology

- State Trait Anxiety Inventory- To assess individual differences in persistent and momentary anxiety, participants were administered the State Trait Anxiety Inventory (STAI), a common clinical measure for diagnosing anxiety. 20 items assess trait anxiety (e.g., "I am tense"), and 20 assess state anxiety (e.g., "I am a steady person"). All items are rated on a 4-point scale from 1 ("Almost Never") to 4 ("Almost Always"), where higher scores indicate greater anxiety levels. Ranging from a minimum score of 20 to a maximum score of 80 on each the State and Trait subscales, State-Trait Anxiety Scale scores are commonly classified as "no or low anxiety" (20-37), "moderate anxiety" (38-44), and "high anxiety" (45-80)[10].
- Liebowitz Social Anxiety Scale- To assess individual differences of fear responses and behavioral avoidance to anxiety-provoking social situations, participants were administered the Liebowitz Social Anxiety Scale (LSAS). This measure explores potential incongruencies between an individual's emotions and behaviors in response to anxious situations. Participants rate their level of fear and frequency of avoidance for 24

social situations (e.g., “Using a telephone in public”). Fear is rated on a 4-point scale from 0 (None) to 3 (Severe), and avoidance is rated on a 4-point scale from 0 (Never) to 3 (Frequently). Ranging from a minimum score of 0 to a maximum score of 144, scores on the Leibowitz Social Anxiety Scale are commonly classified as “little or no social anxiety” (<50), “moderate social phobia” (50-65), “marked social phobia” (65-80), “severe social phobia” (80-95), and “very severe social phobia” (> 95)[11].

- Beck Depression Inventory: To assess individual differences severity of depressive symptom, participants were administered the Beck Depression Inventory (BDI), a measure commonly used for clinical diagnoses. Depression is often comorbid with Anxiety and includes many overlapping symptoms, like worry and rumination. The BDI includes 21 items portraying depressive symptoms on a rating inventory of 0 to 3, where each rating level is associated with a different degree of depressive symptomology. An example item assessing negative self-perception offers the following rating choices: 0- I don’t feel disappointed in myself, 1- I am disappointed in myself, 2- I am disgusted with myself, 3- I hate myself. Participants are instructed to select the number that best characterizes them. Ranging from a minimum score of 23 to a maximum score of 63, scores on the Beck Depression Inventory are commonly classified as “These ups and downs are considered normal” (1-10), “Mild mood disturbance” (11-16), “Borderline clinical depression” (17-20), “Moderate depression” (21-30), “Severe depression” (31-40), and “Extreme Depression” (>40)[12].
- Penn State Worry Questionnaire- Due to the prominent role of worry in anxiety and counterfactual thought, participants were administered the Penn State Worry Questionnaire (PSWQ). The PSWQ includes 16 items (e.g., “My worries overwhelm

me") where participants rate their agreement on a 5-point scale from 1 (not at all typical of me) to 5 (very typical of me). The PSWQ captures three dimensions of worry: excessiveness, generality, and uncontrollability. Higher scores on the PSWQ indicate greater worry[13].

- Ruminative Thought Style Questionnaire: Rumination is a common feature of anxiety. The Ruminative Thought Style Questionnaire (RTSQ) was administered to measure individual differences in frequency of excessive, self-focused thoughts. The RTSQ includes 20 items (e.g., "When I have a problem, it will gnaw on my mind for a long time") measured on a 7-point scale from 1 (Not at all) to 7 (Very well). Higher scores indicate higher levels of ruminative thought[14].

Regret Sensitivity

- Maximization Scale- The Maximization Scale was administered to measure individual differences in maximization, the goal of achieving optimal outcomes relative to other potential outcomes, as opposed to achieving satisfying outcomes regardless of other potential outcomes. Maximization is a common predictor of regret sensitivity. The Maximization Scale includes 13 items (e.g., No matter how satisfied I am with my job, it's only right for me to be on the lookout for better opportunities) measured on a 7-point scale from 1 (Completely Disagree) to 7 (Completely Agree). Higher scores indicate higher levels of maximization[15].
- Regret Scale- The Regret Scale was administered to measure individual differences in regret sensitivity: a person's sensitivity to "the possibility that he or she might regret a decision once made." The Regret Scale includes 5 items (e.g., "Whenever I make a

choice, I try to get information about how the other alternatives turned out.") measured on a 7-point scale from 1 (Completely Disagree) to 7 (Completely Agree). Higher scores indicate higher levels of regret sensitivity[15].

Intolerance of Uncertainty

- Intolerance of Uncertainty Short Form- Participants were administered the Intolerance of Uncertainty Short Form (IUS-S) to measure individual differences in negative arousal from and avoidance of the notion that negative events may occur and that there is way to definitively predict these events. Intolerance of Uncertainty is common in Anxiety. The IUS-S includes 12 items (e.g., It frustrates me not having all the information I need) measured on a 5-point scale from 1 (Not at all characteristic of me) to 5 (Entirely characteristic of me). Higher scores indicate higher levels of intolerance of uncertainty[16].
- Behavioral Inhibition Scale/Behavioral Activation Scale: The Behavioral Inhibition Scale and Behavioral Activation Scale (BIS/BAS) are two conjoined scales administered to assess individual differences in opposing motivational systems related to avoidance and approach, respectively. BIS measures dispositional sensitivity to punishment and inhibition of behavior that may lead to negative outcomes. BAS measures sensitivity to reward and activation of behavior that may lead to positive outcomes. BIS includes 7 items (e.g., "Criticism and scolding hurt me quite a bit"), and BAS includes 13 items (e.g., "When good things happen to me, it affects me quite strongly"). Each item is measured on a 4-point scale from 1 (Quite untrue of me) to 4 (Very true of me). Higher scores on each scale indicate greater levels of behavioral inhibition or behavioral activation, respectively[17].

Procedure

Counterfactual Gambling Task

The current task was adapted from counterfactual gambling paradigms previously used in literature and was modified to assess receptiveness to counterfactual information (Camille et al., 2004; Coricelli et al., 2005; Larquet et al., 2009; Camille et al., 2010; Gillan et al., 2014; Baskin-Sommers et al., 2016) The computer-based task was designed in PsychoPy and distributed via Pavlovia. The task goal is to win as many possible cumulative points over 144 trials broken into 2 blocks, starting at 0 points at the beginning of the task. A 2-minute break was provided between the blocks to allow the participant to rest. On each trial, there are two subsequent stages: the Partial Feedback and Possible Complete Feedback stages (Figure 1).

In the Partial Feedback stage, participants make a choice between gambles, learn the outcome of their choice, and indicate their affective response to the obtained outcome. When making their choice, participants win or lose points by making gambling decisions between two wheels that display potential gains and losses and their respective probabilities. Each wheel offers a pseudo-random predetermined combination of two of the following possible outcomes: +70, -70, +210, or -210. Each potential value is randomly associated with a probability (25%, 50%, or 75%), indicated by the proportion of space on the wheel occupied by that outcome. During a brief (3 second) viewing period, participants choose a circle via button press. If no choice is made within this time, a wheel is chosen at random. Once a wheel is chosen, a red ball begins to move within each wheel. After 1.5 seconds, the ball stops on one of the segments in each wheel, determining the value outcome of each wheel. A black circle covers the outcome of the unchosen wheel before the ball stops moving, revealing their received outcome from the

chosen wheel. Upon seeing their received outcome, participants have unlimited time to make an affective rating by clicking on a 0-100 linear scale ranging from “Very disappointed” to “Very pleased” (Figure 2.1).

In the Complete Feedback stage, participants may view the outcome of the unchosen wheel (i.e. the counterfactual information) and provide affective responses to this information. Three possible trial types are encountered in the Complete Feedback stage: Press to “Seek,” Press to “Avoid,” and “No Choice.” After the Partial Feedback stage, the unchosen wheel is still hidden, and the Complete Feedback stage begins as each trial randomly diverges into either a Seek, Avoid, and No Choice Trial. In a Seek Trial, participants are instructed to press the space bar to see the unchosen outcome, otherwise the counterfactual outcome will not be shown. In an Avoid Trial, participants are instructed to press the space bar to not see the unchosen outcome, otherwise the counterfactual outcome will be shown. In a No Choice Trial, the participant is told that they will inevitably see the unchosen outcome. In the online sample, instructions preceding the beginning of the task clarify that there is no time difference between pressing the space bar or not in any trials (see Discussion for more explanation). After choosing whether to see or not see the complete information (in Avoid and Seek Trials) or being told they will see the complete information (in No Choice Trials), the participant is either shown or not shown the outcome of the non-obtained wheel based on their response and/or the trial type. Upon seeing or not seeing the non-obtained outcome, the participants again have unlimited time to make an affective rating ranging from “Very disappointed” to “Very pleased,” concluding the Possible Complete Feedback stage (Figure 1.2). After the cumulative point count from all the completed trials is revealed, the next trial begins.

In the online version of the CGT, to ensure continued focus throughout the duration of the task and exclude those who were not focused, the participants were shown the following prompt every 36 trials: “Press y if you are paying attention.”

Figure 2. Trial structure of task. This is an example of a Seek trial.

Figure 2(A). Partial Feedback Stage. A participant is presented with 2 wheels with varying probability and value outcomes. After selecting a wheel, the outcome of the chosen wheel is revealed, and the participant is prompted to make an affective response.

