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ORIGINAL PAPER

# Back to the future: self-defining memory recall amplifies effects of episodic future thinking on delay discounting

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## Abstract

Episodic future thinking (EFT), which involves constructing imagined future events utilizing content from memory, decreases delay discounting (DD). DD is related to numerous health and behavior problems. In two studies we examined the use of salient episodic memories to enhance EFT effects. In Study 1, 106 participants were randomized to groups that generated self-defining memories (SDM) or played a memory game to activate memory before EFT, and a control group that generated SDM followed by episodic recent thinking (ERT). Study 2 systematically replicated methods of Study 1 in a sample of 133 high discounters and added a group that generated memories in response to neutral words before EFT. Participants rated phenomenological qualities of episodic cues, as well as whether they activated identity. In both studies, the SDM-EFT group outperformed other groups. This research extends findings on the use of EFT, demonstrating how memories may enhance prospection and decision-making.

**Keywords** Memory · Future thinking · Delay discounting · Episodic memory · Decision-making

Delay discounting (DD) refers to the decrease in the subjective value of rewards as the delay to receive them increases (Bickel & Marsch, 2001). People who steeply discount the future are more likely to make decisions for immediate reinforcement rather than wait for a larger reward (Johnson & Bickel, 2002). DD relates to numerous adverse outcomes such as obesity (Epstein et al., 2010), addiction (Bickel & Marsch, 2001), and other risky behaviors (Daugherty & Brase, 2010), and is targeted in many decision-making and behavior change interventions. One particularly effective intervention is episodic future thinking (EFT), a prospection technique involving imagining specific, vivid, and positive future events in one's life (Atance & O'Neill, 2001; Daniel et al., 2013).

Memory content is used to construct episodic future events. This idea, the constructive episodic simulation hypothesis (Schacter & Addis, 2007), is supported by neuroimaging research showing a network of brain regions supporting memory and prospection (Buckner & Carroll, 2007), and correlational research showing memory deficits relate to parallel prospection deficits (Hassabis et al., 2007; Klein et al., 2002). Experientially, memorable past events and important imagined future events are both emotionally intense, vivid, and central to one's identity (Demblon & D'Argembeau, 2017); however, they are not mirror images of one another, as patterns of brain activation are unique to each process (Thakral et al., 2017), and phenomenological differences, such as the heightened positivity of imagined future events as compared to remembered past events, are observed as well (ex. Demblon & D'Argembeau 2017). Thus, actively recalling experiences before imagining future events may activate otherwise untapped memory content for integration into imagined future events. Some research suggests memory recall may be leveraged to augment episodic future thinking in this manner and influence its effect on DD (Daniel et al., 2016).

Recalling episodic memories can affect behaviors such as charitable giving (Kuwabara & Pillemer, 2010), self-reported physical activity (Biondolillo & Pillemer, 2015), and public speaking (Pezdek & Salim, 2011). Episodic memory may prime relevant aspects of a working self, a schema linked to one's identity (Conway & Pleydell-Pearce, 2000), which may direct behavior. One type of episodic

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memory important to identity is self-defining memory (SDM; Singer & Moffitt, 1991–1992), a form of particularly vivid, emotional, frequently recalled memory representing enduring themes and life goals. Studies show that prompting SDM prospectively affects feelings of well-being and predicts outcomes in important life domains such as relationships and work (Bouizegarene & Philippe, 2016; Philippe et al., 2013). There are also numerous aspects of identity that are more greatly activated by SDM than by other episodic memories, including identity motives (Demblon & D'Argembeau, 2017) and psychological need satisfaction (Philippe et al., 2013). These constructs represent motivational pressures that can direct behavior by influencing how one sees themselves (identity motives) and the degree to which they feel their needs of autonomy, competence, and relatedness are met (psychological need satisfaction) (Demblon & D'Argembeau, 2017; Philippe et al., 2013). Because future thoughts that may guide behavior are judged to be highly emotional, frequently rehearsed, and represent important life milestones (Sanson et al., 2018), and goal-oriented future thoughts are more closely linked to identity than future thoughts not related to a goal (Duffy & Cole, 2021), we presumed amplifying the identity content of EFT by priming it with SDM could amplify its directive effects resulting in better future-oriented decision-making.

The goal of the present research was to examine the impact of activating SDM prior to engaging in EFT on a measure of delay discounting. In Study 1, we examined the effect of engaging in SDM before EFT (SDM-EFT) in comparison to two control conditions. To evaluate the unique effects of using self-defining memories to increase the effectiveness of prospection, we compared SDM-EFT to a group that recalled self-defining memories before an episodic *recent* memory task (SDM-ERT). In addition, we sought to control for the effects of engaging in a non-episodic memory task prior to EFT in a group where participants completed a working memory task prior to EFT (WM-EFT) and then completed the delay discounting measure. We also hoped this task would help equate the duration of participation across conditions.

