Plausibility sampling rather than difficulty influences sequential selection of episodic counterfactual thoughts

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Abstract

People often engage in episodic counterfactual thinking: simulating alternative ways in which past events might have occurred. Existing research has shown that the perceived plausibility of episodic simulations modulates judgments of regret, mood and prosocial behavior. However, knowledge about the factors influencing the perceived plausibility of episodic counterfactuals is limited or derived from studies using vignette-based hypothetical scenarios. Inspired by research on modal cognition, here we test whether counterfactual plausibility is influenced by a sampling process that prioritizes the generation of plausible alternatives. Additionally, we evaluated whether the sequential generation of episodic counterfactual simulations is associated with vividness and difficulty. Across two experiments we demonstrated that when people generate episodic counterfactual thoughts, they initially produce the most plausible and vivid mental simulations, without concurrent changes in difficulty. Our results provide support for a sampling process that prioritizes the generation of more plausible and vivid counterfactual alternatives over less difficult ones.

Keywords: Episodic Counterfactual Thinking; Episodic Simulation; Plausibility; Vividness; Difficulty

Introduction

We often find ourselves revisiting our past but, far from revisiting merely as spectators, we frequently think about how things might have been different. This phenomenon has been called episodic counterfactual thinking, and it refers to the capacity to mentally simulate alternative ways in which one's personal past experiences might have happened differently from how they actually occurred (De Brigard & Parikh, 2019). For instance, when remembering how I became lost in the forest after straying from the correct trail, I may begin thinking about alternative ways in which this past experience could have been different. I can imagine, for example, having asked for directions from a fellow hiker, or I can imagine having brought with me a map of the forest. However, I could also imagine alternative scenarios that are less likely: perhaps I could have run into a hermit living off the grid who provided directions; or perhaps I could have run into Bigfoot, who accompanied me back to the correct path. As this example shows, counterfactuals can vary widely according to how plausible they are perceived to be: ranging from simulations that almost recapitulate what happened, to simulations that importantly diverge from what we think is more likely to have occurred.

While the perceived plausibility of episodic simulations has been shown to influence judgments of regret and responsibility (Petrocelli et al., 2011), mood (Bennett et al., 2022), behavioral change (Kim & Summerville, 2023), attributions of morality (Byrne, 2017), prosocial behavior (Gaesser et al., 2018) and false memories (Pezdek et al., 2006), there is still an open question as to which psychological factors influence the perceived plausibility of episodic counterfactual simulations.

One possible answer can be found on a current model that explains how people, when thinking about alternative possibilities for events, choose from a potentially unlimited pool of alternatives (Knobe & Cushman, 2023). This model suggests that when considering possibilities, people tend to initially sample the most likely and valuable alternatives (Phillips et al., 2019; Phillips & Cushman, 2017). Accordingly, this sampling procedure constrains how people generate alternatives: by default, individuals tend to initially rely on more plausible representations. In the case of episodic counterfactual thinking, the same problem arises: when people imagine how their past could have been different, there is a potentially unlimited number of ways in which the past might have occurred instead. Thus, the same sampling process that prioritizes the generation of more likely alternatives could influence the plausibility of episodic counterfactual simulations. Testing whether this sampling process influences the plausibility of episodic counterfactual thinking is the principal objective of the current study.

In addition to the sampling model, prior work on vignette-based counterfactual thinking suggests at least two other psychological factors that may influence our judgments of plausibility in episodic counterfactual thinking. One the

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one hand, there is the difficulty of the mental simulation, initially posited by Kahneman & Tversky (1982). Based on several experiments in which subjects mentally constructed counterfactual simulations for hypothetical scenarios presented through vignettes, both authors argued that the difficulty (or effort) with which the psychological processes generate a counterfactual simulation determines how plausible the content of that counterfactual simulation is perceived to be. Accordingly, counterfactual plausibility might be determined, not by a sampling mechanism, but by how difficult each counterfactual was to simulate.

