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Remembering Possible Times: Memory for Details of Past, Future, and Counterfactual Simulations

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People's capacity to mentally simulate future events (*episodic future thinking*) as well as what could have occurred in the past but did not (*episodic counterfactual thinking*) critically depends on their capacity to retrieve episodic memories. All 3 mental simulations are likely adaptive in that they involve rehearsing possible scenarios with the goal of improving future performance. However, the extent to which these mental simulations are useful at a later time depends on how well they are later remembered. Unfortunately, little is known about how such simulations are remembered. In the current study, we explored this issue by asking participants to retrieve episodic memories and generate future and counterfactual simulations in response to 4 cues: particular places, people, objects, and times. A day later participants received 3 of the 4 cues and were asked to recall the remaining 1. Our results indicate that people and locations are equally well remembered, regardless of the temporal orientation of the mental simulation. In contrast, objects in future simulations are recalled less frequently than are those in memories. Time was poorly remembered across conditions but especially when remembering a future or a counterfactual simulation. In light of these results, we discuss how temporal information may be incorporated into our hypothetical episodic simulations.

Keywords: episodic future thinking, episodic counterfactual thinking, mental simulation, episodic memory, time

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> On the basis of previous experiences, represented in memories, the brain—one's mind—is automatically busy with extrapolation of future events and, as it appears, constructing alternative hypothetical behavioral patterns in order to be ready for what may happen.
> (Ingvar, 1979, p. 21)

People are not always thinking about the present. Instead, they are often thinking about events beyond the here and now. For instance, when remembering, they focus their thoughts on past events. Imagination also allows them to think about noncurrent times, as when they engage in episodic future thinking (Szpunar, 2010) and mentally simulate possible events that may occur in the future. Research from the last two decades has uncovered significant similarities between retrieving episodic memories

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and future thinking (Schacter et al., 2012), suggesting that common neural and cognitive mechanisms support people's capacity to mentally "travel in time," whether toward the past or the future (Tulving, 1983; Suddendorf & Corballis, 2007).

Building upon an earlier suggestion by David H. Ingvar (1979, 1985), researchers have proposed that shared adaptive purposes drive the neural and cognitive similarities between episodic memory and future thinking (Schacter & Addis, 2007; Szpunar, Addis, McLelland, & Schacter, 2013). Ingvar's key insight was that people are constantly storing and using memory representations, not only to remember prior experiences but also to construct hypothetical "simulations of behavior" in order to anticipate what may happen (Ingvar, 1979, p. 21). For example, when sending a sensitive text message, one might retrieve relevant memories of past experiences to simulate what the friend's reaction might be. Thus, it is not surprising that similar processes are engaged during the reconstruction of episodic memories and in the construction of simulations about possible future events. Ingvar went on to suggest that the usefulness of these simulations depends in part upon remembering these "memories of the future"—that is, one's ability to bring back to mind the content of the future simulations that were previously created (Ingvar, 1985). Returning to the texting example, mentally simulating different possible outcomes will not help one to decide what to write if one cannot remember the friend's imagined reactions.

Although scant, recent research has begun to explore how people remember the content of their episodic future thoughts. Some studies, for instance, have suggested that mental simulations with future-oriented contents are better encoded than are past-oriented or nontemporal contents (Klein, Robertson, & Delton, 2011; McDonough & Gallo, 2010). More recently, Szpunar, Addis, and Schacter (2012) showed that participants had poorer retention of episodic components from negative future simulations relative to both positive and neutral ones. In a similar way, McLelland, Devitt, Schacter, and Addis (2015) asked participants to generate episodic future simulations combining a person, a place, and an object randomly selected from their previously reported autobiographical memories. Participants then rated these simulations on a number of phenomenological measures. McLelland et al.'s results showed that ratings of familiarity, detail, and perceived plausibility during episodic simulation were significant predictors of participants' subsequent successful recollection of the simulated episodic components.