In Study 2, we systematically replicated methods of Study 1 with three changes. First, we added another control group that engaged in episodic, but not self-defining memories, before EFT generation and our delay discounting measure in an episodic past thinking-EFT group to assess the unique effects of SDMs on decision-making. Second, we recruited a sample of participants with high levels of DD as an analogue to high discounters who might participate in interventions to improve their discounting and prospection. Third, we used different identity-related measures. In both studies, we hypothesized SDM-EFT would have larger effects on our DD measure than control manipulations. We also examined differential effects of the groups on identity-related future thinking qualities that might be related to effects on DD performance. We hypothesized identity-related qualities would in EFT cues would differ as a function of group assignment, such that those recalling self-defining memories before EFT would rate their EFT higher in identity-related content than those first performing the working memory task.

## Study 1

### Method

**Participants**. Two hundred eleven adults were recruited from Amazon Mechanical Turk (MTURK). Of these 211, 106 completed the study while passing all screening and attention check measures, representing a screen fail rate of 50%, which is consistent with prior work using MTURK (Thomas & Clifford, 2017). Of the remaining 106 adults, 52% were female, the mean age was $M = 36.41$ years ($SD = 9.45$ years), the mean income was $M$ = \$71,559 ($SD$ = \$80,678), the mean years of education was $M = 14.99$ years ($SD = 1.90$ years), 24% identified as a racial minority (11% African American; 9% Asian; 2% American Indian or Alaskan Native; 1% multiracial), and 7% identified as Hispanic. Participants were included if they had no self-reported psychiatric or neurological conditions, substance abuse, or pregnancy, as these conditions may affect prospection. Power analyses informing the sample size were performed on G*Power 3.1 (Faul et al., 2007) and were based on O'Donnell, Daniel, and Epstein (2017) who observed differences in DD between two different types of EFT with ES Cohen's $d = 0.64$. We estimated that the effect size comparing SDM-EFT to WM-EFT would be of similar magnitude, and in order to detect a similar effect with a power of 0.80 and alpha 0.05, 31 participants per group would be sufficient.

**Procedures.** Participants read a study description on MTURK and followed a link to the survey hosted on Qualtrics. Screening questions screened out participants under 18 years old, those with a history of ADHD, depression, anxiety, or PTSD, those who admitted illicit substance use (besides marijuana), and any who admitted drinking greater than 21 drinks per week as these conditions may affect attention to tasks and/or prospection (Bickel & Marsch, 2001; Gamble et al., 2019; Griffith et al., 2012; Hallford et al., 2018; Klein et al., 2002). After confirming eligibility, participants completed an electronic consent form, demographics and background mood and time perspective questionnaires, and were randomly assigned to one of three groups: self-defining memory-EFT (SDM-EFT; $n = 37$),

working memory-EFT (WM-EFT; $n = 32$), or self-defining memory-ERT control (SDM-ERT; $n = 37$).

Participants assigned to SDM-EFT or SDM-ERT groups completed an SDM task (Singer & Blagov, 2002) where they recalled two SDMs that were each: (1) At least one year old; (2) Remembered very clearly and still feel important; (3) About an important or enduring theme, that help the participant explain who they are as an individual and that they might tell to someone else if they wanted that person to understand them; (4) Linked to other similar memories that share the same theme or concern; (5) Positive, vivid and that lead them to feel strong feelings towards it; (6) Thought about many times; familiar like a picture they have studied or a song they have learned by heart; and (7) Spanning no more than a 24-hour period (no more than 1 day).

Participants created one-sentence description of each event and were then asked to elaborate about each. They were specifically asked to describe who was with them, what they were doing, where they were, and how they were feeling. They then rated each for positive affect, vividness, frequency of rehearsal, centrality to identity, and fulfillment of identity motives. During the SDM task, an attentional check asked that participants enter a specific alphanumeric code.

The WM-EFT group played the Huskerdu memory game hosted on Inquisit 4.0 (Software, 2015). The game involved matching pictures on a simulated $8 \times 8$ board of playing cards turned face down. Participants clicked two cards each turn to display the picture on the face of the cards. If they matched, the cards were eliminated from the board, otherwise they turned face down at the end of the turn. The game ended when all cards were eliminated. Afterwards, participants rated their experience for enjoyment, how positively they felt, and how vivid they found the game. They were then given an alphanumeric code to enter into Qualtrics to validate completion of the task before completing the remainder of the survey.

After the SDM or memory game, participants completed either the EFT task (SDM-EFT and WM-EFT groups) or ERT task (SDM-ERT group) to generate tags and cues for the DD task. The EFT groups described positive future events that could happen at different future time points (6 months, 2 years, and 25 years), whereas the ERT group listed positive events that occurred in the recent past (1, 2, and 3 days prior). Both groups were first asked to generate a one-sentence tag, a statement beginning with the time period when the event occurred that states what the participant is/was doing in the event (ex. "In about 2 years I am celebrating my daughter's birthday"; "About 2 days ago I was visiting my parents"). After creating a tag, participants rated each event for enjoyment, importance, excitement, vividness, how easily it could be pictured (fluency), frequency of rehearsal, centrality to identity, and identity motives. Finally, they were asked to elaborate on the event and provide specific episodic details like those in the SDM task (Who is/was with you? What are/were you doing? Where are/were you? How are/were you feeling?). This longer narrative constituted the event cues. An attentional check during the EFT/ERT asked for participants to enter a specific alphanumeric code. Thus, each participant had to complete two attention checks to complete the survey regardless of condition.

