Learning Inhibition in the Monty Hall Problem: The Role of Dysfunctional Counterfactual Prescriptions

Personality and Social Psychology Bulletin
37(10) 1297–1311

DOI: 10.1177/0146167211410245
http://pspb.sagepub.com
SAGE

John V. Petrocelli[1] and Anna K. Harris[1]

Abstract

Despite repeated trials, people consistently fail to learn the solution to the Monty Hall problem (MHP). This research examines the links between learning, counterfactual thinking, and memory for decision/outcome frequencies. Study 1 participants completed 60 MHP trials and listed their thoughts following losses. Results showed that participants tended to counterfactualize switch losses more than stick losses, adhered to the prescriptions of their counterfactuals more frequently following switch losses than any other decisions/outcomes, and were less likely to learn the solution as counterfactuals increased. Furthermore, memory for switch losses was significantly overestimated, and the relationship between counterfactuals and learning was mediated by misestimation of decision/outcome frequencies. In Study 2, counterfactual salience was manipulated. Learning was less likely to occur when counterfactual salience was high than when it was low, a relationship that was again mediated by memory of decision/outcome frequencies. Findings are discussed in light of their theoretical and applied implications.

Keywords

counterfactual thinking, Monty Hall problem, memory

Received March 5, 2010; revision accepted March 17, 2011

The Monty Hall problem (MHP) is a two-stage decision problem popularized by the game show *Let's Make a Deal*. In the classic version, a MHP contestant is presented with three doors, one of which conceals a prize and two of which conceal something relatively undesirable, such as a goat. Importantly, the prize and goats do not change positions once they have been assigned to a door and Monty (the host) knows which door conceals the prize. The contestant selects a door, and Monty opens a door that does *not* reveal the prize. The contestant is then faced with the decision to stick with his or her initial door or to switch to the other remaining door. Intuitively, the decision to stick or switch appears to be arbitrary as the probability of winning the prize appears to be .50 for both options. However, this assumption is mathematically incorrect, and the counterintuitive solution to the MHP is what makes it one of the most contentious of all brain teasers (see Rosenhouse, 2009).

The probability of winning a MHP trial using the *stick decision* is the same as that when the contestant first begins (i.e., .33), and the probability of winning using the *switch decision* is .67 (see Table 1). Many people fail to see the advantage of uniform switching in the MHP and resist most explanations supporting it (see Krauss & Wang, 2003). In fact, the probability of winning the prize through switching increases as a function of the number of doors (i.e., 1 – probability of selecting the winning door with the first guess). For example, if Monty presented 10 doors (one prize and nine goats), and revealed eight goats after the initial door is selected, the respective probabilities of a win with the stick and switch decisions would be .10 and .90.

Is it possible that people can learn the MHP solution from repeatedly playing the game? After repeated trials, one might expect people to learn the associations between switching and winning and sticking and losing (at least implicitly). After all, there are only three doors, two possible strategies, and two possible outcomes, and players will win twice as many trials with the switch decision as they do with the stick decision.

Use of the MHP as a learning task was first examined by Granberg and Brown (1995; also see Granberg & Dorr, 1998; Franco-Watkins, Derks, & Dougherty, 2003). Granberg and Brown's participants played 50 trials of a computer-simulated MHP. Learning was operationalized as a decision maker's

[1]Wake Forest University, Winston-Salem, NC, USA

Corresponding Author:
John V. Petrocelli, Wake Forest University, Department of Psychology, P.O. Box 7778, Winston-Salem, NC 27109
Email: petrocjv@wfu.edu

Table 1. All Possible Situations Prior to Final Decision, Outcomes, and Percentage of Occurrence When Prize Is Assigned to Door 1

Situation given								
Door 1	Door 2	Door 3	Initial selection	D(s) MH may open	MH opens D	Final decision	Outcome	%
			1	2, 3	2	Stick	Win	16.67
			1	2, 3	3	Stick	Win	16.67
			2	3	3	Stick	Lose	33.33
			3	2	2	Stick	Lose	33.33
Prize	Goat	Goat						
			1	2, 3	2	Switch	Lose	16.67
			1	2, 3	3	Switch	Lose	16.67
			2	3	3	Switch	Win	33.33
			3	2	2	Switch	Win	33.33

switch decision frequency. Switch decision frequency reached approximately 50% in the final block of 10 trials. In two variations, the incentive to switch was increased (i.e., 1 point awarded for *stick wins* and 2 points awarded for *switch wins* or 1 point for stick wins and 4 points for switch wins); nonetheless, participants switched in only 63% and 85% of the final 10 trials, respectively. Participants also tended to believe that success in the MHP was a matter of luck rather than control when no extra incentive to employ the switch decision was used and only slightly above the midpoint on a lucky control response item when the incentive was employed.

As noted above, the likelihood of a switch win increases as the number of goat-revealing doors increases. Granberg and Dorr (1998) tested whether this feature affects learning in a multiple-trial paradigm. Even after 40 trials, with five doors (four with goats) and Monty opening three goat-revealing doors (i.e., an 80% chance of winning with any switch decision), their participants switched in only 76% of their final block of 10 trials. Thus, some learning in the multiple-trial MHP paradigm may be evident under specifiable conditions (advantages). However, our own pilot study and studies conducted by Herbranson and Schroeder (2010) showed that uniform switching failed to emerge even after 100 and 200 trials. The question remains, therefore, why do people experience such difficulty learning the switch concept rule after multiple trials of the MHP?

We propose that mentally simulating alternatives to reality (i.e., counterfactual thoughts), particularly in response to switch losses, inhibits learning and increases the likelihood of decision makers irrationally committing to a losing strategy. Furthermore, we propose that a biased memory process mediates this relationship.

Counterfactual Thinking in the MHP

Granberg and Brown (1995) conducted an exploratory study to examine what people would expect to feel following a *stick loss* versus a *switch loss*. Participants reported greater expectations of anger and frustration following a switch loss than a stick loss. Granberg and Brown reasoned that counterfactual thoughts were more likely to emerge in response to switch losses than stick losses because it is easier to imagine winning if only one had not switched than it is to imagine winning if only one had switched. In the former, one might "kick oneself" because one initially had the prize within one's grasp and let it escape.

The notion that it is easier to imagine winning when losing due to a switch than a stick decision is in line with the emotional amplification effect (or *action effect*) described by Kahneman and Miller (1986), in which people tend to regret their acts of commission more than their actions forgone (*inactions* or *acts of omission*), a tendency also known as the omission bias (Ritov & Baron, 1990; for exceptions to this tendency see Gilovich & Medvec, 1994; Zeelenberg, van den Bos, van Dijk, & Pieters, 2002). Also consistent with this reasoning, Gilovich, Medvec, and Chen (1995) demonstrated that people are more motivated to reduce cognitive dissonance following a switch loss than a stick loss.

The work of Zeelenberg et al. (2002) offers two explanations as to why people are more likely to counterfactualize switch losses than stick losses. First, stronger regrets for actions than inactions in a task tend to emerge when prior, relevant outcomes were desirable or unknown, suggesting that one's general approach should not change. Second, people feel greater responsibility for undesirable outcomes when they result from changes than lack of changes in their approach because they assume that they should not change their approach, given previous desirable and unknown outcomes. In the MHP, the prior situation (i.e., the first of two stages) can be construed as an unknown outcome, given that one cannot be certain that one's initial door possesses the prize; this situation prescribes a stick decision.[1] The tendency to regret one's actions more than one's inactions is also consistent with studies that examine regrets over short-term time frames (Gilovich & Medvec, 1994).

