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Dysfunctional counterfactual thinking: When simulating alternatives to reality impedes experiential learning

John V. Petrocelli[1], Catherine E. Seta[1] and John J. Seta[2]

[1]Department of Psychology, Wake Forest University, Winston-Salem, NC, USA
[2]Department of Psychology, University of North Carolina at Greensboro, NC, USA

Using a multiple-trial stock market decision paradigm, the possibility that counterfactual thinking can be dysfunctional for learning and performance by distorting the processing of outcome information was examined. Correlational (Study 1) and experimental (Study 2) evidence suggested that counterfactuals are associated with a decrease in experiential learning. When counterfactuals were made salient, participants displayed significantly poorer performance compared to their counterparts for whom counterfactuals were relatively less salient. A counterfactual salience × need for cognition (NFC) interaction qualified these findings. High NFC participants outperformed their counterparts when counterfactuals were not salient. Evidence for a memory-based mechanism was also supported.

Keywords: Counterfactual thinking; Experiential learning; Need for cognition.

When people experience negative events, or nearly negative events, they often consider alternatives to reality and mentally play out their consequences (Kahneman & Miller, 1986), a cognitive activity commonly known as counterfactual thinking. Roese and Olson (1993), and Markman, Gavanski, Sherman, and McMullen (1993), proposed that such post hoc mental simulations provide people with several functional possibilities (see Epstude & Roese, 2008). Among the benefits, they suggested that additive counterfactuals (simulations of actions not taken; Roese & Olson, 1993) and upward counterfactuals (simulations of outcomes better than reality; Markman et al., 1993) may serve a preparative function with regard to task

Correspondence should be addressed to John V. Petrocelli, Department of Psychology, Wake Forest University, P.O. Box 7778, Winston-Salem, NC 27109, USA. E-mail: petrocjv@wfu.edu

performance. By following one's "own advice", prescribed by the counterfactual, people can better prepare themselves by taking a different course of action in the future. For instance, if a person generates a counterfactual after missing his/her flight (e.g., "If only I had left earlier . . ."), he/she may be less likely to be late in the future.

Consistent with this notion, Roese (1994) showed that upward counterfactuals, in response to anagram task performance feedback, enhanced performance on a subsequent anagram task (see also Reichert & Slate, 2000). Markman, McMullen, Elizaga, and Mizoguchi (2006) demonstrated that under particular conditions of regulatory fit (i.e., promotion focus) upward counterfactuals can boost persistence in effortful task completion. Further, a counterfactual mindset also appears to facilitate performance on related tasks by serving as a de-biasing function (Kray & Galinsky, 2003; Markman, Lindberg, Kray, & Galinsky, 2007).[1] Markman et al. (1993) also argued that counterfactuals can be functional in the domains of improved affect. In particular, simulating possible outcomes that would have been worse than reality (i.e., downward counterfactuals) can elevate one's mood.

However, Sherman and McConnell (1995) argued that counterfactuals may also have dysfunctional implications. Specifically, they contend that counterfactuals can act as precursors to several cognitive biases, such as the outcome bias (Baron & Hershey, 1988), hindsight bias (Fischhoff, 1975; see also Petrocelli & Sherman, 2010; Roese & Olson, 1996), confirmation bias (Klayman & Ha, 1987), and the illusion of control in non-controllable tasks (Langer, 1975). Furthermore, McCrea (2008) demonstrated that, because counterfactuals provide reasons for poor performance, they can serve as excuses. In such cases counterfactuals can maintain one's self-esteem yet reduce motivation for subsequent improvement (see also Markman & Tetlock, 2000a, 2000b, for a discussion of counterfactual excuse making following negative outcomes). We propose that counterfactuals can have a deleterious effect on learning. Our expectation is that counterfactuals will interfere with learning, for several reasons detailed below.

EXPERIENTIAL LEARNING

For nearly a century, learning from experience has been studied from many levels of analysis (behavioural, cognitive, physiological) in both animal and human populations (e.g., Hull, 1943; Young, 1936; Zald, Curtis, Chernitsky, & Pardo, 2005). Experiential learning paradigms require participants to infer

[1] A counterfactual mindset can promote a relational processing style, yet hinder performance on creative tasks requiring the generation of novel ideas (Kray, Galinsky, & Wong, 2006). Counterfactual subtractive mindsets can enhance analytical/problem-solving tasks, whereas counterfactual additive mindsets can enhance performance tasks that require creative ideas (Markman, McMullen, & Elizaga, 2008).

a task rule or relevant concept through monitoring task feedback (e.g., errors and correct responses). Clear and specific feedback is important for effective trial-by-trial learning (Baldwin & Baldwin, 2000; Kazdin, 2001; Miltenberger, 2001). The acquisition of the correct task rule requires the ability to update and maintain a representation of the selected and unselected stimuli, along with working memory for the trial-by-trial feedback associated with these stimuli. Both neurophysiological and cognitive research suggests that the concept acquisition through experiential learning should be hindered by factors that interfere with any of these processes, all of which involve the operation of working memory systems (e.g., Bardenhagen & Bowden, 1998; Zald et al., 2005).

How might generating counterfactuals affect the processes involved in learning from experience? Failure feedback is often an important component of learning from experience, providing both information and motivation (Feather, 1966; Hull, 1943; Spence, 1954; Weiner, 1966). It is likely that counterfactuals frequently accompany the receipt of this kind of feedback, as upward counterfactual generation is assumed to be a consequence of experiencing negative events (e.g., Gleicher et al., 1990; Markman et al., 1993).

However, counterfactuals clearly draw one's attention away from what actually happened by thinking about what "might have been". To discover concepts or rules through experiential learning it is critically important that people monitor their actual outcomes (e.g., decisions and outcomes). We propose that thinking about alternative realities may interfere with the accurate encoding of the relationship between the actual response and outcome (e.g., "Did I respond X or only think that I should have?"). Further, incorrect prepotent responses (i.e., habitual responses that may not be appropriate for the current circumstance) can hinder rule acquisition in experiential learning (see Zald et. al., 2005); imagined alternative contingencies between responses and outcomes could potentially function as a type of prepotent response which could provide an impediment in this setting. Thus counterfactuals might serve as impediments to experiential learning.