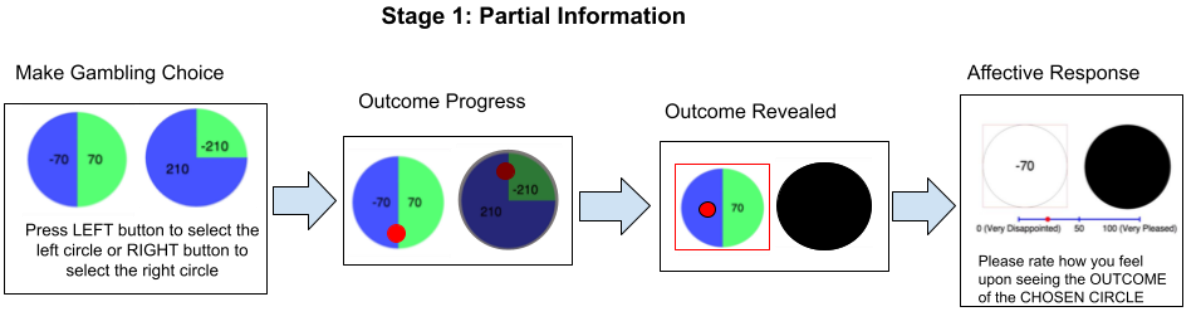
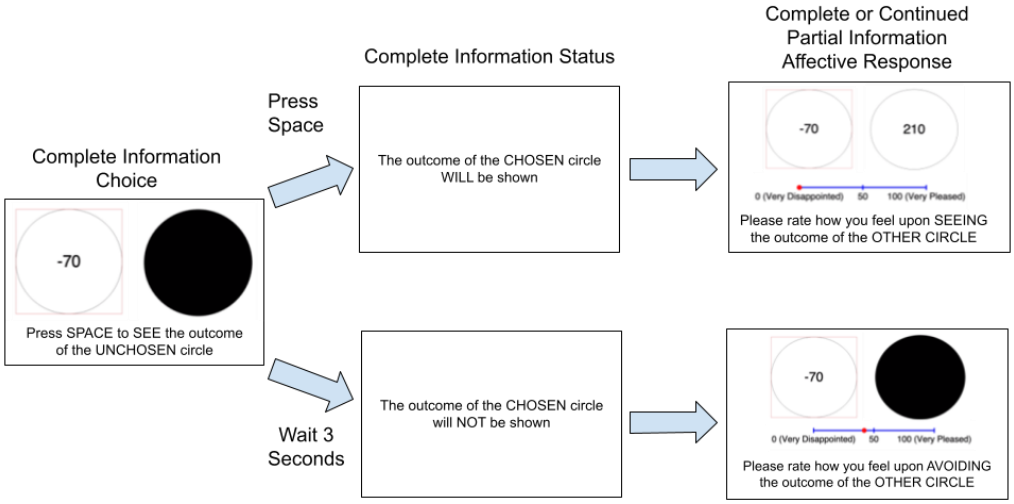


Figure 2(B). Complete Feedback Stage. In this example “Seek” trial, the Possible Complete Information stage begins with the participant having the option to see or avoid the counterfactual outcome of the unchosen wheel. If the participant chooses to see the information, the counterfactual outcome is revealed, but if the participant chooses to avoid the information, the counterfactual outcome remains hidden. The participant then makes an affective response.

Stage 2: Complete Feedback



Data Analysis

Sample Responses on Self-Reports

We took initial descriptive measures of the clinical self-reports (State-Trait Anxiety Index, Leibowitz Social Anxiety Scale, Beck Depression Inventory) in the sample to assess the distribution of participant scores on each questionnaire to assess how representative and generalizable this sample's results were and understand its overall characteristics.

Overall Task Effects at Partial Feedback

We first assessed the efficacy of the novel CGT in generating differences in receptiveness to viewing counterfactual information. We defined wins and losses at partial feedback as whether the participant received the maximum possible outcome within the wheel they chose on this trial. The main effects of win/loss valence and seek/avoid trial type, respectively, on likelihood to view counterfactual information were compared using paired t-tests. The interaction effects of win/loss valence and seek/avoid trial type on likelihood to view counterfactual information were compared in a repeated measures ANOVA. As pressing space in the Avoid condition indicated a

preference to avoid counterfactual information, responses in the Avoid condition were rescaled (1 – the proportion of trials in which space was pressed) so that higher values in all conditions indicate increased willingness to view counterfactual information. Next, we assessed the differences in mean affect between win and loss trials using a paired t-test.

Relation Between Self-Reports and CF Viewing

To assess individual differences in willingness to view counterfactual information, we ran linear mixed effects models predicting viewing proportion (i.e. the number of trials on which the participant chose to view the counterfactual information, relative to the total number of trials in that trial type). Continuous self-report scores, trial type (press to seek, press to avoid), and outcome valence (win/loss) were included as fixed-effect predictors, while participant was modeled as a random effect. In the model, we tested if self-report scores interacted with trial type and win/loss valence to predict frequency of viewing counterfactual information.

Relation Between Self-Reports and Partial Affective Responses

To assess individual differences in emotional responsiveness to winning and losing at the Partial Feedback stage, we ran separate linear regressions for win and loss trials predicting affective responses to partial feedback. Continuous self-report scores were used as the primary predictor variable, and Gender and Sample were controlled for as covariates in the model. In the separate models for win and loss trials, we tested if self-report scores significantly predicted affective responses to wins and losses.

Relation Between Self-Reports and Condition Biases

To more specifically investigate within-subject biases towards seeking and avoiding counterfactual information between trial type (avoid/seek) and partial outcome valence (win/loss), we created differences scores between conditions by subtracting the proportions of each condition in the 2x2 combinations of valence and trial type. The difference scores included the following proportion of pressing space in the following parameters: Seek Win – Seek Loss, Avoid Win – Avoid Loss, Seek Win – Avoid Loss, and Seek Loss – Avoid Loss. To assess individual differences in these difference scores, we ran linear regressions of various self-reports on these difference scores.

Overall Affective Responses to Complete Feedback

We assessed the differences in mean affective responses to complete feedback between win and loss trials using a paired t-test. We defined wins and losses at complete feedback as whether the participant received the maximum possible outcome between the wheel they chose and the counterfactual wheel they didn't choose. We also looked at differences in affective responses to complete feedback across avoid, seek, and complete information trials using an ANOVA.

Relation Between Affective Responses at Complete Feedback and Self-Reports

To assess individual differences in affective responses to complete feedback, we ran linear mixed model regressions of various self-report scores on affective responses to finding out counterfactual outcomes on the unchosen wheel. In the model, we tested how counterfactual win/loss valence interacted with each self-report to predict affective responses to complete feedback. To further investigate these interactions, we ran Pearson's Correlations between each self-report and affective responses to win trials and loss trials, respectively.

Results

Overall Responses to Self-Reports

Based on responses to the State-Trait Anxiety Inventory, we found that found that, on average and controlling for sample, participants in our sample had moderate state anxiety (Mean = 42.97, SD = 10.776) (Figure 3A) and moderate-high trait anxiety (Mean = 45.8, SD = 11.04) (Figure 3B). Based on responses to the Leibowitz Social Anxiety Scale, on average, participants in our sample had moderate social phobia (Mean = 54.48, SD = 27.57) (Figure 3C). Based on the Beck Depression Inventory, on average, participants had no depression (Mean = 10.44, SD = 10.4) (Figure 3D).

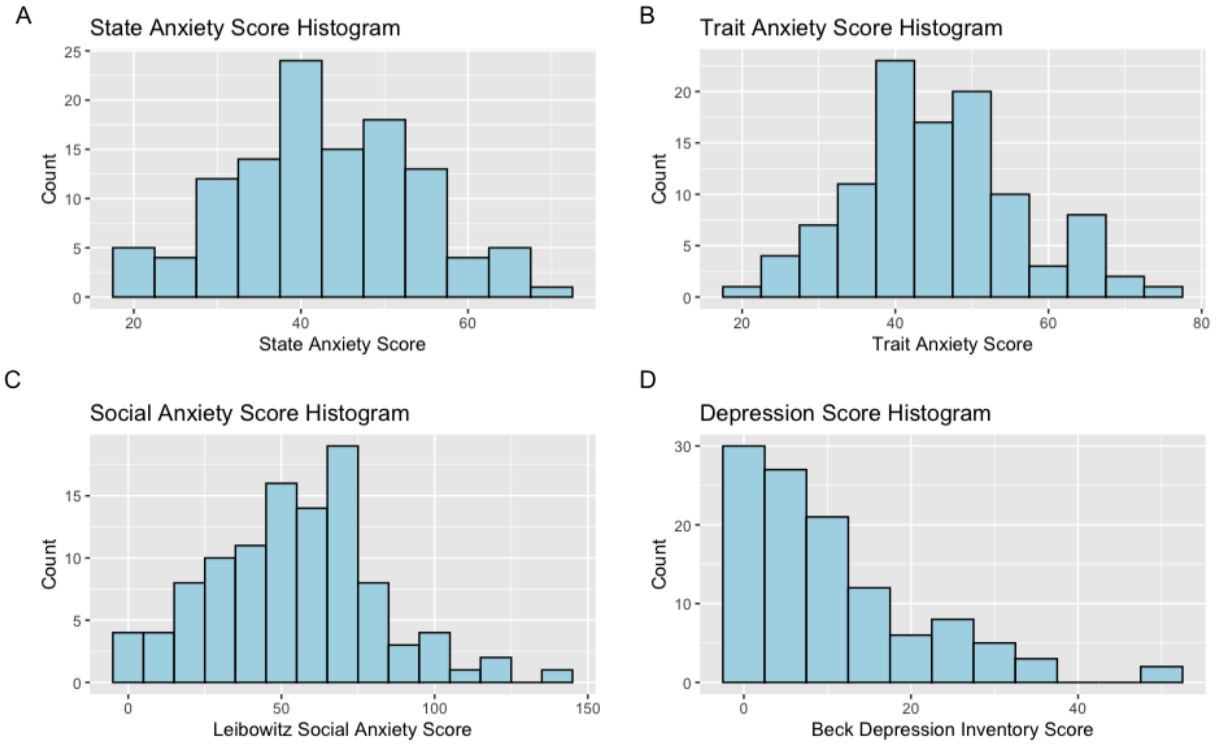


Figure 3: Clinical Self-Report Histograms. (A) On average, the sample had moderate state anxiety (Mean = 42.97, SD = 10.776), (B) moderate-high trait anxiety (Mean = 45.8, SD = 11.04), (C) moderate social phobia (Mean = 54.48, SD = 27.57), and no depression (Mean = 10.44, SD = 10.4).

Overall Affect Responses at Partial Feedback

We used a paired samples t-test to compare affective responses at partial feedback between win trials and loss trials, where win trials are defined as when a participant receives the maximum outcome within their chosen wheel and loss trials are defined as when a participant receives the minimum outcome within their chosen wheel. In line with previous data, participants had significantly higher affective responses to partial feedback during win trials (M = 80.81, SD = 10.88) than loss trials (M = 31.94, SD = 7.82); $t(124) = 32.66$, $p < .001$.