After generating three cues, participants completed the adjusting-amount DD task like that used in prior EFT studies (ex. Daniel et al., 2013) where they were presented with their EFT/ERT tags and asked to imagine their events while making hypothetical choices between receiving smaller sums of money now, or a larger, fixed sum of money ($100) at different delays (in 1 day, 6 months, 1 year, 2 years, 5 years, and 25 years). For each delay, six trials were presented. Participants' choices adjusted the value of the smaller, sooner reward on subsequent trials until reaching an indifference point (IP) when its value was subjectively equivalent to the delayed $100 reward. Choices for a smaller, sooner reward (i.e. $50 now) resulted in its value adjusting downward on a subsequent trial (i.e. to $25 now), whereas choosing the larger, later reward increased its value. Before each delay, participants were instructed to read one of their event cues in its entirety. Each cue was presented prior to two delays, where the most proximal cue was presented for the two most proximal delays, the most distal cue was presented before the two most distal delays, and the remaining cue for the two median delays. Although this was a novel procedure, we reasoned it would be necessary in order to reduce burden on participants as we have observed fatigue effects when coupling EFT procedures with other cognitively taxing procedures (Biondolillo & Epstein, 2021). Since it has been shown that EFT effectively reduces DD regardless of if cues match the delays in DD tasks (O'Donnell et al., 2019), we reasoned EFT effects would still be present.

After completing the DD task, participants were thanked, debriefed, and reimbursed $4 for participation with a $2 bonus for responses corresponding to task instructions. These procedures were approved by the University at Buffalo IRB.

## Measures

***Demographics***. The demographics survey assessed sex, age, height and weight for calculating BMI, race, ethnicity, education level, and income level. We also measured subjective social status using a question from the sociodemographic questionnaire used in the MacArthur Network (Gage-Bouchard & Devine, 2014).

***Positive and Negative Affect Schedule***. The Positive and Negative Affect Schedule

(PANAS; Watson et al., 1988) was used to assesses positive and negative

affective states. Participants were asked to indicate how they felt right now by placing a number next to each of 20 different mood adjectives (i.e., "Interested"; "Alert"; "Proud"; "Upset") that indicated the extent to which how much they were feeling that emotion (1 = Very Slightly or Not at All; 2 = A Little; 3 = Moderately; 4 = Quite a Bit; 5 = Extremely). Scores from half of the items were summed to compute a negative affect score, and those from the other half, a positive affect score.

***Time Perspective***. The Consideration of Future Consequences Scale (CFCS; Strathman et al., 1994) assessed the extent to which individuals considered and were influenced by the potential future outcomes of their current behavior. Participants indicated the degree to which 12 statements were characteristic of themselves (1 = extremely uncharacteristic, 5 = extremely characteristic). An example item stated, "I consider how things might be in the future and try to influence those things with my day-to-day behavior." After reverse scoring several items, responses are summed to represent degree of future thinking.

***Memory and event ratings***. Participants completing the SDM procedure rated each memory for positive affect, vividness, frequency of rehearsal, and centrality to identity on 7-point Likert scales (1 = Not at all; 7 = Extremely). EFT and ERT events were also rated for enjoyment, importance, excitement, fluency, and vividness on 5-point Likert scales (1 = Not at all; 5 = Very much).

*Identity motives.* Memories and EFT/ERT events were rated for each of six identity motives using a scale from Demblon and D'Argembeau (2017). These motives relate to reasons for constructing one's identity. Participants were asked their degree of agreement with statements regarding how they feel while thinking about their events. One item each related to the motives of *self-esteem, competence, meaning, continuity, belonging*, and *distinctiveness.* An example item is, "Thinking of this event makes me feel like a competent and capable person" (*competence)*. Participants responded on 7-point Likert scales (-3 = Completely Disagree; 0 = Neither agree nor disagree; +3 = Completely agree). Items were re-scaled from one to seven. A final item asked the perspective from which participants viewed their memories/events, first person (seen through your own eyes) or third-person (from the perspective of an observer).

***Delay Discounting.*** Delay discounting was calculated from the IPs generated from the adjusting amount task. The six IPs were plotted, and the area under the discounting curve (BAUC) was calculated as the dependent measure of DD according to the procedure in Borges, Kuang, Milhorn, and Yi (2016). This procedure computes the percentage of the total maximum reward across all delays that participants would receive if, at each delay, they received the value of its associated indifference point instead of the larger, later reward. The procedure in Borges et al. (2016) treats delays ordinally rather than as a continuous measure. We thought this appropriate in our design to avoid inflating the weight of the 25-year delay in our computation of delay discounting. In this measure, higher values represent a greater preference to wait for the larger reward; therefore, lower DD.