Counterfactual Thinking, Memory, and Learning

Counterfactuals are clearly involved in the MHP. We propose that upward counterfactual thinking (i.e., simulating alternatives that are more desirable than reality; Markman, Gavanski, Sherman, & McMullen, 1993) inhibits associative learning in the MHP by creating a false association between switching and losing. That is, we suggest that Monty Hall contestants focus on an alternative strategy (i.e., sticking) following switch losses (e.g., "If only I hadn't switched.") to a greater extent than they do following stick losses. Furthermore, we contend that people are more likely to overestimate their switch losses than they are their stick losses. In other words, the thought processing that transpires once the outcome in the MHP is known may lead to associative illusions in memory. Particularly, rather than associating the switch decision with winning and the stick decision with losing, the incorrect assumption of equal win probabilities may be maintained.

Consistent with this reasoning, the research of Gilovich (1983) showed that people spend more time thinking about their losses than their wins. People also tend to explain away their losses with upward counterfactuals and tend to recall more details about their losses than their wins.[2] However, recent results reported by Petrocelli and Crysel (2009; also see Petrocelli, Seta, & Seta, 2009) suggest that counterfactualized events can be misrepresented or distorted in one's memory. Petrocelli and Crysel hypothesized that repeatedly engaging in counterfactual thinking can operate much like imagination inflation effects (Garry, Manning, Loftus, & Sherman, 1996; Goff & Roediger, 1998; for a review, see Garry & Polaschek, 2000). Typically, inflation experiments ask participants to repeatedly imagine things that did not actually occur. The more frequent the imaginative activity, the more likely people are to "recall" events taking place that were only imagined and did not actually occur.

Despite Gilovich's (1983) conclusions, we argue that if particular decisions/outcomes are repeatedly counterfactualized, one's memory, even for losses, can become distorted. Furthermore, Miller and Taylor (1995) theorized that the increased likelihood of self-recriminations in response to acts of commission (e.g., hitting while playing blackjack—taking another card) over those to acts of omission leads to greater availability of acts of commission in memory. Such enhanced availability can lead to overestimates of the frequency in which the events actually occurred.

Using dual alternative decision tasks (e.g., blackjack), Taylor (1991) showed that one's memory can lead to overestimates of undesirable outcomes for which they have highly available counterfactuals. More recently, Kruger, Wirtz, and Miller (2005) demonstrated that the often incorrect assumption that one should stick with one's first instinct on a multiple-choice exam question is maintained by a memory bias. That is, missed exam items due to switching result in greater self-recriminations and over-recall of the frequency by which incorrect responses result from switching. Subsequent avoidance of going against one's first instinct (switching) is justified by the biased memory. These findings align with our reasoning about the differences in how people process and recall their switch- and stick-decision outcomes in the MHP, as they suggest that memory will be distorted for switch losses (regrets of action) more than it will be for stick losses (regrets of inaction).

The MHP provides a unique vehicle for adding to the emerging discussion surrounding the influence of counterfactual thinking on learning. A predominant view is that counterfactuals can lead to functional outcomes (Epstude & Roese, 2008; Markman et al., 1993; Roese, 1994). For instance, Kray, Galinsky, and Markman (2009) showed that generating additive counterfactuals (i.e., adding elements, such as actions not taken; Roese & Olson, 1993) can produce an advantage in strategic interactions and negotiations over that of subtractive counterfactuals (i.e., removing elements, such as actions taken). They inferred that this tendency was due to the learning that can take place when people reflect on how they could have behaved in the past to affect their previous outcome; counterfactuals enhanced experiential learning.

However, another set of studies conducted by Petrocelli et al. (2009) suggested just the opposite; counterfactuals can inhibit experiential learning. In their paradigm, participants made decisions to buy one of two stocks across multiple trials (i.e., sequential years) after observing value-by-month graphs. As participants completed subsequent trials (i.e., year to year), the better of the two stocks simply alternated, creating a simple concept rule to be learned (i.e., A, B, A, B, A, B . . .). Interestingly, the majority of Petrocelli et al.'s participants failed to learn this rule after 30 trials. Consistent with their hypothesis, learning was less likely to occur as the frequency of counterfactualized trials increased. Furthermore, the relationship between counterfactual thinking and learning was mediated by the degree to which participants had overestimated their recent performance. Petrocelli et al. concluded that upward counterfactuals can inhibit learning in at least one of two ways. First, focusing on alternative decisions, outcomes, or both can essentially distort the feedback process. Rather than encoding and decoding reality (i.e., the actual outcomes), participants may have recalled an alternative one to the extent that they made losing decisions. For instance, if a participant lost the third trial but counterfactualized it away, he or she may have been more likely to recall the outcomes (A, B, B, B, A, B . . .) and less likely to learn the actual pattern. A second possibility also implicates memory distortions via counterfactuals: Participants who counterfactualized losing trials were more likely to overestimate their performance and were less likely to learn the more distal pattern emerging. Feeling that one is performing better than one actually is might attenuate either one's motivation or perceived need to improve one's outcomes by testing other strategies.

Given the conflicting findings, it is not entirely clear what effect counterfactuals have on learning from feedback. One might argue that the earlier findings are unique to the particular paradigms employed. Also, both paradigms contained many facets and features that might have been counterfactualized that in some cases could either enhance or impair learning. The MHP, however, is free of such potential distractions, and it is likely to provoke counterfactual thinking. Also, feedback in the MHP is straightforward, and the alternative outcome is clear, an essential feature of potent counterfactuals (Petrocelli, Percy, Sherman, & Tormala, 2011).

Our reasoning that memory is involved in learning the MHP solution is based in part on the results of the Petrocelli et al. (2009) investigation. Furthermore, De Neys and Verschueren (2006) showed that greater working memory capacity enhances one's ability to overcome the "heuristic temptations" and incorrect intuitions about the MHP solution. De Neys and Verschueren concluded that whatever mechanism might explain one's failure to learn the correct solution to the MHP, "its application will depend on the available working memory resources" (p. 129). Given that counterfactuals consume working memory resources, they may increase the likelihood that some outcomes, particularly switch losses, will be overencoded, whereas others, particularly stick losses, will be underencoded. We do not predict that these links will leave the switch decision entirely in disfavor, as some learning should take place due to its advantage over the stick decision.

Overview of Studies

The primary goal of the current investigation was to better understand why people fail to learn the MHP solution following repeated trials and to specifically examine the roles of counterfactual thinking and memory. To this end, we examined three things: (a) the conditions under which counterfactuals emerge in response to MHP outcomes, (b) the conditions under which people follow the implications/prescriptions of their counterfactuals, and (c) the extent to which a memory bias, shaped by counterfactual thinking, further inhibits learning the MHP solution.

Previous MHP studies with attention to counterfactual thinking merely inferred counterfactuals from hypothetical emotional reports and attempts at dissonance reduction (see Granberg & Brown, 1995, and Gilovich et al., 1995, respectively). In Study 1, we directly tested the conditions under which counterfactuals are likely to be generated in response to MHP trials. Earlier research has shown a tendency for people to counterfactualize actions (commissions) more frequently than inactions (omissions; e.g., Kahneman & Tversky, 1982; Landman, 1987), especially in the short term (Gilovich & Medvec, 1994). Therefore, because switching in the MHP is conceptualized as an action, we hypothesized that counterfactuals would emerge more frequently in response to switch losses than stick losses.

Although the "sting" of switch losses may be greater than that of stick losses, it will have little effect on inhibiting one's success in the MHP unless it influences learning and subsequent decisions. To this end, we first examined the degree to which people appear to follow the prescriptions of their counterfactuals. As Roese (1997) argued, counterfactuals represent causal ascriptions that may subsequently influence behavior in ways that are consistent with those ascriptions. This is partly what can make counterfactual thinking functional. However, as Granberg and Dorr (1998) suggested, strategy reversals further complicate one's goal of finding a solution to the MHP. That is, people are more likely to discover the associations between decisions and their outcomes by using uniform decision strategies. Franco-Watkins et al. (2003) tested this very notion in an experiment in which participants completed multiple trials of the MHP. The number of trials in which participants could stick or switch was manipulated by either giving them free choice in each trial or locking in the decision strategy for five consecutive trials. The constrained condition significantly improved learning relative to the free-choice condition.