THE PRESENT RESEARCH

We designed an experiential learning task based on classic concept learning paradigms of stimulus sequencing (see Detambel & Stolurow, 1956). Participants were presented with information about two different stocks in a graphical format and were asked to select the stock that they expected to increase most in value across several trials. Performance was maximised by learning (through experience) that each stock outperformed the other stock every other year (i.e., the best stock simply alternated from year to year: Stock A, Stock B, A, B, ...). In a repeated decision task with only two options, decision makers should be able to learn a recurring pattern of outcomes (i.e., A, B, A, B, A, B, . . .), but only if they accurately recall their recent responses and the outcomes of those responses. As research has shown (Koriat, Ben-Zur, & Sheffer, 1988; Marsh, Hicks, Hancock, & Munsayac, 2002), failures in "output monitoring" can have negative consequences for future behaviour. According to Goff and Roediger (1998), counterfactual information may provide misleading information that disrupts learning and memory for actual outcomes because alternative outcomes (or one's decisions) may be falsely encoded or decoded as reality (or actual decisions). For instance, the actual outcome sequence of A, B, A, B, may be misrecalled as A, A, B, B, if the second and third outcomes are counterfactualised and the alternatives are recalled better than the actual ones. Thus we reasoned that counterfactuals might reduce such accuracy in recall as evidenced by a decrease in overall performance.

Furthermore, people tend to accept positive outcome information at face value, but spend significantly more time searching for feasible explanations in response to negative outcomes (Wong & Weiner, 1981) or explain them away with upward counterfactuals (Gilovich, 1983; Markman et al., 1993). Because people are more likely to generate counterfactuals after experiencing negative outcomes, we hypothesised that we would see the deleterious effects of counterfactual generation more prominently on trials in which participants received failure vs success feedback.

Learning involved in this task is experience-based and is a classic example of concept learning using sequences of stimuli (see Detambel & Stolurow, 1956). In such cases recurring patterns of stimulus features (e.g., trial outcomes) emerge from the sequence of stimuli, and learning is evidenced by increased success as the learner progresses through subsequent trials. In addition to the fact that education is replete with examples of concept learning, we contend that the learning that takes place in our paradigm approximates the learning that one exhibits in various activities such as making multiple stock market decisions. Additionally, presenting information graphically (versus numerically) is a particularly effective way to communicate information (e.g., Schirillo & Stone, 2005) and understanding the factors that promote or hinder effective learning from this sort of display is important for both theoretical and applied reasons.

STUDY 1

First we examined our hypotheses in a naturalistic, correlational study involving a stock market decision task. Participants were asked to play the role of a stock broker with the goal of maximising profits by selecting one of two fictitious stocks ("TVX" and "EDI"). Outcome information was given after each trial (maximum of 30 trials). Learning was evidenced by performance on the stock task, which was maximised by learning the alternating pattern in the stocks (i.e., TVX, EDI, TVX, EDI, . . .).

We expected to find upward counterfactuals to occur more frequently following incorrect decisions than correct decisions. If these counterfactuals interfere with experiential learning, one would expect to find the frequency of counterfactuals generated to be associated with our measure of task rule acquisition. Thus, participants who successfully discovered the task's solution were expected to display a reduced frequency of counterfactuals in response to incorrect decisions than participants who failed to discover the solution. To this end, we also expected to find participants who generated several counterfactuals to have a smaller likelihood of finding the task's solution than participants who generated relatively fewer counterfactuals. Also expected was a significant positive correlation between the proportion of counterfactuals following an incorrect decision and the number of trials needed to complete the experiment. In contrast, if counterfactuals facilitate learning, the opposite pattern should be observed.

Our measured variable was the proportion of counterfactuals generated relative to all other thoughts recorded. Of course, it is possible that any kind of thought process that drew attention away from the task at hand might have disrupted discovery of the correct task rule; but we expected counterfactuals to be especially disruptive. This measure allowed us to disentangle the influences of generating counterfactuals per se, as a special kind of thinking, from the effects of other kinds of thoughts that might occur in this setting.

Method

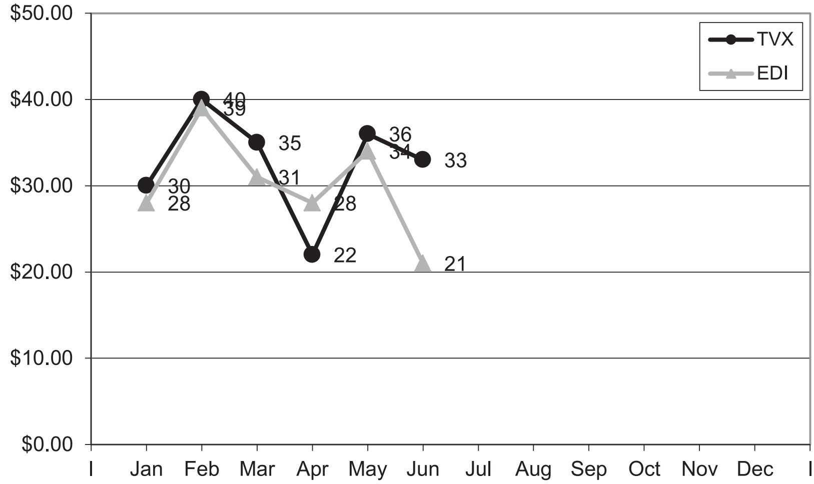
Participants. A total of 65 undergraduates from Wake Forest University participated in exchange for partial course credit. We excluded from the analysis the data of seven participants on the basis of a computer malfunction, failure to follow instructions, or extremely poor performance (i.e., 1 correct decision out of the first 10 decision trials). Thus the final sample included 57 participants.

Procedure. Upon arrival, participants were escorted to a private cubicle equipped with a personal computer. All study materials were presented using MediaLab v2006 Research Software (Jarvis, 2006). The study was described to participants as an examination of how people make decisions. The instructions of the study were self-paced and advanced by pressing a response key.

Participants read that the study involved their ability to make decisions based on the information they received during a stock market decision task. We instructed participants to imagine themselves as a stock broker working with an investment firm for several years. For each sequential year (indicated to the participants) they were presented with information about two stocks ("TVX" and "EDI"). The investment firm desired to buy shares of only one stock, as the two companies manufacture the same types of goods. Participants were to maximise the investment firm's profits by deciding which stock to buy. It was explicitly stated that they must use the information they gained during the task to predict which stock was going to profit the most before the firm decided to sell their shares. The firm desired to buy 10,000 shares of one (and only one) stock at the end of June of every year, and to sell all of their shares at the end of December; that is, the firm would hold onto their 10,000 shares for only 6 months. Participants also read that competition with the firm was great and that it desperately needed to invest in the stock that yielded the greatest return. Participants were informed that, even when they invested in a stock that yielded a gain, the firm would be satisfied only when it invested in the stock that outperformed the other stock.