**Analytic plan.** Survey responses were screened for adequate completion of attention checks and for sensible responding conforming to task instructions as we have done prior research on MTURK (Biondolillo & Epstein, 2021). Continuous background variables and survey duration were screened for outliers ($z \pm 3$ *SD*). ANOVA was used to examine group equivalency in participants' demographics, survey duration, and background questionnaires for continuous variables and chi-square tests were used for categorical variables. Between-group differences were considered as covariates. We examined DD responses for nonsystematic responding as according to the procedure described by Johnson and Bickel (2008). Because IPs were calculated for six different delays, there could be a maximum of six violations of the Johnson and Bickel rules: one violation where the IPs between consecutive delay periods increased greater than by a measure of 20% of the shorter delay IP value, and a final violation if the IP value at the longest delay was not less than the IP at the shortest delay by more than 10% of the shortest delay IP value. We excluded participants committing more than two violations out of the six possible violations that could occur, which is similar to data screening procedures in other studies (ex. Epstein et al., 2021). Given known relationships between income (Green et al., 1996; Reimers et al., 2009) and CFCS (Biondolillo & Epstein, 2021; Daugherty & Brase, 2010) with DD, these variables served as covariates in ANCOVAs examining between-group differences in DD and EFT qualities with post-hoc Tukey's HSD tests to examine between-group contrasts.

## Results

Responses were screened by MB and DC for attention check responses and compliance with task instructions, which resulted in the exclusion of eight participants from analyses. Of those remaining, three additional responses violated greater than two of Johnson and Bickel's (2008) rules and those participants were excluded from analyses as well. Examination of continuous demographic variables and survey duration found one response with a duration $z > 3$ *SD* and another reporting an income of $z > 3$ *SD*. The participants with these responses were also excluded and analyses

**Table 1** Participant Characteristics and Survey Duration in Study 1

| | SDM-ERT | WM-EFT | SDM-EFT | $\chi^2$ | $p$ | $\varphi$ |
|---|---|---|---|---|---|---|
| Sex (% Female) | 62 | 56 | 41 | 3.06 | 0.22 | 0.18 |
| Racial Minority (% Minority) | 14 | 25 | 31 | 2.61 | 0.27 | 0.17 |
| | SDM-ERT<br>*M*<br>(*SD*) | WM-EFT<br>*M*<br>(*SD*) | SDM-EFT<br>*M*<br>(*SD*) | *F* | *p* | $\eta^2$ |
| Age (years) | 36.32<br>(10.48) | 35.75<br>(7.51) | 36.51<br>(9.13) | 0.06 | 0.94 | <0.01 |
| Years of Education | 14.83<br>(1.83) | 14.66<br>(1.84) | 15.19<br>(1.91) | 0.68 | 0.51 | 0.02 |
| Income (US$ in Thousands) | 70.13<br>(47.04) | 68.97<br>(43.26) | 59.69<br>(48.44) | 0.48 | 0.62 | 0.01 |
| BMI | 27.83<br>(4.82) | 28.79<br>(7.81) | 28.30<br>(7.94) | 0.14 | 0.87 | <0.01 |
| Subjective Social Status | 5.62<br>(2.08) | 5.56<br>(1.48) | 5.59<br>(1.85) | 0.01 | 0.99 | 0.00 |
| PANAS Positive | 30.21<br>(7.52) | 32.22<br>(9.03) | 29.00<br>(8.27) | 2.21 | 0.14 | 0.03 |
| PANAS Negative | 12.62<br>(5.43) | 11.59<br>(4.20) | 12.13<br>(7.00) | 1.13 | 0.29 | 0.01 |
| CFCS | 44.72<br>(5.73) | 43.50<br>(9.21) | 41.53<br>(9.41) | 0.72 | 0.40 | 0.03 |
| Survey duration (min) | 39.54<br>(20.13) | 38.34<br>(14.04) | 42.20<br>(20.44) | 0.78 | 0.38 | 0.01 |
| BAUC | 0.38<br>(0.19) | 0.49<br>(0.25) | 0.66<br>(0.21) | 9.18 | <0.01 | 0.13 |

*Note.* $N = 93$; $n = 29$ for SDM-ERT group, $n = 32$ for WM-EFT group, and $n = 32$ for SDM-EFT group. $\varphi$ – Phi coefficient. $\eta^2$ - Eta Squared.