However, next to nothing is known about how people remember another kind of episodic simulation: *episodic counterfactual thinking,* understood as thoughts about alternative ways in which past personal events could have occurred but did not (De Brigard & Giovanello, 2012; De Brigard & Parikh, 2019). Recent studies have strongly suggested neural (De Brigard, Addis, Ford, Schacter, & Giovanello, 2013; Van Hoeck et al., 2013), behavioral (De Brigard & Giovanello, 2012; Özbek, Bohn, & Berntsen, 2017), and developmental (De Brigard et al., 2016; De Brigard, Rodriguez, & Montañés, 2017) commonalities in the processes underlying episodic memory and both future and counterfactual thinking (Schacter, Benoit, De Brigard, & Szpunar, 2015). From the point of view of Ingvar's (1979, 1985) proposal, this functional overlap is unsurprising: Simulated hypothetical behaviors need not be placed in a possible future to inform one's future behavior. They can also be thought of as occurring in the past; for example, one may mentally simulate how a past angry text exchange could have been defused if only one had acted differently. Indeed, there is ample evidence in support of this claim, because numerous experiments have strongly suggested that engaging in episodic counterfactual thinking constitutes a successful strategy to improve future performance in a variety of domains. The strength of this evidence forms the backbone of the "functional theory of counterfactual thinking" (Epstude & Roese, 2008; Roese, 1997; Roese & Epstude, 2017), which frames episodic counterfactual thinking as goal-directed and adaptive.

Given the neural, behavioral, and functional commonalities between episodic future and counterfactual thinking, it is worth asking—in Ingvar's guise—how well one remembers one's episodic counterfactual simulations. The current study explores this question. Inspired by McLelland and colleagues' (2015) design, participants were asked to simulate past, future, and counterfactual personal events and to identify four components for each event: a person, an object, a place, and a time. A day later, participants were given three out of the four components from each simulation and were asked to retrieve the missing component.

This experimental paradigm allowed us to investigate four main questions. First, do people remember the details of hypothetical simulations (i.e., future and counterfactual) at a rate comparable to that of episodic memories? Given that episodic autobiographical memories are likely to be more vivid and detailed relative to imagined hypothetical simulations (e.g., Johnson, Foley, Suengas, & Raye, 1988), we predicted higher retrieval rates of components from episodic memories relative to both future and counterfactual simulations. Second, are there significant differences in what is recalled when remembering the details of future versus counterfactual simulations? Because episodic counterfactual thoughts are usually variations on experienced events, we hypothesized there may be a carryover effect in retention such that the details of counterfactuals may be better remembered than are those of future simulations.

Third, are all types of event details equally well remembered, across the different mental simulations? Based upon recent work by Jeunehomme and D'Argembeau (2017), we hypothesized that person and place information would be better remembered across all conditions relative to object and time (Wagenaar, 1986). Finally, is temporal information equally well remembered across all three conditions? Given prior evidence suggesting somewhat poor retention of temporal information in autobiographical memory (Friedman, 1993, 2004), we hypothesized that, for autobiographical memory, the time component would be less well remembered than would the place, person, and object components. However, given the lack of prior evidence regarding memory for temporal components in episodic future and counterfactual thinking, we had no specific predictions about relative memory performance for the time component across these two conditions.

Method

Participants

Twenty-four young adults ($M_{\text{age}} = 21.83$, $SD = 2.78$, range = 18–30; 19 women) participated in the current study for monetary compensation. Because the current study closely follows McLelland et al.'s (2015) study, the number of participants was based upon their sample size. The study was approved by the Duke University Institutional Review Board, and participants provided written consent prior to participating. All participants were fluent in English and did not suffer any neurological or psychiatric conditions.