For each trial participants were presented with a value-by-month graph of each stock (see the top panel of Figure 1). Graphs were pre-constructed using randomised values. Participants were falsely informed that the computers in the lab had been networked so as to give them a chance to learn a bit about how others thought about the information before they made their final decision. Participants were then given a total of 60 seconds to examine each graph before being asked to type a brief statement about their pre-decision thoughts. These statements were displayed on the very next screen frame with the graph and pre-decision statements allegedly written by two other participants. However, these statements were pre-programmed (e.g., "I'm thinking that TVX is going to increase the most"; "It's tough to tell, but I'm going with EDI"). The stocks endorsed by the two alleged participants who were "linked" to the actual participant were randomised. The statement of the actual participant also varied from trial to trial in its order of presentation. This procedure was used to create a social context for learning and to provide additional trial information to potentially counterfactualise (e.g., mentally simulating what would have occurred had one not concerned oneself with another participant's thoughts). To further enhance motivation for performing at the highest level, it was explained that the better they performed during the task (the more correct decisions they made) the greater were their chances of winning a $100 drawing.

For each trial the post-decision screen frame reminded participants that, for the particular year they had decided to pick either TVX or EDI, the degree to which both stocks either increased or decreased in value, and that their decision was either correct or incorrect. The value-by-month data for the stocks were also displayed for the final six months (see the bottom panel of Figure 1). Participants were informed that their decision resulted in a gain or a loss for the firm in the form of total dollars (i.e., the value per share



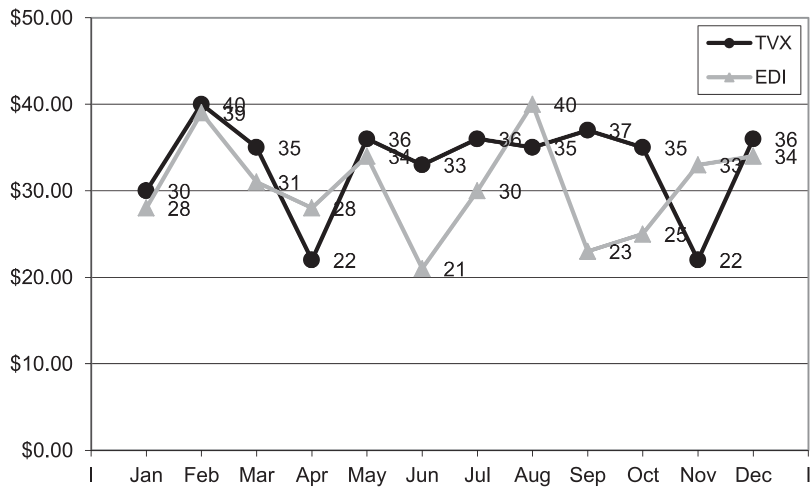


Figure 1. Examples of pre-decision and post-decision value-by-month graphs displayed during the stock market decision task (samples).

times –\$10,000 or +\$10,000). Finally, participants were asked to list the first thought that went through their mind after they learned about the outcome of the decision trial.

Participants were required to respond to a minimum of 10 trials and a maximum of 30 trials. When a participant responded correctly to six trials in a row (with a minimum of 10 trials), at any point during the stock market decision task, they were immediately debriefed and dismissed. If a participant failed to respond correctly to six trials in a row, they were required to complete all 30 trials before being debriefed and dismissed.

The first decision trial asked participants to consider the value-by-month data for the year of 1966. All subsequent trials proceeded by adding a single year; that is, the first trial used "data" from 1966, the second trial used data from 1967, and so on. The order of the winning stocks simply alternated from trial to trial (i.e., TVX, EDI, TVX, EDI, . . .).

Results and discussion

Only 15 of 57 participants found the solution to maximising performance before reaching 30 trials (26.32%). Of the 15 participants who found the solution, the average number of trials needed to correctly respond to six items in a row was 14.67 ($SD = 2.58$).

Two independent coders categorised each of the thought listings recorded by the participants as a counterfactual or non-counterfactual thought. The overall initial agreement reached 90%. A third judge served to settle any disagreements. Examples of counterfactuals listed included: "That was close – if only EDI had held its lead"; and "I should have noted that TVX started higher than EDI". The large majority of the thought responses were non-counterfactual thoughts and read much like a commentary of what actually occurred. Examples of these thoughts included: "I lost that one"; and "I picked EDI and I lost".

To assess the relationships among counterfactual generation, performance feedback, and task-rule acquisition we computed a two-way repeated-measures analysis of variance (ANOVA) on the counterfactual thought-listing proportions using the solution discovery (discovered vs failed to discover) as a between-participants factor and decision outcome (correct vs incorrect) as the within-participants factor. A main effect of solution discovery emerged, such that participants who found the solution generated a smaller proportion of counterfactuals ($M = .05$, $SD = .65$) than did participants who failed to find the solution ($M = .14$, $SD = .10$), $F(1, 55) = 9.59$, $p < .01$. This effect was qualified by the solution-discovery × decision outcome interaction, $F(1, 55) = 15.77$, $p < .001$ (see Figure 2). Participants who failed to learn the solution listed a greater proportion of counterfactuals after an incorrect response than did participants who learned the solution $t(55) = 4.92$, $p < .001$. Following correct decisions, however, participants who failed to learn the solution did not differ significantly from participants who had $t(55) = .98$, *ns*.[2]

[2] With respect to performance on the first 10 trials, participants who learned the solution did not differ significantly from those who failed to learn it (mean performance on the first 10 trials was 5.42).

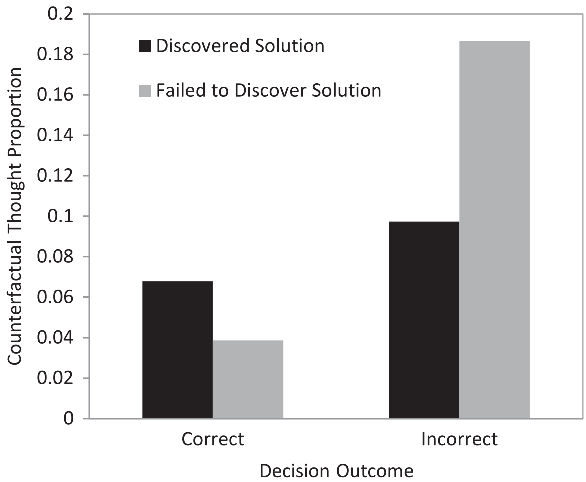


Figure 2. Proportion of counterfactual thoughts by solution discovery and decision outcome (Study 1).

