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Memory for Emotional Simulations: Remembering a Rosy Future

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Abstract

Mental simulations of future experiences are often concerned with emotionally arousing events. Although it is widely believed that mental simulations enhance future behavior, virtually nothing is known about how memory for these simulations changes over time or whether simulations of emotional experiences are especially well remembered. We used a novel paradigm that combined recently developed methods for generating simulations of future events and well-established procedures for testing memory to examine the retention of positive, negative, and neutral simulations over delays of 10 min and 1 day. We found that at the longer delay, details associated with negative simulations were more difficult to remember than details associated with positive or neutral simulations. We suggest that these effects reflect the influence of the fading-affect bias, whereby negative reactions fade more quickly than positive reactions, and that this influence results in a tendency to remember a rosy simulated future. We discuss implications of our findings for individuals with affective disorders, such as depression and anxiety.

Keywords

emotions, episodic memory, autobiographical memory, long-term memory, episodic future thinking

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Over the past several years, research from diverse domains, including cognitive and social psychology, psychopathology, neuropsychology, and cognitive and affective neuroscience, has revealed that memory plays an important role in the mental simulation of future events (for reviews, see Schacter, Addis, & Buckner, 2008; Szpunar, 2010). For example, many brain regions that support memory for past events are similarly involved in the simulation of possible future events (e.g., Addis, Wong, & Schacter, 2007; Okuda et al., 2003; Szpunar, Watson, & McDermott, 2007).

This growing literature has highlighted the adaptive value of memory in allowing people to prepare for the future (Schacter & Addis, 2007; Suddendorf & Corballis, 2007). However, little is known about the functional significance of simulating future events or the fate of such simulations over time: Does remembering the details of simulated future events confer any benefits? Ingvar (1985) suggested that such "memories of the future" represent an important adaptation: Remembering planned actions and reactions makes future behavior more efficient. Indeed, the limited available data suggest that simulated future events are well remembered (Klein, Robertson, & Delton, 2010; McDonough & Gallo, 2010). Nonetheless, simulations of the future can take many forms, and, to our knowledge, no studies have yet examined whether certain kinds of simulations are better remembered than others.

One important characteristic of future-event simulations is whether or not the simulated events are emotionally arousing. D'Argembeau, Renaud, and Van der Linden (2011) reported that nearly two thirds of everyday future-event simulations are emotionally charged (i.e., positive or negative). Moreover, these emotional simulations are rated higher on measures of personal importance than are nonemotional simulations. Given the frequency and importance of emotional simulations, we sought to explore the critical question of whether emotional simulations are better remembered over time than neutral simulations are, and hence more available to influence future behavior. No studies have yet addressed this issue. Although the literature on emotion and memory generally supports the idea that positive and negative events are better remembered than neutral events are (for reviews, see Kensinger, 2009; Phelps, 2006), research has shown that emotional arousal can impair memory under certain conditions (Kensinger, 2009; Mather & Sutherland, 2011).

Moreover, few studies have examined the fate of emotional memories at multiple points in time, and the studies that have

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provide the basis for competing predictions. Studies focusing on future utility have shown that some types of negative stimuli (e.g., highly arousing words or photos) are more resistant to forgetting than are neutral stimuli (e.g., nonarousing words or photos; e.g., Sharot & Phelps, 2004; Sharot & Yonelinas, 2008). Conversely, studies focusing on psychological well-being (Taylor, 1991) have shown that the affect associated with negative experiences tends to fade more quickly than the affect associated with positive experiences does (for a review, see Walker & Skowronski, 2009). Although it is unclear whether this fading-affect bias represents a loss in memory for details associated with negative experiences, there are conditions in which negative experiences are remembered less well over time than positive experiences are (Holmes, 1970; see also Stagner, 1931; Thompson, 1930).

We set out to directly examine, for the first time, the relative memorability of positive, negative, and neutral future-event simulations and to present a new paradigm for approaching such issues that combines recently developed methods for generating simulations of future events (Addis, Musicaro, Pan, & Schacter, 2010; Addis, Pan, Vu, Laiser, & Schacter, 2009) and well-established procedures for testing memory (see also Martin, Schacter, Corballis, & Addis, 2011).

Method

Participants

Forty-eight Boston University students were recruited via the Boston University Job Service. They provided informed written consent in a manner approved by Harvard's institutional review board.

