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BRIEF REPORT

Episodic details are better remembered in plausible relative to implausible counterfactual simulations

Ricardo Morales-Torres[1,2] · Kaylee Miceli[1,3] · Shenyang Huang[1,2] · Karl Szpunar[4] · Felipe De Brigard[1,2,3]

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Abstract

People often engage in episodic counterfactual thinking, or mentally simulating how the experienced past might have been different from how it was. A commonly held view is that mentally simulating alternative event outcomes aids in managing future uncertainty and improving behavior, for which episodic counterfactual simulations need to be remembered. Yet the phenomenological factors influencing the memorability of counterfactual simulations remain unclear. To investigate this, we conducted two experiments using a paradigm where participants recalled autobiographical memories. After 1 week, they created counterfactual mental simulations of these memories, integrating a new object into each one and rating them on various phenomenological characteristics. Memory for these counterfactual mental simulations was tested the next day by recalling the new object. Across the two experiments we found that objects included in more plausible counterfactual simulations were better remembered compared with implausible counterfactual simulations. Our findings suggest that generating episodic counterfactual simulations perceived as plausible enhances their memorability, similar to other memory phenomena in which schematic knowledge improves subsequent episodic memory.

Keywords Episodic counterfactual thinking · Mental simulation · Episodic memory · Plausibility

Introduction

The capacity to engage in hypothetical thinking about possible personal events is common and ubiquitous. People think not only about ways in which their personal life may unfold in the future (episodic future thinking; Szpunar, 2010) but also how past personal events could have occurred differently than they did (episodic counterfactual thinking; De Brigard & Parikh, 2019). A wealth of evidence suggests that people typically engage in these kinds of episodic hypothetical simulations in order to rehearse possibilities that could help them to hedge future uncertainty (Roese & Epstude, 2017; Schacter et al., 2015). For example, upon dropping her ice cream cone, a person may not only imagine how she could have held it more tightly to avoid dropping it (i.e., counterfactual thinking) but also how she may hold the cone more securely the next time she gets ice cream (i.e., future thinking).

However, the extent to which an episodic hypothetical thought—whether future or counterfactual—could be useful at a later time, depends on the capacity to remember the contents of a relevant simulation at the right moment (Ingvar, 1985). As such, understanding how well people remember the content of episodic hypothetical simulations is key to understanding how these kinds of thoughts can help to guide behavior. Recently, a number of studies have started to tackle this issue by exploring how well people remember episodic future simulations. For instance, Szpunar and colleagues (2012) showed that positive episodic future thoughts are better remembered than neutral or negative ones, while Devitt and Schacter (2018, 2020) found that memory for

Ricardo Morales-Torres and Kaylee Miceli both authors contributed equally.

✉ Felipe De Brigard
felipe.debrigard@duke.edu

1 Center for Cognitive Neuroscience, Levine Science Research Center, Duke University, 308 Research Drive, Room C03E, Durham, NC 27708, USA

2 Department of Psychology and Neuroscience, Duke University, Durham, NC, USA

3 Department of Philosophy, Duke University, Durham, NC, USA

4 Department of Psychology, Toronto Metropolitan University, Toronto, ON, Canada

positive as compared with negative details about past event simulation is characterized by a more liberal response criterion. Such results suggest that emotional valence may play a role in the memorability of episodic hypothetical thinking. Nonetheless, McLelland and colleagues (2015) reported that memory for simulations is more strongly tied to the perceived plausibility that a simulated event may occur rather than the emotionality tied to any of its component features.

Unfortunately, when it comes to the capacity to remember the contents of episodic counterfactual simulations, much less is known (De Brigard et al., 2020). Moreover, although previous research has shown that despite strong commonalities between episodic future and counterfactual thinking, both also differ in important ways (De Brigard & Parikh, 2019). For one, while episodic counterfactual thinking involves the mental simulation of a possible past event that one knows did *not* occur, episodic future thinking involves the mental simulation of a possible event that may or may not occur regardless of what already happened. Moreover, experimental evidence suggests affective differences between these two kinds of episodic simulations, as episodic counterfactual thoughts seem to be experienced with less emotional intensity than episodic future thoughts (De Brigard & Giovanello, 2012). Differences in perceived plausibility have also been found, as studies have shown that while repeatedly simulating an episodic counterfactual thought decreases its perceived plausibility (De Brigard et al., 2013), the repeated simulation of an episodic future thought does the opposite and increases its perceived plausibility (Szpunar & Schacter, 2013). Nevertheless, the extent to which either valence or plausibility influence the capacity to remember the contents of episodic counterfactual thoughts remains unknown.