Overall Receptiveness to Counterfactual Information at Partial Feedback

A paired-samples t-test was conducted across samples to compare proportion of pressing space in Seek trials and Avoid trials after receiving partial feedback. Participants pressed significantly more for Seek trials (M= .567, SD = .279) than for Avoid trials (M=.452, SD = .314); $t(124) = 2.3474$, $p = .02$), indicating that participants are more willing to press space to seek than avoid counterfactual information overall. Furthermore, we used a paired samples t-test demonstrate that, across trial type, participants chose to view counterfactual information (Mean = .562, SD = .294) significantly more often than they chose to not view counterfactual information (Mean = .438, SD = .294); ($t(125) = 2.347$, $p = .02$). This indicates that, on average, participants generally prefer to view counterfactual information over not viewing counterfactual information when given a choice (Figure 4).

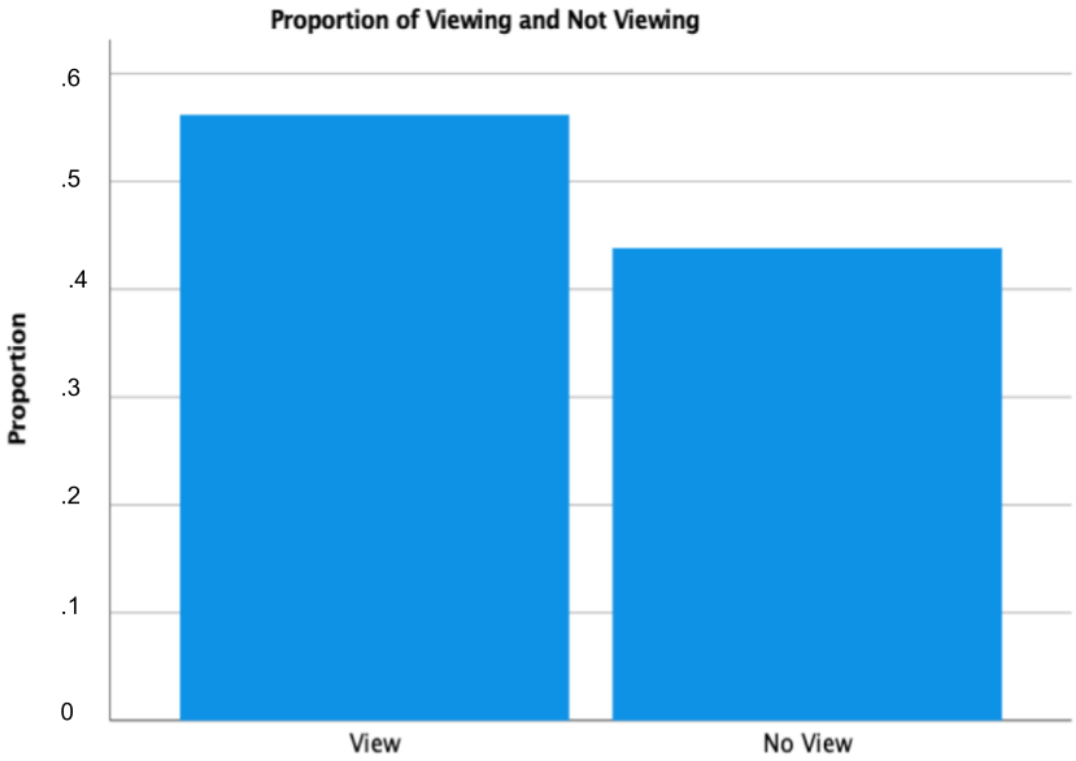


Figure 4: Proportion of Viewing and Not Viewing Counterfactual Information: Across conditions on average, participants more often wanted to view counterfactual information than not view counterfactual information ($t(125) = 2.347$, $p = .02$).

Condition Differences in Receptiveness to Counterfactual Information at Partial Feedback

As previously mentioned, proportions within the Avoid condition were transformed so that higher values in all conditions indicate increased willingness to view counterfactual information. We used a 2 (trial type, press to avoid/press to seek) x 2 (obtained outcome valence, win/loss) repeated measures ANOVA to assess how trial type, outcome valence, and their interaction related to willingness to view counterfactual information. This analysis revealed that

there was no significant main effect of trial type on participant's likelihood to view counterfactual information ($F(1,124) = 2.42$, $p = .123$ $\eta_p^2 = .019$), indicating that willingness to view counterfactual information remained consistent across trial types. Valence significantly predicted likelihood to view counterfactual information ($F(1,124) = 7.1$, $p = .009$, $\eta_p^2 = .054$), indicating that participants were more likely to view counterfactual information after receiving losing outcomes than after receiving winning outcomes. There was also a trial type x valence interaction ($F(1,124) = 24.471$, $p < .001$, $\eta_p^2 = .165$). We used paired t-tests to further examine this interaction. When pressing to avoid there was not a significant effect of Valence ($t(124)=.070$, $p=.944$; $M_{Avoid:Loss} = .54$, $SD_{Avoid:Loss} = .33$; $M_{Avoid:Win} = .54$, $SD_{Avoid:Win} = .33$), but while pressing to seek, there was a significant effect of valence ($t(124)=-4.887$, $p<.001$, $M_{Seek:Loss} = .61$, $SD_{Seek:Loss} = .28$; $M_{Seek:Win} = .53$, $SD_{Seek:Win} = .3$) (Figure 5). This interaction indicates that participants were equally likely to press to avoid regardless of receiving winning or losing outcomes at partial feedback, but participants were more likely to press to view counterfactual information after receiving losing outcomes than after receiving winning outcomes at partial feedback.

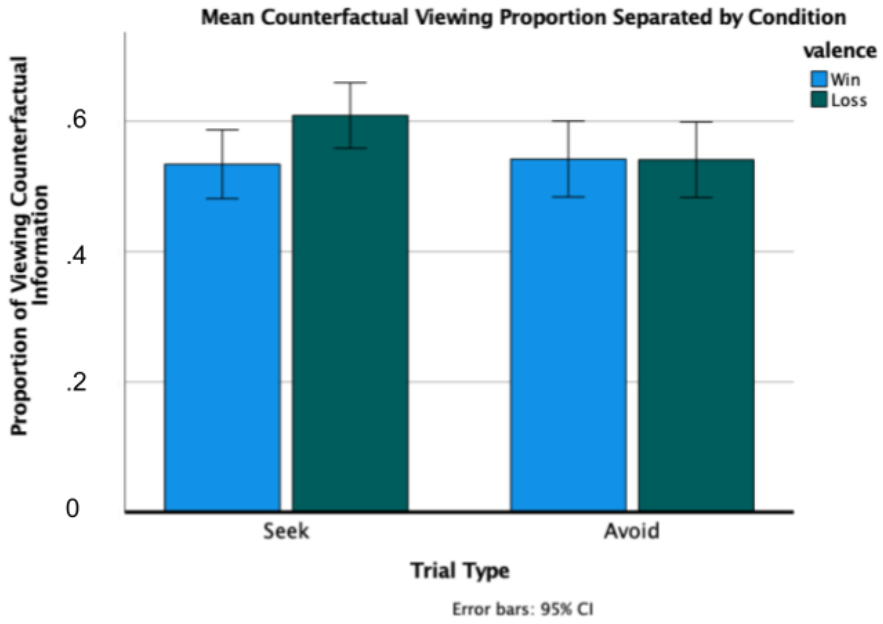


Figure 5: Proportion of Viewing Counterfactual Information, Separated by Condition. Participants are equally likely to view counterfactual information between win and loss outcomes during Avoid trials. They are more likely to view counterfactual information for losses than wins during Seek trials. Overall, participants are most likely to view counterfactual information during Seek:Loss trials (M = .61).

Individual Differences in Affect Responses to Wins vs. Losses at Partial Feedback

To investigate the association between self-reports and affective responses to obtained outcomes at partial information, we ran linear regressions, controlling for Gender and Sample, to assess how various self-report predicted affective responses to obtaining winning and losing outcomes within a chosen wheel.

First, we found that higher scores on the Maximization Scale significantly predicted more positive affective responses to wins ($\beta = .18$, $p = .037$) and more negative affective responses to losses ($\beta = -.134$, $p = .034$). Thus, higher maximization predicted more extreme affective

responses to both wins and losses, respectively (Figure 6).

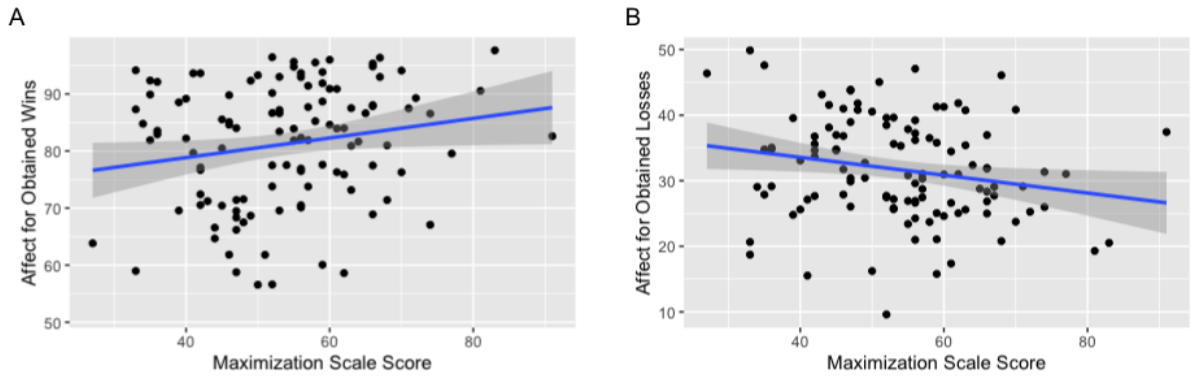


Figure 6: Maximization Scale scores predict more extreme affective responses to wins (A) and losses (B).

Next, we found that higher scores on the Regret Scale were not significantly associated with affective responses to wins ($\beta = .08$, $p = .6$) or losses ($\beta = -.17$, $p = .11$). Thus, higher regret did not predict more extreme affective responses to either wins or losses (Figure 7).