Stimulus collection and preparation

One week before the future-simulation session, participants visited the laboratory and generated a set of 110 familiar people, places, and objects. Participants in Experiment 1a accomplished this task via an adapted version of the *experimental recombination procedure* (Addis et al., 2009, 2010). This procedure required participants to generate a set of 110 personal memories from the past 10 years of their lives; each event in these memories had to be specific to a particular time and place and had to have lasted for no more than 1 day. For each memory, participants provided a brief description that included the following details: a person other than themselves who was involved, the location where the event occurred, and a salient object present during the event (Fig. 1). A given person, place, or object could be mentioned only once in the entire set of 110 memories. We provided participants with an extensive list of common experiences to help them generate their lists of memories. In Experiment 1b, to ensure that the retrieval of personal memories did not interfere with participants' later memory for future simulations, we had participants provide separate lists of 110 familiar people (drawn from Facebook friends lists), 110 familiar places, and 110 familiar objects. The stimulus-collection phase lasted approximately 3 hr in Experiment 1a and approximately 2 hr in Experiment 1b.

The lists were subsequently examined for quality; we selected the 93 best examples of people, the 93 best examples of places, and the 93 best examples of objects from each list and randomly recombined them to create 93 simulation cues (i.e., novel combinations of people, places, and objects; see Fig. 1).

Future-event simulation

One week after the stimulus-collection phase, participants returned to the laboratory to simulate 30 positive, 30 negative, and 30 neutral future events (in random order). On each of the 90 trials, participants were presented with a simulation cue that was accompanied by one of three emotion tags (positive, negative, or neutral; see Fig. 1). Participants were allotted 12.5 s to generate a plausible future event that included the person, place, and object in the simulation cue; that could possibly take place within the next 5 years; and that would evoke the emotion indicated by the tag. After each trial, participants used 5-point scales to rate the simulation they had generated on three phenomenological measures: valence (1 = *very negative*, 5 = *very positive*), arousal (1 = *very exciting*, 5 = *very relaxing*), and level of detail (1 = *few details*, 5 = *many details*). Participants had 5 s to make each rating. The order of ratings was counterbalanced across participants for a total of six possible orders.

To ensure that participants understood all instructions and were able to simulate future events within the stipulated time period, we ran three practice trials in which participants described the content of their simulations to the experimenter. In order to make the task of engaging in mental simulation as natural as possible, we did not collect verbal descriptions during experimental trials. After the experimental trials, all participants reported that their simulations were novel (i.e., the participants had not previously thought about or experienced the simulations). Study materials were presented with E-Prime software Version 1.0 (Psychology Software Tools, Pittsburgh, PA) on a Dell desktop computer, and participants used a keyboard to rate the valence, arousal, and level of detail of each simulation. The simulation phase lasted approximately 40 min.

Cued-recall test

Immediately after the simulation phase in both experiments, participants were told that they would work through a set of logic puzzles for 10 min and that they would complete an additional set of simulation trials either immediately after they finished the puzzles or 1 day later (counterbalanced between subjects). Either after they had completed the puzzles or 1 day later, participants were presented with a surprise cued-recall memory test. None of the participants reported that they had expected this test. The test consisted of 90 trials. On each trial,