The current studies sought to explore this issue. To investigate which phenomenological aspects make the content of episodic counterfactual thoughts more likely to be remembered, we conducted two behavioral experiments in which participants were asked to generate several autobiographically based episodic counterfactual thoughts. After a delay of 1 day, participants were asked to remember a specific detail of the content of the simulated counterfactual thought. To anticipate, we found that plausibility was associated with the successful retrieval of this episodic detail.

Experiment 1

Method

Participants

Sample size was determined based on a prior study (see Supplemental Information, Sect. 1, for a full description of the study). Thirty-five participants from Duke University and the broader Durham community were initially recruited for the study. In our preregistration (https://osf.io/z8wrm), we specified that we would exclude subjects whose average memory performance deviated by more than 3 standard deviations from the mean, but we also excluded data from three individuals whose average memory performance, although not exceeding the 3 standard deviations, was exceptionally low (0%, 0%, and 3%). Their performance raised doubts about their task engagement. Additionally, we excluded data from one participant who demonstrated a memory performance of 100%. This exclusion aligned with the experiment's objective to compare plausibility between remembered and forgotten counterfactuals. No other subjects were excluded. Consequently, the final sample comprised 31 participants (17 women; $M_{\text{age}} = 24$ years, $SD = 3.9$). It is important to note that we ended up with one additional participant beyond what was specified in the preregistration ($N = 30$), as extra participants were scheduled in the event some did not provide usable data. All participants were fluent in English and had no preexisting neurological disorders. The study was approved by the Duke University Campus IRB.

Procedure

This study consisted of three sessions (Fig. 1A). During the first session, participants were asked to generate and describe 66 unique autobiographical events that took place within the past 10 years (see Supplemental Information, Sect. 2, for an evaluation of the similarity between memories). For each autobiographical event, participants wrote a short description of the event and provided a short title. The purpose of this title was to serve as a cue to help participants remember the event during Session 2. Additionally, participants wrote the time of the event (year and month), the location where the event took place, a person involved in the event (other than themselves), and one object that was present during the event. Participants were then asked to rate the valence (1: *Highly Negative* to 5: *Highly Positive*), vividness (1: *Vague with no/few details* to 5: *Vivid and Highly Detailed*) and the perspective (first or third person) of each memory.

One week later, participants completed Session 2, which consisted of an episodic counterfactual generation session. During this session, participants were asked to generate an episodic counterfactual for 60 of the 66 events described in Session 1 (three memories served as practice trials; the remaining three were not used). For each event, participants were asked to engage in one of three types of counterfactual *emotional mutations*: upward, neutral, or downward. In total, 20 events were assigned to each type of counterfactual simulation. For each simulation, participants were cued with the title, person, location, and object of one of the memories that they provided during Session 1. The heading of the screen

