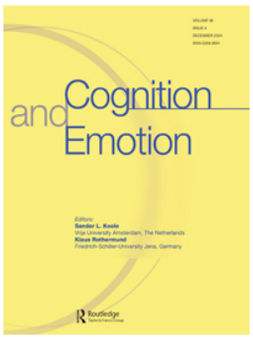

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ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/pcem20

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To cite this article: Crystal Reeck & Kevin S. LaBar (2024) Reining in regret: emotion regulation modulates regret in decision making, Cognition and Emotion, 38:8, 1368-1375, DOI: 10.1080/02699931.2024.2357847

To link to this article: https://doi.org/10.1080/02699931.2024.2357847

COGNITION AND EMOTION
2024, VOL. 38, NO. 8, 1368–1375
https://doi.org/10.1080/02699931.2024.2357847

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Reining in regret: emotion regulation modulates regret in decision making

Crystal Reeck[a] and Kevin S. LaBar[b]

[a]Fox School of Business, Temple University, Philadelphia, PA, USA; [b]Department of Psychology & Neuroscience, Duke University, Durham, NC, USA

ABSTRACT

Whereas the influence of regret on decision making is well-established, it remains unclear whether emotion regulation may modulate both the affective experience of regret and its influence on decisions. To examine this question, participants made decisions about options involving uncertainty using two different, instructed emotion regulation strategies. In one case, they were instructed to treat each choice individually, while in the other they were encouraged to treat a series of decisions as a portfolio. The present experiment demonstrates that approaching a series of decisions as a portfolio led to less extreme affective reactions to outcomes and lowered physiological arousal levels compared to focusing on each decision in isolation. However, the different emotion regulation strategies did not alter the influence of anticipatory regret on choices. The results indicate that these different emotion regulation strategies can be used to alter the experience of regret. These findings support a role for cognitive strategies in mitigating the affective experience of regret and suggest a means to encourage consumer welfare.

ARTICLE HISTORY
Received 2 December 2020
Revised 13 May 2024
Accepted 14 May 2024

KEYWORDS
Regret; emotion regulation; risky decision making; financial decision making

Our choices don't always work out. Perhaps the stock we bought underperforms, a new appliance needs repairs, or our child's school posts lower-than-expected statewide test results. Particularly after experiencing negative outcomes, people think counterfactually, reflecting on what might have been (Roese, 1997), and experience regret. Regret is a negative emotion that relies on counterfactual thinking, imagining what might have happened if one had chosen differently. Unlike disappointment, which emerges when we wish for a different state of the world (e.g. a stock posts a negative return), regret emerges when we wish we had taken a different action (e.g. a stock underperforms another we had considered buying). Thus, having counterfactual information about a foregone outcome is essential to evoking experienced regret. Regret involves a sense of responsibility and agency (Connolly & Zeelenberg, 2002; Frijda et al., 1989) and can be *experienced*, as when one learns that another stock would have outperformed one's investment, or *anticipated*, when one simply imagines how they would feel if an option they chose underperformed (Mellers et al., 1999). Interestingly, in contrast to other decision making biases such as loss aversion that tend to reduce risk taking, regret can either increase or decrease risk taking, depending on which is most likely to minimise the experience of regret (e.g,. Zeelenberg, 1999; Zeelenberg et al., 1996). Given that people seek to minimise regret (Bell, 1982; Loomes & Sugden, 1982; Zeelenberg et al., 1996; Zeelenberg & Pieters, 2007), especially when it promotes suboptimal choices (e.g. neglecting to take risks that are likely to pay off), it would be helpful to find a means to decrease regret to improve the decision-making experience and, potentially, the quality of one's choices.

Fortunately, people can reduce unwanted feelings by changing how they think about events (Gross,

CONTACT Crystal Reeck crystal.reeck@temple.edu Fox School of Business, Temple University, 1801 Liacouras Walk, 19122, Philadelphia, PA, USA

Supplemental data for this article can be accessed online at https://doi.org/10.1080/02699931.2024.2357847.