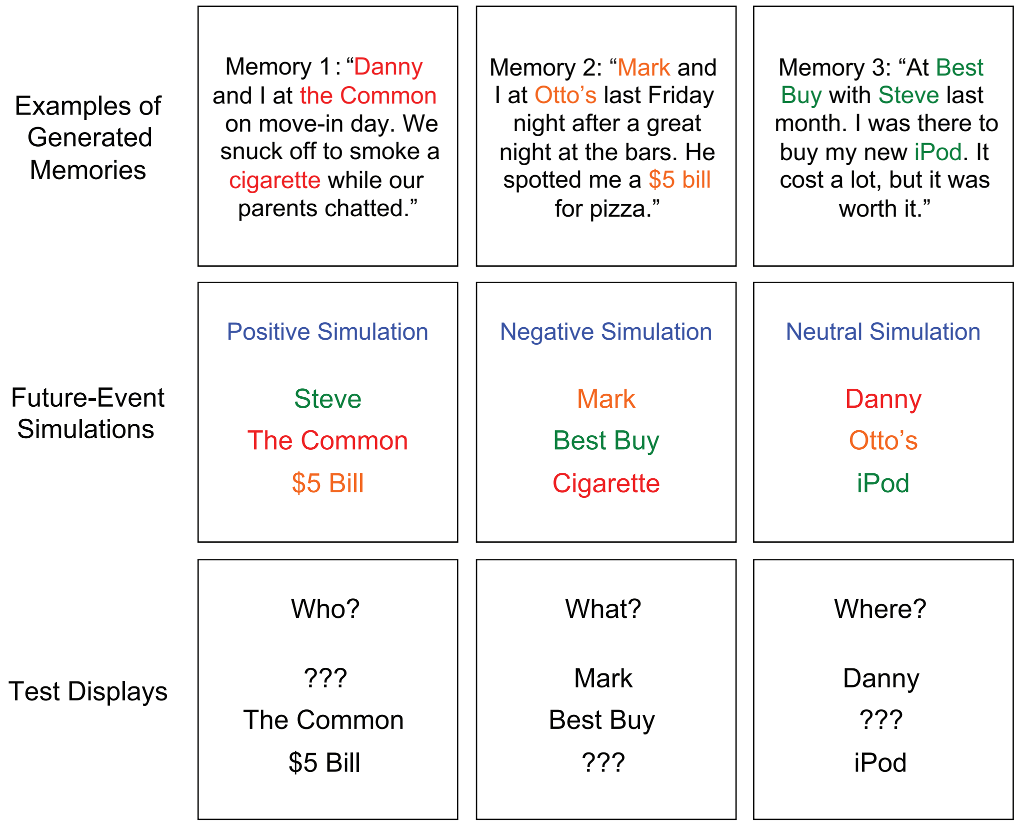

Fig. 1. Illustration of materials, stimuli, and test displays from Experiments 1a and 1b. The top row shows three example memories generated by participants in Experiment 1a; each memory had to include a familiar person, place, and object (highlighted here by colored fonts). In Experiment 1b, participants instead generated lists of familiar people, places, and objects. The middle row illustrates how simulation cues were created in the two experiments. Each simulation cue consisted of a familiar person, place, and object randomly drawn from participants' generated memories or lists; participants used these cues to mentally simulate positive, negative, and neutral future events. The bottom row illustrates test displays corresponding to the simulation cues; participants were shown two details from a simulation cue and had to recall the third detail.

two of the three details (person and place, place and object, or person and object) from a simulation cue were presented, and participants were instructed to recall the corresponding simulation they had generated and to fill in the missing detail (Fig. 1; cf. Jones, 1976). The three types of details were missing an equal number of times in each of the three emotion conditions (i.e., positive, negative, or neutral simulations; note that emotion tags were not presented during the test). Participants were told that they were allowed to guess, but only if they were reasonably certain of the correct answer. Test materials were presented with E-Prime software Version 1.0 on a Dell desktop computer, and participants made their responses using a keyboard. The test was self-paced and lasted approximately 30 min.

Results

Phenomenological ratings

Table 1 presents the mean phenomenological ratings for positive, negative, and neutral simulations. Mann-Whitney *U* tests showed that ratings did not differ as a function of experiment (Experiment 1a or Experiment 1b) or delay (10 min or 1 day; all $zs \leq 1.73$), so we collapsed the ratings across these factors. Friedman tests demonstrated that ratings of valence, level of detail, and arousal differed significantly as a function of emotion—valence: $\chi^2(2, N = 48) = 92.17, p < .001$; level of detail: $\chi^2(2, N = 48) = 27.83, p < .001$; arousal: $\chi^2(2, N = 48) = 60.76, p < .001$. Wilcoxon tests further showed that positive and negative simulations were rated as more positive ($z = 6.03$,

Table 1. Mean Phenomenological Ratings in Experiments 1a and 1b

Phenomenological aspect	Positive simulations	Negative simulations	Neutral simulations
Valence	4.11 (0.30)	1.89 (0.51)	3.22 (0.38)
Level of detail	3.79 (0.46)	3.58 (0.56)	3.45 (0.61)
Arousal	2.91 (0.63)	1.97 (0.46)	2.97 (0.31)

Note: Standard deviations are shown in parentheses.

$p < .001$) and more negative ($z = 6.03$, $p < .001$), respectively, than neutral simulations were. Positive simulations were rated as more detailed than negative ($z = 3.68$, $p < .001$) and neutral ($z = 5.26$, $p < .001$) simulations were, and negative simulations were rated as more detailed than neutral simulations were ($z = 2.06$, $p = .04$). Negative simulations were rated as being more arousing than positive simulations ($z = 5.76$, $p < .001$) or neutral simulations ($z = 6.00$, $p < .001$), whereas positive and neutral simulations did not differ in arousal ratings ($z = 1.03$, $p = .30$).

Memory performance

The proportion of correct responses on the cued-recall test was subjected to a 2 (experiment: Experiment 1a, Experiment 1b) × 2 (delay: 10 min, 1 day) × 3 (emotion: positive, negative, neutral) × 3 (type of detail: person, place, object) mixed analysis of variance (ANOVA), with experiment and delay entered as between-subjects factors and emotion and type of detail entered as within-subjects factors.