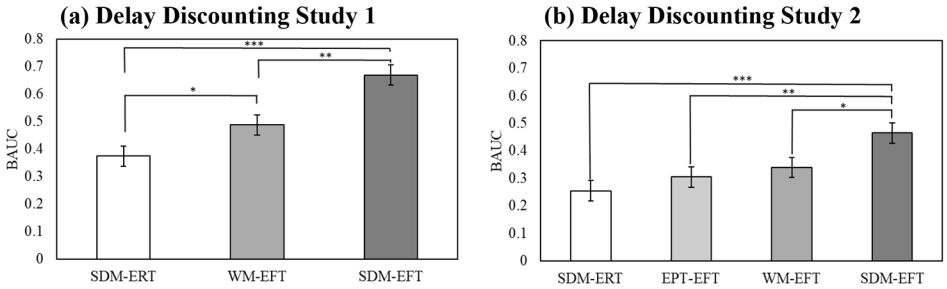


**Fig. 1** *a-b.* Delay discounting between groups in Studies 1 and 2. Values are mean ± SEM. Asterisks indicate significance of one-way ANCOVA between groups on DD controlling for CFCS and income. *** p < .001, ** p < .01, * p < .05. Error bars = ± 1 SE. 1a. Estimated marginal mean BAUC values in Study 1. 1b. Estimated marginal mean BAUC values in Study 2

were carried out on the remaining 93 participants with valid responses ($n = 29$ for SDM-ERT; $n = 32$ for WM-EFT; and $n = 32$ for SDM-EFT).

No significant between-group differences in participant characteristics or survey duration were observed (see Table 1). Our primary analysis of covariance showed that groups differed significantly in BAUC, $F(2, 88) = 16.27$, $p < .001$, $\eta^2_p = 0.29$. As shown in Fig. 1a the estimated marginal mean BAUC of the SDM-EFT group ($M = 0.68$, $SE = 0.04$) was significantly higher than that of both the SDM-ERT group ($M = 0.38$, $SE = 0.04$), 95% CI [0.20, 0.41], and the WM-EFT group ($M = 0.49$, $SE = 0.04$), 95% CI [0.09, 0.30]. The difference between the SDM-ERT and the WM-EFT groups was also significant, $p = .035$, 95% CI [0.01, 0.22]. In addition, CFCS scores were positively related to BAUC, $\beta = 0.007$, 95% CI [0.001, 0.01], $F(1, 88) = 6.67$, $p = .011$, $\eta^2_p = 0.07$. No significant differences in EFT ratings were noted (see Table 2). Discounting results are shown in Fig. 1a.

## Discussion

Study 1 supported the hypothesis that self-defining memories can be leveraged to increase the effectiveness of prospection and improve EFT-related outcomes. Participants generating self-defining memories prior to EFT discounted

**Table 2** Estimated Marginal Mean EFT Cue Ratings Study 1

| | WM-EFT *M* (*SE*) | SDM-EFT *M* (*SE*) | *F* | *p* | $\eta^2_p$ |
|---|---|---|---|---|---|
| Enjoyment[a] | 4.57 (0.10) | 4.63 (0.10) | 0.16 | 0.70 | <0.01 |
| Importance[a] | 4.32 (0.12) | 4.34 (0.12) | 0.01 | 0.91 | 0.00 |
| Excitement[a] | 4.56 (0.11) | 4.42 (0.11) | 0.84 | 0.36 | 0.01 |
| Fluency[a] | 4.43 (0.12) | 4.32 (0.12) | 0.53 | 0.47 | 0.01 |
| Vividness[a] | 4.48 (0.12) | 4.30 (0.12) | 1.18 | 0.28 | 0.02 |
| Rehearsal[b] | 5.51 (0.21) | 5.64 (0.20) | 0.20 | 0.66 | <0.01 |
| Centrality[b] | 5.18 (0.23) | 5.58 (0.23) | 1.46 | 0.23 | 0.02 |
| Esteem[b] | 5.36 (0.22) | 5.72 (0.22) | 1.34 | 0.25 | 0.02 |
| Competence[b] | 5.65 (0.20) | 5.57 (0.19) | 0.08 | 0.78 | <0.01 |
| Meaning[b] | 5.63 (0.21) | 5.92 (0.21) | 0.91 | 0.34 | 0.02 |
| Continuity[b] | 5.51 (0.22) | 5.74 (0.22) | 0.46 | 0.56 | 0.01 |
| Relatedness[b] | 5.55 (0.21) | 5.82 (0.21) | 0.78 | 0.38 | 0.01 |
| Distinctiveness[b] | 4.68 (0.27) | 5.34 (0.26) | 3.08 | 0.08 | 0.05[+] |

*Note.* Marginal mean values computed by ANCOVA controlling for CFCS and income. [a]Measured on a 1-to-5 Likert scale. [b]Measured on a 1-to-7 Likert scale. [+]p < .10.

less than participants completing a working memory task prior to EFT and those generating self-defining memories prior to a control ERT task. In addition, the typical EFT effect that is observed in the absence of a memory pre-task was still observed as participants in the working memory task-EFT group discounted less than participants generating self-defining memory prior to ERT. The magnitude of the discounting effect in the self-defining memory-EFT group suggests that effects on delay discounting were not the result of simply recalling memories or performing EFT, but rather resulted from the combination of self-defining memory and EFT. Although we also expected identity-related event qualities to differ between the EFT groups, this was not the case. Therefore, our results did not support that priming identity through memory was the mechanism behind EFT-group delay discounting differences.