To calculate the degree to which counterfactual thinking influenced subsequent decisions, we totaled the frequency of *strategy reversals*, specifically, the proportion of trials that participants made a *stick decision* following a switch loss as well as the proportion of trials that participants made a *switch decision* following a stick loss.[3] Like Gilovich et al. (1995) and Granberg and Brown (1995), we reasoned that counterfactual thoughts would be most salient and create the strongest sense of regret following switch losses (e.g., "I should have stayed . . .") than stick losses (e.g., "I should have switched . . ."). We expected strategy reversals to occur more frequently following switch losses than stick losses and more frequently following switch losses than switch wins.

Another goal of the current investigation was to test our hypothesis that false memory associations emerge over repeated trials. On the basis of earlier work (Miller & Taylor, 1995; Petrocelli & Crysel, 2009), we expected learning in our paradigm (i.e., increase in switch decisions as one progresses through trials) to be inhibited by counterfactual thinking. Furthermore, we expected this relationship to be mediated by the extent to which our participants misrecalled the actual outcomes they experienced.

In Study 1, we examined whether spontaneous counterfactual thinking was associated with inhibition of experiential learning in a multiple-trial MHP paradigm and further tested whether this relationship is mediated by the degree to which memory for what actually occurred (i.e., one's actual decisions and their outcomes) is distorted. In Study 2, we manipulated the salience of counterfactual thoughts and tested these same hypotheses in an experimental design.

Study 1

We designed a computer simulated version of the MHP and asked participants to complete 60 trials. After each loss trial, participants listed the first thought that came to mind. At the conclusion of the trials, participants estimated their win and loss frequencies with respect to their decisions (i.e., stick and switch decisions). Finally, participants reported which strategy was most effective and which strategy they would employ if they were to play additional trials of the MHP.

Method

Participants. In exchange for partial course credit, 57 undergraduates from Wake Forest University participated. Because learning is the focus of the current investigation, the data of 10 participants were excluded from the analysis based on their apparent foreknowledge of the MHP solution; these participants switched on each trial, indicating that there was nothing to learn. Thus, the final sample included 47 participants.

Procedure. Upon arrival, participants were greeted by a laboratory assistant, received a brief oral introduction to the experiment, and 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 as an examination of how people make decisions. The instructions of the study were self-paced, and participants advanced the instructions by pressing the space bar or a response key.

To ensure that participants were motivated to perform well on the task, they were informed that they would have a chance to win a $50 drawing. It was explained that their chances of winning the drawing would depend on how well they performed on the task.

Monty Hall problem. Participants were introduced to the MHP and were informed that they were to play 60 trials of a computerized version of the game show popularly known as *Let's Make a Deal*. They then read the following description:

> In this game, Monty Hall, a thoroughly honest game-show host, has placed money behind one of three doors. There is a goat behind each of the other doors. Monty will ask you to pick a door. Then he will open one of the other doors (one you did not pick). Then, Monty will ask you to make a final choice between the remaining doors, and you will win whatever is behind the door you select. Monty always knows where the money is and does not change its location once you begin a trial. Try to win as much money as possible.

Participants were then reminded about their chance to win a $50 drawing and began play.

During game play, the trial number was displayed at the top of the screen frame. For each trial, the prize-revealing door was randomized by the computer software. At the beginning of each trial, three closed doors were presented, as well as three response buttons labeled 1, 2, and 3. After participants selected their initial door, the following screen frame read, "You picked Door X. Let's see what is behind one of the doors you did not pick." Importantly, when Monty was permitted to open one of two doors (in cases whereby the money was behind the initially selected door), a randomly selected goat-concealing door was opened. The next screen frame read, "Behind Door Z, a door you did not pick, is a goat. You picked Door X. You now have the option to stay with your original door, Door X, or you may switch to the other remaining door. It's up to you. What would you like to do?" Participants made their decision by clicking one of two response buttons labeled "Stick" and "Switch." Each trial concluded with the following message: "Your final choice is Door X [Y]. The money is behind Door X [Y]. You Win [Lose] this trial."

Because we did not want participants to rely on memory cues to estimate their decision/outcome frequencies at the end of the study, the amount of money behind the money-revealing door was left ambiguous and cumulative amounts were not reported.

Thought-listing task. Following each losing trial, participants were asked to list the first thought that came to mind once they learned about the outcome of the trial. Following winning trials, participants were simply forwarded to the next trial. We made the decision to collect thoughts only after losses because our pilot data suggested that people take wins at face value and do not generate counterfactuals, as Gilovich (1983) argued.

Dependent variables. After participants played 60 trials of the MHP, we first measured memory for decision/outcome frequencies along four items using a single HTML page that displayed four fill-in-the-blank questions. Specifically, participants read the following:

> You played a total of 60 games of Let's Make a Deal. In the appropriate spaces below, enter the number of games in which you recall that you: 1) STAYED with your initial door and LOST; 2) STAYED with your initial door and WON; 3) SWITCHED to the other door and LOST; and 4) SWITCHED to the other door and WON. Make sure that the sum of your estimates is equal to 60. Click the submit button only after you have entered an estimate in each space below and the sum of your estimates is equal to 60.

Estimates were summed by the software, and on the next screen frame, participants were presented with the following message:

> The sum of your estimates equals X. If the sum of your estimates equals 60, then click the continue button below. If the sum of your estimates does not equal 60, then click the go back button below and make sure your estimates sum to 60.

All of the participants successfully complied with these instructions.

Table 2. Mean Frequencies of Decisions and Outcomes for 60 Trials of the Monty Hall Problem (Study 1 and Study 2)

				Study 2					
		Study 1		Low CS[a]		High CS[b]			
Decision	Outcome	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*
Stay	Win	13.68	4.88	11.65	5.71	13.77	5.56	2.30	.13
Stay	Lose	26.36	7.69	20.73	7.04	23.90	8.67	2.64	.12
Switch	Win	12.66	7.04	18.35	8.56	15.41	9.83	1.65	.20
Switch	Lose	7.29	4.95	9.26	4.19	6.87	3.82	5.75	.02

CS = counterfactual salience.
[a]$n = 34$.
[b]$n = 31$.

Participants then responded to two additional questions: (a) "Regarding the Let's Make a Deal game that we had you play, would you say that on any particular trial it is best to stick with your initial door or to switch to the other door in order to win?" (participants responded using an 11-point scale labeled with 1 = *it is definitely best to stick*, 6 = *it really doesn't matter*, and 11 = *it is definitely best to switch* as the anchors) and (b) "If you were to play another 60 trials of this game, what would be your strategy?" (participants responded using an 11-point scale labeled with 1 = *I would almost always stick with my initial door*, 6 = *I would stick and switch evenly*, and 11 = *I would almost always switch to the other door* as the anchors). These items were highly correlated, $r(60) = .83$, $p < .001$; thus, we computed their average as a single subjective index of learning.

On average, the entire session was completed in approximately 45 minutes. At the conclusion of each session, participants were debriefed and thanked for their time.

Results and Discussion

Actual performance. Frequencies of decisions and their outcomes are displayed in Table 2. These data were subjected to a 2 (decision: stick vs. switch) × 2 (outcome: win vs. lose) repeated measures analysis of variance (ANOVA). As expected, participants made stick decisions ($M = 40.04$, $SD = 11.25$) more frequently than switch decisions ($M = 19.96$, $SD = 11.25$), $F(1, 46) = 37.49$, $p < .001$. Also as expected, given the predominant tendency to make stick decisions, participants lost more trials ($M = 33.66$, $SD = 4.35$) than they won ($M = 26.34$, $SD = 4.35$), $F(1, 46) = 37.49$, $p < .001$.