Results for the between-subjects factors revealed that there was no main effect of experiment, $F(1, 44) = 1.10$, $p = .30$, but there was a main effect of delay, $F(1, 44) = 31.33$, $p < .001$, $\eta_p^2 = .42$; simulations were better remembered after 10 min ($M = .63$) than they were after 1 day ($M = .32$). We found no interaction between experiment and delay ($F < 1$).

Results for the within-subjects factors revealed a main effect of emotion, $F(2, 88) = 7.36$, $p = .001$, $\eta_p^2 = .14$, and post hoc paired-samples t tests showed that positive simulations ($M = .51$) were better remembered than were negative simulations ($M = .46$), $t(47) = 2.90$, $p = .006$, $d = 0.42$, or neutral simulations ($M = .46$), $t(47) = 3.66$, $p = .001$, $d = 0.53$. We also found a main effect of type of detail, $F(2, 88) = 48.36$, $p < .001$, $\eta_p^2 = .53$, and post hoc paired-samples t tests showed that participants performed best when they were cued to remember people ($M = .58$) as opposed to objects ($M = .43$), $t(47) = 7.70$, $p < .001$, $d = 1.12$, or places ($M = .42$), $t(47) = 9.53$, $p < .001$, $d = 1.38$. We found no interaction between emotion and type of detail, $F(4, 176) = 1.65$, $p = .17$.

Critically, the only interaction of between-subjects and within-subjects factors was an interaction between delay and emotion, $F(2, 88) = 7.73$, $p < .001$, $\eta_p^2 = .15$ (see Fig. 2); all other higher-order interactions were nonsignificant. The interaction between delay and emotion was similar in Experiments 1a and 1b, which suggests that the reactivation of personal memories in Experiment 1a had little or no influence on later

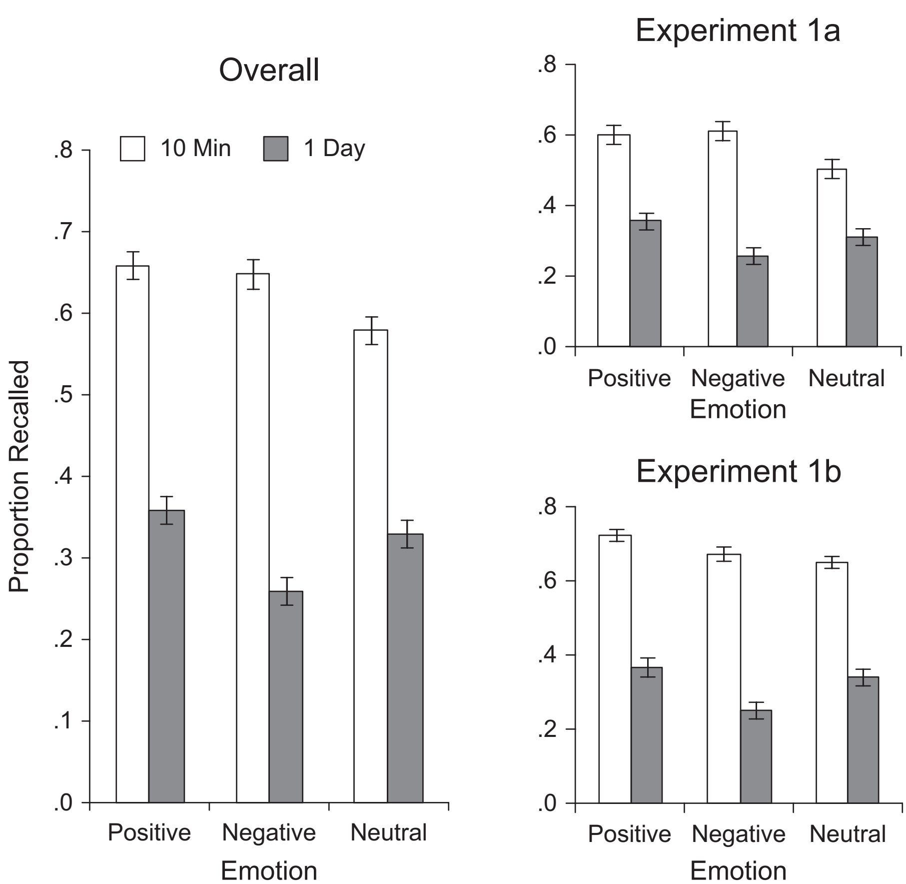

Fig. 2. Proportion of positive, negative, and neutral simulations recalled in each delay condition (10 min or 1 day). The panel on the left presents results for the two experiments combined, and the panels on the right present results separately for the two experiments. Error bars represent standard errors of the mean.

