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An Optimistic Outlook Creates a Rosy Past: The Impact of Episodic Simulation on Subsequent Memory

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Abstract

People frequently engage in future thinking in everyday life, but it is unknown how simulating an event in advance changes how that event is remembered once it takes place. To initiate study of this important topic, we conducted two experiments in which participants simulated emotional events before learning the hypothetical outcome of each event via narratives. Memory was assessed for emotional details contained in those narratives. Positive simulation resulted in a liberal response bias for positive information and a conservative bias for negative information. Events preceded by positive simulation were considered more favorably in retrospect. In contrast, negative simulation had no impact on subsequent memory. Results were similar across an immediate and delayed memory test and for past and future simulation. These results provide novel insights into the cognitive consequences of episodic future simulation and build on the optimism-bias literature by showing that adopting a favorable outlook results in a rosy memory.

Keywords

emotion, episodic future simulation, episodic memory, future thinking, positivity bias, open data, open materials

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In everyday life, people frequently simulate possible future episodes (D'Argembeau, Renaud, & Van der Linden, 2011), a process that provides functional benefits (Schacter, Benoit, & Szpunar, 2017). To serve an adaptive purpose, a future simulation must be of an event that is likely to occur and should be maintained in memory long enough to be useful when the event occurs. Supporting the first point, a substantial proportion of simulated future events eventually takes place; Spreng and Levine (2013) found that 61% of the future events simulated by their participants took place over the subsequent year, whereas Weiler, Suchan, and Daum (2010) report that 49% of simulated future events occurred over the following winter break. Supporting the second point, future simulations are remembered over time, particularly if they are plausible and detailed (Jeunehomme & D'Argembeau, 2017; McLelland, Devitt, Schacter, & Addis, 2015). Because many simulated future events come to occur, and such simulations are remembered over time, competition might exist between mental representations of the simulated and actual events. It is well known that imagination interacts with and can distort memories of past events (e.g., Garry, Manning, Loftus, & Sherman, 1996; Gerlach, Dornblaser, & Schacter, 2014), so it is conceivable that future simulation could likewise alter memory for the actual event.

However, little is known about how episodic future simulation interacts with subsequently formed memories. A few studies have explored the possibility that generalized future thinking alters subsequent memory. One such experiment by Klaaren, Hodges, and Wilson (1994) led some participants to expect that an upcoming film would be highly enjoyable but provided no prior expectations of the film for others. Participants then underwent either a favorable or an unfavorable viewing experience. A week later, those with positive expectations reported enjoying the film more than those with no expectations, regardless of viewing experience. Positive expectations improved memory for

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positive aspects of the favorable viewing experience and negative aspects of the unfavorable experience. More recently, Chun, Diehl, and MacInnis (2017) found that savoring an upcoming experience increased enjoyment ratings during and after the experience. The authors propose that savoring creates affective memory traces, which are later reactivated and integrated into the actual and remembered experience. These findings are an initial indication that positive future thinking influences subsequent memory. However, strong conclusions cannot be drawn about the effect of negative future thinking on subsequent memory. Moreover, the question of whether episodic future simulation in particular, rather than other, related forms of future thinking (i.e., expectations and savoring; see Szpunar, Spreng, & Schacter, 2014, for a taxonomy of future thinking), can influence subsequent memory remains open.

Across two experiments, we set out to directly examine, for the first time, whether the emotional valence of episodic future simulation influences memory for emotional aspects of a corresponding subsequent event. Participants simulated positive and negative future events, then read narratives describing the hypothetical outcome of each event and describing events that had not been simulated. Each narrative was neutral overall in tone and contained positive and negative details. To explore biases in memory as a result of prior simulation, we assessed memory for true and false narrative details in a recognition test. In Experiment 1, we examined the impact of testing delay, and in Experiment 2, we explored the role of the temporal orientation of simulation. We expected emotional future simulation to facilitate true memory for emotionally congruent narrative details, while either suppressing or enhancing true memory for incongruent details. We further expected simulation to contribute to source confusion and increase false alarms for congruent details, while decreasing false alarms for incongruent details. We also collected subjective ratings of narrative emotional tone immediately after participants read the narratives and after the recognition test in Experiment 2. If episodic future simulation impacts event experience, immediate narrative emotion ratings should correspond with simulation valence. If future simulation predominately impacts retrieval, then emotion ratings should match simulation valence only after the recognition test.

Experiment 1

Negative future simulations are forgotten more quickly than positive or neutral simulations (Szpunar, Addis, & Schacter, 2012). In Experiment 1, we explored whether this memory reduction over time differentially impacts responses in an immediate recognition test versus after a 48-hr delay. We expected negative simulation to influence responses in the immediate but not delayed test, while an effect of positive simulation should be evident at both delays.