Viewed another way, it is important to test whether or not generating a large proportion of counterfactuals following incorrect responses decreased the likelihood of learning the solution and whether or not generating a relatively smaller proportion of counterfactuals following incorrect responses increased this likelihood. To test these possibilities the sample was split by the median found for proportion of counterfactuals following incorrect responses (median = .11). Proportion (high vs low) was then crossed with discovery of the solution (yes vs no) in a two-way chi-squared test of independence. The result revealed that the two variables were related, $\chi^2(1, N = 57) = 15.92$, $p < .001$. Among participants who generated a relatively low proportion of counterfactuals following incorrect decisions ($n = 28$), 50% found the solution and 50% did not. However, among participants who generated a relatively high proportion of counterfactuals following incorrect decisions ($n = 29$), only 3.4% found the solution and 96.6% did not.[3]

An important distinction in the literature, with regard to counterfactuals and learning/performance, is that between additive and subtractive counterfactuals (see Kray, Galinsky, & Markman, 2009; Markman et al., 2007). Additive counterfactuals add new elements to, and subtractive counterfactuals delete elements from, reality to construct alternative worlds (e.g., "If

[3] The correlation between the proportion of counterfactuals generated after an incorrect response and the number of trials needed to complete the experiment (i.e., learn the solution) was positive and significant, $r(55) = .45$, $p < .001$.

only I had studied my notes . . .”; “If only I hadn’t partied the night before the exam . . .”, respectively). In cases whereby counterfactuals have been associated with learning and performance benefits, additive counterfactuals have tended to be more beneficial than subtractive counterfactuals. Among our participants who listed at least one counterfactual ($N = 44$), they listed a greater proportion of additive counterfactuals ($M = .46$, $SD = .40$) than they did subtractive counterfactuals ($M = .17$, $SD = .29$), $t(43) = 3.26$, $p <$ .01. However, neither the proportion of additive nor subtractive counterfactuals predicted learning above and beyond that of the proportion of counterfactuals (regardless of their structure).

In response to repeated outcome information, the data suggest that counterfactuals are associated with failure to recognise recurring and predictable outcomes crucial in a experiential learning task. We found that counterfactual thinking was associated with lower likelihoods of learning the pattern to the stock buying problem. Also as expected, the data suggest that a seemingly small ratio of counterfactuals to total thoughts is necessary to disrupt the recognition of the recurring pattern.

STUDY 2

As with all correlational studies, our Study 1 findings have important limitations; from these findings we cannot infer that counterfactual thinking causes a detriment in learning. Thus in Study 2 we attempted to confirm our correlational findings experimentally by directly manipulating counterfactual generation and measuring its effect on experiential learning.

Study 2 was designed with respect to three additional goals. First, to further rule out a distraction-based account of the effects we reported in Study 1, we compared the learning rates of participants with varying levels of counterfactual thought salience. We manipulated the salience of counterfactuals by requesting half of the sample to list an “if” or “if only” statement after receiving outcome information for each trial (high counterfactual salience), and requesting the other half of the sample to list the first thought that came to mind after receiving outcome information for each trial (low counterfactual salience). We predicted that participants assigned to the high counterfactual salience condition would need a significantly greater number of trials to learn the solution to the stock market decision task than would participants assigned to the low salience condition. Although it was possible for participants in the low salience condition to still generate counterfactual thoughts, we expected greater focus on counterfactual implications to occur when participants were directly requested to list their thoughts.

Second, much of our theorising regarding the impact of counterfactuals on learning in our stock decision task depends on thinking about the implications of reality and alternatives to reality for subsequent decisions. People with a high need for cognition (NFC; Cacioppo & Petty, 1982) find effortful cognitive tasks to be intrinsically rewarding. Without direct instructions to generate counterfactuals, high NFCs would seem likely to generate many other thoughts, besides counterfactuals, that would not be expected to interfere with learning. Interestingly, high NFCs may process information more thoroughly than low NFCs, but they do not appear to counterfactualise information any more than low NFCs (Petrocelli & Dowd, 2009). In contrast, low NFCs may not process the information provided by the task as thoroughly and may therefore not discover the task rule as quickly as high NFCs. This pattern of results would be consistent with other studies that have found high NFCs to outperform low NFCs on tasks requiring cognitive effort or attention resources (for an extensive review, see Cacioppo, Petty, Feinstein, & Jarvis, 1996). High NFCs also tend to recall more task relevant information than low NFCs (Cacioppo, Petty, & Morris, 1983). Thus we expected high NFCs to learn the task rule more quickly than low NFCs when they were permitted to approach the problem in the mode of their choice (i.e., low counterfactual thought salience condition). However, we expected to reduce the effect of this individual difference in learning by making counterfactuals salient in another condition in which we directly requested counterfactual thought listings. In other words, we expected the performance among high and low NFCs to be equally poor when focusing their attention on alternatives to reality, but to differ significantly when not asked to focus on alternatives to reality (such that high NFCs outperformed low NFCs).[4] Moderation of the effects by NFC would further suggest that thought processing, relatively less saturated with counterfactuals, might enhance experiential learning. Furthermore, this pattern of findings would provide converging evidence that the mechanism responsible for learning deficits is indeed related to counterfactual thinking.

Third, we directly examined the memory-based hypothesis that counterfactuals distort memory, and subsequently reduce the likelihood of successful experiential learning in our stock market decision paradigm. As alluded to earlier, more accurate memories about the stocks selected, and their outcomes, would facilitate learning in our paradigm. We expected participants who read general thoughts to have more accurate recall of their performance, which we believe would facilitate learning in our paradigm. Thus we hypothesised that the relationship between the type of post-outcome task (i.e., list counterfactuals vs read general thoughts) and performance (i.e., learning) would be mediated by the degree to which one overestimates one's performance.