2015). Emotion regulation strategies influence the subjective experience of emotion, emotional behaviour, physiological arousal (Gross, 1998), and activation of brain regions associated with emotional experience (Goldin et al., 2008). Prior research indicates that regulation during decision making diminishes loss aversion (Sokol-Hessner et al., 2009) and reduces activation in affective processing neural regions (Sokol-Hessner et al., 2013). Specifically, this research examined how two different emotion regulation strategies during decision making can mitigate the influence of loss aversion. Building on prior emotion regulation research showing that reappraising outcomes can reduce their affective impact (Gross, 2015), this prior work examined how reinterpreting outcomes might influence loss aversion (Sokol-Hessner et al., 2009). Specifically, they distinguished between focusing on each outcome individually compared to using more of a "portfolio" approach in which people instead considered their performance overall. These findings dovetail with a number of demonstrations that emotion regulation can improve decision making, including reducing the effects of option framing (Miu & Crisan, 2011) and promoting healthy food choices (Boswell et al., 2018). Prior work has highlighted the emotional nature of regret and demonstrated that regions of the brain involved in affective processing play a central role in regret during decision making (e.g. Camille et al., 2004; Coricelli et al., 2005), and these same regions are influenced by emotion regulation (e.g. Goldin et al., 2008). It therefore seems likely that emotion regulation would alter regret during decision making. The present research extends these findings by examining how these different strategies can regulate a specific emotion – regret – during decision making.

The present research investigates the influence of top-down regulation on regret in decision making. Specifically, we manipulate the emotion regulation strategy participants use when making decisions involving risk. On each trial, participants chose between two different gambles and then learned the outcome of their decision. Counterfactual feedback was manipulated, such that on some trials participants also learned the outcome if they had chosen the other option instead. Between different blocks of the decision-making task, we manipulated which emotion regulation strategy participants were instructed to use, asking them to use either a strategy that focused on decisions as a portfolio or a strategy that focused on individual outcomes. We predict that these strategies will have an influence on multiple facets of regret, including participants' subjective experience, physiological arousal, and the influence of regret on choices. We hypothesise that thinking of outcomes as a portfolio will result in less extreme subjective emotional reactions to outcomes than focusing on each outcome in isolation. We also hypothesise that this portfolio strategy will diminish physiological reactivity during the task compared to the individual strategy. Finally, we predict that the portfolio strategy will diminish anticipatory regret's influence on decisions. We demonstrate that such top-down strategies can alter emotional experiences during decision making, but do not reduce the influence of anticipatory regret on choice. This work transforms our understanding of emotional influences on decision making, as we document that emotion regulation can alter the experience of regret.

Methods

Participants

Data were collected in two batches. During the first batch, thirty participants (21 women; Age $M = 21.6$ years, range = 18 - 31) without history of psychological or neurological disorders were recruited to take part in this study. Following a suggested change to the task instructions by one of the reviewers, a second batch of thirty participants (16 women; Age $M = 22.5$ years, range = 18 - 32) without history of psychological or neurological disorders were recruited to take part in this study with slightly altered task instructions (see below). Analyses confirmed that the batch in which data were collected did not moderate any of the results (p's > .05), so results were combined across the two data batches for a total of sixty participants (37 women; Age $M =$ 22.0 years, range = 18 - 32). These participants provided written informed consent in accordance with the Duke University Medical Center Institutional Review Board and data are available online (https://osf.io/94jyf/). The sample size was selected to exceed the sample sizes used in previously published research using similar experimental paradigms (Camille et al., 2004; Coricelli et al., 2005; Sokol-Hessner et al., 2009). A sensitivity analysis using an alpha of .05 and power of .8 revealed this sample size was sufficiently powered to detect differences of $d = 0.32$ or f = 0.15.