On the other hand, the vividness of a simulation—how detailed or lively a simulated content appears in the 'mind's eye'— has been also posited as a determinant of its perceived plausibility. Extant research has shown that the more vivid the mental representation of an event, the more likely it is that individuals would attribute its origin to something that was directly experienced, as opposed to merely imagined (Dijkstra et al., 2022; Simons et al., 2017, 2020). As a result, some have thought that the vividness of an episodic simulation may influence participants into thinking that the hypothetical situation is rather plausible, as its content is experienced more vividly; or, conversely, that the imagined scenario may be implausible, as its content is experienced comparatively less vividly (Barlett & Brannon, 2006). Thus, counterfactual plausibility might be derived from the vividness of the simulation.

In the current study, we tested whether a sampling process that prioritizes more plausible representations influences the generation of episodic counterfactuals. To test this hypothesis, we ran two experiments in which participants recalled one autobiographical memory. Then, participants were asked to generate four different episodic counterfactual alternatives for the same memory. After each simulation, participants rated the plausibility, difficulty, and vividness of each simulation. If our hypothesis is correct, we expect that plausibility ratings should decrease as participants generate more counterfactuals. Critically, we expect this manipulation to influence only plausibility, not vividness or difficulty.

Experiment 1

In Experiment 1, we asked participants to recall one episodic autobiographical memory and then to sequentially generate four different ways in which that event could have been different. If a sampling process in which the sequential generation of episodic counterfactual simulations possesses an inverse relation to perceived plausibility, we should see a pattern of results whereby counterfactuals generated earlier would be more plausible than those generated later, with no concurrent changes in either vividness or difficulty.

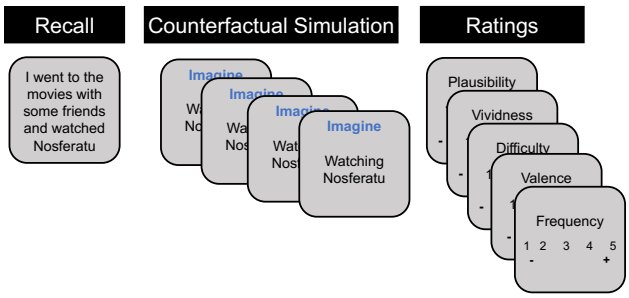

Figure 1: Schematic of the experiment. Participants recalled 1 memory and, immediately after, sequentially generated 4 different counterfactuals for the same memory. After generating the simulation, participants rated the plausibility, vividness, difficulty, valence, and frequency of each simulation.

Methods

To test whether counterfactual plausibility decreases as a function of sequentially simulating counterfactual alternatives for the same episodic autobiographical memory, we conducted a pilot study (N = 50). Using the pilot data, we performed a sensitivity analysis by generating 100 simulations and testing how often we observed a significant relationship between plausibility and the sequence of simulations. This approach was repeated with varying sample sizes (N), ranging from 10 to 200 participants. Based on these simulations, and using an alpha threshold of 5%, we determined that a sample size of 120 participants was needed to achieve 80% power. To account for online attrition, we recruited a total of 156 Prolific workers. After excluding participants with at least one invalid counterfactual description (e.g., overly general responses like "buying a car," invalid responses such as "12:41 PM," blank responses, or nonsensical strings like "idk"), we retained a final sample of 136 participants (85 female, 2 did not report gender; Mage = 35.8, SD = 9.5). All Prolific participants were based in the US, were native English speakers, and had an approval rating of 90% or higher. The study was approved by Duke University IRB.

Procedure

Participants completed an online survey in which they were asked to recall a specific autobiographical event not older than 10 years (**Figure 1**). They provided a brief description of the event, gave it a title, and specified the date, location, a person, and an object associated with the event. Participants then rated the valence of the memory (1: Very negative to 5: Very positive) and its vividness (1: Vague with no/few details to 5: Vivid and highly detailed). After generating the memory, participants were asked to create a counterfactual alternative for it. Specifically, participants were asked to 'Imagine an alternative way in which the remembered event could have occurred'. They were given 12 seconds to generate the mental simulation. Once the 12-second period

ended, participants rated the plausibility (1: Not likely to 5: Very likely), vividness (1: Vague with no/few details to 5: Vivid and highly detailed), difficulty (1: Very easy to 5: Very hard), valence (1: Highly negative to 5: Highly positive), and frequency of thought for that counterfactual simulation (1: The first time I think about this to 5: I have thought about this several times). Then, participants repeated this process three more times. Each time they were prompted with the sentence 'Now you will need to think about a DIFFERENT way in which the event could have happened'. In total, participants generated four alternative versions for the same memory. At the beginning of the experiment, participants completed a practice trial in which they recalled one autobiographical event and generated one counterfactual for it. Critically, participants were not informed beforehand that they would be generating more than one counterfactual for the event. The entire experiment lasted approximately 15 minutes.