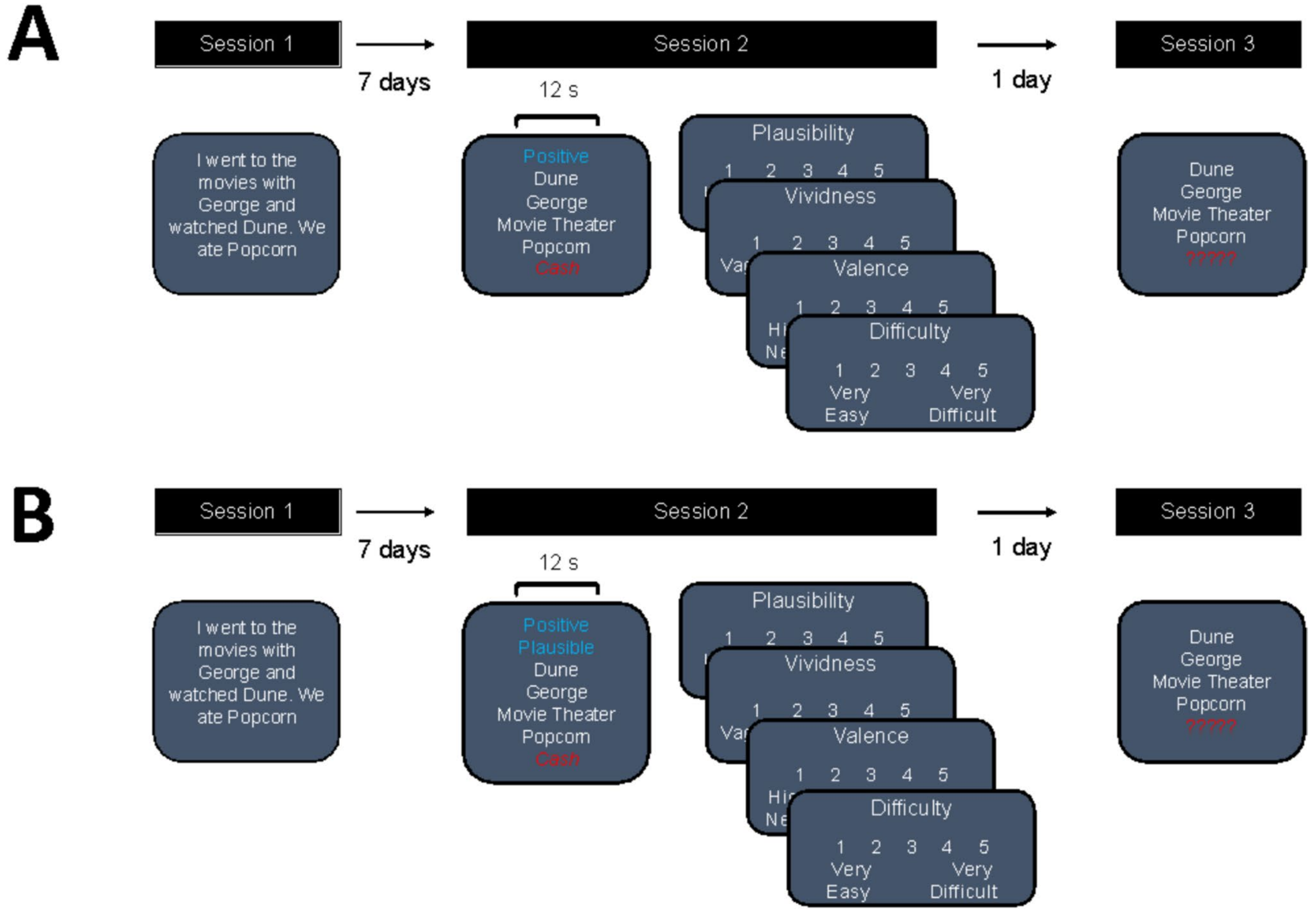

Fig. 1 In both experiments, participants recalled 66 memories during Session 1, providing a short description and a title for each memory. In Session 2, participants generated 60 counterfactuals for their memories and integrated a new object (indicated in red). For Experiment 1, participants generated upward, neutral, or downward counterfactuals. In Experiment 2, participants generated upward and downward counterfactuals, as well as plausible and implausible counterfactuals. In Session 3, participants were cued with the title and elements from their memories and were asked to type the object they had integrated during Session 2. (Color figure online)

indicated which type of simulation participants needed to generate. The heading would either read "Positive," "Neutral," or "Negative," which would indicate that participants needed to imagine an alternative way in which the cued event might have been better (upward counterfactual), an alternative way in which the event might have been different without changing its valence (neutral counterfactual), or an alternative way in which the event might have been worse (downward counterfactual), respectively.

Critically, participants were instructed to include a new object—selected from a list of concrete nouns—in the counterfactual at the time of generation. For instance, if a participant described going to eat at a restaurant as one of their events and were asked to generate a positive counterfactual including the new object "cake," one possible counterfactual would be "I was given a free slice of cake for dessert." The new object is the target item that allowed us to measure the recollection of the episodic details of the counterfactual simulation (see Supplemental Information, Sect. 3, for the full list of objects). Participants were given 12 s to generate the episodic counterfactual simulation. Afterwards, they were asked to rate how vivid the counterfactual was (1: *Vague with no/few Details* to 5: *Vivid and Highly Detailed*), the valence of the counterfactual (1: *Highly Negative* to 5: *Highly Positive*), the plausibility of the counterfactual (1: *Not Plausible* to 5: *Very Plausible*) and how difficult it was to generate the simulation (1: *Really Easy* to 5: *Really Hard*). Memories from Session 1 were randomized such that each memory was assigned to one of three emotional mutation conditions (upward, neutral, or downward). However, we constrained the assignment to ensure that the three sets of memories had the same average emotional valence. To achieve this, we iteratively selected random memories while ensuring that the average valence of the three sets differed by no more than 10% of the total range of the valence scale. The order in which the memories were presented was randomized.