Procedure

The current study consisted of two sessions. In Session 1, participants generated 72 episodic simulations, with 24 in each of three conditions: memory, future, and counterfactual. For the memory condition, participants retrieved 24 single episodic recollections and identified a unique person, a unique object, and the precise location and time (year and month) in which the event took place. All events were restricted to the past 10 years. For the future condition, participants described 24 single imagined episodes that could plausibly occur to them in the next 10 years and were asked to identify a unique person, a unique object, and the precise location and time (year and month) in which the event would take place. Finally, in the counterfactual condition, participants described 24 single imagined events that could have plausibly occurred to them in their past 10 years and were asked to identify a unique person, a unique object, and the precise location and time (year and month) in which the event could have taken place. Participants' simulations were registered in a spreadsheet, with a column indicating the event type (i.e., memory, possible past, possible future); a column for them to type a short description of the event; a column for a short title; and then columns to type the time, person, place, and object components. Additionally, participants also provided ratings of vividness for each simulation, rated from 1 (*Low*) to 5 (*High*), and valence, rated from 1 (*Negative*) to 5 (*Positive*). Trials were interspersed. In cases where participants reported difficulty generating simulations, we prompted them to think of their Facebook friends, because this support strategy has successfully helped participants to generate events in other experiments (e.g., Szpunar et al., 2012). Finally, to help ensure adherence to the instructions, we provided participants with examples for each condition and access to the instructions throughout (see the online supplemental materials).

Session 2 took place a day later. Participants performed a self-paced cued-recall test in which they saw the title of each simulation generated in the previous session, as well as three of the four simulation components. Their task was to remember the fourth component and to type the answer in the relevant space on the screen. Presented in random order, trials were counter-balanced over components, with 18 trials testing memory for person, 18 for place, 18 for object, and 18 for time across the three conditions, respectively. Following McLelland et al. (2015), only trials where participants provided the correct event component were considered successfully retrieved. At the end, participants were paid and debriefed.

Results

Cued Recall

Data were analyzed in jamovi, implemented in R (R Core Team, 2018), and are available at https://github.com/IMC-Lab/MemTime. To explore differences in retrieval for the four types of details, we conducted an initial 3 (simulation type: memory, counterfactual, future) × 4 (component: location, object, person, time) analysis of variance (ANOVA) on the proportion of components correctly recalled (see Figure 1). This analysis revealed main effects of simulation type, $F(2, 46) = 24.43$, $p < .001$, $\eta^2 = .515$, and component, $F(3, 69) = 33.80$, $p < .001$, $\eta^2 = .595$, modified by a Simulation Type × Component interaction, $F(6, 138) = 4.63$, $p < .001$, $\eta^2 = .168$.

To clarify this interaction, we conducted four one-way ANOVAs to examine the effects of simulation type on each of the four to-be-remembered components. Neither the analysis of location ($p = .369$) nor the analysis of person ($p = .612$) yielded a significant effect of simulation type: Locations and people were equally likely to be recalled across the three simulation types. However, the ANOVA on memory for objects yielded a main effect of simulation type, Fisher's $F(2, 69) = 4.72$, $p < .012$. Tukey post hoc tests indicated that objects in episodic memories were more likely to be remembered than were objects in future simulations ($M_{\text{difference (diff)}} = .208$), $t(69) = 3.07$, $p = .008$. There were no statistical differences in recollection of objects between memories and counterfactual simulations ($M_{\text{diff}} = .111$, $p = .237$) or between the counterfactual and future simulations ($M_{\text{diff}} = .097$, $p = .329$).