Skin conductance

After participants in the first batch of data collection[1] provided informed consent, they were prepped for skin conductance response (SCR) recording with a BIOPAC MP-150 system (Goleta, CA). A conductive saline-based gel was utilised with Ag/AgCL electrodes, which were placed on the middle phalanges of the non-dominant hand. SCR was recorded continuously at 200 Hz and analysed offline (AcqKnowledge software, BIOPAC systems, Goleta, CA). SCR magnitudes were extracted from the deliberation phase and outcome phase of each trial by time-locking responses to the onset of the option display and the onset of outcome feedback, respectively. Only SCRs greater than 0.02 μS arising between 1 to 4 s after the onset of each phase and lasting between 0.5 and 5 s were recorded as valid responses; otherwise the data were scored as zeros. Skin conductance data from two participants were not analysed due to a lack of measurable SCRs. SCRs were square-root transformed to normalise their distribution prior to analysis. As initial exploratory analyses revealed partial and complete feedback did not significantly differ in the SCRs they produce during either the outcome or decision phases (p's > .3), SCR data were combined across both partial and complete feedback trials. Additional exploratory analyses of outcome SCRs to wins versus losses and upward versus downward comparisons did not interact with effects of strategy (p's > .15), so outcome data were combined across both outcomes and comparisons.

Gamble structure

Forty gamble pairs were generated from combinations of outcomes (−200; − 50; 50; 200) and probabilities (0.2; 0.5; 0.8) for use in this study. The two gambles presented in any pair always differed in their expected values and in their actual outcome values. The same set of forty gamble pairs was employed for each of the conditions (*i.e.* "Multiple" Complete Feedback, "Multiple" Partial Feedback, "Individual" Complete Feedback, and "Individual" Partial Feedback), but the gamble presentation order was randomly determined for each participant.

Experimental procedure

Participants completed eight blocks each consisting of 20 trials of an incentive-compatible decision-making task. The task was adapted from previous research examining the influence of regret on choices (Camille et al., 2004; Coricelli et al., 2005). Each trial consisted of a decision between two gambling options, each with different probabilities of financial gains or losses represented by different coloured sectors of a circle (Figure 1).

In order to assess how different emotion regulation strategies impact the influence of regret on decision making, the strategies participants were instructed to employ also varied across blocks. At the outset of the experiment, two different strategic approaches adapted from previous research (Sokol-Hessner et al., 2009) were described to participants (See Supplemental Online Material for Instructions). In the Multiple strategy, subjects were instructed to consider a block of decisions as a portfolio, focusing on the context of multiple decisions. In the Individual strategy, subjects were instructed to consider each decision in isolation of others, focusing on individual decisions as if each were the only decision they were going to make in the study. The instructions in the first data collection batch were adapted from previous research (Sokol-Hessner et al., 2009). During the peer review process, one of the reviewers noted that these instructions made explicit reference to emotions in the Individual strategy but not the Multiple strategy. This difference between the instructions was amended and a second batch of data collection was conducted (both sets of instructions are included in the Supplemental Online Material). As noted above, analyses revealed the results were not moderated by data collection batch, so the results are reported below for the data combined across the two data collection batches. To promote incentive compatible strategies, subjects were told that they would be paid a bonus based on the strategy they used and their decisions in a randomly selected block. If a Multiple block were randomly selected, subjects were paid based on an average of all of the outcomes within that block. If an Individual block were selected, subjects were paid based on a single randomly chosen outcome within that block. To ensure comprehension of the two strategies, participants were asked to describe the strategies in their own words, apply the strategies to a real-world vignette involving stock investments (see Supplemental Online Material), and complete a short quiz on the strategies prior to the experiment. After the experiment, a surprise quiz on the strategies was given. Every participant answered all of the post-task quiz questions correctly, confirming that all