Method

Participants. We recruited 33 young adults via postings at Harvard University. All participants were fluent English speakers; had no history of learning disabilities or neurological or psychiatric impairments; and had normal or corrected-to-normal vision. Participants gave informed consent in a manner approved by Harvard University's ethics board and were compensated with either course credit or $25 for participation. Six participants were excluded: 3 because of experimenter error, 1 for not completing the experiment, and 2 for noncompliance. Therefore, data from 27 participants were included in analyses (12 male; age: M = 22.59 years, SD = 3.18; education: M = 15.28 years, SD = 2.05). A power analysis (G*Power; Faul, Erdfelder, Lang, & Buchner, 2007) based on effect sizes from pilot data used to refine the paradigm determined that a sample of at least 21 was necessary to detect an effect of simulation on hits and false alarms (power > .95, η_p^2 = .15). Thus, we aimed for a sample of 25, and stopped data collection once approximately enough usable participants had been run to reach this number.

Stimuli. We devised short narratives (M = 303 words, SD = 32) in the second person for 18 scenarios that could plausibly be experienced within the next year (e.g., "Going to see a play"). Each narrative contained nine target details (three positive, three negative, and three neutral) and was neutral overall in tone. We devised two versions of each narrative to balance any item effects with details of opposing valence (e.g., positive: "it was a beautiful sunny day"; negative: "it was a miserable rainy day"; see the Supplemental Material available online for an example narrative).

Verification of target detail and narrative valence was collected by 37 independent raters participating for course credit (nine male, age: M = 19.81 years, SD = 1.31; education: M = 13.84 years, SD = 1.38). Each participant saw one of the two narrative versions, and using 7-point scales, rated the target details and narratives overall for emotional valence (1 = *strongly negative*, 4 = *neutral*, 7 = *strongly positive*), arousal (1 = *calming/boring*, 7 = *exciting/agitating*), and plausibility (1 = *low*, 7 = *high*). Overall the narratives were rated as neutral in tone (M = 4.36, SD = 0.60). A 2 × 3 mixed analysis of variance (ANOVA) with narrative version as a between-subjects variable and detail type (positive, negative, neutral) as a within-subjects variable confirmed emotional categorization of target details. No differences in emotional arousal or plausibility between positive and negative details were found (see Narrative Ratings and Table S1 in the Supplemental Material for full statistical descriptions).

Procedure. This study comprised two sessions, spaced 48 hr apart. Session 1 involved a simulation phase, an encoding phase, and a recognition test for half the narratives. Session 2 involved a recognition test for the other half of the narratives. At the beginning of the study, participants were informed that we were examining how people remember the past and imagine the future and that they would complete simulation tasks in Session 1 and memory exercises in Session 2. Participants were tested individually in a private testing room. All stimuli were presented on a computer using E-Prime Version 3 (Psychology Software Tools, 2016).

In the simulation phase, participants were presented with 12 of the 18 scenarios (random selection), and in response to each were asked to simulate a future event that might happen in the next year, going either well (*positive condition*) or poorly (*negative condition*; six of each, random order). The remaining six scenarios were withheld to form the *no-simulation condition*. Future events were to be plausible, not previously experienced by the participant, and to focus on one day within the next year. For each simulated event, participants described aloud as much information as possible within 3 min, while being audio-recorded. The experimenter remained in the room during the recording and provided general prompts if the participant stopped speaking before the 3 min were up (e.g., "Is there anything else that comes to mind?"). At the end of the 3 min, a bell sounded to indicate that participants should stop talking, and they then rated the simulation on a 5-point scale for emotional valence (1 = *strongly negative*, 3 = *neutral*, 5 = *strongly positive*), vividness, personal significance, plausibility, and similarity to previous experiences (1 = low, 5 = high).

The encoding phase followed a 15-min break, during which participants completed a word search or sudoku puzzle. Participants were told to pretend that it was a year later and they were going to find out how the events they simulated played out via short narratives. A total of 18 narratives were presented, one at a time, 12 corresponding to the simulated events (positive and negative conditions) and 6 describing new events (no-simulation condition). Narratives belonging to the three conditions were presented in a random order. Participants were instructed to read each narrative carefully, self-paced, then press "enter" to move on. They were then asked to rate the emotional valence of the narrative on a 5-point scale (1 = *strongly negative*, 3 = *neutral*, 5 = *strongly positive*; note that this is a different rating scale than that used during stimuli verification). Valence ratings were intermixed with interest, visualization, and plausibility ratings to mask the focus of this study on emotion.

After a second 15-min break, a recognition test took place for half the narratives (three each for positive, negative, and no-simulation conditions) while the other half were tested after a 48-hr delay. Both tests followed an identical procedure. Participants were presented with a narrative title, followed by 12 details: 4 true details from the narrative (2 positive, 2 negative), 2 false details of alternative valence than in the narrative (1 positive, 1 negative), 2 false foil items that had not been presented in the narrative (1 positive, 1 negative) and 4 neutral distractor details (2 true, 2 false). For each detail, participants were asked to indicate whether they saw that information in the narrative or not. The neutral details were included to mask the purpose of the study for participants and so were not included in the statistical analyses. Because response patterns did not differ across false alternative and false foil details according to simulation condition, collapsed false memory results follow.[1] See the Supplemental Material for full participant instructions for each task.