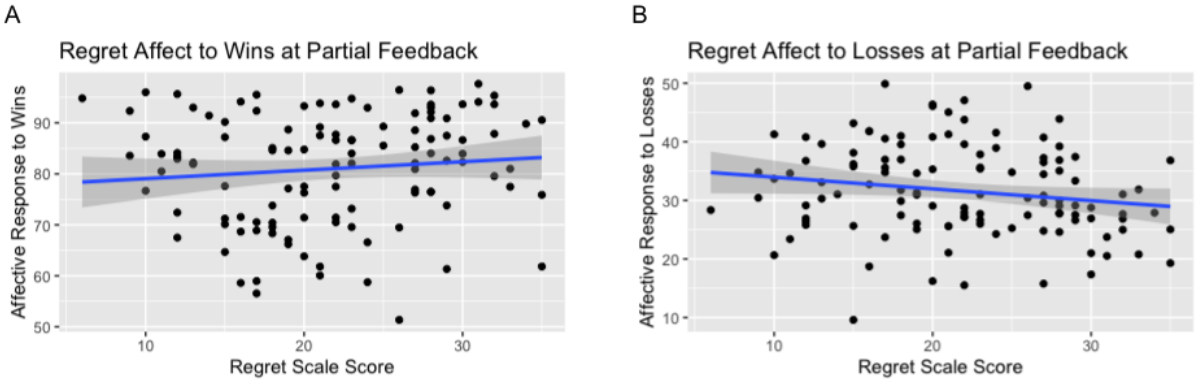


Figure 7: Regret Scale scores do not predict more extreme affective responses to wins (A) or losses (B).

We also found that higher scores on the Intolerance of Uncertainty Scale did not significantly predict affective responses to wins (β = -.016, p =.875), but did significantly predict more negative responses to losses (β = -.15, p =.046). Thus, higher intolerance of uncertainty predicted more extreme affective responses to losses, but not to wins (Figure 8).

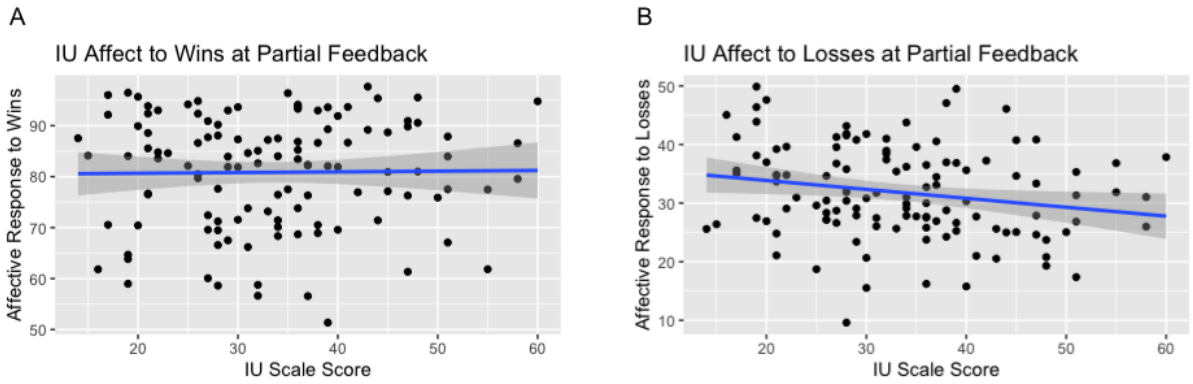


Figure 8: Intolerance of Uncertainty Scale Scores do not predict more extreme affective responses to wins (A), but do predict more extreme effective responses to losses (B).

We also found that higher scores on Behavioral Activation Scale for Reward Responsiveness significantly predicted more positive affective responses to wins (β = 1.04, p =.00567) and more negative affective responses to losses (β = -.714, p =.00889). Thus, higher Behavioral Activation Scale for Reward Responsiveness predicted more extreme affective responses to both wins and losses, respectively.

We found that the State Anxiety levels did not significantly predict affective responses in either win (β = .0623, p = .549) or loss trials (β = -.0513, p = .468). In addition, the Leibowitz Social Anxiety Scale also failed to significantly predict affective responses in win (β = .048, p

= .239) or loss trials (β = -.022, p = .44). Thus, State Anxiety and Social Anxiety do not significantly predict affective responses to partial feedback when winning or losing.

Importantly, we found that Trait Anxiety did not significantly predict affective responses to wins (β = .062, p = .549) but did significantly predict more negative affective responses to losses at Partial Information (β = -.15., p = .0435). This indicates that Trait Anxiety predicts more extreme negative affective responses to losses (A) but do not predict affective responses to wins (B) (Figure 9).

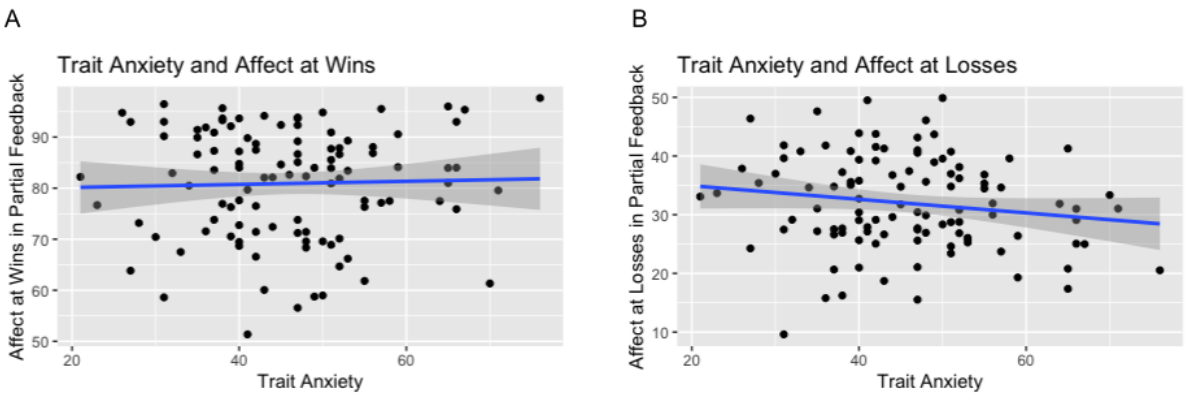


Figure 9: Trait Anxiety Scale Scores do not predict affective responses to wins (A), but predict more negative affective responses to losses (B).

Individual Differences in Willingness to View Counterfactual Information

We ran linear mixed-effects model analyses to assess the relationship between individual differences in self-report measures and willingness to view counterfactual information. Again, proportions within the Avoid condition were transformed to obtain a parameter of viewing counterfactual information. In each model, frequency of viewing counterfactual information was

included as the outcome variable, self-report, trial type, obtained outcome valence, and their interactions were included as fixed effects, and subject was included as a random effect.

First, we found that the Maximization Scale significantly predicted willingness to view counterfactual information ($\beta = .00529$, $p = .027$) and that outcome valence ($p=.87$) and trial type ($p = .4$) were not significant in the model. There was no significant interaction in Maximization Scale x outcome valence ($p = .8045$), Maximization Scale x Trial Type ($p = .4$), or Maximization Scale x outcome valence x trial type ($p = .8$). Thus, higher scores on the Maximization Scale were associated with increased willingness to view counterfactual information regardless of trial type and outcome valence.

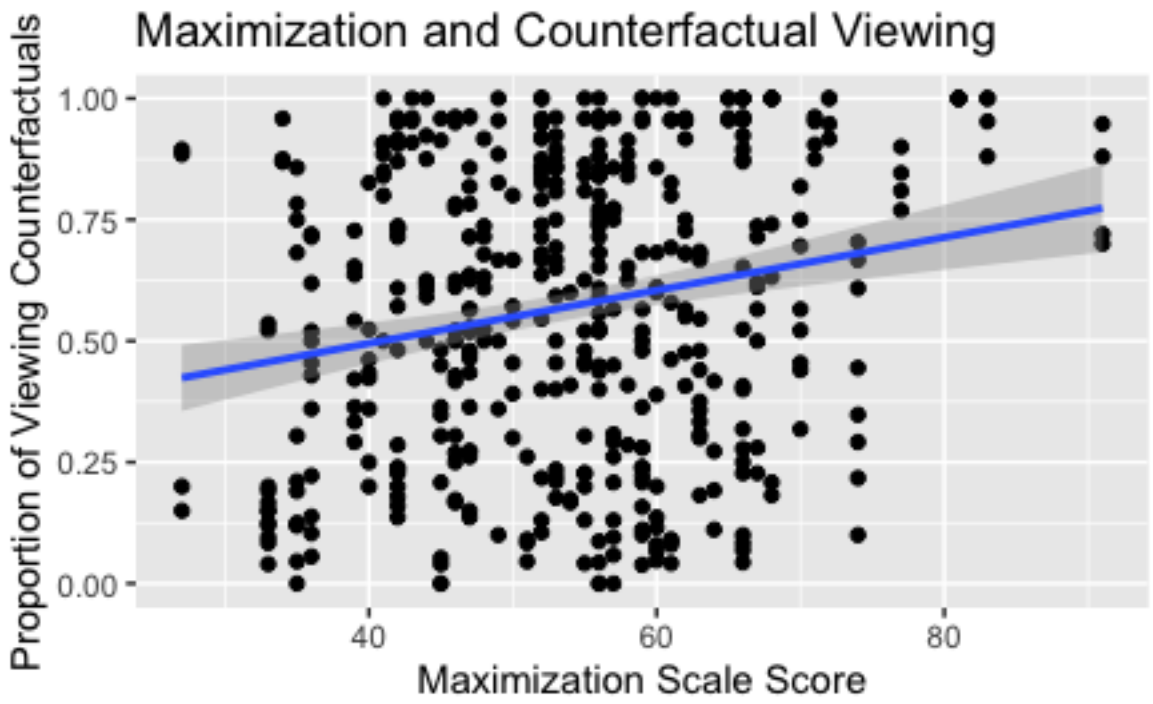


Figure 10: Maximization Scale scores positively predict willingness to view counterfactual information.