memory for simulations of future events. We further assessed this interaction with three additional 2 (delay) × 2 (emotion) mixed ANOVAs and associated paired-samples *t* tests. There was a significant interaction between delay and emotion in the ANOVA including positive and negative simulations, $F(1, 46) = 4.94$, $p = .031$, $\eta_p^2 = .10$; positive and negative simulations were remembered equally well after 10 min, but negative simulations were remembered less well than positive simulations were after 1 day, $t(23) = 3.68$, $p = .001$, $d = 0.80$. There was also a significant interaction between delay and emotion in the ANOVA including negative and neutral simulations, $F(1, 46) = 16.80$, $p < .001$, $\eta_p^2 = .27$; negative simulations were remembered better than neutral simulations after 10 min, $t(23) = 2.74$, $p = .012$, $d = 0.57$, but were remembered less well than neutral simulations after 1 day, $t(23) = 3.17$, $p = .004$, $d = 0.69$. We found no interaction between delay and emotion in the ANOVA including positive and neutral simulations, $F(1, 46) = 2.28$, $p = .14$, although positive simulations were better remembered than neutral simulations after 10 min, $t(23) = 4.21$, $p < .001$, $d = 0.88$.[1]

Discussion

These experiments demonstrate that, over time, details associated with negative simulations of future events are more difficult to remember than are details associated with positive and neutral simulations. Our data fit well with previous studies showing that emotional reactions to negative life experiences fade more quickly than emotional reactions to positive life experiences do. Although most studies demonstrating this fading-affect bias have lacked objective measures of memory (for a discussion, see Walker & Skowronski, 2009), experimental evidence suggests that negative experiences are sometimes remembered less well over time than positive experiences are (Holmes, 1970; Stagner, 1931; Thompson, 1930).

Why are details associated with simulations of negative future events difficult to remember over time? We propose a hypothesis that links the fading-affect bias with binding of and memory for details of events. Mather and her colleagues have argued that emotional arousal facilitates the binding of event details when people attempt to integrate those details into a coherent mental representation (for a review, see Mather & Sutherland, 2011). Extending this idea, we suggest that the affect associated with the mental simulation of a future event serves to link together the components of that simulation. As the affective component dissipates, so too does the integrity of the associated mental simulation. If negative affect fades more quickly over time than positive affect does, as research on the fading-affect bias has shown, then long retention intervals should affect memory for negative simulations more adversely than memory for positive or neutral simulations.[2]

Although this account fits well with the results of our experiments, it is uncertain how broadly the hypothesis can be extended. For example, it is unclear whether the hypothesis could explain why traumatic experiences are resistant to forgetting (Porter & Peace, 2007). Moreover, simulations of emotional future events often have to do with the distant future (e.g., retirement); it remains to be seen whether a pattern of results similar to the results reported here would emerge over extended delays. Finally, although participants in our experiments were instructed to simulate future events during the simulation phase and to retrieve those simulations during the cued-recall test, associations among person-, place-, and object-related details formed during the simulation phase (i.e., during encoding) probably influenced performance on the test.

Nonetheless, our data fit nicely with theories that emphasize the importance of adaptive cognitive processes that promote psychological well-being (Taylor, 1991). Healthy adults often think about their futures in an overly positive light (Sharot, Riccardi, Raio, & Phelps, 2007; Weinstein, 1980). The present data suggest that optimistic views of the future can be compounded by the effects of the fading-affect bias, such that the "remembered future" is extremely rosy. In light of these considerations, future research examining memory for emotional simulations in patients with affective disorders, such as depression and anxiety, would be of considerable interest. Previous studies have revealed that future-event simulations tend to be negatively biased in such patients (e.g., MacLeod, Tata, Kentish, & Jacobsen, 1997; Williams et al., 1996), but have not examined the nature of patients' memories for those simulations. Understanding when the remembered future is rosy and when it is not so rosy should increase researchers' understanding of the relations among emotion, memory, and future-directed thinking.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Notes

1. A multilevel hierarchical analysis demonstrated that ratings of detail, but not arousal, were related to performance on the cued-recall test, and that memory for negative simulations after a 1-day delay was impaired even when ratings of detail and arousal were statistically taken into account.
2. Although neutral simulations were remembered less well than negative simulations after a short delay, the positively biased valence of the neutral simulations may have benefitted their long-term retention relative to negative simulations.

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