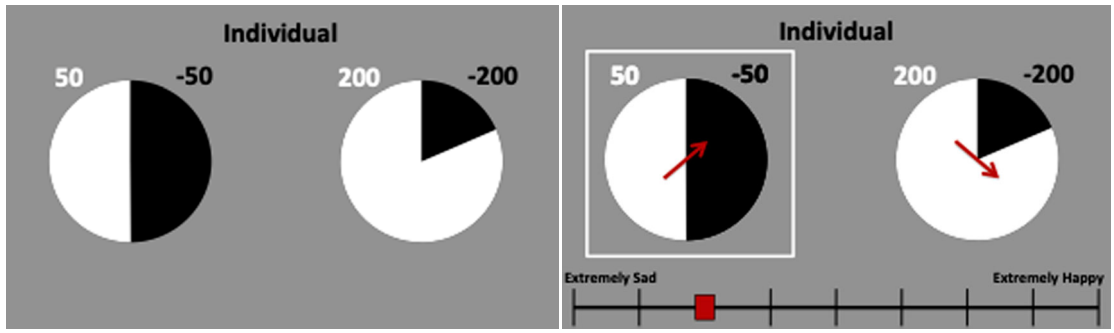

Figure 1. Depiction of a sample trial from the decision-making task. Figure 1. Depiction of a sample trial from the decision-making task. The option on the left had a 50% probability of winning 50 and a 50% probability of losing 50, while the option on the right had an 80% probability of winning 200 and a 20% probability of losing 200. In the trial shown, the left option was selected and the outcome of the chosen option was indicated by the arrow (in this example, a loss of 50). On this Complete Feedback trial, information was also provided about the outcome of the alternative (in this example, a win of 200). Participants were asked to rate their emotional experience using the slider at the bottom of the display, and the strategy being used on this block is displayed throughout the trial ("Individual").

participants understood the instructions throughout the decision-making task.

The type of feedback participants received regarding the outcomes was also manipulated across blocks. In Complete Feedback blocks, the outcomes of both the chosen and unchosen gambles were revealed. In Partial Feedback blocks, only the outcome of the chosen gamble was revealed. Thus, the Complete Feedback runs enabled the participant to compare the outcome of their decision versus the outcome of the foregone alternative, which would allow for counterfactual comparisons that underlie the experience of regret. The presence of counterfactual information is a hallmark of regret, allowing for outcome evaluation based on not only the attributes of the chosen gamble outcome, but also its relation to the foregone gamble outcome.

Each block commenced with a five-second cue indicating which strategy the participant should employ for the duration of the block (Individual or Multiple) and what type of feedback they would receive ("Both outcomes revealed" in the Complete Feedback condition or "Only chosen outcome revealed" in the Partial Feedback condition). Subsequently, the strategy cue appeared at the top of the screen during each trial.

On each trial, participants contemplated a decision between two gamble options and indicated which gamble they would prefer to play. Responses were given on a 4-point scale that indicated both choice and strength of preference: "Strongly prefer left gamble," "Somewhat prefer left gamble," "Somewhat prefer right gamble," or "Strongly prefer right gamble." Once selected, a white square appeared around the chosen gamble to indicate the participant's selection. Subsequently, the outcome of the gamble was randomly determined and displayed to the participant. Participants then rated their emotional response to the gamble outcome on a 9-point affect scale ranging from "Extremely Sad" to "Extremely Happy." The durations of the decision phase and the outcome phase were jittered to allow the detection of physiological responses to both events in each trial. The decision phase could last from 7 to 9 s (varied in half-second steps) and the outcome phase always lasted 8 s but was followed by a variable intertrial interval of 1 to 2 s (varied in half-second steps) during which a central fixation cross was presented.

Choice modelling

Participants' choices in the present task were modelled to examine the influence of anticipatory regret, disappointment, and expected value on decisions (Camille et al., 2004; Coricelli et al., 2005). The probability of selecting gamble 1 was modelled for each individual i on each trial t as a function of these three parameters on Complete Feedback trials, $P(g1_{it}) = F[r_{it}, d_{it}, ev_{it}]$ where $F(\theta)$ indicates $e^{\theta}/(1+e^{\theta})$. The highest, x, and lowest, y, outcomes of each gamble option were employed along with the probabilities of the lowest outcome for both gamble 1, p, and gamble 2, q, in computing the parameters corresponding to anticipatory regret ($r = |y_2 - x_1| - |y_1 - x_2|$), disappointment ($d = (|y_2 - x_2|q) - (|y_1 - x_1|p)$, and

expected value ($ev = ((1 - p)x_1 + py_1) - ((1 - q)x_2 + qy_2)$). Choices were modelled employing a panel logit procedure with individual random effects separately for Individual and Multiple trials. Data from five participants could not be examined due to a failure of the model to converge for these participants.