These main effects were qualified, however, by the expected decision × outcome interaction, $F(1, 46) = 331.37$, $p < .001$. When participants made stick decisions, they lost more trials than they won, $t(46) = 18.09$, $p < .001$, but when they made switch decisions, they won more trials than they lost, $t(46) = -7.65$, $p < .001$.[4]

Counterfactual thinking. To examine our hypothesis regarding the situation in which counterfactual thoughts would be generated most frequently, we calculated the proportion of trials that participants submitted counterfactuals following switch losses and stay losses. Thought listings were coded by two raters, blind to the decisions made by participants. Coders were instructed to code responses as counterfactuals only when an antecedent was clearly mutated (e.g., "Should've stayed with my initial instinct. Would've won."). Initial agreement was 80.30%. A third coder was used to settle discrepancies in the initial ratings. The average number of counterfactuals generated by the sample was 3.68 ($SD = 2.99$).

For subsequent analyses, frequencies of counterfactuals were converted to proportions with respect to the type of decision (i.e., stick/switch). The proportion of switch losses that participants responded to with counterfactuals ($M = 0.23$, $SD = 0.28$) was significantly greater than the proportion of stick losses that they responded to with counterfactuals ($M = 0.09$, $SD = 0.09$), according to a dependent t test, $t(46) = 3.51$, $p < .01$. Thus, we obtained direct support for our hypothesis that counterfactuals would emerge most frequently in response to switch losses.

Strategy reversals: Adhering to counterfactual prescriptions. Next, we examined our hypotheses regarding the degree to which people appear to follow the prescriptions of their counterfactuals on subsequent trials, as evidenced by strategy reversals. We calculated the proportions of trials that participants made stick decisions following switch losses and switch wins as well as the proportions of trials that participants made switch decisions following stick losses and stick wins. The mean frequency of strategy reversals was 21.60 ($SD = 10.77$).

Because counterfactuals were expected to be most salient and produce the greatest negative affect following switch losses, we expected to find a greater proportion of strategy reversals following switch losses than following switch wins or stick losses. To this end, we subjected the strategy-reversal proportions to a 2 (decision: stick vs. switch) × 2 (outcome: win vs. lose) repeated measures ANOVA. From this analysis, a main effect of decision emerged, $F(1, 46) = 32.67$, $p < .001$, such that strategy reversals were followed by switch

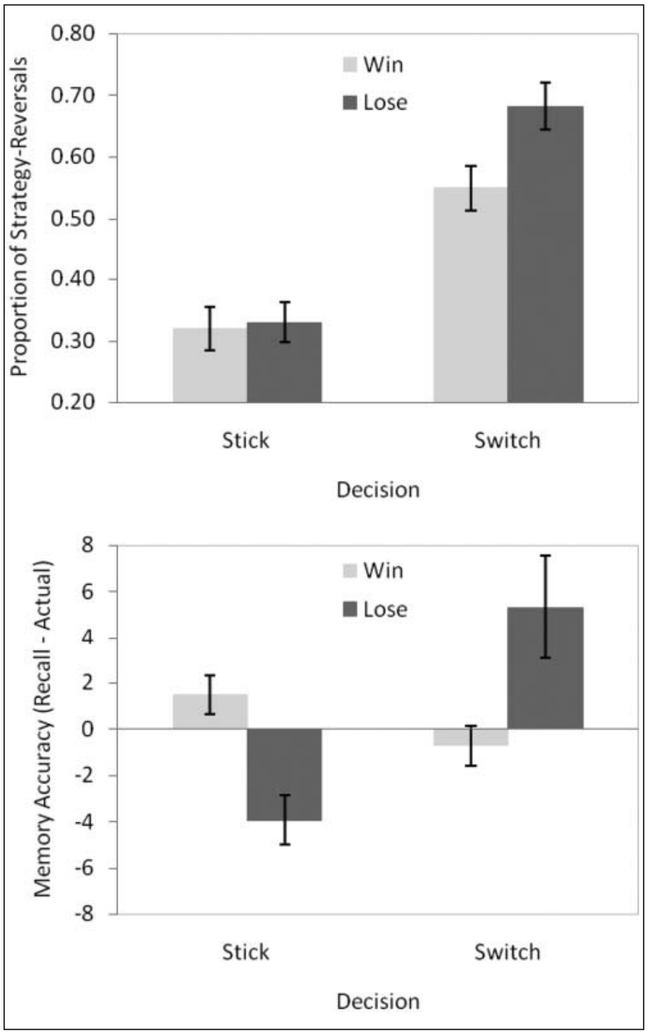

Figure 1. Mean proportion of strategy reversals following decisions and outcomes and memory accuracy (recall – actual) results by decisions and outcomes (Study 1)
Errors bars indicate one standard error above and below the means.

decisions more frequently (M = 0.62, SD = 0.20) than stick decisions (M = 0.32, SD = 0.21). A main effect also emerged for outcome $F(1, 46) = 7.84$, $p < .01$, such that strategy reversals were followed by losses more frequently (M = 0.51, SD = 0.12) than wins (M = 0.43, SD = 0.16).

However, these effects were qualified by the expected two-way interaction, $F(1, 46) = 5.69$, $p < .03$; see the top panel of Figure 1. When participants experienced a stick loss they were no more likely to switch on the next trial than when they had experienced a stick win, $t(46) = 0.26$, *ns*. However, participants were significantly more likely to stick on trials following switch losses than they were to stick on trials following switch wins, $t(46) = 3.61$, $p < .001$. Also as expected, participants were significantly more likely to stick on trials following switch losses than they were to switch on trials following stick losses, $t(46) = 9.56$, $p < .001$. Interestingly, participants were also relatively more reluctant to switch on trials following stick wins than they were to stick on trials following switch wins, $t(46) = 6.21$, $p < .001$. Thus, the bias against the switch strategy was evident in our study.

Influence of counterfactuals on strategy reversals. We were also interested in the degree to which counterfactualized decisions/outcomes led to strategy reversals compared to non-counterfactualized decisions/outcomes. To this end, we calculated the proportion of strategy reversals following stick losses and switch losses and crossed them with whether or not the decisions/outcomes had been counterfactualized. We subjected these four proportions to a 2 (decision: stick vs. switch) × 2 (counterfactual thinking: present vs. absent) repeated measures ANOVA. A main effect of counterfactual thinking emerged, $F(1, 46) = 14.16$, $p < .001$, such that strategy reversals were more likely to occur following counterfactualized losses (M = 0.39, SD = 0.27) than non-counterfactualized losses (M = 0.26, SD = 0.27). A marginal effect of decision also emerged, $F(1, 46) = 3.45$, $p < .08$, such that the strategy reversals tended to occur more frequently following switch losses (M = 0.39, SD = 0.37) than stick losses (M = 0.27, SD = 0.32).

However, these effects were qualified by the expected two-way interaction, $F(1, 46) = 4.34$, $p < .05$. When participants lost by sticking, strategy reversals were no more frequent following counterfactualized (M = 0.29, SD = 0.39) than non-counterfactualized stick losses (M = 0.24, SD = 0.29), $t(46) = 1.02$, *ns*. However, this difference was significant when participants lost by switching; that is, strategy reversals were more frequent when participants counterfactualized their switch losses (M = 0.50, SD = 0.47) than when they did not (M = 0.29, SD = 0.38), $t(46) = 3.96$, $p < .001$.

Overall, participants apparently minimized their strategy reversals to some extent. Once a strategy was adopted for a particular trial, participants tended to continue using the strategy for another trial or two before abandoning it. Yet consistent with our hypothesis concerning the negative affect associated with switch losses, counterfactual thinking appeared to have a more potent influence on subsequent decisions when losses resulted from switching than when they resulted from sticking.