Analysis

To test whether ratings of plausibility, vividness, and difficulty for each episodic counterfactual version changed across the four simulations, we constructed three linear mixed-effects models (LMM), with plausibility, vividness, or difficulty as the dependent variables. The simulation order (First, Second, Third, or Fourth) was included as the primary predictor. Frequency and valence of the counterfactuals were added as covariates, and subjects were included as random intercepts. All analysis were conducted in RStudio (RStudio Team, 2020) and LMMs were constructed with the LME4 and LmerTest packages.

Results

The LMMs results (**Figure 2A**) revealed a progressive decline across simulations in plausibility (b = -0.08, SE = 0.04, 95% CI = [-0.15 -0.01], p = .03) and vividness ratings (b = -0.07, SE = 0.03, 95% CI = [-0.12 -0.01], p = .02). However, there was no effect on difficulty (b = 0.06, SE = 0.04 95% CI = [-0.01 0.12], p = .08).

Discussion

Consistent with the sampling view, the results of Experiment 1 showed a decline in plausibility across the four simulations. Vividness, too, decreased as the number of episodic counterfactual simulations increased. Finally, we found no differences in the difficulty with which the counterfactual simulations were generated. We take these results as extending the sampling view from generic and vignette-based hypothetical thoughts to the realm of episodic counterfactual simulations.

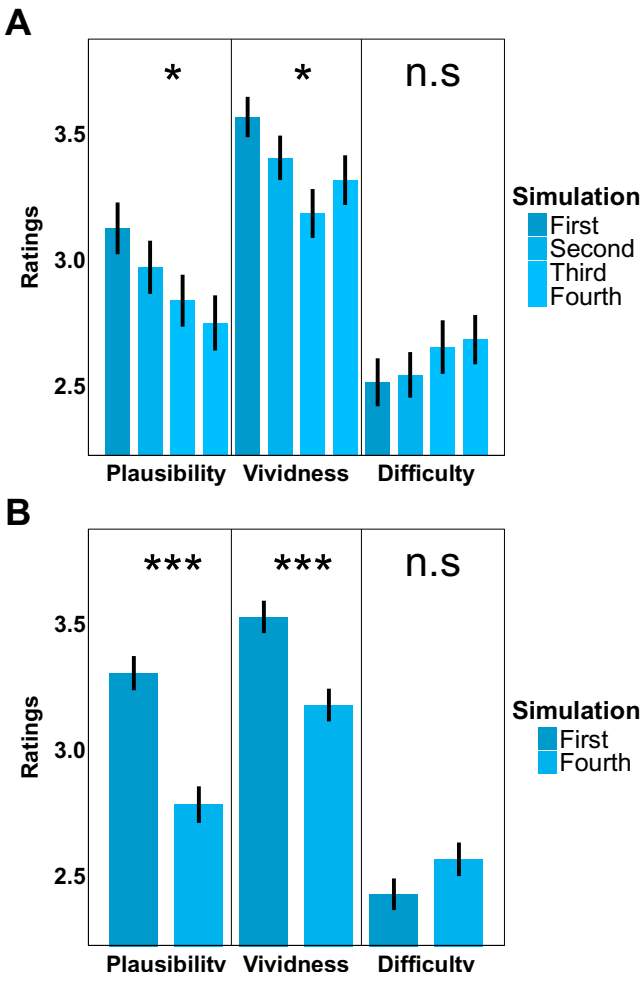

Figure 2: Plausibility, vividness, and difficulty ratings as a function of the order of counterfactual simulation for Experiment 1a (A) and 1b (B). Each dot represents the average rating, error bars represent the Standard Error of the Mean. * p < .05, *** p < .001.