Statistical analyses. We calculated discriminability using d', by subtracting the standardized proportion of hits from that of false alarms (Macmillan & Creelman, 2004). Higher d' values indicate greater discrimination between true and false details. We calculated response bias using C, by multiplying the sum of the standardized hit and false alarm rates by −0.5 (Macmillan & Creelman, 2004). Higher C values indicate a more conservative response bias (i.e., more likely to say "false" regardless of memory status), whereas a lower C indicates a liberal bias (more likely to say "true"). To correct for response proportions of 0 or 1, we used $1/(2N)$ and $1 - 1/(2N)$ respectively (Macmillan & Creelman, 2004). All statistical analyses were performed with SPSS Version 24. Note that unless explicitly stated as "target" details from the narratives, we refer to the valence of details as presented in the recognition test.

Results

Subjective ratings. A paired-samples t test revealed that simulation valence ratings were more positive when participants were instructed to simulate an event "going well" (positive condition) compared with "going poorly" (negative condition), confirming that participants were following instructions, $t(26) = 13.96$, $p < .001$, $d = 2.69$. Positive simulations were rated higher than negative simulations in personal significance, $t(26) = 3.59$, $p = .001$, $d = 0.69$, and similarity to previous events, $t(26) = 2.08$, $p = .048$, $d = 0.40$. No difference was found in vividness or plausibility ($p > .073$; see Table 1).

Table 1. Mean Subjective Ratings During Simulation for Experiments 1 and 2, Broken Down by Simulation Condition (Positive and Negative, Past and Future)

	Experiment 1: future simulation		Experiment 2: future simulation		Experiment 2: past simulation	
Measure	Positive	Negative	Positive	Negative	Positive	Negative
Emotional valence[a,b]	3.74 (0.49)	1.95 (0.47)	3.68 (0.53)	2.02 (0.54)	3.92 (0.54)	2.15 (0.40)
Emotional arousal[b]	—	—	2.51 (0.75)	2.76 (0.97)	3.15 (0.50)	3.09 (0.76)
Vividness	3.49 (0.64)	3.47 (0.59)	3.42 (0.98)	3.42 (0.88)	3.69 (0.59)	3.45 (0.70)
Plausibility[a]	3.09 (0.76)	2.81 (0.78)	3.52 (0.85)	3.12 (0.88)	3.55 (0.13)	2.93 (0.87)
Personal significance[a]	2.67 (0.54)	2.25 (0.70)	2.43 (0.92)	2.19 (0.79)	2.97 (0.81)	2.36 (0.71)
Similarity to previous events[a]	2.22 (0.64)	1.95 (0.67)	2.33 (0.67)	1.82 (0.57)	2.64 (0.73)	2.03 (0.70)

Note: Standard deviations are given in parentheses. [a]For each experiment in this row, means in the positive and negative conditions are significantly different ($p < .05$). [b]In this row, means for the past- and future-simulation conditions are significantly different ($p < .05$).

A repeated measures ANOVA showed that simulation condition (positive, negative, no simulation) did not influence immediate narrative valence ratings, $F(2, 52) = 0.08$, $p > .250$, $\eta_p^2 = .003$ (see Table 2). Prior simulation also did not influence time taken to read each narrative ($M_{\text{positive}} = 57.41$ s, $SD = 13.30$, $M_{\text{negative}} = 56.23$ s, $SD = 16.64$, $M_{\text{no-simulation}} = 66.89$ s, $SD = 42.74$), $F(1.11, 27.85) = 2.41$, $p = .130$, $\eta_p^2 = .09$.

Recognition measures. To explore the influence of simulation valence on recognition of emotional narrative details, we ran separate 2 × 2 × 3 repeated measures ANOVAs with test delay (immediate, 48 hr), recognition detail type (positive, negative), and simulation valence (positive, negative, no simulation) for hits, false alarms, discriminability, and response bias.

For proportion of hits, a main effect of delay was found, with more hits for the immediate test delay, $F(1, 26) = 33.97$, $p < .001$, $\eta_p^2 = .57$. No main effects of detail type, simulation valence, or interactions were observed ($p > .098$; see Fig. 1a). For proportion of false alarms, the main effect of delay was significant, with more false alarms for the 48-hr test delay, $F(1, 26) = 27.20$, $p < .001$, $\eta_p^2 = .51$. The main effect of detail type was also significant, with more false alarms for positive details, $F(1, 26) = 10.48$, $p = .003$, $\eta_p^2 = .29$. No main effect of simulation valence or interactions were found ($p > .119$; see Fig. 1c).

For d', the main effect of delay was significant, with better discrimination in the immediate memory test, $F(1, 26) = 60.25$, $p < .001$, $\eta_p^2 = .70$. A main effect of detail was also found, with better discrimination for negative details, $F(1, 26) = 10.81$, $p = .003$, $\eta_p^2 = .29$. No main effect of simulation valence or interactions were found ($p > .150$; see Fig. 2a).