Memory accuracy. Next, we examined our hypothesis that memory of decision/outcome frequencies would be biased against switching. To do so, all four of the actual decision/outcome frequencies were subtracted from the four estimated decision/outcome frequencies that we asked participants to recall. These difference scores were then subjected to a 2 (decision: stick vs. switch) × 2 (outcome: win vs. lose) repeated measures ANOVA. A single main effect for decision emerged, $F(1, 46) = 6.73$, $p < .02$, such that greater accuracy was observed for stick decisions (M = –1.23, SD = 3.16) than for switch decisions (M = 2.29, SD = 7.71).

However, this effect was qualified by the expected two-way interaction, $F(1, 46) = 16.29$, $p < .001$. Most salient in the bottom panel of Figure 1 is the degree to which our

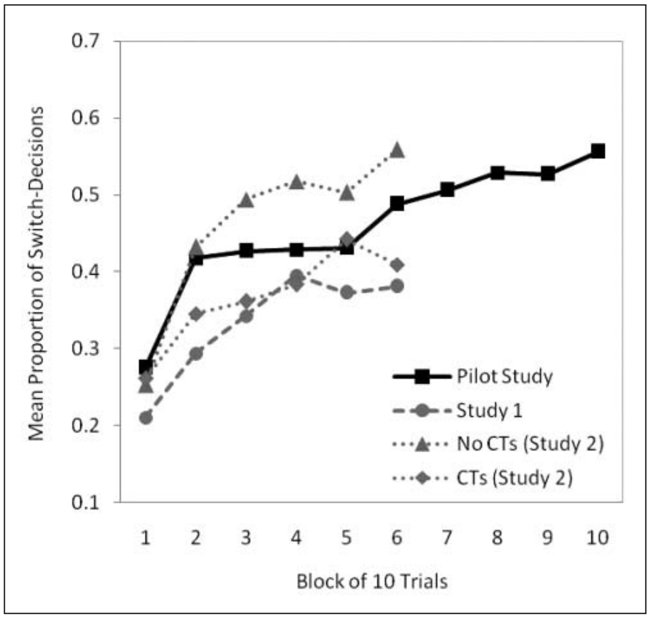

Figure 2. Mean proportion of switch decisions by block of 10 trials and condition (pilot study, Study 1, and Study 2).

participants over-recalled the success of their stick decisions and under-recalled the success of their switch decisions. Post hoc analyses showed that the interaction was driven primarily by the overestimation of switch losses, which differed significantly from both switch wins, $t(46) = 3.01$, $p < .01$, and stick losses, $t(46) = 4.61$, $p < .001$. Although the recall of stick wins differed significantly from that of stick losses, $t(46) = 2.70$, $p < .01$, it did not differ from that of switch wins, $t(46) = 1.09$, *ns*. We suspect that the extraordinarily frequent misrecall of switch losses may be due to a combination of at least two factors: (a) use of the incorrect assumption that stick and switch decisions are equally likely to lead to a win as a cue to recall and (b) counterfactual thoughts that favor sticking over switching in the future.

Learning. Next, we examined our indicators of learning, namely switch decision frequency and the subjective learning index.

Switch decision frequency. As displayed in Figure 2, our participants clearly failed to recognize the correct strategy to employ. One argument is that some learning may have taken place, as the average reluctance to switch decreased as participants proceeded through the trials. In fact, the average proportion of switch decisions increased significantly from the first block of 10 trials ($M = 0.21$, $SD = 0.22$) to the last block of 10 trials ($M = 0.38$, $SD = 0.26$), $F(1, 46) = 20.48$, $p < .001$. However, this result still does not dismiss the fact that participants generally failed to learn that the switch decision is twice as successful as the stick decision after 60 trials.[5]

Subjective estimate of learning index. The two subjective estimates of learning were averaged for each participant. This index also indicated a failure of our sample to learn that the switch decision was optimal as responses were below the midpoint of the index ($M = 5.56$, $SD = 2.57$), although not significantly below according to a one-sample *t* test, $t(46) = -1.16$, $p = .25$.

Mediation analyses. Of primary interest was the test of our prediction that the link between one's tendency to engage in counterfactuals in response to commission losses (i.e., switch losses) and learning the MHP solution is due to a memory distortion biased against the switch decision. We employed meditational analysis (Baron & Kenny, 1986) to test this possibility.

Because we expected and found counterfactual thinking to emerge more frequently in response to switch losses than stick losses, we expected each participant's tendency to do so to be a potent predictor of his or her memory bias against the switch decision. For each participant, we subtracted his or her proportion of counterfactualized stick losses from his or her proportion of counterfactualized switch losses (i.e., using *z* scores), such that greater scores indicated a greater ratio of counterfactualized switch losses to counterfactualized stick losses. This variable served as our initial predictor. Then, for each participant, we subtracted his or her misrecalled stick losses from his or her misrecalled switch losses (i.e., using *z* scores) as our mediator because this memory variable best reflects the memory bias against the switch decision (greater scores indicating more bias against switching).

Consistent with our expectations, as the proportion of counterfactualized switch losses increased over that of counterfactualized stick losses, the subjective learning index decreased significantly, $\beta = -.35$, $t(45) = -2.48$, $p < .02$. The proportion of counterfactualized switch losses over that of counterfactualized stick losses was also a significant predictor of the proposed memory mediator, $\beta = .34$, $t(45) = 2.45$, $p < .02$, suggesting that the more frequently participants counterfactualized their switch losses over their stick losses the more their memory became biased against switching. When the subjective estimate of learning index was regressed onto both of the predictor variables simultaneously, the tendency to counterfactualize switch losses over stick losses was no longer significant, $\beta = -.13$, $t(44) = -1.14$, $p = .26$, but the memory bias was, $\beta = -.62$, $t(44) = -5.25$, $p < .001$, explaining 46% of the variance, $F(2, 44) = 18.68$, $p < .001$. Furthermore, a modified Sobel test indicated that the reduction in the effect of one's tendency to counterfactualize switch losses over stick losses on learning was significant when the memory bias was included in the model, $z = -2.21$, $p < .05$.

Thus, we found learning the MHP solution to be inhibited by the degree to which our participants counterfactualized their switch losses relative to their stick losses. Furthermore, this relationship appears to be mediated by a memory distortion that emerges against the strategy that leads to the lowest frequency of losses relative to the strategy that leads to the greatest frequency of losses.

We reasoned that if counterfactual thinking is the starting point for biased memory, it should be possible to manipulate the salience of counterfactual thinking and observe corresponding inhibition of learning when salience is high compared to when it is low. We investigated this possibility in Study 2.

Study 2

In Study 2 we tested similar hypotheses as those drawn for Study 1 and again used a multiple-trial MHP paradigm. We directly manipulated the salience of counterfactual alternatives by spoon-feeding half of our participants with counterfactual statements (i.e., high counterfactual salience). In this manner, we further examined the condition whereby our research has found counterfactual thinking to be most prevalent (following switch losses). The other half of our sample was not spoon-fed counterfactuals (i.e., low counterfactual salience). Consistent with our reasoning in Study 1, we expected strategy reversals to occur most frequently following switch losses. However, we also expected this tendency and the memory bias against the switch strategy to be augmented by our counterfactual salience manipulation, such that strategy reversals following switch losses and the memory bias against switching would be especially likely for participants who were spoon-fed counterfactuals after switch losses.

We also hypothesized that subjective evidence of learning would again be inhibited, but more so for participants assigned to the high than the low counterfactual salience condition. We again tested the possibility that memory distortions mediate the relationship expected between counterfactual thinking and learning inhibition.

Method

Participants. In exchange for partial course credit, 80 undergraduates from Wake Forest University participated. Again, the data of some participants (15) were excluded from the analysis on the basis of already knowing the solution to the problem. Thus, the final sample included 65 participants.

Procedure. The procedures were similar to those of Study 1 with two important exceptions. First, participants were led to believe that the computers in the lab were networked and that all participants were randomly assigned to be either decision makers or observers (although all were assigned to be decision makers). It was explained that the alleged observers (i.e., one of other participants in the same experimental session) would observe the decisions of a decision maker on their monitors and would type their comments *only after losses* by the decision maker. It was further explained that observer comments would be displayed on the decision maker's monitor. We implemented a brief delay after each decision to boost the feasibility of the alleged observer's role in the experiment. During these delays, the words "Waiting for observer's feedback" were displayed at the top of the screen frame.