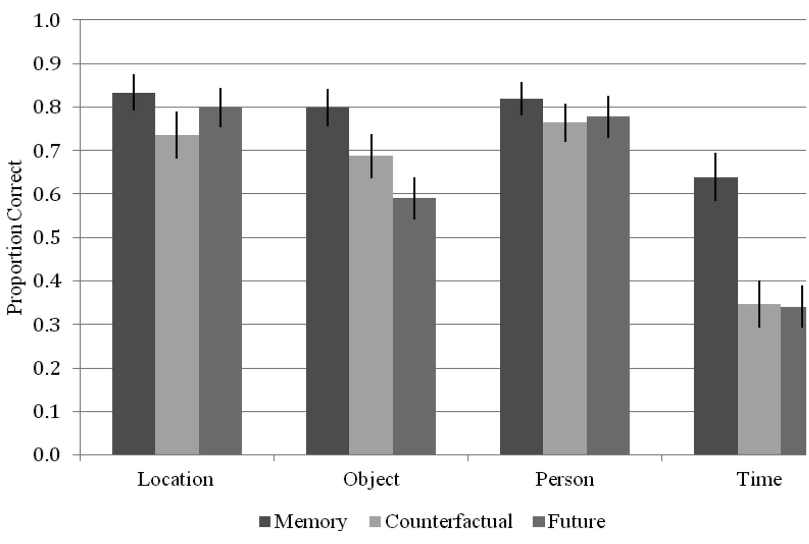

Figure 1. Proportion of correct responses in the recall task for each episodic component (i.e., location, object, person, and time) as a function of condition (i.e., memory, counterfactual, and future). Error bars indicate standard error or the mean.

Finally, for the time component, there was a main effect of simulation type, Fisher's $F(2, 69) = 10.3$, $p < .001$. Tukey post hoc tests indicated that participants were better at remembering the temporal components of episodic memories than those of counterfactual ($M_{diff} = .291$), $t(69) = 3.88$, $p < .001$, and future ($M_{diff} = .299$), $t(69) = 3.98$, $p < .001$, simulations. There was no statistical difference in memory for temporal information between the counterfactual and future simulations ($p = .994$).

Because memory for temporal information was poor, we reexamined it using a coarser accuracy measure. Answers were recoded as correct if the temporal direction was correct (i.e., past dates were coded as correct for memories and counterfactuals, whereas future dates were considered to be correct for future simulations). We conducted a one-way ANOVA on the proportion of responses with the correct temporal direction, yielding a significant effect of simulation type, Welch's $F(2, 39) = 4.36$, $p = .02$. Tukey post hoc pairwise comparisons, with Games-Howell correction for unequal variances, indicated that temporal direction was better remembered for episodic memories (97.92% correct recall) relative to future simulations (88.89% correct recall), $t(29) = 2.60$, $p = .038$, but not relative to counterfactual simulations (93.06 correct recall; $p = .185$). There was no significant difference between the counterfactual and future simulations ($p = .569$).

Finally, to better understand relative memory for the four components within a given type of simulation, we conducted pairwise comparisons for all components within each condition. For the episodic memories, this analysis revealed that the time component was recalled less frequently than were the person, object, and location components (largest $p = .051$), which did not differ from each other (all ps $> .1$). For counterfactual simulations, the time component was recalled less frequently than were the person, object, and location components (largest $p = .002$), which did not differ from each other (all ps $> .1$). Finally, for future simulations, the time component was recalled less frequently than were the person, object, and location components (largest $p = .001$). For this type of simulation, however, the object component was recalled less frequently than were both the location and the person components, $t_{location}(23) = 4.13$, $p = .002$, Cohen's $d = .912$, 95% confidence interval [CI: .063, .354]; $t_{person}(23) = .3.87$, $p = .005$, Cohen's $d = .792$, [.048, .327]. Thus, we confirmed that memory for temporal information was the least likely to be recalled across conditions but that memory for future simulations differed in one important way from the other conditions: In the future condition only, objects were less likely to be recalled than were locations and people.

Vividness and Valence

To explore differences in vividness and valence across simulation types, we conducted separate one-way ANOVAs on ratings of averaged vividness and valence. For vividness, this analysis revealed an effect of simulation type, $F(2, 222) = 32.41$, $p < .001$, $\eta^2 = 0.23$. Post hoc tests revealed that vividness ratings were higher for episodic memories ($M = 3.91$, $SD = 1.07$) than for future simulations ($M = 3.23$, $SD = 1.22$), $t(575) = 10.33$, $p < .001$, which did not differ from counterfactual simulations ($M = 3.05$, $SD = 1.13$; $p = .160$). For valence, this analysis revealed an effect of simulation type, $F(2, 222) = 23.05$, $p < .001$, $\eta^2 = 0.17$. Post hoc tests revealed that possible future events ($M = 3.93$, $SD = 1.13$) were rated more positively than were episodic memories ($M = 3.68$, $SD = 1.26$), $t(575) = 3.90$, $p < .001$, which in turn were rated as more positive than were counterfactual simulations ($M = 3.28$, $SD = 1.19$), $t(575) = 5.44$, $p < .001$.