During Session 3, which happened 1 day after, participants were once again cued with the title, person, place, and object of the 60 original events that were selected for Session 2. Critically, participants were also asked to fill in the blank with the new object introduced in Session 2 (e.g., "cake"). We considered a counterfactual simulation as correctly "remembered" if participants typed the name of the new object introduced in Session 2 or a close synonym (for instance, if a participant wrote "handgun" instead of "pistol"), and as "forgotten" if they typed anything else or left the space blank. Before Sessions 2 and 3, participants were given three practice trials, one for each counterfactual condition, before beginning the task. All data and data analysis code can be accessed online (https://osf.io/xtszf).

Data analysis

To analyze the data, we employed two mixed-effects models. The first model aimed to test whether the three types of emotional mutations elicited different valence ratings across subjects. Valence ratings served as the dependent variable, while the independent variable was the emotional mutation (upward, neutral, and downward), modeled as a linear trend. Subjects and the objects integrated during Session 2 were included as random intercepts. The second model examined the influence of plausibility and the emotional mutation on memory for each counterfactual. This analysis used a logistic mixed-effects model, with recall success (1: correctly recalled the new object; 0: failed to recall the new object) as the dependent variable. Plausibility ratings were included as a continuous predictor, and emotional mutation served as a categorical predictor. As we were inspired by the approach followed by Szpunar et al. (2012), we employed two zero-sum contrasts to compare upward against downward counterfactuals and upward against neutral counterfactuals. Additionally, we included the interactions between all variables. Subjects and the new object were included as random intercepts. Before running the analysis, we excluded one object (toothbrush) due to extremely low recall rates (less than 3 standard deviations below the mean; see Supplemental Information, Sect. 3, for details).

The data analysis was conducted in R (RStudio Team, 2020). Mixed-effects models were conducted with the packages *lme4* (Bates et al., 2015) and *lmerTest* (Kuznetsova et al., 2017).

Results

To validate our emotional mutation manipulation (upward, neutral, and downward) in Session 2, we tested whether participants exhibited a linear trend, with valence decreasing from upward to downward simulations. As expected, we observed a significant linear trend ($b = -1.12$, $SE = 0.02$, 95% CI $[-1.16, -1.07]$, $p < 0.001$): upward counterfactuals were rated with the highest valence ($M = 3.99$, $SD = 0.35$), followed by neutral counterfactuals ($M = 3.11$, $SD = 0.16$), while downward counterfactuals ($M = 1.74$, $SD = 0.38$) were rated with the lowest valence.

Next, to examine the influence of counterfactual emotion on memory, we tested whether plausibility and the emotional mutation influenced the probability of recalling the new object. The logistic model (Fig. 2) revealed that