The reasoning behind our hypothesis that counterfactuals, and not just any type of self-generated thoughts, would be especially detrimental

[4] Interestingly, counterfactual thought frequency does not correlate reliably with NFC (Petrocelli & Dowd, 2009).

to experiential learning is grounded in earlier findings and theoretical analyses of imagination inflation (Garry, Manning, Loftus, & Sherman, 1996; Goff & Roediger, 1998). In these studies people imagine events that did not occur and later falsely remember the events as if they did occur. Source monitoring research (see Johnson, 1988; Johnson, Hashtroudi, & Lindsay, 1993) suggests that the accuracy of one's memory can be distorted because the source of a memory (experienced reality vs imagined alternative reality) is forgotten. We propose that counterfactuals may operate as a special case of imagination inflation: counterfactual inflation (Petrocelli & Crysel, 2009). Essentially, rather than recalling the correct solution to the concept learning task (i.e., A, B, A, B, A, B . . .), someone who actively counterfactualises may recall an alternative reality that was (inaccurately) thought to be the correct conceptualisation of the problem (e.g., A, A, B, B, B, A . . .). Thus this type of memory distortion would make it unlikely that persons would learn the correct concept underlying the problem. Just as actual gains or success experiences may serve as retrieval cues, alternative realities that are falsely recalled might serve as distorted retrieval cues because they might lead to retrieving the simulated alternatives, not the actual outcomes. Studies conducted by Petrocelli and Harris (2011) also support our reasoning. In their studies participants were asked to complete several trials of the classic version of the Monty Hall problem.[5] Petrocelli and Harris showed that people tend to counterfactualise switch-losses more so than stick-losses. More important to our hypotheses, their findings also suggest that memory distortions, particularly overestimates of switch-losses, result from frequent counterfactuals and mediate the relationship between counterfactual thinking and learning.

Although memory distortions that either overestimate or underestimate performance could disrupt learning, overestimates of one's performance may be particularly detrimental. If by listing counterfactuals people falsely believe that they are performing well, counterfactuals might not only affect the encoding and retrieval of actual outcomes (necessary for recognising a recurring pattern), but they might also perpetuate or justify one's initial strategy and reduced the likelihood of exploring other possible strategies. This would in turn impede the learning process. Thus we hypothesised that overestimations of performance would mediate the relationship between post-outcome task and learning.

[5] In the classic Monty Hall problem a prize is randomly assigned to one of three doors and an undesirable object (e.g., a goat) is assigned to the two remaining doors. The respondent is first asked to select one of the three doors. Then one of the doors not selected is opened and always reveals an undesirable prize. The respondent is then asked to make a final decision between the door initially selected and the other remaining door.

Method

Participants and procedure. A total of 120 undergraduates from Wake Forest University participated in exchange for partial course credit. Data were collected over a 3-day period.

The current study design was similar to that of Study 1, with three exceptions. First, the current study included 35 trials rather than 30 trials. Second, counterfactual thought salience was manipulated by randomly assigning participants to one of two salience conditions. The *high counterfactual salience* condition was asked to list an "if" or "if only" statement after receiving outcome information for each trial, whereas the *low counterfactual salience* condition was simply asked to list the first thought that came to mind. Finally, the current study also included a measurement of recall.

Dependent variables. Following the conclusion of the tenth trial of the stock decision task, participants were asked to recall their last four decisions (i.e., selection of TVX or EDI) as well as the outcomes of those decisions (i.e., correct or incorrect). This enabled us to examine the accuracy of their performance estimates and its effect on subsequent performance.

Although participants were required to complete all 35 trials, we again used 6 correct trials in a row as our criterion for learning the solution. Although our primary dependent variable was ordinal in nature, it was necessary to employ additional parametric statistical analyses to test our hypotheses. Treating ordinal variables with seven or more categories as interval variables has been supported by statisticians (e.g., Rhemtulla, Brosseau-Liard, & Savalei, 2012). Because the variable had so many categories, we converted the dependent variable to its rank-order (fewer trials needed to learn the solution were assigned lower rank-order values). This also reduced some of the negative skew in the variable.

Results and discussion

Thought-listing responses. Although counterfactual thought generation is believed to be a relatively spontaneous and effortless mental activity (Goldinger et al., 2003; Roese, Sanna, & |Galinsky, 2005), we first investigated the possibility that high counterfactual salience instructions demand more cognitive effort than do low counterfactual salience instructions. To do this we calculated thought-listing completion times (i.e., the time to complete a thought-listing box beginning from the time it was first presented to the time it was submitted) for each of the 35 thought-listing boxes. To simplify our analyses we calculated the average completion times of five consecutive blocks of seven trials for each participant and computed six one-way ANOVAs using thought-listing condition as the independent variable (five for each of the five blocks of seven trials and one for the overall 35 thought listings). The mean thought-listing completion times for the first to fifth blocks for the high counterfactual salience condition were 20.02, 12.45, 11.15, 9.43, and 7.70 seconds (overall 12.15 seconds), whereas the mean thought-listing completion times for the first to fifth block for the low counterfactual salience condition in seconds were 22.05, 13.87, 13.18, 10.16, and 9.07 seconds (overall 13.67 seconds), all Fs(1, 118) < 2.75, *ns*. These results suggest that the tasks of listing a counterfactual thought, or the first thought that comes to mind, do not differ in the cognitive effort needed to complete the tasks. Furthermore, we suspect that once our participants completed a few trials, the instructions and the repeated listing of their thoughts (or counterfactuals) became a more fluent process as evidenced by increasingly faster average thought-completion times as participants progressed.

Learning

Only 30 of 120 participants found the solution to maximising performance before reaching 35 trials (25.00%). Of the 30 participants who found the solution, the average number of trials needed to correctly respond to six items in a row was 20.96 ($SD = 3.86$; range = 14–35).

To test our hypotheses regarding NFC ($M = 3.32$, $SD = .51$) and counterfactual thought salience, we employed hierarchical multiple regression procedures recommended by Cohen and Cohen (1983). NFC scores were centred, and counterfactual salience condition was dummy coded (0 = low; 1 = high). NFC scores did not significantly differ between low ($M = 3.33$, $SD = .45$) and high counterfactual thought salience conditions ($M = 3.30$, $SD = .57$), $F(1, 118) = .11$, *ns*. NFC and counterfactual salience condition were entered in the first step, and their interaction term was entered in the second step of the regression analysis.

A main effect was observed for NFC, $\beta = -.22$, $t(117) = -2.44$, $p < .02$, revealing faster learning for high than low NFC individuals. A marginal main effect of counterfactual thought salience was also observed, $\beta = .13$, $t(117) = 1.45$, $p = .14$, such that faster learning trended toward the low ($M_{rank} = 56.88$, $SD = 29.12$) than the high counterfactual salience condition ($M_{rank} = 64.08$, $SD = 23.21$). However, consistent with expectations, the counterfactual salience condition × NFC interaction term qualified these effects, $\beta = .30$, $t(116) = 3.36$, $p < .01$.