Despite the promising results in Study 1, there were limitations. First, we did not know if memories of less salient episodes could increase the effectiveness of EFT in a similar way to self-defining memory. In addition, although identity motives did not differ by group, other unmeasured identity-related memory qualities may have. Furthermore, we were interested in if the SDM-EFT procedure could be useful for participants evidencing a delay discounting deficit and who might function as an analogue for individuals who participate in interventions to improve prospection and problematic health behaviors. To address these issues, we systematically replicated methods from Study 1 with three differences. First, we added a control condition wherein participants generated episodic memories in response to neutral cue words to control for the salience of memory preceding EFT. Second, we used a different identity measure to examine between-group differences in EFT qualities. Finally, we recruited participants with a high degree of delay discounting.

## Study 2

### Method

Study 2 systematically replicated the procedures of Study 1 in a sample of participants who showed a high degree of temporal discounting with the addition of a control condition that prompted for less salient memories prior to EFT and with a different measure of identity ratings.

**Participants**. Two hundred sixty-three adults were recruited from Amazon Mechanical Turk (MTURK). Of these 263, 133 completed the study while passing all screening and attention check measures, representing a screen fail rate of 49%; similar to Study 1 and consistent with prior MTURK research (Thomas & Clifford, 2017). Of remaining participants, 46% were Female, the mean age was $M = 35.38$ years ($SD = 10.10$ years), the mean income was $M = \$64{,}128$ ($SD = \$35{,}384$), the mean years of education was $M = 14.88$ years ($SD = 1.67$ years), 26% identified as a racial minority (2% American Indian or Alaskan Native; 5% Asian; 21% African American), and 5% identified as Hispanic. Participants were included if they had no self-reported psychiatric or neurological conditions, substance abuse, or pregnancy, and were high discounters as indicated by a $k$ value greater than 0.01 on the 5-trial adjusting amount discounting task (Koffarnus & Bickel, 2014). Power analyses informing Study 2 were the same as Study 1.

**Procedures.** Procedures unique to Study 2 are discussed below. Participants read a description of the Study on MTURK and followed a link to the survey on Qualtrics. The screening survey included the 5-trial adjusting amount discounting task to screen for DD (Koffarnus & Bickel, 2014). Participants completed an electronic consent form and the same background questionnaires as Study 1 before being randomly assigned to one of four groups: self-defining memory-EFT (SDM-EFT; $n = 34$), working memory-EFT

(WM-EFT; $n = 31$), self-defining memory-ERT (SDM-ERT; $n = 33$), or episodic past thinking-EFT (EPT-EFT; $n = 35$).

The EPT-EFT group was asked to generate two episodic memories of events from a particular place and time not lasting more than a day (24 h) in response to cue words. The EPT procedure was modeled after the Autobiographical Memory Test (AMT; Williams & Broadbent 1986). In order to ensure we did not invoke too salient of recollection, participants were shown neutral cue words (NICKNAME and LIBRARY) used to prompt memory in a prior study (Dritschel et al., 2014).

Participants rated memories and EFT/ERT events as in Study 1, with the exception that psychological need satisfaction in memory was rated in lieu of identity motives. They then performed the EFT-cued DD task, were thanked, debriefed, and reimbursed $4 for participation with a $2 bonus for responses corresponding to survey instructions. Procedures were approved by the University at Buffalo IRB.

**Measures.** Measures unique to Study 2 are discussed below.

**5-trial adjusting amount task.** The 5-trial adjusting amount discounting task (Koffarnus & Bickel, 2014) was used to screen for discounting. Participants were asked five questions regarding their preference for an immediate $50 reward or a delayed $100 reward. Choices on one question influenced the delay of the $100 on the subsequent question, such that choosing to wait for $100 increased the delay on the subsequent trial, and choosing the immediate $50 decreased the delay. DD was quantified in terms of a $k$ value, which describes the shape of the discounting curve. Higher $k$ values represent greater discounting, and those with $k$ values above 0.01 were considered eligible as in our prior research fewer than 50% of MTURK respondents would meet this criterion (Biondolillo & Epstein, 2021). This $k$ value equates to having a similar preference for $50 now and $100 in 3 months. For normality, $k$ values were log transformed as in prior studies (ex. Biondolillo & Epstein 2021).

***Psychological need satisfaction***. For memories and EFT/ERT events, participants rated the degree to which events satisfied each of three psychological needs (*autonomy, competence*, and *relatedness*) derived from Self-Determination Theory (SDT; Deci & Ryan 2000). These relate to the degree to which an individual feels a sense of agency (autonomy), self-efficacy (competence), and connection to others (relatedness). These needs are an essential component of episodic memory (Milyavskaya et al., 2013) and relate to one's identity (Bouizegarene & Philippe, 2016). Items began with the stem, "In this event," and were followed by a feeling state related to each need: for *autonomy*, "I felt (feel) free to do things and to think how I wanted"; for *competence*, "I felt (feel) confident in myself"; for relatedness, "I felt (feel) connected to one or more people." Participants responded on 7-point Likert scales corresponding with the degree of agreement with statements (-3 = completely disagree; 0 = neither agree nor disagree; 3 = completely agree). Responses were recoded from one to seven and summed as in previous research (Milyavskaya et al., 2013). The average needs score for memories and EFT/ERT events was used in analyses.