Given these differences in vividness and valence, we further explored whether participants' impoverished recall of the time component in the future and counterfactual conditions could be due to the relatively low vividness of the relevant simulations. To that end, we used a binomial logistic regression to determine whether vividness predicted recall success for each trial, over and above the effects of simulation type. The model was statistically significant, $\chi^2(df = 3, N = 24) = 37.24$, $p < .001$, confirming that simulation type significantly predicted successful recall (ps $< .001$). However, vividness did not explain additional variance ($p = .587$; 95% CI of odds ratio [0.89, 1.07]). A similar logistic regression examined whether valence explained additional variance above and beyond the effects of condition on successful recall. Although the model was again significant, $\chi^2(df = 3, N = 24) = 37.00, p < .001$, valence did not play a significant role in predicting recall success ($p = .815$; 95% CI of odds ratio [0.93, 1.10]).

Discussion

The current experiment investigated memory for three kinds of episodic simulations: episodic autobiographical memories, episodic future thinking, and episodic counterfactual thoughts. Specifically, our experimental design allowed us to explore four research questions: (a) whether people remember the details of hypothetical simulations (i.e., future and counterfactual) at a rate comparable to that of episodic memories, (b) whether there are significant differences in what is recalled when remembering the details of future versus counterfactual simulations, (c) whether all types of information (objects, people, places, times) are equally well remembered across the three simulations, and (d) whether temporal information is equally likely to be retrieved across the three conditions.

Regarding the first question, we hypothesized that the details of retrieved episodic memories would be more memorable than would those in future and counterfactual simulations. Our results only partially supported this hypothesis: Overall, people remembered more details from their episodic memories, but this effect was driven by differences in remembering objects and temporal information. Locations and people were equally well remembered for all three types of mental simulation. These results are consistent with those in previous work showing people are good at remembering locations in retrieved episodic memories (Robin & Moscovitch, 2014) and future thoughts (Jeunehomme & D'Argembeau, 2017). In a similar way, extant evidence has shown that information about people is better remembered than is temporal information in autobiographical memories (Dijkstra & Misirlisoy, 2006), as well as information about objects in episodic future simulations (McLelland et al., 2015; Szpunar et al., 2012). The novel finding in our study is the extension of these observations to memories of episodic counterfactual simulations. Locations and people are central components of people's mental simulations of how the past might have been, in the same way that they are important components of episodic memories and future thoughts.

As for the second question, we hypothesized that the details of counterfactual simulations might be more memorable than would those of future simulations, given that the former often involve variations on actual memories, the details of which tend to be better retained. Although the pattern was as predicted, this numerical difference was not statistically significant. It is possible that with longer retention intervals or with different retrieval strategies, such differences may emerge. Further research is needed to fully explore whether these two kinds of hypothetical simulations are remembered differently.

As mentioned, our results indicate that objects from future simulations were less likely to be remembered than were objects from retrieved memoires. Moreover, when examined within a given condition, only in future simulations were objects remembered at a lower rate than were locations and people. This result is consistent with those in prior reports (Jeunehomme & D'Argembeau, 2017; McLelland et al., 2015) showing better recall of places and persons than objects from future simulations. It is interesting to note that we did not find a similar disadvantage for objects when remembering counterfactual thoughts. One possibility is that objects from counterfactual—as opposed to future—simulations are better remembered because they likely involve smaller variations on remembered past events, allowing the use of extant contextual associations to improve the retrieval of object information (Roese & Epstude, 2017). Future simulations are less constrained by what actually occurred and, therefore, have fewer contextual associations that could help to retrieve object information. Thus, to answer our third question, we did find that objects are less well remembered than are places and people but only for future simulations, which lends partial support to the first half of our hypothesis. Our findings did corroborate the second part of our hypothesis: Temporal information was less well remembered than were all other components across all conditions, albeit, as we discuss next, it was disproportionally worse for episodic future and counterfactual thinking relative to episodic memories.