Next, we found that the Regret Scale significantly predicted willingness to view counterfactual information (β = .011, p = .008) and that outcome valence (p=.14) and trial type (p = .19) were not significant in the model. There was no significant interaction in Regret Scale x outcome valence (p = .13), Regret Scale x Trial Type (p = .65), or Regret Scale x outcome valence x trial type (p = .51). Thus, higher scores on the Regret Scale were associated with increased willingness to view counterfactual information regardless of trial type and outcome valence.

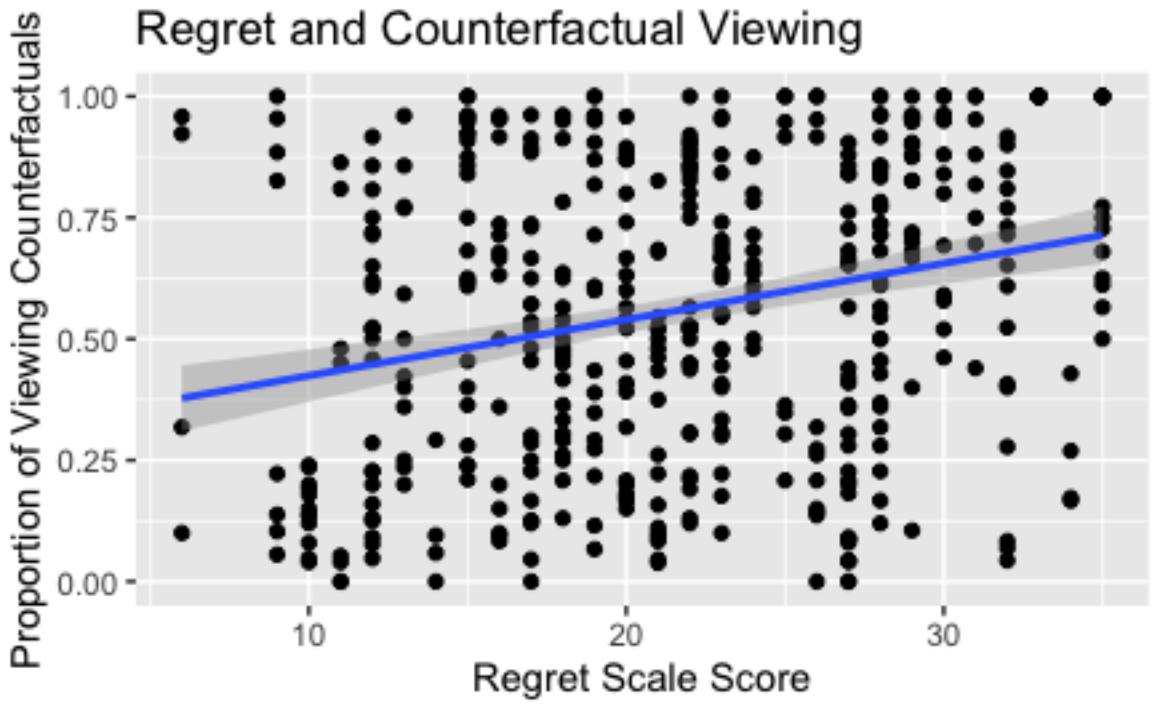


Figure 11: Regret Scale scores positively predict willingness to view counterfactual information.

Next, we found that the Intolerance of Uncertainty Scale was marginally significant in predicting willingness to view counterfactual information (β = .0048, p = .073) and that outcome valence (p=.36) and trial type (p = .57) were not significant in the model. There was no

significant interaction in Intolerance of Uncertainty Scale x outcome valence (p = .39), Intolerance of Uncertainty Scale x Trial Type (p = .77), or Intolerance of Uncertainty Scale x outcome valence x trial type (p = .39). Thus, higher scores on the Intolerance of Uncertainty Scale were associated with increased willingness to view counterfactual information regardless of trial type and outcome valence.

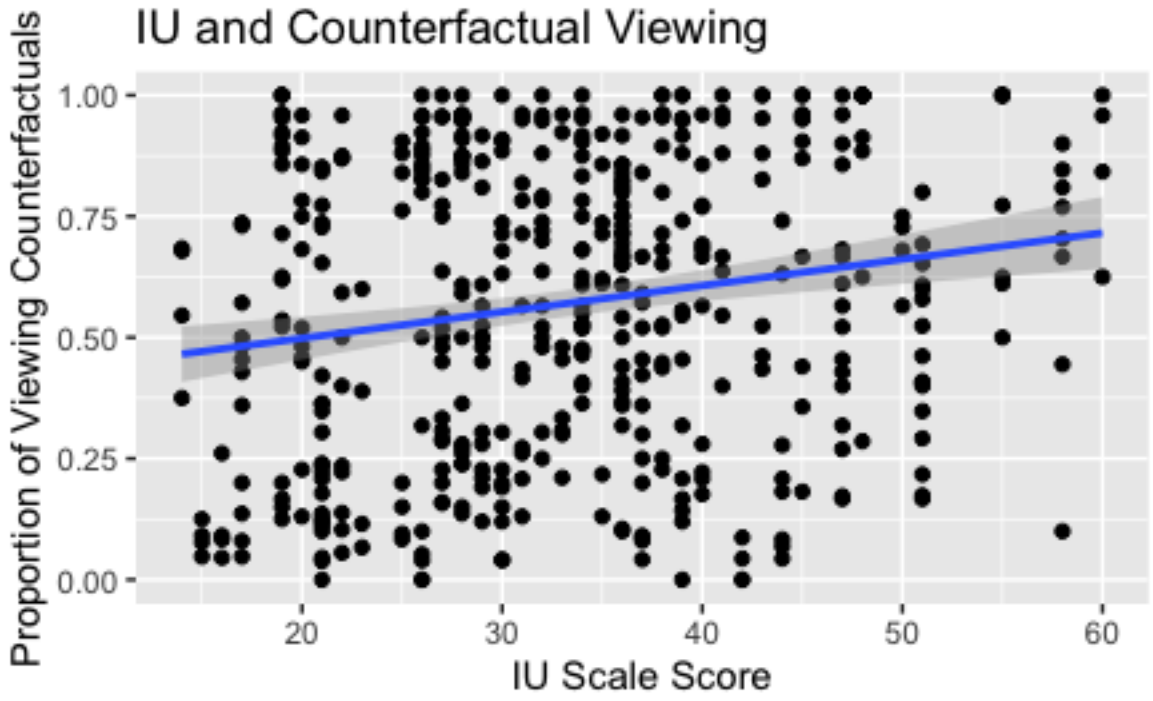


Figure 12: Intolerance of Uncertainty Scale scores positively predict willingness to view counterfactual information.

Next, we found that the Behavioral Inhibition Scale significantly predicted willingness to view counterfactual information (β = .015, p = .014) and that outcome valence (p=.75) and trial type (p = .13) were not significant in the model. There was no significant interaction in Behavioral Inhibition Scale x outcome valence (p = .74), Behavioral Scale x Trial Type (p = .38), or Behavioral Scale x outcome valence x trial type (p = .55). Thus, higher scores on the

Behavioral Inhibition Scale were associated with increased willingness to view counterfactual information regardless of trial type and outcome valence.

Contrary to our hypotheses, neither anxiety measure (State-Trait Anxiety Index and Leibowitz Social Anxiety Scale) were found to significantly predict willingness to view counterfactual information. The State-Trait Anxiety Index (β_{state} = -.002, p_{state} = .489; β_{trait} = -.002, p_{trait} = .492) and Leibowitz Social Anxiety Scale (β = .0007, p = .6) failed to predict willingness to view counterfactual information.

Individual Differences in Difference Scores of Receptiveness to Counterfactual Information

To further investigate individual differences in willingness to see and avoid counterfactual between conditions in relation to self-report scores, we ran linear regressions assessing the difference scores of 2 (trial type) x 2 (obtained outcome valence) conditions and their association with various self-reports. We obtained the difference scores by subtracting the proportion of space pressing in each of the 4 conditions subtracted from each other condition, generating Seek:Win – Seek:Loss, Seek:Win – Avoid:Win, Avoid:Win – Avoid:Loss, and Avoid:Loss – Seek:Loss.

We first tested the relation between the Maximization Scale and difference scores. We found that higher scores on the Maximization Scale significantly predicted increased differences between Seek:Win - Avoid:Win (β = .011, p = .0141). This indicates that higher scores on the Maximization Scale are associated with increased likelihood of seeking, as opposed to avoiding, counterfactual information when winning. Furthermore, higher scores on the Maximization Scale significantly predicted decreased differences between Avoid:Loss – Seek:Loss (β = -.0095, p = .031). This result further demonstrates that greater Maximization scores are associated with

increased likelihood of seeking, as opposed to avoiding, counterfactual information when losing. Together, these results provide further evidence that increased Maximization Scale scores are associated with increased willingness to see counterfactual information regardless of win or loss valence. Maximization Scale scores did not significantly predict Seek:Win – Seek:Loss and Avoid:Win – Avoid:Loss ($p > .05$).

Next, we tested the relation between the Regret Scale and difference scores. Higher scores on the Regret Scale significantly predicted increased differences between Seek:Win - Avoid:Win ($\beta = .026$, $p < .001$). This indicates that higher scores on the Regret Scale are associated with increased likelihood of seeking, as opposed to avoiding, counterfactual information when winning. Furthermore, higher scores on the Regret Scale significantly predicted decreased differences between Avoid:Loss – Seek:Loss ($\beta = -.0165$, $p = .0319$). This result further demonstrates that greater Regret scores are associated with increased likelihood of seeking, as opposed to avoiding, counterfactual information when losing. Together, these results provide further evidence that increased Regret Scale scores are associated with increased willingness to see counterfactual information regardless of win or loss valence.

Importantly, we found that higher scores on the Regret Scale significantly predicted decreased differences between Avoid:Win and Avoid:Loss ($\beta = -.0065$, $p = .011$). This result indicates that increased scores on the Regret Scale are associated with increased likelihood of avoiding counterfactual information for loss trials over win trials (Figure 13). This result seems contrary to the prior linear mixed effects model indicating that outcome valence had no significant interaction with regret in predicting willingness to view counterfactual information. However, these seemingly contrary results can be reconciled as the difference score test is a more sensitive test of differences in avoidance behavior than losses and wins. While the linear

mixed model tested a transformed viewing proportion (as described in prior sections) in relation to Regret, the difference score test specifically frequency of pressing to avoid during loss versus win trials. In addition, the difference score regression controlled the covariates of Gender and Sample, whereas the linear mixed model did not. Thus, this more sensitive test is more reliable in revealing the significant increased willingness to avoid counterfactual information for loss trials over win trials. Regret Scale scores did not significantly predict Seek:Win – Seek:Loss ($p > .05$).