To interpret the interaction, simple slope analyses were conducted according to the procedures recommended by Aiken and West (1991). Thus simple slopes were plotted and examined at one standard deviation above and below the mean of NFC. These analyses showed that, when counterfactual salience was low, participants significantly improved performance as they increased in NFC, $\beta = -.58$, $t(116) = -4.21$, $p < .001$, but no difference in learning was observed between high and low NFCs when counterfactual

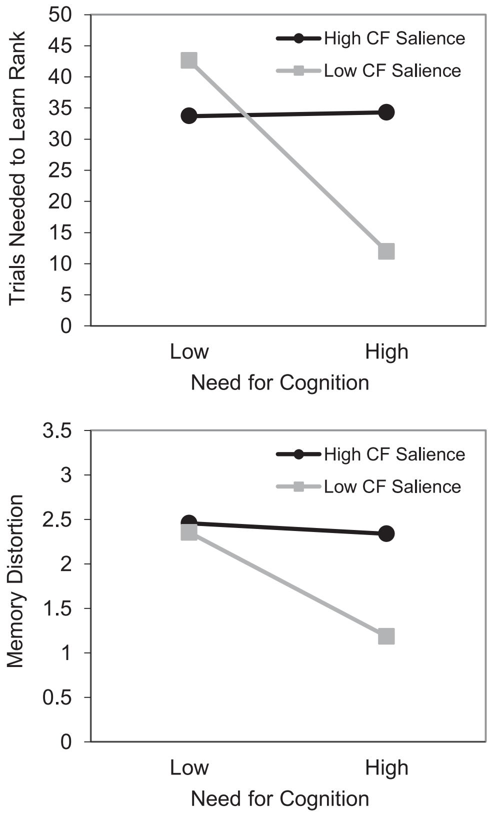


Figure 3. Predicted regression means of number of trials needed to learn the solution rank and memory distortion by counterfactual (CF) salience condition and level of need for cognition (Study 2).

salience was high, $\beta = .01$, $t(116) = .10$, *ns* (see the top panel of Figure 3). Also, among high NFCs the number of trials needed to find the solution was significantly reduced when counterfactual salience was low than when it was high, $\beta = .42$, $t(116) = 4.70$, $p < .001$; among low NFCs, counterfactual salience did not appear to affect learning, $\beta = -.17$, $t(116) = -1.87$, *ns*.[6]

Because it was possible for low counterfactual salience condition participants to also write counterfactuals, we coded their thought responses using the same procedures as those of Study 1. Doing so enabled us to test whether

[6] We accounted for both additive and subtractive counterfactuals. The instructions made the addition of elements more salient as the large majority of the counterfactuals listed were additive (i.e., > 80%). This proportion did not predict learning above and beyond counterfactual salience and NFC, nor did it interact with these variables.

or not our Study 1 findings replicated among the Study 2 participants who encountered instructions most similar to our Study 1 participants. This portion of the sample averaged 1.80 counterfactuals ($SD = 1.73$). Next we subjected the trials needed to learn the solution rank to the same hierarchical regression analysis described above for the low counterfactual salience condition ($n = 60$). As expected, a main effect was observed for NFC, $\beta = -.41$, $t(57) = -4.12$, $p < .001$, revealing faster learning for high than low NFC individuals. A main effect of counterfactual thought frequency was also observed, $\beta = .51$, $t(57) = 5.24$, $p < .001$, such that slower learning was associated with counterfactual thinking. However, consistent with expectations, a marginal counterfactual frequency $\times$ NFC interaction term qualified these effects, $\beta = 1.30$, $t(56) = 1.82$, $p < .08$.

The pattern of the interaction was very similar to that obtained for the full sample. Simple slopes analysis (plotted with one standard deviation above and below the means of counterfactual frequency and NFC) showed that when counterfactual frequency was low, participants significantly improved performance as they increased in NFC, $\beta = -.56$, $t(56) = -4.04$, $p < .001$, but no difference in learning was observed between high and low NFCs when counterfactual salience was high, $\beta = -.22$, $t(56) = -1.73$, *ns*. Also, among high NFCs the number of trials needed to find the solution was significantly reduced when counterfactual frequency was low than when it was high, $\beta = .70$, $t(56) = 2.10$, $p < .05$; among low NFCs, counterfactual frequency did not appear to affect learning, $\beta = .36$, $t(56) = .58$, *ns*.

Memory distortion

The degree of possible memory distortion was calculated by summing the incorrect responses among the four items that asked participants to recall their selected stock for trials 7–10 and the four items that asked participants to recall the outcomes of their decisions for trials 7–10. Thus greater scores indicated greater memory distortion ($M = 2.08$, $SD = 1.42$).

As expected, the pattern of data observed for the memory distortion variable was similar to that of the learning data. Main effects were observed for counterfactual thought salience, $\beta = .22$, $t(116) = 2.56$, $p < .02$, and for NFC, $\beta = -.23$, $t(116) = -2.53$, $p < .02$, revealing greater accuracy in memory for decisions and outcomes for the low counterfactual salience condition and higher NFC individuals. Again, the counterfactual salience condition $\times$ NFC interaction term qualified the main effects, $\beta = .19$, $t(116) = 2.07$, $p < .05$.

Consistent with our hypothesis, when counterfactual salience was low, significantly less memory distortion was observed as NFC increased, $\beta = -.41$, $t(116) = -2.95$, $p < .01$, but no difference in memory distortion was observed between high and low NFCs when counterfactual salience was high,

$\beta = -.04$, $t(116) = -.37$, *ns* (see the bottom panel of Figure 3). Also, among high NFCs greater memory distortion was observed when counterfactual salience was high than when it was low, $\beta = .41$, $t(116) = 3.28$, $p < .01$; among low NFCs counterfactual salience did not appear to affect the degree of memory distortion, $\beta = .04$, $t(116) = .29$, *ns*.

Our data suggest that as long as high NFCs are not engaging in counterfactual thinking they are more likely than low NFCs to base their judgements and beliefs on empirical information as they normally do (Leary, Sheppard, McNeil, Jenkins, & Barnes, 1986). When they do engage in counterfactual thinking, high NFCs inflate their perceived performance as low NFCs tend to typically do (Venkatraman, Marlino, Kardes, & Sklar, 1990).