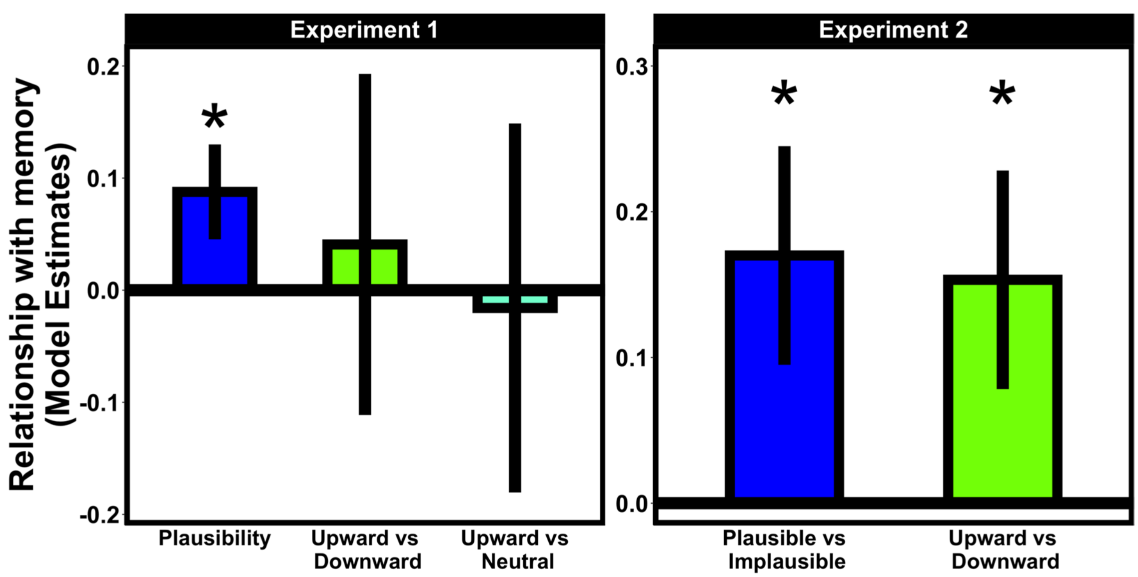

Fig. 2 More plausible counterfactuals are more likely to be remembered. The estimates of the logistic mixed-effects models are plotted as a function of experiment and contrast. Error bars represent the standard error of the mean. $^*p < 0.05$

there was no significant difference between upward (recall proportion = 0.6, $SD = 0.2$) and downward (recall proportion = 0.57, $SD = 0.24$; $b = 0.04$, $SE = 0.15$, 95% CI [−0.25 0.34], $p = 0.7$), nor between upward and neutral counterfactuals (recall proportion = 0.58, $SD = 22$; $b = -0.02$, $SE = 0.16$, 95% CI [−0.34 0.34], $p = 0.9$). However, there was a positive relationship between the plausibility of the counterfactual simulation and the probability of recalling the new object ($b = 0.09$, $SE = 0.04$, 95% CI [0.004 0.17], $p = 0.04$). No interaction was significant (all p values > 0.7).

Discussion

The results of Experiment 1 did not align with the findings of Szpunar et al. (2012), where positive simulations of the future were shown to be more likely remembered. Instead, our results indicated that upward counterfactuals (alternative versions of the past with better outcomes) were no more likely to be remembered compared with neutral or downward counterfactuals (alternative versions with worse outcomes). Instead, our findings dovetail with the results of McLelland et al. (2015), suggesting that episodic details in more plausible simulations were more likely to be remembered.

While our results support the idea that plausibility enhances memory for simulations (McLelland et al., 2015), a key limitation of Experiment 1 lies in its correlational nature: The plausibility of the simulations was measured, instead of directly manipulated. Thus, we conducted a new experiment to address this limitation.

Experiment 2

Experiment 2 was conducted to directly test the role of plausibility in memory for counterfactuals. In this experiment, participants were explicitly asked to generate either plausible or implausible episodic counterfactual simulations. If plausibility indeed enhances memory, this new experiment should replicate the findings of Experiment 1.

Method

Procedure

The procedure of Experiment 2 was identical to that of Experiment 1, barring two differences. The first—and more crucial—difference was that participants were explicitly asked to generate either plausible or implausible simulations (see Fig. 1.B). The second modification involved the removal of neutral counterfactuals, requiring participants to generate only upward or downward counterfactuals. This latter adjustment helped to make the experimental task less taxing because generating neutral counterfactual simulations proved difficult for participants, who tended to generate somewhat positive rather than neutral counterfactuals in Experiment 1. Next, we selected 60 of the 66 memories generated during Session 1 and sorted them into four groups. We iteratively selected random memories while ensuring that the average valence of the four groups differed by no more than 10% of the total range of the valence scale. Following this, the first group of memories was assigned to generate episodic counterfactual simulations that were plausible and upward, the second group plausible and downward, the third group implausible and upward, and the last group implausible and downward.