The actual random assignment involved the types of comments typed by the alleged observer. Participants assigned to the *low counterfactual salience* condition were exposed to non-counterfactual comments after each trial (e.g., "Well, you can't win them all."). Participants assigned to the *high counterfactual salience* condition were exposed to similar non-counterfactual statements following each of their stick losses. Following switch losses, these participants were exposed to counterfactuals allegedly typed by the observer (e.g., "If only you had stayed with Door 2, you would've won."). Different comments (120) were preprogrammed for each condition and displayed only after losses.

Results and Discussion

Actual performance. Decision/outcome frequencies are displayed in Table 2. These frequencies were subjected to a 2 (decision: stick vs. switch) × 2 (outcome: win vs. lose) × 2 (counterfactual salience: high vs. low) mixed ANOVA. As expected, participants made more stick decisions ($M = 34.91$, $SD = 12.66$) than switch decisions ($M = 25.08$, $SD = 12.65$), $F(1, 63) = 10.59$, $p < .01$.

However, this main effect was qualified by the expected decision × outcome interaction, $F(1, 63) = 393.09$, $p < .001$. When participants made stick decisions, they lost ($M = 22.25$, $SD = 7.96$) more trials than they won ($M = 12.66$, $SD = 5.70$), $t(63) = 14.60$, $p < .001$, but when they made switch decisions, they won ($M = 16.95$, $SD = 9.24$) more trials than they lost ($M = 8.12$, $SD = 4.17$), $t(63) = -13.45$, $p < .001$. No other effects emerged as significant (all Fs < 1.00).

Strategy reversals: Adhering to counterfactual prescriptions. As in Study 1, we calculated the proportions of trials in which our participants changed to a switch or stick decision strategy after winning and losing trials and subjected these totals to a 2 (decision: stick vs. switch) × 2 (outcome: win vs. lose) × 2 (counterfactual salience: high vs. low) mixed ANOVA (see Figure 3). This analysis revealed a main effect of decision, $F(1, 63) = 7.60$, $p < .01$, such that switch decisions were followed by strategy reversals more frequently ($M = 0.51$, $SD = 0.28$) than stick decisions ($M = 0.37$, $SD = 0.25$).

However, this effect was qualified by a decision × outcome interaction, $F(1, 63) = 3.80$, $p < .05$. The pattern of these data was very similar to that found in Study 1. Participants were no more likely to reverse strategy following stick losses than they were following stick wins, $t(63) = 0.59$, *ns*. However, as expected, participants were significantly more likely to stick on trials following switch losses than they were to stick on trials following switch wins, $t(63) = 2.17$, $p < .05$. Also, as expected, participants were significantly more likely to reverse strategy following switch losses than they were following stick losses, $t(63) = 5.85$, $p < .001$. This interaction was not qualified by the three-way interaction ($F < 1.00$).

Thus, we failed to detect evidence for the possibility that counterfactual salience augments the decision × outcome interaction with our strategy-reversal data. However, it is important to note that there was nothing in our experimental

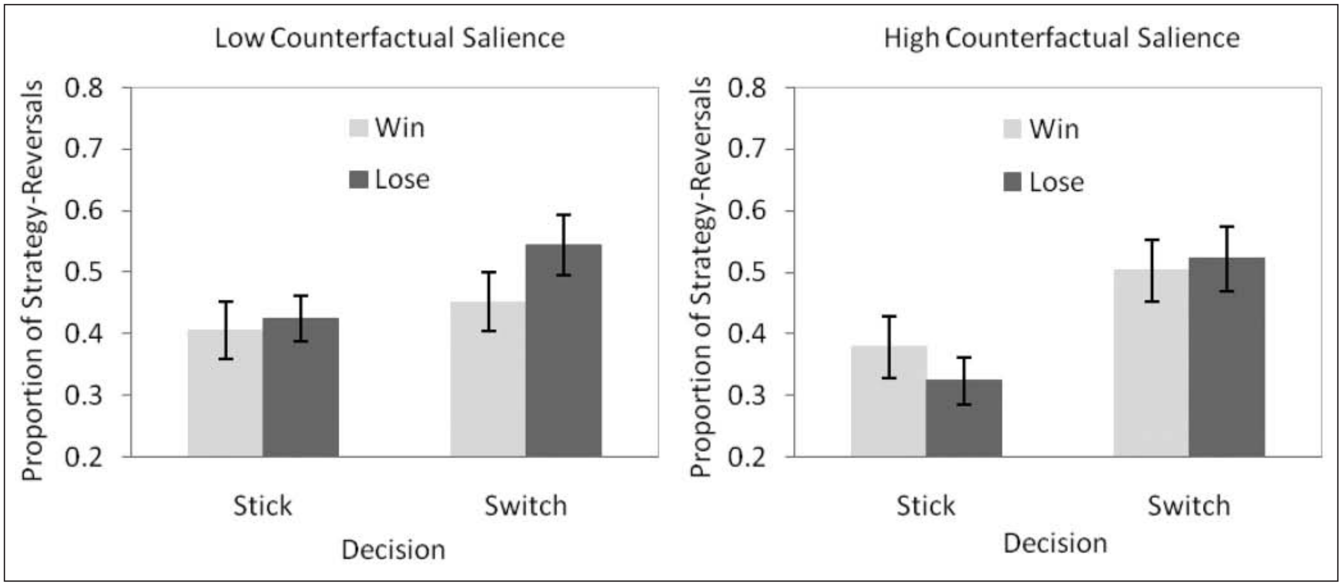

Figure 3. Mean proportion of strategy reversals following decisions and outcomes by counterfactual salience condition (Study 2)
Errors bars indicate one standard error above and below the means.

paradigm that would have prevented participants in the low salience condition from generating their own counterfactual thoughts. Given that we observed counterfactual thinking to emerge in an open-ended thought-listing format (Study 1), we suspect that many of our low counterfactual salience condition participants did generate counterfactuals in response to switch losses. If so, they also appeared to follow the prescriptions of these thoughts as much as our high counterfactual salience condition participants.

Memory accuracy. Next, we subjected the decision/outcome memory accuracy data to the same mixed ANOVA as that used for the strategy-reversal data (see Figure 4). This analysis revealed a main effect for decision, $F(1, 63) = 7.29$, $p < .01$, such that switch decisions were overestimated ($M = 1.26$, $SD = 6.51$) more than stick decisions ($M = –1.10$, $SD = 6.25$). This effect was qualified by a decision × outcome interaction, $F(1, 63) = 44.85$, $p < .001$. Post hoc analyses showed that the interaction was driven primarily by the overestimation of switch losses ($M = 4.28$, $SD = 5.77$), which differed significantly from both switch wins ($M = –1.75$, $SD = 5.81$), $t(63) = 5.32$, $p < .001$, and stick losses ($M = –3.38$, $SD = 6.00$), $t(63) = 6.76$, $p < .001$.

This interaction was further qualified, however, by the expected decision × outcome × counterfactual salience interaction, $F(1, 63) = 3.75$, $p < .05$. As displayed in Figure 4, the pattern of the decision × outcome data was similar to that found in Study 1 in both the low and high counterfactual salience conditions. However, the three-way interaction was driven by the fact that the decision × outcome interaction was stronger in the high counterfactual salience condition, $t(63) = 8.64$, $p < .001$, than in the low counterfactual salience condition, $t(63) = 2.60$, $p < .05$.