High NFCs in the low counterfactual salience condition were most accurate in their recall of their decisions and the outcomes of those decisions. This finding is consistent with our expectation that overestimates of one's performance would be especially detrimental to learning the task rule. A conservative estimate of how well one is actually performing would seem to enhance motivation toward improvement. Being overconfident, or overestimating how well one is actually performing, would seem to decrease such motivation (e.g., "I'm doing fine. Why fix a bike that isn't broke?").[7]

Mediation analysis. Mediated moderation, as described by Muller, Judd, and Yzerbyt (2005; see also Wegener & Fabrigar, 2000), occurs when distal variables interact to influence a mediator variable, with that mediator directly carrying the effects of the interacting variables to the dependent measure. Parallel counterfactual salience condition × NFC interactions on learning and memory distortion are consistent with memory distortion mediating the counterfactual salience × NFC interaction on learning. This type of mediated moderation would be reflected in the observed counterfactual salience × NFC interaction on memory distortion, coupled with a direct relationship between memory distortion and learning.

Muller et al. (2005) specified a set of hierarchical regression analyses (see also Wegener & Fabrigar, 2000) in which the interaction term (controlling for the main effects) is used as the initial predictor. The most conventional and efficient way to conduct this analysis involves a bootstrap procedure that constructs bias-corrected confidence intervals based on 5000 random samples with replacement from the full sample, as recommended by methodologists and statisticians (Preacher & Hayes, 2004, 2008). This method tests whether or not the size of an indirect effect differs significantly from zero.

[7] In a very similar study ($N = 72$) that contrasted the high counterfactual salience condition with a control condition that read non-counterfactual thoughts by other alleged participants, we essentially replicated the counterfactual salience × NFC interaction for both learning and memory.

As described earlier, we obtained a significant counterfactual salience × NFC interaction on memory distortion and learning. We computed a final regression analysis including the effects of all the distal predictors on the criterion (learning) as reported in the previous regression and the mediator (memory distortion). The size of the indirect effect was 5.06 ($SE = 3.27$), and the 95% confidence interval excluded zero, 95% CI [.15, 12.83]. Thus memory distortion significantly mediated the relationship between the counterfactual salience × NFC interaction and learning.

GENERAL DISCUSSION

This research is the first to investigate the influences of counterfactual thinking on experiential concept learning, and is the first to show a dysfunctional role of counterfactuals in this type of classic learning paradigm. Learning from experience requires memory for the relationships between responses (e.g., choices) and subsequent outcomes. Therefore any factor that interferes with accurate encoding and memory of these relationships should impede optimal learning. Counterfactual thinking appears to induce distortions in accurate memory for these kinds of relationships and, therefore, interferes with experiential concept learning. Given the importance of experiential learning for effective functioning, these findings have important theoretical and applied implications.

In our studies both high and low NFC participants overestimated their overall levels of success. Prior research has identified two reasons why people may exaggerate their performances: motivated self-enhancement and memory distortions (e.g., Gramzow & Willard, 2006; Willard & Gramzow, 2008). Our findings fit a memory distortion explanation better than one based on motivated self-enhancement, in part because we found that memory distortions of performance mediated the relationship between the post-outcome task and learning. Although counterfactuals involving performance exaggerations might (and probably do) serve a self-enhancement role, it is not clear how this influence would translate into interference in learning.

In a repeated decision task with only two options one might expect decision makers to easily learn the recurring pattern of outcomes (i.e., A, B, A, B, . . .). Further, our participants were motivated to perform highly (and perhaps implicitly competing), as they were informed that their chance of winning a prize was tied to their performance. For such tasks recognition of the pattern is enhanced by remembering one's decisions and the outcomes of those decisions. On the other hand, if decision makers either encoded the outcomes incorrectly, or misremembered them, they would be less likely to recognise the recurring pattern. Our data suggest that counterfactuals may interfere with these processes. Some clarity in feedback was apparently lost as decision makers confused reality with its alternatives. When this occurred, learning was inhibited. This was especially the case when the memory distortion was characterised by overestimated performance, which might also decrease one's motivation to improve their strategy.

One view of our results suggests that our paradigm led participants astray, by providing them with irrelevant value-by-month data. If this were true it would not mean that the more general pattern that emerged was irrelevant (recall that participants were informed that the stocks were competitors and the sequence of trials was given meaning by increasing the year, by one, for each subsequent trial). Even if the outcomes of the stock decisions were not based on some predictable pattern, one strategy that would enhance performance in such tasks involves accurately recalling previous decisions and actual outcomes.

A major contention guiding our work is that the *spontaneous generation of counterfactuals* can impede learning. We found support for this assumption when participants were asked to list the first thought that went through their mind rather than counterfactual thoughts in particular (see Study 1 and the low counterfactual salience condition in Study 2). In addition we found that the counterfactuals generated following failure vs success feedback were especially detrimental for learning. Thus we can conclude that under particular conditions people do spontaneously generate counterfactuals while engaged in experiential learning and that this process can provide an impediment to effective learning from failure feedback.

Our results also indicate that counterfactuals are more disruptive to learning a task rule than are more general types of thought responses. This notion is supported, for example, by the fact that the proportion of counterfactuals following incorrect responses was positively associated with failure to find the solution in Study 1. We also do not conceptualise the observed learning impediment to be the result of distraction. If it was, any and all types of thoughts might be considered dysfunctional. Rather we theorise that counterfactuals can serve as distortions of the encoding and recall of decisions and their outcomes. Because counterfactual thinking typically involves focusing on reality and its alternatives (and in some cases only on the alternatives; see Markman & McMullen, 2003), it is possible for alternatives to be treated as reality. Such errors would be detrimental to learning that depends on the accurate encoding/recall of responses and outcomes.

In support of this reasoning, Study 2 provided clear evidence that one's memory for performance is important to the link between counterfactual salience and evidence of experiential learning. In our paradigm it would be difficult to categorise any of the counterfactuals that emerged as correct or incorrect causal inferences. However, it would be incorrect to assume that any and all counterfactuals would be irrelevant in terms of their semantic content. Focusing on irrelevant implications of a counterfactual would lead to poor performance in our paradigm, but counterfactuals that prescribed paying more attention to reality would be beneficial.

Given that we argue in favour of a memory distortion mechanism, our explanation for the dysfunctional effects demonstrated here have some commonalities with the content-neutral pathway described by Epstude and Roese (2008). However, the dysfunctional effect of counterfactuals on experiential learning appears to have less to do with mindsets, motivation, and self-inferences as it does with recalling and using information about what actually happened.