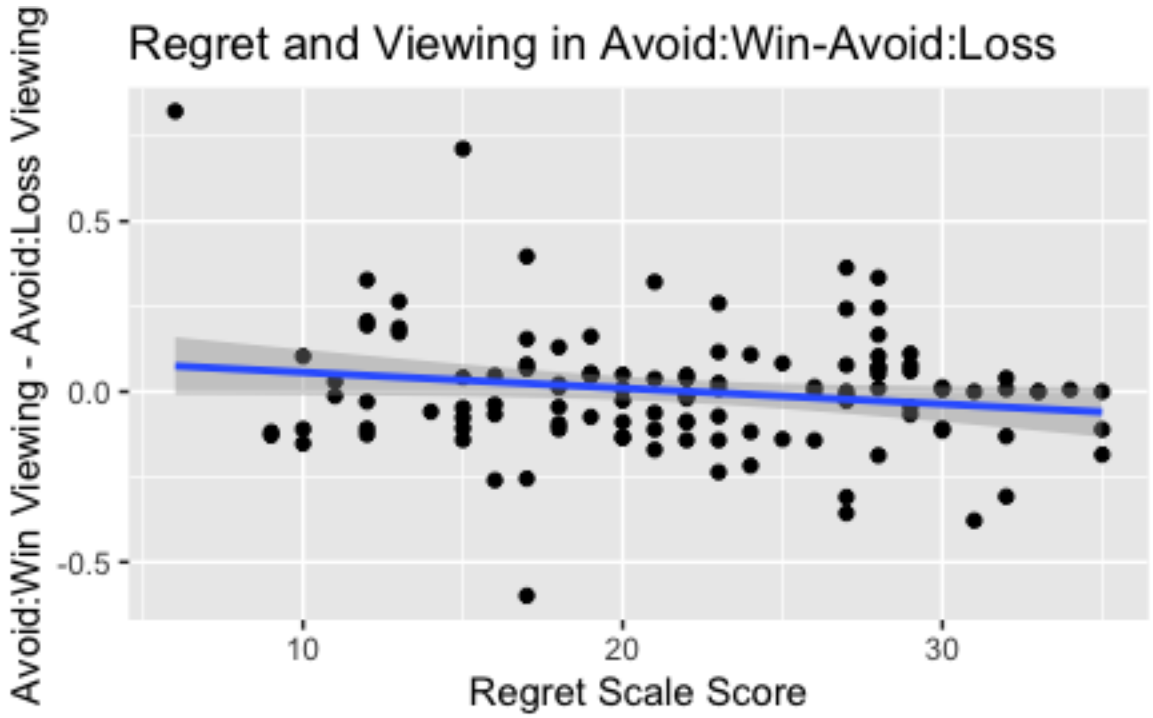


Figure 13: Regret Scale scores predict increased willingness to avoid counterfactual information for losses over wins.

We also assessed the relation between the Intolerance of Uncertainty Scale and difference scores. Higher scores on the Intolerance of Uncertainty Scale significantly predicted increased differences between Seek:Win - Avoid:Win ($\beta = .012$, $p = .0214$). This indicates that higher scores on the Intolerance of Uncertainty Scale are associated with increased likelihood of

seeking, as opposed to avoiding, counterfactual information when winning. Furthermore, higher scores on the Intolerance of Uncertainty Scale significantly predicted decreased differences between Avoid:Loss – Seek:Loss (β = -.0099, p = .0394). This result indicates that greater Intolerance of Uncertainty scores are associated with increased likelihood of seeking, as opposed to avoiding, counterfactual information when losing. Together, these results provide further evidence that increased Intolerance of Uncertainty Scale scores are associated with increased willingness to see counterfactual information regardless of win or loss valence. Intolerance of Uncertainty Scale scores did not significantly predict Seek:Win – Seek:Loss and Avoid:Win – Avoid:Loss ($p > .05$).

We also assessed the relation between the Behavioral Inhibition Scale and difference scores. Higher Scores on the Behavioral Inhibition Scale significantly predicted decreased differences between Avoid:Loss – Seek:Loss (β = .022, p =.0478). This indicates that higher scores on the Behavioral Inhibition Scale are associated with increased likelihood of seeking, as opposed to avoiding, counterfactual information when losing. Behavioral Inhibition Scale scores did not significantly predict Seek:Win-Avoid:Win, Seek:Win – Seek:Loss, and Avoid:Win – Avoid:Loss ($p > .05$).

Contrary to our hypotheses, no anxiety measures significantly predicted changes in difference scores. The State-Trait Anxiety Index and Leibowitz Social Anxiety Scale failed to significantly predict changes in Seek:Win – Seek:Loss ($p_{state} > .05$, $p_{trait} > .05$, $p_{social} > .05$), Seek:Win – Avoid:Win($p_{state} > .05$, $p_{trait} > .05$, $p_{social} > .05$), Avoid:Win – Avoid:Loss ($p_{state} = .489$, $p_{trait} > .05$, $p_{social} > .05$), or Avoid:Loss – Seek:Loss ($p_{state} > .05$; $p_{trait} > .05$, $p_{social} > .05$). Thus, anxiety level did not reflect any changes in willingness to view counterfactual information across trial type and obtained outcome valence.

Overall Affect at Complete Feedback to Counterfactual Wins vs. Losses

We used a paired samples t-test to compare affective responses to complete feedback between counterfactual win trials (when the received outcome from the chosen circle is better than the counterfactual outcome on the unchosen circle) and counterfactual loss trials (when the received outcome from the chosen circle is worse than the counterfactual outcome on the unchosen circle). Participants had significantly higher affective responses to complete feedback during counterfactual win trials ($M = 80.55$, $SD = 26.81$) than loss trials ($M = 12.18$, $SD = 10.78$); $t(124) = 28.199$, $p < .001$. Thus, participants provided significantly higher affective positive responses for wins and lower affective responses for losses at complete feedback.

Individual Differences in Affective Responses to Counterfactual Information at Complete Feedback

We ran linear mixed-effects model regressions of various self-report scores on affective responses at complete feedback across Avoid, Seek, and No Choice trials. In the model, we tested if self-report scores interacted with counterfactual win/loss valence to predict affective responses, and we ran Pearson's correlation to further test the interaction of how each self-report influences affect for counterfactual wins vs. losses.

First, we found a significant interaction between the Maximization Scale and valence of obtained counterfactual outcome valence ($\beta = .498$, $p < .001$). Scores on the Maximization Scale were positively correlated with affective responses to counterfactual wins ($R(113) = .28$, $p = .0023$) and negatively correlated with affective responses to counterfactual losses ($R(113) = -.231$, $p = .0129$). Thus, greater scores on the Maximization Scale are associated with more

extreme negative affective responses to counterfactual losses and more extreme positive affective responses to counterfactual wins.

We also found a significant interaction between the Regret Scale and valence of obtained counterfactual outcome valence ($\beta = .8287$, $p < .001$). Scores on the Regret Scale were positively correlated with affective responses to counterfactual wins ($R(115) = .24$, $p = .0091$) and negatively correlated with affective responses to counterfactual losses ($R(115) = -.256$, $p = .0054$). Thus, greater scores on the Regret Scale are associated with more extreme negative affective responses to counterfactual losses and more extreme positive affective responses to counterfactual wins.

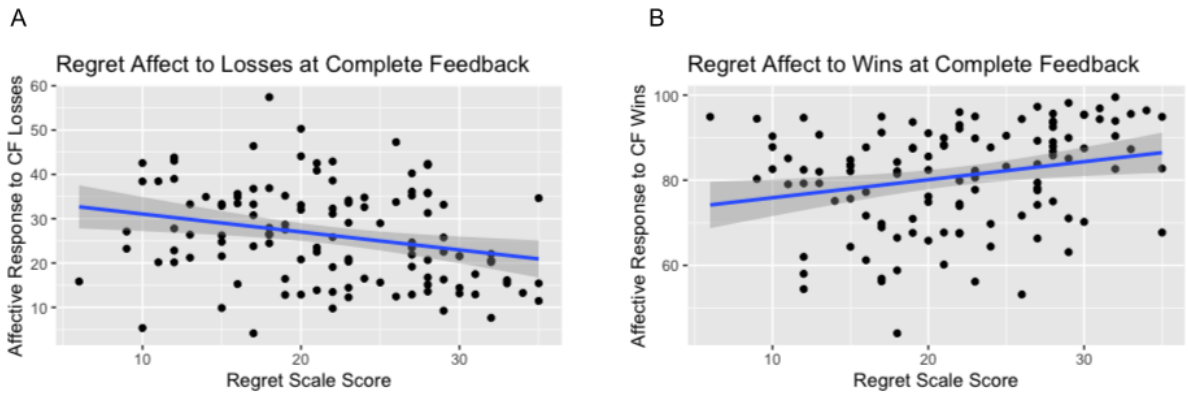


Figure 14: Regret Scale scores predict more extreme affective responses to complete feedback for counterfactual losses (A) and wins (B).

We also found a significant interaction between the Intolerance of Uncertainty Scale and valence of obtained counterfactual outcome valence ($\beta = .3471$, $p = .0149$). Scores on the Intolerance of Uncertainty Scale were not significantly correlated with affective responses to counterfactual wins ($R(116) = .086$, $p = .3512$), but significantly negatively correlated with

affective responses to counterfactual losses ($R(116) = -.241$, $p = .0086$). Thus, greater scores on the Intolerance of Uncertainty Scale are associated with more extreme negative affective responses to counterfactual losses, but are not significantly associated with affective responses to counterfactual wins.

We also found a significant interaction between the Behavioral Inhibition Scale and valence of obtained counterfactual outcome valence ($\beta = .814$, $p = .0173$). Scores on the Behavioral Inhibition Scale were not significantly correlated with affective responses to counterfactual wins ($R(103) = .128$, $p = .166$), but significantly negatively correlated with affective responses to counterfactual losses ($R(103) = -.197$, $p = .0435$). Thus, greater scores on the Behavioral Inhibition Scale are not associated with affective responses to counterfactual wins, but are associated with more extreme positive affective responses to counterfactual losses.