Results

Subjective emotion ratings

At the end of each trial after the outcome of the selected gamble was revealed, participants rated their subjective emotional experience. These ratings were examined to evaluate the effect of emotion regulation on responses to experienced outcomes. A repeated-measures ANOVA was conducted to evaluate the effects of the gamble outcome (win or loss) and strategy (Individual or Multiple) on participants' affective ratings (Table 1; Figure 2, left panel). There was a main effect of outcome, as participants provided higher emotional valence ratings in response to wins than losses, $F(1, 59) = 811.63$, $p < .001$, $\eta_P^2 = .93$ (90% CI = .90, .95). The main effect of strategy was not significant, $F(1, 59) = 0.43$, $p = .516$, $\eta_P^2 = .01$ (90% CI = .00, .08). Importantly, there was a significant interaction between outcome and strategy, such that there was a greater effect of gamble outcome when participants employed the Individual strategy as compared to the Multiple strategy, $F(1, 59) = 13.50$, $p < .001$, $\eta_P^2 = .19$ (90% CI = .06, .32). Post hoc *t*-tests revealed that participants experienced more positive affect following wins when using the Individual strategy compared to the Multiple Strategy, $t(59) = 3.07$, $p = .003$, $d = 0.40$ (95% CI = 0.13, 0.66). Additionally, participants experienced more negative affect following losses when using the Individual strategy compared to the Multiple Strategy, $t(59) = 2.69$, $p = .009$, $d = 0.35$ (95% CI = 0.09, 0.61). Thus, the strategy a participant deployed altered their subjective responses to experienced wins and losses, such that the effects of outcomes were more extreme when they were employing the Individual compared to the Multiple strategy.

Table 1. Mean ratings (and standard deviations) of emotional experience based on chosen outcome.

	Outcome	
Emotion Regulation Condition	Win	Loss
Individual	7.33 (0.65)	3.13 (0.59)
Multiple	7.20 (0.70)	3.31 (0.70)

To examine how the strategy employed altered the impact of counterfactual information on participants' subject experience, Complete Feedback trials were examined as a function of whether they involved an upward counterfactual (i.e. the foregone gamble outperformed their selected option) or a downward counterfactual (i.e. their chosen gamble outperformed the foregone gamble) comparison. A repeated-measures ANOVA was conducted to examine the extent to which both strategy (Individual or Multiple) and comparison (upward or downward counterfactual comparison) impacted subject responses during Complete Feedback trials in which participants learned the outcome of the foregone alternative gamble (Table 2; Figure 2, right panel). There was a main effect of comparison, $F(1, 59) = 556.83$, $p < .001$, $\eta_P^2 = .90$ (90% CI = .86, .93), as valence ratings were higher on trials involving a downward counterfactual comparison. The main effect of strategy was not significant, $F(1, 59) = 0.01$, $p = .907$, $\eta_P^2 < .001$ (90% CI = .00, .01). However, there was a significant interaction between strategy and comparison, $F(1, 59) = 5.48$, $p = .023$, $\eta_P^2 = .09$ (90% CI = .01, .21), as the difference in ratings across counterfactual comparisons was larger when participants were employing the Individual compared to the Multiple strategy. While emotional experience was rated higher for downward than upward counterfactual comparisons when using both the Individual, $t(59) = 23.19$, $p < .001$, $d = 2.99$ (95% CI = 2.40, 3.59), and Multiple strategies, $t(59) = 22.73$, $p < .001$, $d = 2.93$ (95% CI = 2.35, 3.52), the effect was larger when employing the Individual strategy. Stated colloquially, the highs (downward counterfactuals) are higher and the lows (upward counterfactuals) are lower in the Individual strategy than the Multiple strategy, demonstrating the efficacy of the Multiple strategy in dampening emotional response at the subjective experiential level.