Prior to conducting Studies 1 and 2 we conducted a pilot test ($N = 20$) using the procedures described in Study 1, but without asking participants to list their thoughts; 80% of the participants learned the solution before 30 trials. Furthermore, each participant who finished the task early (i.e., learned the solution) was briefly probed by the experimental assistant. Each participant expressed ease in recognising the recurring pattern. Given that the likelihood of learning the solution to the stock decision task is .80 when not asked to list thoughts, roughly .50 when listing thoughts but generating very few counterfactuals, and only about .30 when listing thoughts and generating more than a few counterfactuals, generating counterfactuals can clearly have a negative impact on concept learning. However, the requirement to list thoughts does as well. Thus our data do not necessarily rule out other potential explanations for our effects. For instance, the requirement to list thoughts in our paradigm may affect other performance relevant variables such as attention and motivation in addition to working or recall memory. In any case, one possibility appears to be that the generation of counterfactuals augments the effect of the requirement to list thoughts on concept learning in tasks that employ sequential chains of stimuli.

Further research will do well to investigate the possibility that the discrepancy between the learning rates observed in the pilot test, and that of the Studies 1 and 2, implicates recall memory. Perhaps any delay, whether it involves a thought-listing task or a filler task, could impair learning because it inhibits accurate both working and recall memory. Counterfactual thinking in this context should be particularly damaging, but not because it requires more cognitive effort compared to simply listing the first thought that comes to mind. In fact, researchers (Goldinger et al., 2003; Roese et al., 2005) have reason to argue that counterfactual thinking is largely an automatic and spontaneous mental activity, especially in the case of undesirable outcomes that are easy to mentally undo. Rather, simulating alternative outcomes to reality (rather than reality itself) should cause confusion regarding the actual pattern of outcomes—the primary cue to the concept rule to be learned.

Comparisons with prior research

Clearly our results contrast with the results of earlier studies (Kray et al., 2009; Markman et al., 2008, 2006; Reichert & Slate, 2000; Roese, 1994) that showed counterfactual thinking to lead to enhanced task performance (e.g., finding solutions to anagrams). Yet there are obvious and important differences between our paradigm and those employed in other studies. For instance, our paradigm permitted participants to draw conclusions or counterfactuals about the decision situation in addition to their performance. The outcome of each trial was also made clear to participants (the outcome favoured one of two possible stocks), whereas the "correct answers" in anagram paradigms remained ambiguous. Thus the certainty of the outcomes for participants in our studies was likely to be associated with greater confidence in counterfactuals. Further, the potential benefits of counterfactuals found for anagram performance were heavily dependent on the amount of time spent finding a solution (Markman et al., 2008, 2006); performance in our stock decision task was not dependent on the amount of time expended. Also, we believe that the distinction between performance and learning is an important one. Performance in our studies served as a marker of learning, whereas the earlier anagram studies involved performance but not experiential concept learning.

Nevertheless we believe that, under certain circumstances, reflecting on the past and considering alternatives can be useful to learning. In addition to research that suggests exaggeration of one's performance can enhance future performance (Willard & Gramzow, 2009), there is evidence that additive counterfactuals do facilitate some types of learning from experience. Kray et al. (2009), for example, found evidence that the structure of counterfactuals (e.g., additive vs subtractive) influenced the type of strategy used in mixed-motive negotiations. Although learning may be inferred from shifting negotiation strategies, it does not involve learning a new concept, but rather when a particular negotiation strategy is effective. Thus, the type of learning paradigm examined by Kray et al. is qualitatively different from our concept learning paradigm.

For particular tasks, counterfactual thinking may provide certain benefits for performance (e.g., Kray et al., 2006). However, it is important to understand how and when counterfactuals can be dysfunctional for learning and performance. It is clear that increased effort and attention allocation can increase learning from experience. Our data, however, suggest that this may not be the case when increased attention is allocated towards alternative outcomes as opposed to reality. Counterfactual thinking may also lead to enhanced perceptions of competence which in turn reduces effort and attention leading to reduced levels of performance. It is important to note that whether counterfactuals impede learning because of the memory distortions they produce or because they alter feelings of efficacy, our results implicate memory distortions stemming from counterfactuals. As a cause of learning deficits, these distortions either impede learning directly or via changes in perceived confidence level.

Such false illusions of competence fit nicely with our findings of NFC moderation. That is, high NFCs would be expected to expend more cognitive effort and perform better than low NFCs. Yet, if after counterfactualising their incorrect decisions high NFCs feel overly competent in the task, they may expend less effort than they might otherwise. Thus it was not surprising to find that high NFCs, in addition to low NFCs, showed lower performance when they were exposed to counterfactual information. In fact, such findings are consistent with data that suggest that high NFCs exhibit judgements similar to those of low NFCs when they generate counterfactuals.

Overcoming impediments

Finally, it should be clear that we do not advocate a strategy by which people avoid engaging in counterfactual thinking. On the contrary, relevant evidence suggests that in many cases counterfactuals will be unavoidable (e.g., Goldinger et al., 2003) and can be beneficial (e.g., Markman et. al., 1993; Roese, 1994). However, we do suggest that people can think about counterfactuals in ways that are less likely to be dysfunctional for learning and performance. One suggestion that we offer involves a metacognitive aspect of counterfactual thinking. Petrocelli, Percy, Sherman, and Tormala (2011) theorised that *counterfactual potency* (i.e., the subjective sense that both the mutated antecedent in a counterfactual conditional statement, and the causal link implied between the antecedent and the outcome, are feasible and likely) plays a crucial role in the link between counterfactuals and variables such as regret, judgements of blame and responsibility, ascriptions of causality, and victim compensation. Their data suggest that the influence of counterfactuals could be attenuated to the extent that people feel less confident about the counterfactuals they generate. Thus considering the possibility that one's counterfactual thought might be incorrect may offset its dysfunctional potential.

Conclusion

Our data suggest that counterfactual thinking can have a dysfunctional implication for learning and performance. Counterfactual thinking was associated with inhibited experiential learning of a concept rule. The advantage of high NFC for learning the concept rule was significantly attenuated when counterfactuals were made salient. Our data also showed that counterfactuals are associated with distorted memory for decisions and better performance than was actually achieved. Further, memory for one's performance appears to be one mechanism by which counterfactuals influence learning and performance. This research is the first to demonstrate that generating spontaneous counterfactuals, while attempting to learn from experience, can interfere with learning. These findings have important applied and theoretical implications. Further research is needed to understand the conditions under which counterfactuals play both functional and dysfunctional roles.

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