For C, no main effects of delay, detail, or simulation valence were observed ($p > .250$, $\eta_p^2 = .01$). The interaction between detail type and simulation valence was significant, indicating that response criterion to emotional details shifted depending on the valence of prior simulation, $F(1.55, 40.33) = 3.96$, $p = .036$, $\eta_p^2 = .13$. Pairwise comparisons demonstrated that following

Table 2. Mean Emotional Valence Ratings of Narratives During Encoding and Recognition in Experiments 1 and 2

	Simulation valence		
Experiment and procedure	Positive	Negative	No simulation
Experiment 1: future simulation			
Encoding	2.97 (0.30)	3.01 (0.42)	2.98 (0.36)
Experiment 2: future simulation			
Encoding	2.94 (0.48)	3.03 (0.33)	3.11 (0.33)
Recognition	3.17_a (0.43)	2.72_b (0.48)	2.94_b (0.52)
Experiment 2: past simulation			
Encoding	3.00 (0.41)	2.88 (0.32)	3.05 (0.40)
Recognition	3.28_a (0.66)	2.83_b (0.58)	2.92_b (0.40)

Note: Standard deviations are given in parentheses. Ratings were made on a 5-point scale (1 = *strongly negative*, 3 = *neutral*, 5 = *strongly positive*). Within a row, means with different subscripts are significantly different ($p < .05$).

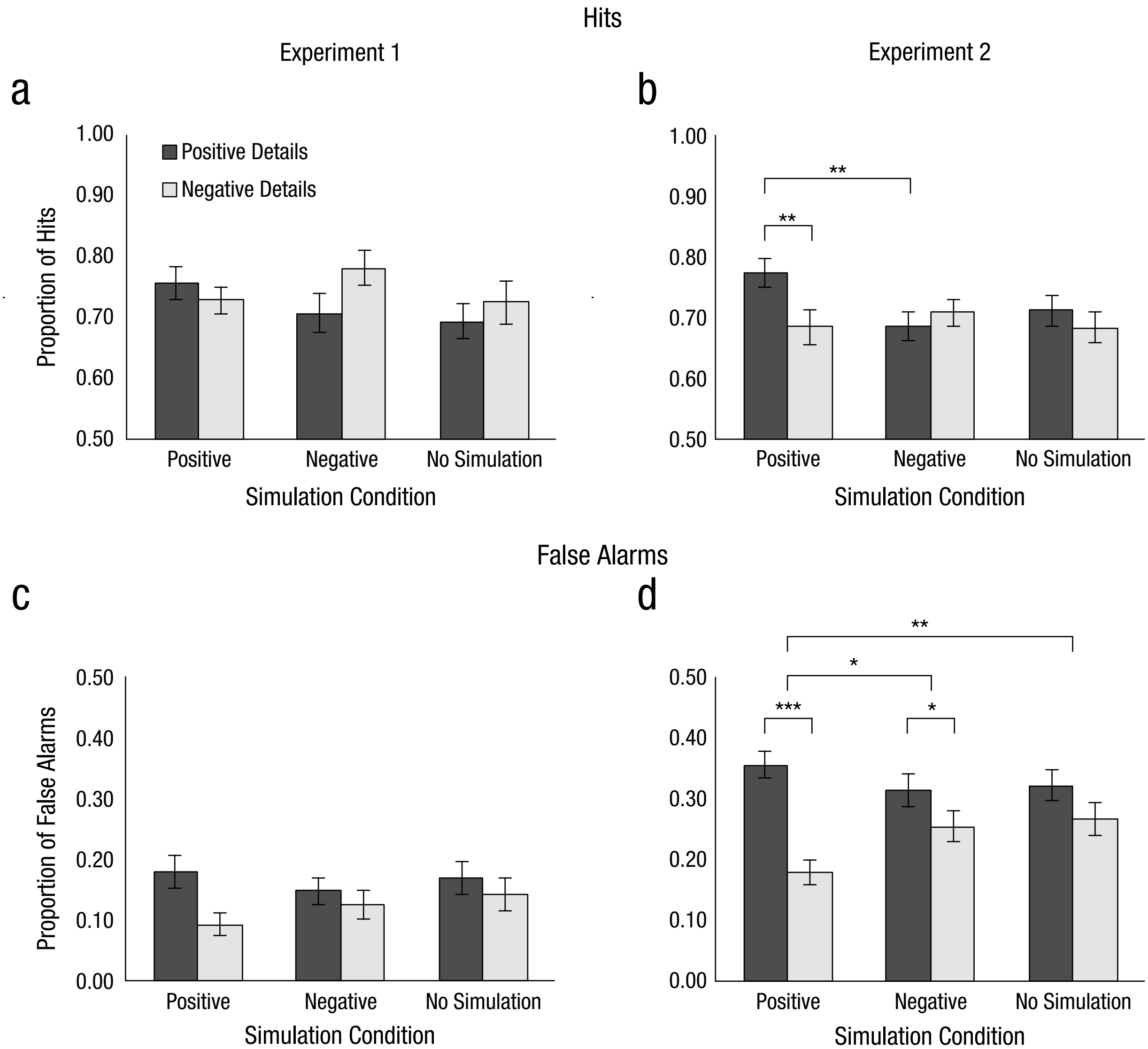

Fig. 1. Mean hit and false alarm rates for Experiment 1 (collapsed across time delay; a and c) and Experiment 2 (collapsed across past and future simulation; b and d) by simulation valence (positive, negative, no simulation) and valence of detail presented at recognition (positive, negative). Error bars depict standard errors. Asterisks indicate significant differences between conditions (*$p < .05$, **$p < .01$, ***$p < .001$).

positive simulation, response criterion was more liberal to positive compared with negative details ($p = .005$). No interactions with delay were significant ($p > .209$; see Fig. 2c).