Participants

Based on pilot data, we conducted a sensitivity analysis to calculate the number of subjects needed to test whether counterfactuals generated to be plausible would be more likely to be remembered when compared with counterfactuals generated to be implausible (see Supplemental Information, Sect. 4, for details). Based on the sensitivity analysis, a total of 60 subjects would be needed to detect whether counterfactuals generated to be plausible would be more memorable than counterfactuals generated to be implausible. As parameters, we employed a power of 80% and an alpha value of 5%. A total of 70 participants from Duke University and the broader Durham community successfully completed the three experimental sessions. As per the preregistration (https://osf.io/snv6c), from the total 70 participants, we removed 10 participants with a memory performance of over 2 standard deviations lower than the mean, as their performance raised doubts about their task engagement. The final sample comprised 60 participants (47 women, five other; $M_{age} = 23.66$ years, $SD = 4.18$). Due to an error during screening, we included two participants with ages higher (37 and 41) than the registered range of ages (18 to 30).

Data analysis

To analyze the data, we employed three mixed-effects models. The first two models aimed to validate the experimental manipulations. The first model tested whether upward counterfactuals had higher ratings of valence than downward counterfactuals. For this model, valence ratings served as the dependent variable, while the predictor was the emotional mutation (upward compared with downward). The second model tested whether counterfactuals generated to be plausible had higher subjective ratings of plausibility when compared with counterfactuals generated to be implausible. This model had as the dependent variable the plausibility ratings and as the predictor variable the plausibility manipulation (counterfactuals generated to be plausible compared with counterfactuals generated to be implausible). The last model was conducted using a logistic mixed-effects model, with recall success (1: correctly recalled the new object; 0: failed to recall the new object) as the dependent variable. The predictor variables were plausibility (plausible vs. implausible) and emotional mutation (upward vs. downward). Every model had subject and the new object introduced in Session 2 as random intercepts. As per the preregistration, we did not include the interaction between plausibility and emotional mutations, as neither the supplemental experiment (see Supplemental Information, Sect. 1; all p values > 0.18) nor Experiment 1 (all p values > 0.7) showed any significant interaction between plausibility and emotional mutation.

Results

We first tested whether the emotional mutation manipulation was successful. As expected, upward counterfactuals ($M = 4.00$, $SD = 0.31$) were rated with higher valence than downward counterfactuals ($M = 1.77$, $SD = 0.34$; $b = 2.32$, $SE = 0.03$, 95% CI [2.18 2.28], $p < 0.001$). Second, we tested whether the plausibility manipulation was successful. The results revealed that counterfactuals generated to be plausible ($M = 3.09$, $SD = 0.57$) received higher plausibility ratings when compared to counterfactuals generated to be implausible ($M = 1.64$, $SD = 0.33$; $b = 1.45$, $SE = 0.03$, 95% CI [1.38 1.51], $p < 0.001$).

Our next analysis focused on whether the plausibility and/or emotional mutation manipulations influenced memory for counterfactuals (Fig. 2). Replicating the results of Experiment 1, new objects included in counterfactuals generated to be plausible (recall proportion = 0.65, $SD = 0.20$) were more likely to be remembered than new items included in counterfactuals generated to be implausible (recall proportion = 0.61, $SD = 0.21$; $b = 0.17$, $SE = 0.08$, 95% CI [0.02 0.31], $p = 0.02$). Turning to the emotional mutation, results revealed that new items included in upward counterfactuals (recall proportion = 0.65, $SD = 0.21$) were more likely to be remembered than those included in downward counterfactuals (recall proportion = 0.62, $SD = 0.21$; $b = 0.15$, $SE = 0.07$, 95% CI [0.006 0.3], $p = 0.04$).

General discussion

Across two experiments, we found that an episodic detail (i.e., an imagined object) featuring in the content of more plausible episodic counterfactual simulations has a higher likelihood of being recalled than in less plausible ones. Additionally, although we did not find that the emotional direction of the counterfactual simulation was related to the likelihood of the episodic detail being recalled in Experiment 1, we did find a significant relationship between the two in Experiment 2. We now elaborate on the significance of these findings, addressing certain limitations of the studies.

A consistent finding across both experiments is that episodic details may be better remembered in plausible relative to implausible episodic counterfactual simulations. Common definitions of plausibility associate it with how well an event aligns with prior knowledge, so that more plausible events exhibit stronger alignment with extant knowledge (Connell & Keane, 2006; Phillips et al., 2019). This characterization of plausibility aligns too with the impact of schemas on episodic memory (Gilboa & Marlatte, 2017; van Kesteren et al., 2012), whereby items consistent with previously stored schemas are more likely to be recalled. When evaluating the plausibility of each episodic counterfactual simulation, participants might engage in various evaluative processes. One relevant aspect of this evaluative process involves how the simulation compares with their past experiences (De Brigard et al., 2021; Stanley et al., 2017), serving as a broader context that could influence memory for counterfactuals, similar to how schemas influence memory for items coherent within a context.