Skin conductance response (SCR)

We predicted that the Multiple strategy would diminish levels of peripheral arousal during the decision-making task compared to the Individual strategy. To test this assertion, a repeated-measures ANOVA was conducted with the factors of strategy (Individual or Multiple) and time (mean SCR magnitude from the Outcome or Decision phase). There was a significant main effect of strategy, $F(1, 25) = 4.52$, $p = .044$, $\eta_P^2 = .15$ (90% CI = .00, .35), with more pronounced SCRs

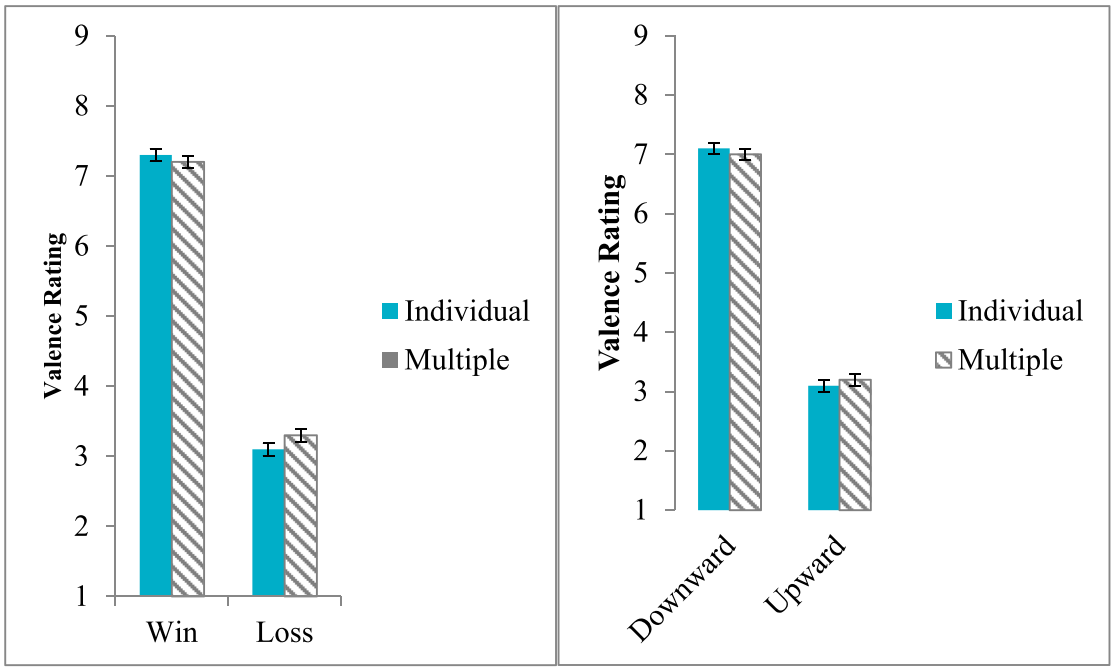

Figure 2. Strategies change emotional responses. Figure 2. Left panel: Mean subjective valence ratings following win or loss outcomes across different strategies. The difference in ratings across different outcomes was more pronounced when participants employed the Individual strategy compared to the Multiple strategy. Right panel: Mean subjective valence ratings on Complete Feedback trials for upward and downward counterfactual comparisons across different strategies. The difference in ratings across counterfactual comparisons was more pronounced when participants employed the Individual strategy compared to the Multiple strategy. Error bars are +/− 1 s.e.m (Masson & Loftus, 2003).

on Individual ($M = 0.68$) compared to Multiple ($M = 0.63$) trials. The main effect of time was not significant, $F(1, 25) < 0.001$, $p = .994$, $\eta_p^2 < .001$ (90% CI = .00, .00), nor was there a significant interaction, $F(1, 25) = 0.32$, $p = .579$, $\eta_p^2 = .01$ (90% CI = .00, .15). These findings support our hypothesis that the Multiple strategy should result in reduced peripheral arousal during the task compared to the Individual strategy.