Discussion

Experiment 1 examined the influence of future emotional simulation and testing delay on subsequent memory for emotional detail in event narratives. Positive simulation resulted in a liberal response bias for positive details and a conservative bias for negative details, regardless of test delay. Contrary to our hypotheses, negative simulation did not influence memory. These results are consistent with the wider literature showing a privileged position of positive future thinking on event likelihood ratings and subjective experience (e.g., Rasmussen & Berntsen, 2013; Sharot, 2011). We attempted to replicate and extend these results in Experiment 2 by examining whether past-oriented simulation exerts similar effects as future-oriented simulation.

Experiment 2

A number of studies have shown a greater positivity effect on likelihood and phenomenological ratings for future relative to past events (Berntsen & Bohn, 2010; Berntsen & Jacobsen, 2008; D'Argembeau & Van der

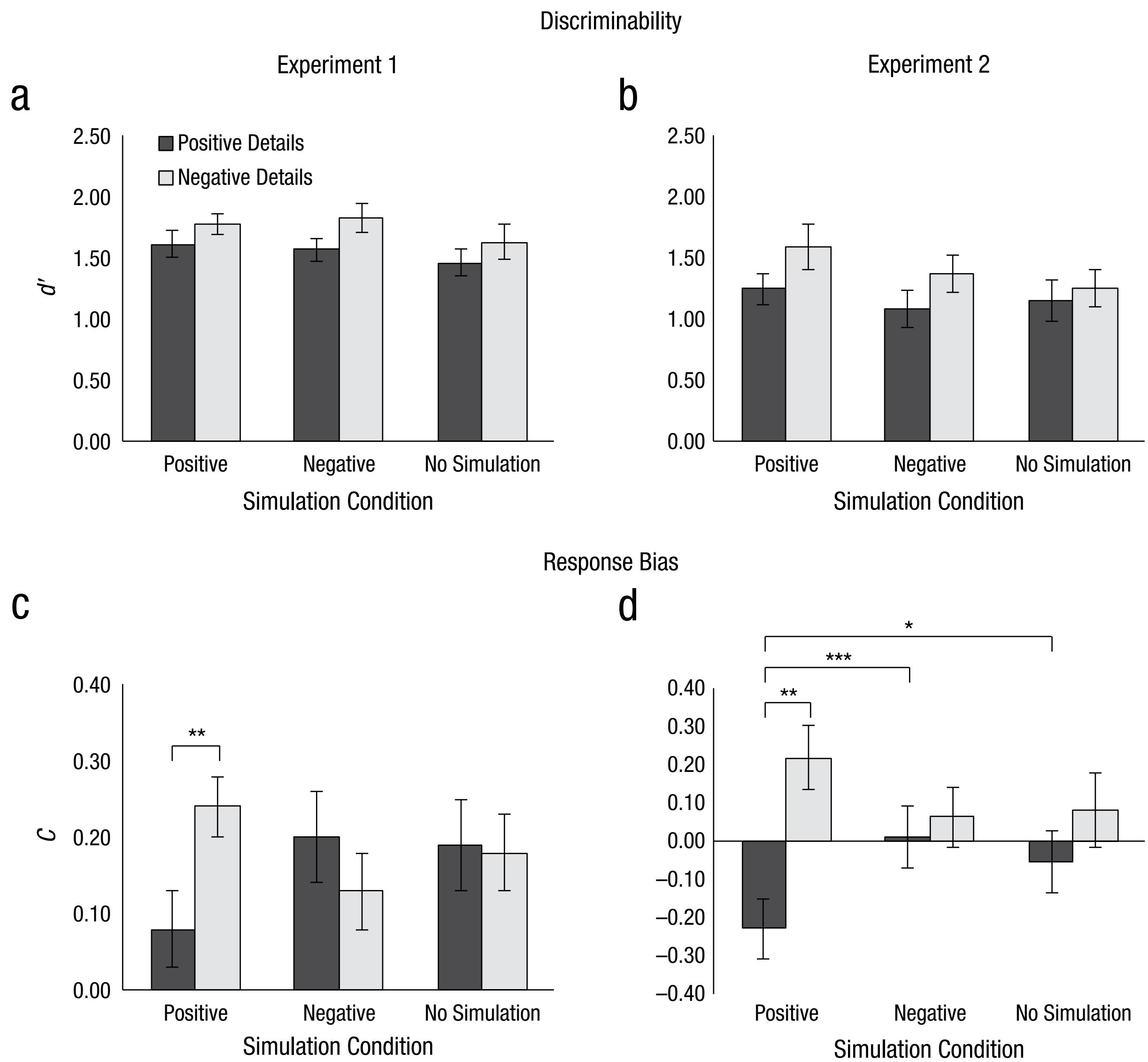

Fig. 2. Mean discriminability scores and response bias for Experiment 1 (collapsed across time delay; a and c) and Experiment 2 (collapsed across past and future simulation; b and d), by simulation valence (positive, negative, no simulation) and valence of detail presented at recognition (positive, negative). Higher *d*′ values indicate more accurate responses. Higher *C* values indicate more conservative responses. Error bars depict standard errors. Asterisks indicate significant differences between conditions (**p* < .05, ***p* < .01, ****p* < .001).