Next, we found a significant interaction between the Ruminative Thought Style Scale and valence of obtained counterfactual outcome valence ($\beta = .282$, $p < .001$). Scores on the Ruminative Thought Style Scale significantly positively correlated with affective responses to counterfactual wins ($R(109) = .289$, $p = .0021$), and significantly negatively correlated with affective responses to counterfactual losses ($R(109) = -.259$, $p = .0061$). Thus, greater scores on the Ruminative Thought Style Questionnaire are associated with more extreme negative affective responses to counterfactual losses and more extreme positive affective responses to counterfactual wins.

Furthermore, we found a significant interaction between the Penn State Worry Questionnaire and valence of obtained counterfactual outcome valence ($\beta = .231$, $p = .031$). Scores on the Penn State Worry Questionnaire were not significantly correlated with affective

responses to counterfactual wins (R(109) = .13, p = .16), but trended towards significance in negatively correlating with affective responses to counterfactual losses (R(109) = -.159, p = .096). Thus, greater scores on the Penn State Worry Questionnaire are not associated with affective responses to counterfactual wins, but are slightly associated with more extreme negative affective responses to counterfactual losses.

Importantly, we found a significant interaction between the Leibowitz Social Anxiety Scale and valence of obtained counterfactual outcome valence (β = .133, p = .0179). Scores on the Leibowitz Social Anxiety Scale were not significantly correlated with affective responses to counterfactual wins (R(103) = .13, p = .17), but significantly negatively correlated with affective responses to counterfactual losses (R(103) = -.185, p = .0439). Thus, greater scores on the Leibowitz Social Anxiety Scale are not associated with more affective responses to counterfactual wins, but are associated with more extreme negative affective responses to counterfactual losses.

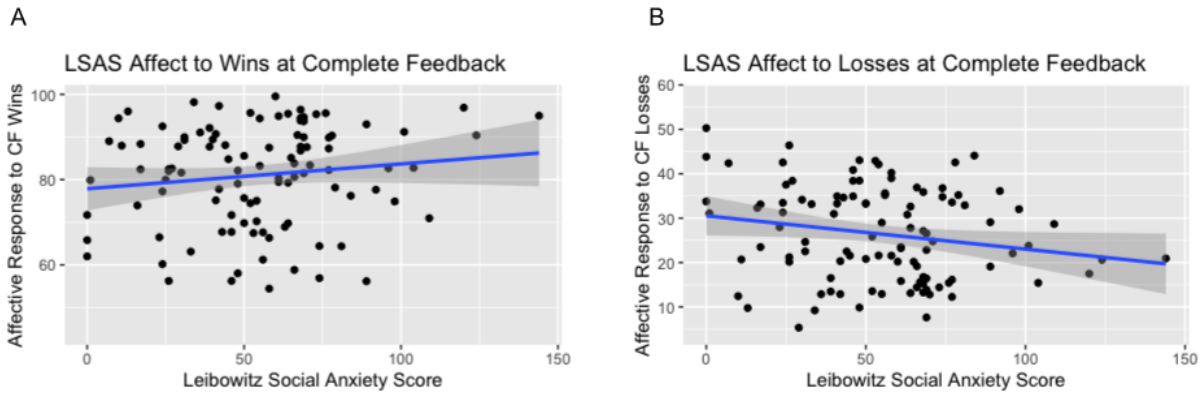


Figure 15: Leibowitz Social Anxiety Scale scores do not predict affective responses to complete

feedback for counterfactual wins (A), but do predict more extreme affective responses to losses (B).

Unexpectedly, scores on the State-Trait Anxiety Index did not significantly predict affective response to counterfactual feedback (β_{state} = .0281, p_{state} = .780; β_{trait} = -.139, p_{trait} = .175) or interact with valence of obtained counterfactual outcome valence to predict affective responses to counterfactual feedback (β_{state} = -.118, p_{state} = .405; β_{trait} = .2434, p_{trait} = .0929). Thus, greater scores on the State-Trait Anxiety Index are not associated with affective responses to counterfactual losses or wins.

Discussion

Although numerous studies have investigated how people make decisions between risky options and affective responses to obtained outcomes compared to counterfactual information (Camille et al., 2004; Coricelli et al., 2005; Larquet et al., 2009; Camille et al., 2010; Gillan et al., 2014; Baskin-Sommers et al., 2016) to date, no studies have assessed what aspects of an individual's character, personality, and psychopathology are associated with their willingness to seek or avoid counterfactual information. In this study, we aimed to clarify what factors are associated with willingness, or lack of, to discover counterfactual information. Furthermore, despite the prominence of anxiety and counterfactual thinking in anxiety, no prior studies have investigated how the two interact (Epstude & Roese, 2008). Thus, we strived to understand how anxiety relates to counterfactual decision-making and affective responses to partial and complete feedback. To address these gaps, we administered a battery of self-reports relating to anxiety as

well as the Counterfactual Gambling Task (CGT) that included a novel manipulation differing trials to seek or avoid counterfactual information.

Our results revealed that, overall, participants were more willing to view than not view counterfactual information across trial type at partial feedback, indicating that people generally prefer to know more information when given a choice. Overall, the manipulation of Avoid vs. Seek trial conditions revealed no significant difference in willingness to view counterfactual information between these conditions. However, participants were more willing to view counterfactual information when receiving winning outcomes and less willing to view counterfactual information when receiving losing outcomes. Furthermore, participants were similarly likely to view counterfactual information Avoid:Loss, Avoid:Win, and Seek:Win trials, but they were most likely to view counterfactual information during Seek:Loss trials. It is possible that participants are more compulsively driven to make a physical button press to discover counterfactual information to alleviate emotions of losing (i.e. if it turns out that the counterfactual wheel turns out to be a worse outcome than what they received on the chosen wheel, revealing a counterfactual win), and this desire for information is decreased when experiencing feelings of winning. In addition, this compulsive desire for information during loss might be selective to Seek trials, as participants could alleviate their desire with physical action, whereas in Avoid trials, they were required to alleviate their desire by waiting 3 seconds. Thus, inaction throughout this state of negative emotion during Avoid trials might be less desirable than pressing to discover counterfactual information that might alleviate their negative state in Seek trials.

Importantly, we found that increased trait anxiety was associated with more negative affective responses to losses, but not more positive responses to wins, at partial feedback. This partially confirms our hypothesis that anxiety would predict more intense affective responses in both directions, as our results indicate that anxiety only predicts intensified emotions for losses. This result aligns with the prior evidence of negative perceptual and attentional biases prevalent in anxiety (Cisler & Koster, 2009; Hartley & Phelps, 2011), as anxiety was selectively associated with negative emotions.

In line with our hypotheses, increased Intolerance of Uncertainty was associated with increased willingness to view counterfactual information. However, contrary to our hypotheses, regret sensitivity, as measured by the Regret Scale and Maximization Scale, was not associated with decreased willingness to view counterfactual information. Rather, these measures were consistently associated with increased viewing.

There are multiple possible explanations for this result. Prior evidence has shown that high maximization is associated with decreased satisfaction, greater frequency of upward comparison, and increased emotional sensitivity to upward comparison (Schwartz et al., 2002). There is an extreme overlap between regret and maximization within individuals. In fact, maximization is a causal mechanism in generating increased regret. Thus, it makes sense that those who scored higher in maximization would seek out counterfactual information when striving for optimization. Furthermore, prior evidence indicates that high maximizers, despite experiencing intensified regret, will seek out information even if it exacerbates negative emotions when not achieving optimal outcomes (Schwartz et al., 2002). This trait is confirmed by our results that increased maximization and regret were associated with more intense

emotional responses to both counterfactual losses and wins. Thus, the increased desire to view counterfactual information in high regret and maximization is emotionally masochistic in the context of counterfactual losses, but emotionally optimal in the context of counterfactual wins.

In addition, higher Regret Scale scores were associated with more intense affective responses at complete feedback but not partial feedback. This is likely because the nature of regret relates to counterfactual information, in that those high in regret are concerned with what could have been if another choice had been made. Given that partial feedback only related to information within chosen options, it makes sense that regret would not exacerbate stronger affective responses as it would in complete feedback, where counterfactual information outside of chosen outcomes becomes relevant.

Interestingly, the Leibowitz Social Anxiety Scale was associated with more intense emotional responses to counterfactual losses, but not wins, at complete feedback, but the State-Trait Anxiety Index was not associated with either. It is possible that the State-Trait Anxiety Index, as it is not clinically conclusive of anxiety on its own without a clinician opinion, was not a sensitive enough measure to identify anxious individuals who would be more emotionally affected by counterfactual information. Furthermore, it is possible that the CGT did not provide salient enough rewards and punishments to exacerbate the emotional exaggeration in individuals with anxiety. However, social anxiety is strongly associated with upward comparison and negative attentional biases (Mitchell & Schmidt, 2014), which aligns with our results indicating that the Leibowitz Social Anxiety Scale was associated with more intense negative but not positive affective responses to complete feedback. As social comparison is a core component of

social anxiety, it makes sense that social anxiety would selectively track with more extreme negative affect for losses at counterfactual feedback, but partial feedback.

Limitations and Future Directions

There are several relevant limitations of this study. Importantly, qualitative debriefing interviews with in-person participants revealed that the CGT was quite long and fatiguing (sometimes reaching 45-60 minutes), making it hard to focus and provide quality results in the task as it went on. Although the extensive length of this task was originally intended to cover every variation of values and probabilities between each wheel equally spread across Avoid, Seek, and Complete trials, this fatigue effect might have reduced data quality. Thus, in future replications of this research, we want to reduce the length of this task by removing trials that might be redundant in probing decision-making and affective responses.

In addition, as previously mentioned, it is possible that the CGT lacked external validity by not providing salient enough rewards and punishments to trigger emotional exaggeration in anxious individuals. Thus, instead of the task being based on symbolically meaningless points, future iterations of the task might use real money. Furthermore, due to the relevance of counterfactual decisions and anxiety to social situations, especially in the context of "FOMO" (Dempsey et al., 2019) and social media (Keles et al., 2020), we strive to create future iterations of this task using more salient social outcomes emulating a social media platform which is likely to access decision-making and affective alterations prevalent in general and social anxiety.