Experiment 2

Experiment 1 showed that when generating counterfactual alternatives, participants tended to simulate more plausible and vivid ones first. Conversely, there was no change in difficulty across simulations. However, Experiment 1 only tested a linear trend across the four simulations without directly comparing differences between ratings. Hence, the objective of Experiment 2 was to explicitly assess whether the changes in plausibility were significantly different from changes in vividness and difficulty.

Methods

Based on a power analysis (employing the same simulation approach as in Experiment 1) using the data of Experiment 1, a sample of 330 participants was needed to test for significant differences across ratings, with 80% power and an alpha of

1.6% (to account for three comparisons). To account for online attrition, we recruited a total of 360 subjects from Prolific. After removing participants, using the same criteria as in Experiment 2a, we ended up with a final sample of 332 participants (M_{age} = 39.37, *SD* = 10.61; 186 Females, 4 did not wish to specify). Prolific participants were based in the US, were native English speakers, and had an approval rating of 90%. The study was approved by Duke University IRB.

Procedure

The procedure mirrored that of Experiment 1.

Analysis

To test whether the changes across simulations were significantly different across ratings, we employed a repeated-measures design using LMMs. We included 2 within-subject factors: Simulation (First/Fourth) and Feature (Plausibility/Vividness/Difficulty). Frequency and valence of the counterfactual simulations were added as covariates, and subjects were included as random intercepts. To perform post-hoc comparisons, we generated three LMMs. Each model independently tested whether the effect of simulation was significantly different for each of the three features. Frequency and valence were included as covariates, and subjects were included as random intercepts.

Results

The repeated measures analysis (**Figure 2B**) revealed a main effect of Simulation ($F(1,1712) = 9.92$, $p = .002$) and Feature ($F(2,1652) = 61.24$, $p < .001$). The interaction between Simulation and Feature was significant ($F(2,1652) = 14.4$, $p < .001$). This interaction was driven by subjects generating more plausible (b = -0.38, SE = 0.08, 95% CI = [-0.54 -0.23], $p_{bonf} < .001$) and vivid (b = -0.26, SE = 0.06, 95% CI = [-0.38 -0.14], $p_{bonf} < .001$) episodic counterfactuals during the first simulation. There was no difference in difficulty ratings between simulations (b = 0.13, SE = 0.7, 95% CI = [-0.02 0.27], $p_{bonf} = .28$).

Discussion

The results of Experiments 1 and 2 demonstrated that when people think about counterfactual alternatives to the past, they tend to generate more plausible alternatives first. This finding aligns with a sampling process which suggests that when considering possibilities, individuals prioritize generating the most plausible alternatives first (Phillips et al., 2019; Phillips & Cushman, 2017). Surprisingly, we also found that during the generation of episodic counterfactual simulations, the initial alternatives that come to mind are not only more plausible but also more vivid. We explore this finding in greater depth in the general discussion. Lastly, neither experiment showed a relationship between the simulation order and difficulty.

General Discussion

In the current experiments, we tested whether a sampling process that prioritizes more plausible mental representations influences the generation of episodic counterfactual simulations. Our results showed that when mentally generating episodic counterfactual simulations, people tend to initially sample the most plausible and vivid alternatives to past personal episodes, without concurrent changes in difficulty. These findings and the limitations of the study are discussed in the following paragraphs.

Experiments 1 and 2 illustrated that, when thinking about alternative versions to past personal events, people tend to initially sample the more plausible and vivid counterfactual alternatives. This result suggests that when people think about a counterfactual alternative, of all the myriad possible ways in which their personal past might have been different, the possibilities that first come to mind are the more plausible and vivid ones. These results align with current findings on modal condition, which have shown that when people think about alternatives possibilities in general, they are initially constrained by representations that are both plausible and valuable (Phillips et al., 2019; Phillips & Cushman, 2017). In our study, we showed that the same sampling process might be responsible for the selection of episodic counterfactual alternatives. These results open an interesting avenue for future research, exploring whether in pathologies in which episodic counterfactual simulations have negative consequences —such as anxiety (Parikh et al., 2020; 2022) and depression (Broomhall et al., 2017; Markman & Miller, 2006)— this sampling process might be influenced by other factors, perpetuating such conditions.