Linden, 2004; Newby-Clark & Ross, 2003; Rasmussen & Berntsen, 2013; Sharot, Riccardi, Raio, & Phelps, 2007), although whether this bias is a result of thinking about the future or of thought unconstrained by reality is difficult to determine, given that such comparisons typically confound temporal direction with memory and simulation (see Schacter et al., 2012; Sharot et al., 2007). Evidence for a role of temporal direction comes from episodic counterfactual thoughts, which involve simulating alternative outcomes to past personal episodes. While counterfactuals share many commonalities with future simulation, such as similar neural underpinnings and phenomenological characteristics (Schacter, Benoit, De Brigard, & Szpunar, 2015), they do not display a positivity bias (Özbek, Bohn, & Berntsen, 2017). However, counterfactuals are more constrained by reality than are future simulations, given that they are alterations of actual past events rather than entirely novel simulations, and so the distinction between temporality and factual constraints is still unclear. We disentangled these effects in Experiment 2 by manipulating past and future simulation as a between-subjects variable. Critically, past simulation in the current study was of events that did not take place and was therefore less constrained by reality than counterfactuals. If the positivity effect observed in Experiment 1 was a function of time, we would not expect a response bias following past simulation. However, if the positivity effect resulted from the absence of factual constraints, we expected a response bias following both past and future positive simulation.

Method

Participants. We recruited 59 young adults via postings at Harvard University. All participants were fluent English speakers; had no history of learning disabilities or neurological or psychiatric impairment; and had normal or corrected-to-normal vision. Participants gave informed consent in a manner approved by Harvard University's ethics board and were compensated with either course credit or $25 for participation. Three participants were excluded because they did not complete the experiment, and 6 were excluded for noncompliance. Therefore, data from 50 participants were included in analyses. As with Experiment 1, we aimed for a sample of 25 participants per between-subjects condition (past and future simulation). Participants in the past and future conditions did not differ in age—M_{past} = 23.40 years, SD = 3.34, M_{future} = 21.72 years, SD = 3.25, $t(48) = 1.80$, $p = .078$—or years of education—albeit this effect was trending, M_{past} = 15.69, SD = 1.97, M_{future} = 14.58, SD = 1.97, $t(47)$ = 1.97, $p = .055$. The future condition contained more males (11) than the past condition (4), $\chi^2(1) = 4.67$, $p = .031$.

Stimuli. Scenarios and narratives were the same as those used in Experiment 1, with the exception that false foil details (details not presented in the narrative) were replaced with false alternative details (details of opposing valence from the narrative). Therefore, each narrative contained 12 target details (4 positive, 4 negative, and 4 neutral).

Procedure. Experiment 2 followed a similar two-session protocol as Experiment 1, with notable differences described below. During the simulation phase, half the participants were randomly assigned to the *future condition* and received the same instructions as in Experiment 1. Half the participants were assigned to the *past condition* and were instructed to simulate each event happening at some point within the past year. Besides the temporal direction of simulation, all other instructions were identical to those in Experiment 1. Ratings of similarity to previous events for past simulations were low (M = 2.33 on a 5-point scale), indicating that participants were following instructions to simulate novel experiences, rather than recounting memories. To separate emotional valence effects from potential arousal differences, we asked participants to rate simulations for subjective arousal (1 = *calming/boring*, 5 = *exciting/agitating*), in addition to the ratings described in Experiment 1.

During the encoding phase, participants in the future condition received the same instructions as used in Experiment 1. Participants in the past condition were told to pretend they had regained memories of the last year and that they were going to find out how the events they simulated actually played out. Participants rated narratives for subjective arousal (1 = *calming/boring*, 5 = *exciting/agitating*), in addition to the ratings described in Experiment 1.

The recognition test for all narratives took place after a 48-hr delay and followed an identical procedure as in Experiment 1. Following the recognition test, participants rated the valence of each narrative (1 = *strongly negative*, 3 = *neutral*, 5 = *strongly positive*).

Results

Subjective ratings. Mixed 2 × 2 ANOVAs with simulation temporality (between subjects; past, future) and valence (within subjects; positive, negative) were run for each simulation rating (see Table 1). Positive simulations were rated higher than negative simulations in positive valence, confirming that participants were following instructions, $F(1, 48) = 186.82$, $p < .001$, $\eta_p^2 = .80$. Positive simulations were also rated higher in plausibility, $F(1, 48)$ = 28.20, $p < .001$, $\eta_p^2 = .37$, personal significance, SD = 0.75, $F(1, 48) = 23.58$, $p < .001$, $\eta_p^2 = .33$, and similarity to previous events, $F(1, 48) = 40.97$, $p < .001$, $\eta_p^2 = .46$. Compared with future simulations, past simulations were rated as more positive, $F(1, 48) = 6.98$, $p = .011$, $\eta_p^2 = .13$, and emotionally arousing, $F(1, 48) = 7.10$, $p = .010$, $\eta_p^2 = .13$.