**Analytic plan**. Surveys were screened as in Study 1. Between-group differences in background characteristics and survey duration were examined. In addition, the average temporal distance for memories for participants in the SDM and EPT were examined for between-group differences. Any differences were covaried along with income and CFCS in ANCOVA for the between-group analyses of DD and EFT qualities with post-hoc Tukey's HSD tests to examine between-group contrasts.

## Results

Responses were screened by MB, DC, and KS to ensure compliance with task instructions, which resulted in the exclusion of 12 responses. Of those remaining, one violated greater than two of Johnson and Bickel's (2008) rules. Two respondents reported an income of $z > 3$ *SD* and one respondent's survey duration was $z > 3$ *SD*. These three responses were excluded and analyses were carried out on the 117 remaining responses $n = 29$ for SDM-ERT group; $n = 28$ for EPT-EFT group; $n = 30$ for WM-EFT group; and $n = 30$ for SDM-EFT group).

No significant between-group differences in participant characteristics were observed (Table 3). ANCOVA showed between-group differences in BAUC, $F(3, 111) = 5.72$, $p = .001$, $\eta^2_p = 0.13$. As shown in Fig. 1b., the estimated marginal mean BAUC of the SDM-EFT group ($M = 0.46$, $SE = 0.04$) was significantly higher than the SDM-ERT group ($M = 0.25$, $SE = 0.04$), $p < .001$, 95% CI [0.11, 0.31], the EPT-EFT group ($M = 0.31$, $SE = 0.04$), $p = .004$, 95% CI [0.05, 0.26], and the WM-EFT group ($M = 0.34$, $SE = 0.04$), $p = .02$, 95% CI [0.02, 0.23]. No other significant between-group differences were noted. CFCS scores again positively related to BAUC, $\beta = 0.006$, 95% CI [0.001, 0.01], $F(1, 111) = 6.63$, $p = .01$, $\eta^2_p = 0.06$. No significant differences were noted in EFT ratings (see Table 4). Discounting results are shown in Fig. 1b.

## Discussion

Study 2 further supported the hypothesis that memory can be systematically prompted to increase the effectiveness of EFT and helped to clarify the conditions leading to DD differences. Participants generating SDM prior to EFT again

**Table 3** Participant Characteristics, Survey Duration, and Memory Age in Study 2

| | SDM-ERT | EPT-EFT | WM-EFT | SDM-EFT | $\chi^2$ | $p$ | $\varphi$ |
|---|---|---|---|---|---|---|---|
| Sex (% Female) | 48 | 61 | 57 | 57 | 0.95 | 0.81 | 0.09 |
| Racial Minority (% Minority) | 17 | 32 | 40 | 30 | 3.74 | 0.29 | 0.18 |
| | SDM-ERT *M* (*SD*) | EPT-EFT *M* (*SD*) | WM-EFT *M* (*SD*) | SDM-EFT *M* (*SD*) | $F$ | $p$ | $\eta^2$ |
| Age in Years | 36.47 (11.77) | 36.90 (10.50) | 33.88 (7.74) | 34.74 (8.22) | 0.64 | 0.59 | 0.02 |
| Years of Education | 15.00 (1.73) | 14.39 (1.69) | 14.70 (1.64) | 15.23 (1.55) | 1.41 | 0.24 | 0.04 |
| Income (US$ in Thousands) | 62.03 (39.72) | 56.00 (24.44) | 57.21 (38.66) | 57.98 (32.01) | 0.17 | 0.92 | <0.01 |
| BMI | 25.57 (5.83) | 27.43 (7.22) | 25.30 (6.42) | 27.14 (6.43) | 0.81 | 0.49 | 0.02 |
| Subjective Social Status | 5.38 (1.61) | 5.68 (1.66) | 5.50 (1.72) | 5.60 (1.87) | 0.16 | 0.92 | <0.01 |
| PANAS Positive | 33.24 (9.93) | 34.50 (8.19) | 33.67 (8.27) | 34.63 (8.27) | 0.17 | 0.92 | <0.01 |
| PANAS Negative | 15.31 (9.13) | 12.36 (4.40) | 12.77 (4.92) | 15.10 (8.10) | 1.42 | 0.24 | 0.04 |
| CFCS | 41.76 (8.42) | 41.75 (7.89) | 43.10 (8.59) | 39.50 (7.87) | 0.99 | 0.40 | 0.03 |
| Survey duration (min) | 44.06 (22.12) | 47.22 (22.57) | 44.64 (18.55) | 44.80 (20.55) | 0.13 | 0.95 | <0.01 |
| Temporal distance of memories (years) | 7.27 (8.74) | 8.61 (9.58) | | 6.07 (7.98) | 0.61 | 0.55 | 0.01 |
| Log $k$ | -2.88 (1.19) | -2.71 (1.41) | -2.60 (1.61) | -2.49 (1.54) | 0.38 | 0.77 | 0.01 |
| BAUC | 0.26 (0.14) | 0.31 (0.18) | 0.35 (0.20) | 0.45 (0.28) | 4.77 | <0.01 | 0.11 |

*Note.* $N = 117$; $n = 29$ for SDM-ERT, $n = 28$ for EPT-EFT, $n = 30$ for WM-EFT, and $n = 30$ for SDM-EFT; $\varphi$ – Phi coefficient; $\eta^2$ - Eta Squared.