Learning: Switch decision frequency. As displayed in Figure 2, participants in both counterfactual salience conditions failed to learn the MHP solution. However, we hypothesized that learning was less likely to occur for participants assigned to the high than the low counterfactual salience condition, and thus we should observe a greater increase in the frequency of switch decisions among the low than the high salience condition as participants progressed through the task. To test this hypothesis, we conducted a 2 (counterfactual salience: high vs. low) × 2 (trial set: first 10 vs. last 10) mixed ANOVA for the switch decision frequency data. A main effect of trial set was observed, $F(1, 63) = 37.53$, $p < .001$, such that switch decisions were more frequent across the final 10 trials ($M = 4.88$, $SD = 2.90$) than the first 10 trials ($M = 2.57$, $SD = 1.78$).

However, this effect was qualified by the expected counterfactual salience × trial set interaction, $F(1, 63) = 4.51$, $p < .05$. Among the first set of 10 trials, the frequency of switch decisions did not differ between the high ($M = 2.61$, $SD = 1.74$) and low counterfactual salience conditions ($M = 2.53$, $SD = 1.83$), $t(63) = 0.16$, *ns*. However, among the final set of 10 trials, switch decisions were more frequent among the low ($M = 5.59$, $SD = 3.07$) than high counterfactual salience condition ($M = 4.10$, $SD = 2.53$), $t(63) = –2.84$, $p < .01$. These results suggest that counterfactual salience inhibited learning of the MHP solution.

Subjective estimate of learning index. The two subjective estimates of learning were highly correlated, $r(63) = .67$, $p < .001$, and therefore averaged for each participant. As expected, the low counterfactual salience condition showed significantly greater evidence of learning ($M = 6.90$, $SD = 2.22$) than did the high counterfactual salience condition ($M = 5.72$, $SD = 2.03$), $F(1, 63) = 4.88$, $p < .05$.

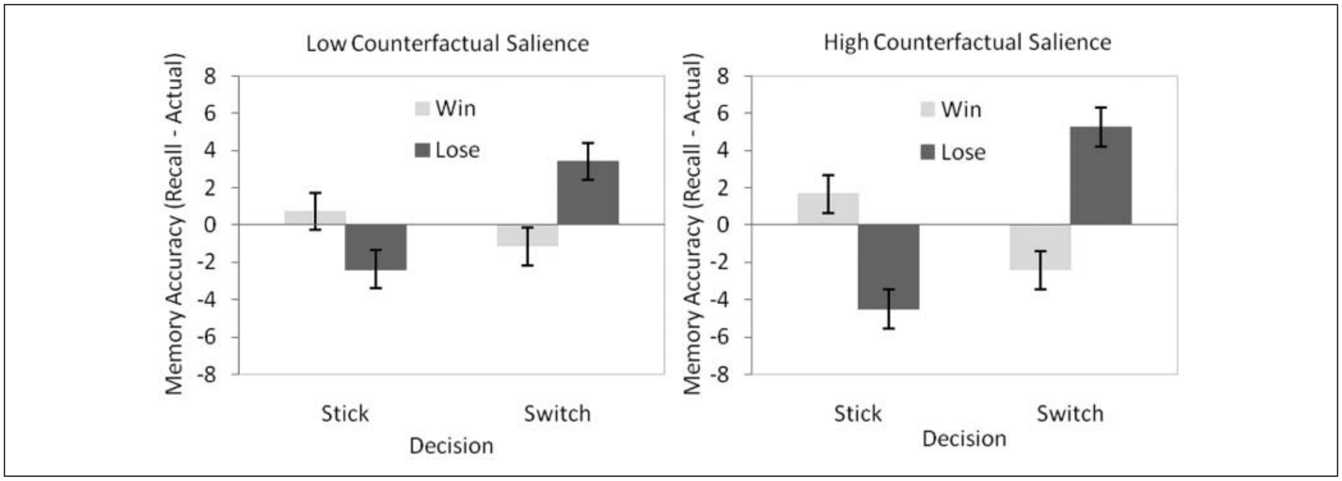

Figure 4. Mean memory accuracy (recall – actual) results by decision, outcome, and counterfactual salience condition (Study 2)
Errors bars indicate one standard error above and below the means.

Mediation analyses. Finally, we tested our hypothesis that the counterfactual-learning inhibition link is mediated by a memory distortion biased against the switch decision. However, this time, the counterfactual salience condition served as our initial predictor. As in Study 1, we calculated the discrepancy between misrecalled switch losses and misrecalled stick losses (i.e., using *z* scores) and tested this variable as our mediator.

As noted above, greater evidence of learning on the subjective estimates of learning index was associated with the high counterfactual salience condition, $\beta = -.27$, $t(63) = -2.21$, $p < .05$. Counterfactual salience condition was also a significant predictor of the proposed memory mediator, $\beta = .30$, $t(63) = 2.53$, $p < .02$, such that the memory bias against switching increased with more counterfactual salience. When the subjective estimate of learning index was regressed onto both of the predictor variables simultaneously, counterfactual salience was no longer significant, $\beta = -.15$, $t(62) = -1.29$, $p = .20$, but the memory bias was, $\beta = -.38$, $t(62) = -3.21$, $p < .01$, explaining 20% of the variance, $F(2, 62) = 7.97$, $p < .01$. Furthermore, a modified Sobel test indicated that the reduction in the effect of counterfactual salience on learning was significant when the memory bias was included in the model, $z = -1.98$, $p < .05$.

Thus, we again found learning the MHP solution to be inhibited by the degree to which our participants were exposed to counterfactual thoughts following their switch losses. Furthermore, this relationship appears to be caused by a memory distortion that emerges against the switch strategy despite the fact that it leads to the lowest frequency of losses.

General Discussion

Consistent with earlier findings (e.g., Granberg & Brown, 1995; Granberg & Dorr, 1998), our results indicate that people are somewhat reluctant to switch their doors in the MHP. Although the odds of winning via the stick decision are stacked against the MHP contestant, he or she persists in using it.

Because every loss is almost a win, the MHP is ideal for eliciting counterfactual thoughts. Although counterfactuals clearly complicate learning in the MHP, one might argue that the dysfunction is not found only in the generation of counterfactuals, but in the haste to follow their prescriptions in the future. This tendency provides some insight as to why people persist in gambling with their money. There too the odds of winning are usually stacked against the player. However, when it is easy to imagine winning and distort one's memory of losing, people are enticed to persist in their gambling. Casino owners seem to know this fully well; in many of their games, every loss is nearly a win.

Yet the critical bias that prevents one from learning the MHP solution appears to rest with how people react cognitively to losses tied to their acts of commission versus those of omission. In the MHP, losses resulting from acts of commission appear to be explained away with counterfactuals that prescribe dysfunctional decisions for the future. These tendencies also appear to produce a distorted memory of decision/outcome frequencies, further rendering dysfunctional decisions for future trials. Losses resulting from acts of omission (i.e., sticking) appear to be explained away, but not with counterfactuals that would otherwise prescribe functional decisions for future trials.

Theoretical Implications

Previous MHP studies have supported numerous mechanisms underlying the resistance to the switch decision as the optimal strategy. These mechanisms have typically been described as involving some form of failure to mentally represent the problem properly (Burns & Wieth, 2004; Johnson-Laird, Legrenzi, Girotto, Legrenzi, & Caverni, 1999; Krauss & Wang, 2003). Although these contributions implicate cognitive mechanisms operating in one's approach to the MHP, our analysis implicates a cognitive mechanism that results from completing several trials.

Our view is in line with the conclusions of De Neys and Verschueren (2006), to the extent that their theoretical position also implicated memory. These researchers argued that failure to recognize the optimal strategy could be explained by a dual-processing model. Specifically, the default heuristic used to approach the problem competes with more deliberate and logical processing. Inhibition of the heuristic process and activation of the systematic process require working memory resources—thus, the greater the working memory resources, the greater the likelihood of recognizing the correct solution. Although their results supported this reasoning, our results implicated memory in another way. Specifically, counterfactual thinking acts as an antecedent to dysfunctional behavior and memory distortions, which ultimately have negative consequences for learning.