Finally, our last question involved whether temporal components were equally likely to be retrieved across the three simulation conditions. Consistent with past research, temporal information was the least well remembered detail of memories (see extant evidence in autobiographical memory research: Burt, 1992; Friedman, 1987; Thompson, 1982; Wagenaar, 1986; for a more recent review, see Friedman, 2004). Our novel finding was showing a similar pattern for future and counterfactual simulations.

However, temporal information was even less well remembered for future and counterfactual simulations than for memories. Although current theories of memory for temporal information have yet to be applied to memories of hypothetical simulations, reconstructive views of memory for time can be extended to simulations of hypothetical, as opposed to actual, episodes. In broad terms, such theories posit that temporal information is inferred from a memory's content, rather than explicitly stored as part of the memory (as suggested by temporal tag or temporal distance estimator views; Brown, Rips, & Shevell, 1985; Friedman & Wilkins, 1985; Linton, 1975; Undewood, 1977). Accordingly, people often remember when something occurred by retrieving the contents of the memory and then inferring, often involuntarily, and often by reference to other memories and personal knowledge, that the event occurred during a certain season or at a particular time of day. One may remember, for instance, that a particular experience of watching a live Red Sox game occurred one night in the fall of 2013 because one may remember details about the light and clarity of day, as well as general knowledge about baseball schedules, where one was living at the time, and so forth. Indeed, reconstructive theories explain why it is that people are worse at remembering the day or week an event happens but are better at remembering both smaller (e.g., hour, time of day) and larger (e.g., month, season, year) time scales (Friedman & Wilkins, 1985). The former tends to be inferred from particular details of the memory per se, whereas the latter are often inferred from both the memorial content and other stored general and autobiographical knowledge.

Applying this view to our results, it is possible that the time component was better recalled in episodic memories not only because the contents of the simulation were better retained overall but also because there is more autobiographical knowledge associated with each particular memory and, thus, more information to draw accurate temporal inferences from. However, in the case of episodic future and counterfactual thinking, people's simulations likely had fewer connections to other possible future or counterfactual events, and thus, there was less information available to guide one's inference about the particular day or month in which the hypothetical event was temporally placed. Nevertheless, when we analyzed accuracy simply as correctly remembering the temporal direction, we saw very good performance in both hypothetical conditions, indicating that the general temporal direction of the event was successfully encoded even if the particular time or month could not be recalled. General temporal directions may thus be inferable from general information about simulated contents that, if they were to happen, would have to occur either in a possible future or in a possible past. For example, if the content of the simulation includes a person's grandchildren, the person may infer that it must be about a possible future because they do not have grandchildren now. Or, if the simulation includes a person choosing a different major, then they infer it must have been in a possible past, because they already finished college.

Conclusion

Many theorists hold that the cognitive and neural commonalities between episodic memory, future thinking, and counterfactual thinking stem from a shared adaptive goal: simulating possible events to hedge future uncertainty. Yet, following Ingvar's (1985) suggestion, it is likely that the success afforded by such hypothetical simulations depends on people's capacity to remember them when they are needed at a future time. In this study, we explored memory for episodic details in these three kinds of mental simulation. In all three, locations and people were better remembered than were objects and temporal information. However, the deficit in remembering objects and temporal information was particularly pronounced for the episodic future and counterfactual simulations, compared to episodic memories. Moreover, participants' recollection of imagined temporal information was disproportionately worse in the future and counterfactual simulations (even after noting that details of these simulations were less likely to be remembered overall), suggesting that a temporal component may not be necessary when generating mental simulations of possible events. Further research is needed to fully understand how time features in people's hypothetical simulations as well as in their capacity to remember them.

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