Interestingly, our results also showed that the first alternatives that come to mind are not only more plausible, but more vivid as well. This pattern aligns with prior literature showing the influence of previous knowledge on the episodic details of simulations. Research on patients with semantic dementia has shown that, even when these patients possess an intact capacity to retrieve personal memories (Irish et al., 2012), they also have an impaired capacity to integrate episodic details into simulations of their personal future. This finding suggests that general knowledge plays a crucial role in influencing the level of detail and vividness in episodic simulations (Irish & Piguet, 2013). Moreover, computational models have demonstrated that events that better align with general knowledge are rated as more plausible (Connell & Keane, 2006) and elicit more vivid mental representations (Riley & Davies, 2023). Taken together, these models suggest that the plausibility of a simulation might act as a 'scaffolding' that supports the integration of episodic details into the simulation (De Brigard et al., 2022; Irish & Piguet, 2013; Irish & Vatansever, 2020). In the case of our results, outputs from a mechanism that prioritizes plausible representations might serve as the foundation of which vivid representations can be constructed from. However, our results could not rule out the possibility that vividness may be influencing plausibility —not the other way around. In order to test this possibility, future

experiments should directly manipulate both plausibility and vividness separately and test whether changes in one variable led to changes in the other variable.

While classical models have posited that difficulty determines the plausibility of a counterfactual simulation (Kahneman & Tversky, 1982), we found no relationship between difficulty and the order of the simulations. While prior research has found that difficulty might vary with plausibility (Stanley et al., 2017), our results highlight that manipulations targeting plausibility need not involve changes in difficulty. While further research is needed to disentangle the relationship between the difficulty and plausibility of a simulation, our findings suggest that these two properties should be considered independent attributes of a simulation, potentially influenced by different mechanisms.

While we propose that our results are driven by a sampling mechanism that selects the more plausible counterfactuals first, another potential explanation lies in the familiarity of each counterfactual. Given the strong influence of fluency on metacognitive judgments (Fleming, 2024) one potential possibility is that participants were generating first already rehearsed counterfactuals, in which prior experience generating such counterfactuals could increase the plausibility of the simulation. However, we sought to account for this possibility by asking participants to rate the frequency with which they thought of each counterfactual. Although our results show that the decrease in perceived plausibility as a function of repeated simulations cannot be attributed to the fluency of the simulation, other strategies to evaluate frequency of simulation that do not depend on self-report could further corroborate this finding to rule out a fluency-based explanation.

Although in the current studies we focused on two features of episodic counterfactual simulations, their difficulty and vividness, there are other features that have been related to perceived plausibility. More specifically, the perceived similarity between what actually happened and what could have occurred has been shown to be correlated with plausibility (De Brigard et al., 2021; Stanley et al., 2017). Additionally, whether the counterfactuals reflect a better or a worse outcome has been associated with changes in the perceived plausibility of the simulation (De Brigard et al., 2016; De Brigard & Giovanello, 2012)—although it's worth mentioning that in the current studies we controlled for the affective valence of each simulation. Future research should focus on assessing the influence, and potential interactions, between other phenomenological properties and counterfactual plausibility.

Another limitation of the current study is that we only asked participants to generate alternative versions of events, without specifying whether those mutations should reflect changes to their actions or circumstances. Crucially, prior research has shown that participants that mutate their actions or their circumstances led to different neural and behavioral results (Khoudary et al., 2022). Whether the same sampling mechanisms take place in these two types of mutations is an open avenue for future research.

Given the influence of the perceived plausibility of episodic counterfactual thinking on behavioral interventions and affective processes (Bennett et al., 2022; Kim & Summerville, 2023; Petrocelli et al., 2011), we sought to answer what influences this phenomenological appraisal. Ultimately, we demonstrated that while difficulty might serve as a heuristic, it does not fully explain the plausibility of episodic counterfactual simulations. More importantly, our results provide support for a sampling process that prioritizes the generation of more plausible and vivid counterfactual alternatives.

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