Our evidence that counterfactual thinking appears to inhibit learning in the MHP is also consistent with findings from a study conducted by Franco-Watkins et al. (2003). In their study, participants were required to observe a hypothetical individual play a fictitious card game based on the MHP. Participants then completed a MHP word problem that probed learning. The experimenters manipulated the decisions and outcomes of the individual. Approximately 45% of the participants who observed the individual lose 90% of the time via stick decisions decided to switch when responding to the word problem. Yet when the individual lost 90% of the time via switch decisions, approximately 85% of their participants decided to stick when responding to the word problem. These results also suggest that people are more likely to follow the prescriptions of the default counterfactual in response to a switch loss (simulation of a win via a stick decision) than those that might emerge in response to a stick loss (simulation of a win via a switch decision). Our data suggest that counterfactuals that undo switch decisions are potent enough to affect subsequent decisions as well as distort one's memory for what actually occurred.

Counterfactual Dysfunction

Given that our data suggest that counterfactual thinking can serve as a detriment to learning, memory, and functional decision making, they run counter to the conclusions of other researchers who have endorsed the functional view of counterfactual thinking (Epstude & Roese, 2008; Kray et al., 2009; Markman et al., 1993; Markman & McMullen, 2003; Roese, 1997). On the other hand, it is important to note that we do not make the argument that counterfactuals are uniformly dysfunctional. In fact, the default MHP counterfactuals that emerge are entirely functional and in some cases would be expected to enhance the likelihood of adopting a more advantageous uniform switch decision strategy (an advantage to learning). In particular, the default counterfactual in response to a stick loss (i.e., mentally simulating a win via a switch decision) is entirely correct (i.e., a win surely would have occurred via a switch decision), just as the default counterfactual in response to a switch loss (i.e., mentally simulating a win via a stick decision) is entirely correct (i.e., a win surely would have occurred via a stick decision). However, the former counterfactual prescribes the correct strategy for approaching subsequent trials, whereas the latter does not.

We agree with Kray et al.'s (2009) assertion that reflecting on the past is a critical ingredient for successful learning. However, we contend that when people reflect on the recent past they should focus more on reality than its alternatives. As we have demonstrated here, repeatedly reflecting on what could have been can have unwanted effects.

Our results may generalize to decisions that involve making an initial selection, becoming privy to additional information, and then making a final decision. However, they do not characterize all situations in which people learn from experience. Of course, there are situations in which counterfactual thinking enhances learning (see, e.g., Kray et al., 2009). Determining whether counterfactual thinking will have a functional or dysfunctional effect appears to hinge partly on the types of behaviors naturally prescribed by one's counterfactuals and the extent to which those prescriptions are functional in the given system.

However, memory distortions (e.g., misrepresentations of prior probabilities) would be a dysfunctional outcome of counterfactual thinking to the extent that memory influences future decisions—a strong relationship in the current paradigm. The potential functionality of counterfactual thinking can be likened to that of an offensive football play. Typically, there is a significantly greater number of ways that an offensive football play can fail than there are ways to successfully execute it. The functionality of a counterfactual appears to rest on at least six criteria: (a) generation of a counterfactual that implies the correct casual antecedent; (b) accurate memory for actual occurrences, such that dysfunctional decisions are not prescribed; (c) ability to change behavior in the direction of the counterfactual's prescriptions; (d) motivation to follow the prescriptions; (e) a similar situation in the future; and (f) either successfully making the necessary behavioral change before the similar situation is encountered again or activating the counterfactual prescriptions and adhering to them at the critical moment.

Our studies suggest that counterfactual thinking is linked to two potential dysfunctional effects within the MHP: (a) enhancing the development of a dysfunctional response bias and (b) distorting memory for actual occurrences. We suspect that, like the offensive football play, there are several additional routes to a dysfunctional influence of counterfactual thinking on learning and performance. For instance, the memory distortions associated with counterfactual thinking may signal a sense of overconfidence and unfounded competence (see Petrocelli & Crysel, 2009; Petrocelli et al., 2009). Subsequently, people may fail to accurately anticipate future performance (also see examples described by Sherman & McConnell, 1995).

Applied Implications

We contend that the dysfunctional decision making observed with the MHP reaches well beyond the game show, casinos, and the current investigation. In fact, people make several real-life decisions that generally follow the same two-stage decision pattern of the MHP. In many situations, people make a tentative but revocable decision, become privy to additional information, and then make a final decision. In some situations, a clearly optimal decision strategy is abandoned for a suboptimal one. For instance, in medicine, decision makers are to adhere to available clinical practice guidelines (CPGs) in treating their patients. Despite the fact that actuarial decision making is usually more efficient than "clinical" decision making (Swets, Dawes, & Monahan, 2000), there is clearly much resistance to CPGs (Farr, 2000; Mottur-Pilson, Snow, & Bartlett, 2001; Rello et al., 2002; Tunis et al., 1994).

Conclusion

Our results from two MHP studies suggest that counterfactual thinking occurs most frequently in response to switch losses, that people adhere to the prescriptions of their counterfactuals most frequently in such cases, and that they are less likely to learn the solution as counterfactuals increase. Furthermore, a memory bias against switching appears to be a viable culprit. Memory for previous MHP trials tends to be biased in such a way that further prevents people from learning the actual associations between switch decisions and winning and stick decisions and losing.

Of course, strategies such as sticking and switching equally or probability matching (i.e., making switch decisions in 67% of one's trials and stick decisions in 33% of one's trials) will lead to some success (i.e., most likely win percentages of 50% and 55.78%, respectively). However, they will not lead to as much success as would be the case if people successfully learned something functional from their experience. Fortunately, people can learn through other means (e.g., thought experiments, a persistent persuader) that a uniform switch-decision strategy is best when it comes to the MHP (see Table 1 or see Krauss & Wang, 2003). If only learning life's lessons were so simple.

Acknowledgments

The authors thank Wayne Pratt, William Gordon, Alan Gittis, John Statzer, Paul Hutman, Matthew Facciani, Catherine Seta, and John Seta for their feedback on earlier versions of this work.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Notes

1. The probability that a Monty Hall problem (MHP) contestant possesses the prize-revealing door at this stage is actually 33%, which prescribes a switch decision. Most people would seem to agree that one would surely make a switch decision given the choice between sticking with their initial selection and switching to the other two doors—an essential reframe of the MHP (Stibel, Dror, & Ben-Zeev, 2009).
2. It is worth noting that Gilovich (1983) asked his participants, after recalling the games in which they had placed a bet, to recall which team they bet on, the score, and key plays, but not how many bets they won or lost. Gilovich's data clearly suggest that people remember more information about their losses than their wins, but they do not indicate how many bets his participants thought they won or lost. Also, the success rate of the 13 participants was not reported, and it is possible that they lost more than 50% of their bets. If so, it would seem that they recalled more about their losses than their wins as a function of the content to be recalled.
3. Interestingly, such illusions appear to be related to the phenomena of lane switching on the highway (James & Nahl, 2000) and line switching at the grocery store checkout (Maister, 1985), in which people often feel a sense that whichever lane or line they switch to, the other one seems to move faster.
4. Actual performance (i.e., win %) was included as a covariate in many of our subsequent analyses. However, in no case did we find it to affect our results. We suspect that this was due to the fact that performance was heavily dependent on switch decision frequency and the fact that we omitted from our analyses participants who switched uniformly. Thus, we do not focus on this variable in subsequent analyses and report results computed without it.
5. This was also true in our pilot study that used 100 trials (see Figure 2) as well as studies conducted by Herbranson and Schroeder (2010). It is worth noting that the average proportion of switch decisions that we observed in the first 10 trials appears to be less than that of others who have implemented a multiple-trial paradigm. However, it is important to recall that we excluded data from participants who already knew the solution, ultimately reducing the overall mean.

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