Choice model

We next sought to examine whether the Multiple strategy diminished not only the experience of regret but also anticipatory regret's influence on decisions (see Supplemental Results for analyses of other parameters). The parameter corresponding to regret, *r*, was examined for both Individual and Multiple trials. On trials in which participants employed the Individual strategy, *r* was significantly different from 0, $t(54) = 4.23$, $p < .001$, $d = 0.57$ (95% CI = 0.28, 0.85), indicating that anticipated regret made participants more likely to select regret-minimizing options. A similar pattern emerged on trials involving the Multiple strategy, with *r* significantly different from 0, $t(54) = 3.58$, $p < .001$, $d = 0.48$ (95% CI = 0.20, 0.76). A direct comparison between the *r* parameters in the Individual strategy and Multiple strategy conditions yielded no significant differences, $t(54) = 0.24$, $p = .808$, $d = 0.03$ (95% CI = −0.23, 0.30). Thus, the strategies did not appear to diminish the influence of anticipatory regret on participants' choices.

Table 2. Mean ratings (and standard deviations) of emotional experience based on counterfactual outcome.

	Counterfactual Comparison	
Emotion Regulation Condition	Downward	Upward
Individual	7.10 (0.91)	3.10 (0.75)
Multiple	7.00 (1.00)	3.19 (0.68)

Discussion

The present research investigated how strategies influenced regret during decisions involving risk. These top-down regulatory strategies influenced multiple facets of emotional responding during the decision-making process. Specifically, when

participants focus on their decisions as a portfolio rather than treat each choice in isolation, they experience dampened subjective emotional experience in response to outcomes and reduced physiological arousal during the task. However, the different emotion regulation strategies did not diminish the influence of regret on choices.

The manipulations utilised in the present research share features with choice bracketing. Prior research demonstrates that focusing on individual decisions compared to sets of decisions alters choice, as decisions made in isolation are often suboptimal (Benartzi & Thaler, 1999; Read et al., 1999; Webb & Shu, 2017). The present research builds on these findings by demonstrating that such differences also have implications for emotions during decision making. Thus, the present findings complement previous research showing that a broader consideration set during decision making promotes more adaptive choices.

The present research also complements prior demonstrations that different strategies can alter the influence of loss aversion on decision making (Sokol-Hessner et al., 2009; Sokol-Hessner et al., 2013). By reinterpreting outcomes to focus on either each outcome individually or the performance of one's portfolio overall, people can regulate their emotional responses during decision making. In contrast to prior work, the present findings link regulation to a specific emotion, regret, and show how such strategies can influence multiple facets of emotion during decision making. We also extend beyond the prior demonstrations that these strategies can influence loss aversion to show they can alter reactions to both gains and losses. Future work can extend these results by examining other applications of top-down regulation to emotional influences on decision making.

It is interesting that the present findings identified that different emotion regulation strategies altered subjective experience and physiological responding during the task, but did not change the influence of anticipatory regret on choices. However, these observed changes in affective experience are relevant in their own right. Enhancing consumer satisfaction is an important end for many marketers and can improve firm profitability (Rust & Zahorik, 1993), so improving emotional experience during financial decision making can be beneficial. Moreover, research in finance has demonstrated that traders with less extreme emotional reactions also earn higher returns (Lo et al., 2005). Regret can also be experienced in other domains, such as when a coach sees a player they declined to recruit enjoy a record-breaking season. Thus, over the long-term, less extreme emotional responding may support improved decision-making performance. Additionally, the present research only examined one potential choice model of regret. It could be the case that emotion regulation instead alters the effect of cumulative regret on decisions, or that a version of the model that incorporated learning across trials might have revealed differences based on emotion regulation. Future research should examine how these more complex aspects of regret's influence on decisions might be altered by emotion regulation.

Overall, the present findings demonstrate that regret is amenable to top-down regulation, and that emotion regulation can shift regret when making choices under uncertainty. Such findings suggest a simple intervention that can be used to promote consumer welfare during financial decision making. In general, we demonstrate a simple, top-down shift in strategy can rein in regret and promote an improved decision-making experience.

Note

1. Due to restrictions in place during the COVID-19 pandemic, SCR data could not be collected from participants in the second batch of data collection.

Acknowledgements

We are grateful for assistance from Carmen Lai with data collection and John Pearson with choice modelling.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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