The relationship between congruency and memory success seems to be mediated by the medial prefrontal cortex (mPFC) and the medial temporal lobe (MTL). Specifically, it has been proposed that activity in the mPFC integrates events congruent with preexisting cortical representations, while activity in the MTL enhances the integration of novel events into new cortical representations (van Kesteren et al., 2012). A recent behavioral study supported this model, showing that episodic details for imagined events were more likely to be remembered when events were either maximally schema-congruent or maximally schema-incongruent (Fenerci et al., 2024). In contrast, our results showed a memory advantage only for more plausible, or schema-congruent, simulations. This difference is not surprising: Unlike imagined novel events, episodic counterfactual thinking requires subjects to reactivate a specific autobiographical memory against which to mentally contrast the counterfactual alternative. Imagined events, by contrast, do not necessitate such reactivation and contrast.

While in Experiment 1 we found no relationship between recall and emotional mutation, in Experiment 2 we found that the imagined object was more likely to be remembered during upward (i.e., positive) relative to downward (i.e., negative) counterfactual simulations. This finding aligns with the results from Szpunar et al. (2012), whose experimental design inspired the current work, whereby imagined objects within positive episodic future thoughts were better remembered than those within negative episodic future thoughts. That being said, how might the discrepancy between the valence results of Experiments 1 and 2 be explained? One possibility is that the effect of valence in episodic counterfactual thinking is subtler than both the effect of plausibility as well as the effect of valence in episodic future thought, and thus only detectable with the larger sample size of Experiment 2. Further studies should be able to clarify the similarities and differences in the memorability of episodic details between episodic future and counterfactual simulations (Schacter et al., 2015).

A potential limitation of our study is the method used to test memory for each counterfactual, where memory of an individual item serves as a proxy for the episodic content of the mental simulation. Simulations have numerous details and some may be better remembered than others. Extant research has shown, for instance, that people are better at remembering "where" or "who" was involved in an episodic counterfactual simulation relative to the "when" of the simulation (De Brigard et al., 2020). The current work sought to employ a relatively easily manipulable item (i.e., an imagined object) as a stable measure of recall, but further research should explore potential differences in the memorability of different episodic contents during counterfactual simulations. Additionally, people may use different recollective strategies to remember past episodic counterfactual simulations. We reasoned that, since participants were instructed to incorporate the new object by integrating it with other elements of their counterfactual simulation, measuring the recollection accuracy for the new object would allow us to infer that remembered objects were more robustly encoded than forgotten ones, likely because the episodic contents as wholes are better remembered. Nevertheless, it is important to acknowledge that this measure of retrieval is indirect, and further studies using alternative methods to assess the recollection of imagined contents should be employed to further corroborate our findings.

In conclusion, our two experiments demonstrate that participants more readily recall the episodic details of plausible counterfactual simulations. This insight into the phenomenological factors influencing the memorability of counterfactual simulations enhances our fundamental understanding of how people conceive and remember alternative versions of their past experiences, and thus which types of simulations are more likely to be used to inform future behavior.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.3758/s13423-025-02670-0.

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Authors Contribution Conceptualization: F.D.B.
Methodology: F.D.B., R.M.T
Investigation: F.D.B., R.M.T, K.M.
Funding acquisition: F.D.B
Project administration: F.D.B
Supervision: F.D.B.
Writing—original draft: F.D.B, R.M.T., K.M
Writing—review & editing: F.D.B, R.M.T., K.M, S.H., K.S.

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Availability of data and materials All data, and data analysis code are available at: https://osf.io/xtszf/

Code availability All data, and data analysis code are available at: https://osf.io/xtszf/

Declarations

Ethics Approval The study was approved by Duke Campus Institutional Review Board under protocol number: 2022–0253.

Consent to participate Not Applicable.

Consent for publication Not Applicable.

Open practice statement All data and data analysis code can be accessed and are available here (https://osf.io/xtszf). Experiment 1 (https://osf.io/z8wrm) and Experiment 2 (https://osf.io/snv6c) were preregistered.

Conflict of interest No author declares any conflict of interest.

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