Mixed 2 × 3 ANOVAs revealed no influence of simulation temporality (past, future) or valence (positive, negative, no simulation) on immediate narrative valence ratings or time taken to read each narrative (M = 60.03 s, SD = 19.94 s; $p > .081$). Simulation valence did impact narrative valence ratings collected after the recognition test, $F(2, 96) = 20.85$, $p < .001$, $\eta_p^2 = 0.30$ (see Table 2). Pairwise comparisons demonstrated that narratives were rated more positively if they were preceded by positive simulation, compared with both negative ($p <$ .001) and no simulation ($p < .001$). No effect of temporality was found ($p > .250$; see Table 2).

Recognition measures. To explore the influence of simulation temporality and valence on recognition of emotional narrative details, we ran separate 2 × 2 × 3 mixed ANOVAs with simulation temporality (between subjects; past, future), recognition detail type (within subjects; positive, negative), and simulation valence (within subjects; positive, negative, no simulation), for hits, false alarms, discriminability, and response bias.

For proportion of hits, no main effects of detail type, simulation valence, or temporality were found ($p > .064$). The detail-type-by-simulation-valence interaction was significant, indicating that prior simulation valence influenced correct identification of emotional narrative details, $F(2, 96) = 4.02$, $p = .021$, $\eta_p^2 = .08$. Pairwise comparisons revealed that, compared with negative details, positive details were more likely to result in hits following positive simulation ($p = .006$). Compared with negative simulation, positive simulation was more likely to result in hits for positive details ($p = .002$). No interactions with temporality were found ($p > .250$; see Fig. 1b).

For proportion of false alarms, there was a main effect of detail type, $F(1, 48) = 23.90$, $p < .001$, $\eta_p^2 = .33$, with more false alarms for positive details. No main effect of simulation valence or temporality was observed ($p > .250$). The detail-type-by-simulation-valence interaction was significant, $F(2, 96) = 8.62$, $p < .001$, $\eta_p^2 = .15$. Pairwise comparisons revealed that the increase in false alarms to positive compared with negative details was stronger following positive simulation ($p < .001$) than negative ($p = .036$) and no simulation ($p = .058$). Negative details were less likely to be falsely identified when the narratives were preceded by positive simulation, compared with both negative ($p = .011$) and no simulation ($p = .004$). The detail-type-by-temporality interaction was also significant, $F(1, 48) = 4.27$, $p = .044$, $\eta_p^2 = .08$. Pairwise comparisons show that although both past and future simulation were associated with more false alarms for positive compared with negative details, this difference was larger in magnitude for past simulation ($p < .001$) than future simulation ($p = .052$). No other interactions were found ($p > .227$; see Fig. 1d).

For d' a main effect of detail type was found, $F(1, 48) = 14.02$, $p < .001$, $\eta_p^2 = .23$, with better discrimination for negative details. A main effect of simulation valence was also observed, $F(2, 96) = 4.88$, $p = .010$, $\eta_p^2 = .09$, with better discrimination following positive simulation compared with negative ($p = .049$) and no simulation ($p = .029$). No main effect of temporality or interactions were found ($p > .115$; see Fig. 2b).

For *C,* we observed a significant main effect of detail type, $F(1, 48) = 19.47$, $p < .001$, $\eta_p^2 = .29$, with a more liberal bias for positive details. No main effect of simulation valence or temporality was observed ($p > .250$). The interaction between detail type and simulation condition was significant, $F(2, 96) = 9.11$, $p < .001$, $\eta_p^2 = .16$. Pairwise comparisons demonstrated that compared with negative details, response criterion was more liberal for positive details following positive simulation ($p < .001$). Moreover, response criterion was more liberal for positive details that were preceded by positive simulation, compared with both negative ($p < .001$) and no simulation ($p = .022$). No interactions with temporality were found ($p > .151$; see Fig. 2d).

Alternative explanations. In both Experiments 1 and 2, positive and negative simulations differed on subjective dimensions other than valence (plausibility, personal significance, and similarity to previous events). Negative future simulations also deviated more from the neutral midpoint in valence ratings than did positive simulations—Experiment 1: $t(26) = 2.35$, $p = .027$; Experiment 2: valence-by-temporality interaction, $F(1, 48) = 6.98$, $p = .011$, $\eta_p^2 = .13$; pairwise comparisons—future: $p = .004$, past: $p > .250$. We used the difference between positive and negative simulations for these ratings (for valence deviation, this was the difference between deviation of valence rating and midpoint) as covariates in the ANOVAs exploring response bias and found no effects on the detail-type-by-simulation-valence interaction, demonstrating that these factors do not account for the observed positivity bias.

To rule out the possibility that recognition differences were driven by a greater overlap between narrative content and positive simulation compared with negative simulation, we used the simulation audio recordings to identify the number of narrative target details spontaneously generated during future simulation in Experiment 2 (which exhibited the strongest positive bias). No differences were found in the number of positive target details generated in positive simulation and negative details in negative simulation: $M_{\text{positive}} = 0.71$, $SD = 0.34$, $M_{\text{negative}} = 0.86$, $SD = 0.49$; $t(24) = 1.56$, $p = .131$. Moreover, a positive bias was still apparent when excluding these generated target details, demonstrating that spontaneous generation of corroborating details does not account for the response bias following positive simulation. An important implication is that positive simulation results in a positive memory bias even when the specific details do not overlap between the simulated and actual event.