Furthermore, as previously mentioned, no official clinical diagnoses of Generalized Anxiety Disorder or Social Anxiety were conducted. Thus, it is unclear how valid of a measure the State-Trait Anxiety Index and Leibowitz Social Anxiety Scale were in capturing anxiety that would

generate meaningful variation in the CGT. In future research, it would be valuable to have official clinical diagnoses to see how those with Anxiety and those without differentially respond to self-reports and behave on the CGT.

Another important limitation is the restricted demographic of the sample we collected. The convenience sample we collected only included college-age students at an elite private university, severely limiting the generalizability of our results. In future research, we would like to use a more community based sample with a variety of greater age, education, and socioeconomic statuses.

Another limitation to consider is that there was a systemic difference between the instructions in each sample. In the in-person sample, which we collected prior to the online sample, the instructions didn't include information stating that pressing or not pressing in the Avoid and Seek Trials had no difference in timing or speed of task completion. However, debrief interviews with the participants revealed that participants sometimes believed that they could get through the task faster by choosing to seek or avoid more often. Thus, we clarified in the instructions of the online sample that there was no timing difference between the two. Although there were no large differences between samples, the difference in instructions might have created systemic differences between how the participants approached the task. In future replications, we will include the updated instructions to ensure proper completion of the task.

In future analyses, there are more that we will run to better test our hypotheses. Most importantly, we plan to run trial-wise analyses to investigate how participants make initial decisions between circles. We want to investigate how differing values and probabilities for outcomes between circles might influence decision-making for individuals with varying anxiety,

regret sensitivity, and intolerance of uncertainty. By calculating the parameters of expected value, potential loss, potential gain, risk, and prospective regret for each trial across all participants, we can assess how various self-reports, primarily anxiety levels, predict variations in decision-making based on these parameters.

Furthermore, we plan to assess how each self-report predicts partial affective responses using a linear mixed effects model to directly assess the interaction effects of self-report and winning and losing at partial feedback. Currently, we ran linear regressions of self-reports predicting affect in separate models for wins and losses, but this fails to directly assess interactions between wins and losses. We will re-run these analyses using linear mixed model regression to directly test the interaction between outcome valence and self-report score in predicting affect at partial feedback.

In addition, we collected data on what psychiatric medications participants used. It is possible that testing anxiety levels in relation to the CGT lost some variation because of not accounting for anxiolytic medications. In future analyses, we will account for medication in relation to anxiety levels and CGT performance.

Anxiety is commonly comorbid with depression. Although participants responded to Beck Depression Inventory in the self-reports, our convenience sample did not provide sufficient variation in depression scores to make any meaningful analyses of depression in relation to our behavioral measures. In future analyses, we will first log transform the right-skewed data to assess if depression has any meaningful relationship with behavioral measures. In future studies, we might actively recruit subjects that are greater in depression to investigate these relationships.

Lastly, although we found that increased Regret Scale scores predicted decreased willingness to view counterfactual information for partial feedback losses over wins, we did not find any self-report measures that significantly predicted general desire to avoid counterfactual information regardless of outcome valence, and we didn't find any self-reports that account for the sizeable proportion of counterfactual avoidance across conditions. Thus, in the future, we will test other personality and clinical measures such as pessimism (Norem & Cantor, 1986), anxiety sensitivity (Berman et al., 2010), experiential avoidance (Arnaudova et al., 2017), threat appraisal (Stepinski et al., 2010), and other measures which might relate to avoidance of counterfactual information.

Conclusions

In sum, the present study offers a novel experimental manipulation to test receptiveness to counterfactual information and investigates how anxiety relates to affect and decision-making affective responses in the Counterfactual Gambling Task. We identified Regret Sensitivity and Intolerance of Uncertainty as predictors of increased willingness to view counterfactual information. Furthermore, various anxiety measures are associated with intensified affective responses to negative outcomes, but not positive outcomes, at both partial and complete feedback. The current data is crucial in clarifying what factors increase receptiveness to counterfactual information and how different people emotionally respond to it. To further our understanding, future research should strive to identify what mechanisms reduce willingness to discover counterfactual information, and more emotionally salient and environmentally valid paradigms should be used to probe differences in decision making and affect.

List of Figures

References

1. Epstude, K., & Roese, N. J. (2008). The functional theory of counterfactual thinking. *Personality and social psychology review*, *12*(2), 168-192.

2. Byrne, R. M. (2016). Counterfactual thought. *Annual review of psychology*, *67*, 135-157

3. Cisler, J. M., Olatunji, B. O., Feldner, M. T., & Forsyth, J. P. (2010). Emotion regulation and the anxiety disorders: An integrative review. *Journal of psychopathology and behavioral assessment*, *32*(1), 68-82.

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

5. Iyengar, S. S., Wells, R. E., & Schwartz, B. (2006). Doing better but feeling worse: Looking for the "best" job undermines satisfaction. *Psychological Science*, *17*(2), 143-150.

6. Nolen-Hoeksema, S. (2000). The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. *Journal of abnormal psychology*, *109*(3), 504.

7. Maner, J. K., Richey, J. A., Cromer, K., Mallott, M., Lejuez, C. W., Joiner, T. E., & Schmidt, N. B. (2007). Dispositional anxiety and risk-avoidant decision-making. *Personality and Individual Differences*, *42*(4), 665-675.

8. Carleton, R. N. (2012). The intolerance of uncertainty construct in the context of anxiety disorders: Theoretical and practical perspectives. *Expert Review of Neurotherapeutics*, *12*(8), 937-947.

9. Roese, N. J., Epstude, K. A. I., Fessel, F., Morrison, M., Smallman, R., Summerville, A., ... & Segerstrom, S. (2009). Repetitive regret, depression, and anxiety: Findings from a nationally representative survey. *Journal of Social and Clinical Psychology*, *28*(6), 671-688.

10. Spielberger, C. D. (1983). State-trait anxiety inventory for adults.

11. Liebowitz, M. R., & Pharmacopsychiatry, M. P. (1987). Social phobia. *New York, NY: Guilford Publications*.

12. Beck, A. T., Steer, R. A., & Brown, G. K. (1987). *Beck depression inventory*. New York:: Harcourt Brace Jovanovich.

13. Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the penn state worry questionnaire. *Behaviour research and therapy*, *28*(6), 487-495.

14. Brinker, J. K., & Dozois, D. J. (2009). Ruminative thought style and depressed mood. *Journal of clinical psychology*, *65*(1), 1-19.

15. Schwartz, B., Ward, A., Monterosso, J., Lyubomirsky, S., White, K., & Lehman, D. R. (2002). Maximizing versus satisficing: happiness is a matter of choice. *Journal of personality and social psychology*, *83*(5), 1178.

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

17. Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: the BIS/BAS scales. *Journal of personality and social psychology*, *67*(2), 319.

18. Camille, N., Coricelli, G., Sallet, J., Pradat-Diehl, P., Duhamel, J. R., & Sirigu, A. (2004). The involvement of the orbitofrontal cortex in the experience of regret. *Science*, *304*(5674), 1167-1170.

19. Coricelli, G., Critchley, H. D., Joffily, M., O'Doherty, J. P., Sirigu, A., & Dolan, R. J. (2005). Regret and its avoidance: a neuroimaging study of choice behavior. *Nature neuroscience*, *8*(9), 1255-1262.

20. Larquet, M., Coricelli, G., Opolczynski, G., & Thibaut, F. (2010). Impaired decision making in schizophrenia and orbitofrontal cortex lesion patients. *Schizophrenia research*, *116*(2-3), 266-273.

21. Camille, N., Pironti, V. A., Dodds, C. M., Aitken, M. R. F., Robbins, T. W., & Clark, L. (2010). Striatal sensitivity to personal responsibility in a regret-based decision-making task. *Cognitive, Affective, & Behavioral Neuroscience*, *10*(4), 460-469.

22. Gillan, C. M., Morein-Zamir, S., Kaser, M., Fineberg, N. A., Sule, A., Sahakian, B. J., ... & Robbins, T. W. (2014). Counterfactual processing of economic action-outcome alternatives in obsessive-compulsive disorder: further evidence of impaired goal-directed behavior. *Biological psychiatry*, *75*(8), 639-646.

23. Baskin-Sommers, A., Stuppy-Sullivan, A. M., & Buckholtz, J. W. (2016). Psychopathic individuals exhibit but do not avoid regret during counterfactual decision making. *Proceedings of the National Academy of Sciences*, *113*(50), 14438-14443.

24. Mitchell, M. A., & Schmidt, N. B. (2014). An experimental manipulation of social comparison in social anxiety. *Cognitive Behaviour Therapy*, *43*(3), 221-229.

25. Dempsey, A. E., O'Brien, K. D., Tiamiyu, M. F., & Elhai, J. D. (2019). Fear of missing out (FoMO) and rumination mediate relations between social anxiety and problematic Facebook use. *Addictive Behaviors Reports*, *9*, 100150.

26. Keles, B., McCrae, N., & Grealish, A. (2020). A systematic review: the influence of social media on depression, anxiety and psychological distress in adolescents. *International Journal of Adolescence and Youth*, *25*(1), 79-93.

27. Norem, J. K., & Cantor, N. (1986). Defensive pessimism: harnessing anxiety as motivation. *Journal of personality and social psychology*, *51*(6), 1208.

28. Berman, N. C., Wheaton, M. G., McGrath, P., & Abramowitz, J. S. (2010). Predicting anxiety: The role of experiential avoidance and anxiety sensitivity. *Journal of anxiety disorders*, *24*(1), 109-113.

29. Arnaudova, I., Kindt, M., Fanselow, M., & Beckers, T. (2017). Pathways towards the proliferation of avoidance in anxiety and implications for treatment. *Behaviour Research and Therapy*, *96*, 3-13.

30. Stapinski, L. A., Abbott, M. J., & Rapee, R. M. (2010). Evaluating the cognitive avoidance model of generalised anxiety disorder: Impact of worry on threat appraisal, perceived control and anxious arousal. *Behaviour Research and Therapy*, *48*(10), 1032-1040.