Discussion

In Experiment 2, we examined whether the temporal orientation of simulation had differential effects on subsequent memory for corresponding events and found similar effects for past and future simulation. Replicating Experiment 1, results showed that positive simulation biased responses toward positive information and away from negative information. Moreover, narratives preceded by positive simulation were rated more positively at retrieval.[2] While previous reports established future simulations as more positive than past memory (Berntsen & Bohn, 2010; Newby-Clark & Ross, 2003; Rasmussen & Berntsen, 2013; Sharot et al., 2007), we found that for simulated events the past was rated more favorably than the future. The current findings indicate that the positivity effect is not a function of time but a consequence of the relaxed factual constraints of simulation.

General Discussion

These experiments are the first to show that simulating a future event changes how that event is remembered once it comes to pass, a vital topic given the frequency with which we simulate upcoming events in everyday life (D'Argembeau et al., 2011). We demonstrated that neutral events were remembered as more positive if they were first simulated in a positive way: This pattern was evident in both a liberal response bias for positive information and more favorable emotion ratings for the event in retrospect. In contrast, negative simulation did not impact subsequent memory.

Why is the effect of simulation on subsequent memory specific to positive simulation? Emotional valence is thought to differentially impact encoding processes, with negative affect enhancing specific item processing and therefore memory accuracy and positive affect increasing schematic processing and memory distortions (Bless et al., 1996; Bohn & Berntsen, 2007; Kensinger, 2009; Kensinger & Schacter, 2006; Levine & Bluck, 2004; Mather, 2007; Storbeck & Clore, 2005). Consistent with this premise, our results revealed more false alarms for positive than negative details overall. By this account, memory for positive simulations would be more conceptual and contain fewer cues useful for determining source than negative simulations would (cf. source-monitoring framework; Johnson, Hashtroudi, & Lindsay, 1993). With fewer source cues available, the affect associated with positive simulations is more likely to be misattributed as belonging to the narrative, which would then bias responses toward positive details. Simulation did not influence narrative valence ratings during encoding, suggesting that this transfer of affect occurs during consolidation or retrieval. However, an important caveat to note is that in contrast to the participant-generated simulations, the narratives in the current study were experimenter-generated substitutes for personally experienced events, and these results remain to be replicated using real-world events.

Our results dovetail with findings that healthy adults often adopt an unrealistically favorable outlook (Sharot, 2011; Sharot, Korn, & Dolan, 2011). It is generally beneficial for motivation and well-being to be optimistic about the future and to remember positive events that could help obtain future rewards (Scheier & Carver, 1992; Sharot, 2011; Walker & Skowronski, 2009). Future thoughts tend to be positively biased (Berntsen & Jacobsen, 2008; D'Argembeau et al., 2011), and positive simulations are more easily constructed, contain greater sensorial and time details, and are better remembered over time compared with neutral and negative simulations (D'Argembeau et al., 2011; D'Argembeau & Van der Linden, 2004; de Vito, Neroni, Gamboz, Della Sala, & Brandimonte, 2015; Sharot et al., 2007; Szpunar et al., 2012). We extend these findings by showing that an optimistic outlook can transfer to a rosier reflection once upcoming experiences become part of the personal past. In light of the current findings, examining the influence of simulation on memory in populations with negatively biased future thoughts, such as patients with affective disorders, would be of interest (Korn, Sharot, Walter, Heekeren, & Dolan, 2014; MacLeod, Tata, Kentish, & Jacobsen, 1997).

In sum, the current study expands our understanding of optimistic biases in future thinking by demonstrating that adopting a positive outlook results in a rosy memory. These results add to recent attempts to understand the adaptive functions of future-directed thinking (e.g., Schacter et al., 2017), providing novel insights into the cognitive consequences of episodic future simulation.

Action Editor

Kathleen McDermott served as action editor for this article.

Author Contributions

A. L. Devitt and D. L. Schacter developed the study design. A. L. Devitt collected and analyzed the data. A. L. Devitt and D. L. Schacter wrote the manuscript.

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Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Supplemental Material

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Open Practices

All data and materials have been made publicly available via Harvard Dataverse and can be accessed at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/JLWQY9. The design and analysis plans for these experiments were not preregistered. The complete Open Practices Disclosure for this article can be found at http://journals.sagepub

.com/doi/suppl/10.1177/0956797617753936. This article has received badges for Open Data and Open Materials. More information about the Open Practices badges can be found at http://www.psychologicalscience.org/publications/badges.

Notes

1. No significant interactions were found between false-detail type and simulation condition in a 2 × 2 × 2 × 3 repeated measures ANOVA with false-detail type (alternative, foil), delay (immediate, 48 hr), detail valence (positive, negative), and simulation condition (positive, negative, no simulation).
2. Given that recognition test performance may have biased retrospective emotional valence ratings, the question of whether events preceded by positive simulation would be rated more favorably without a prior recognition test remains open.

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