**Table 4** Marginal Mean EFT Cue Ratings Study 2

| | EPT-EFT *M* (*SE*) | WM-EFT *M* (*SE*) | SDM-EFT *M* (*SE*) | $F$ | $p$ | $\eta^2_p$ |
|---|---|---|---|---|---|---|
| Enjoyment[a] | 4.52 (0.09) | 4.66 (0.09) | 4.57 (0.09) | 0.65 | 0.52 | 0.02 |
| Importance[a] | 4.59 (0.10) | 4.46 (0.10) | 4.49 (0.10) | 0.41 | 0.66 | 0.01 |
| Excitement[a] | 4.55 (0.10) | 4.53 (0.09) | 4.66 (0.09) | 0.57 | 0.57 | 0.01 |
| Fluency[a] | 4.46 (0.10) | 4.51 (0.10) | 4.44 (0.10) | 0.11 | 0.90 | <0.01 |
| Vividness[a] | 4.42 (0.11) | 4.48 (0.11) | 4.46 (0.11) | 0.07 | 0.93 | <0.01 |
| Rehearsal[b] | 6.17 (0.17) | 5.72 (0.16) | 5.87 (0.16) | 1.90 | 0.16 | 0.04 |
| Centrality[b] | 5.86 (0.18) | 5.61 (0.18) | 5.99 (0.18) | 1.05 | 0.35 | 0.03 |
| Need Satisfaction[c] | 19.43 (0.31) | 18.90 (0.30) | 19.23 (0.30) | 0.76 | 0.47 | 0.02 |

*Note.* Marginal mean values computed by ANCOVA controlling for CFCS and income. [a]Measured on a 1-to-5 Likert scale. [b]Measured on a 1-to-7 Likert scale. [c]Sum of three items each measured on 1-to-7 Likert scales.

demonstrated the least temporal discounting, and significantly less than those generating SDM before ERT, those performing a neutral word-cued episodic memory task before EFT, and those completing a non-episodic working memory game before EFT. No other between-group differences in DD were demonstrated. These results may be of practical significance given the sample chosen for its high degree of DD, which corresponds with many negative health outcomes. We did not find evidence that psychological need satisfaction differed between groups.

## General discussion

These two studies represent the first attempt to our knowledge to systematically increase the effectiveness of prospection with content from memory to improve performance on a task influenced by prospection. In Study 1, participants recalling salient self-defining memories prior to generating future events (SDM-EFT) demonstrated lower levels of delay discounting than participants recalling SDMs before recalling recent episodes (SDM-ERT) and participants completing a working memory game before generating future events (WM-EFT). In addition, those completing the working memory game before generating future events (WM-EFT) also demonstrated lower discounting than those recalling SDMs followed by recent episodes (SDM-ERT), which replicated the typical EFT effect observed in studies of DD. Study 2 replicated procedures from Study 1 in a sample of high temporal discounters selected as an analogue for those who might participate in interventions to improve prospection, used different identity scales, and included an additional control group to control for salience of episodic memory content by recalling neutral word-cued memories before EFT (EPT-EFT). Again, the SDM-EFT group discounted less than other groups. Unlike Study 1, in Study 2 there were no other significant between-group differences on the event-cued delay discounting measure. Because the non-salient memory-EFT group (EPT-EFT) and the self-defining memory-ERT group (SDM-ERT) demonstrated higher discounting than the self-defining memory-EFT group (SDM-EFT), delay discounting effects in the SDM-EFT group cannot be attributed to either SDM or EFT alone, nor were they a result of episodic memory in a more general sense combined with EFT. Instead, they must be the result of the combined effect of SDM and EFT. Thus, self-defining memory recalled before performing EFT helped amplify the effect of EFT on delay discounting in the SDM-EFT group.

Contrary to hypotheses, self-reported qualities of EFT did not differ between groups in either study, meaning that differences in the identity-related content of EFT did not drive observed between-group differences. Despite identity variables failing to explain differences in DD, the superiority of the SDM-EFT condition was demonstrated in both studies, including in a sample of high discounters. Thus, prompting SDM before EFT is an effective way to decrease temporal discounting and may be useful for those coping with issues related to DD and prospection.

Despite these promising results, there are some limitations. First, both samples were chosen from MTURK, and participants self-disclosing psychological or substance use issues known to influence memory processes (Gamble et al., 2019; Griffith et al., 2012; Hallford et al., 2018) were excluded. Although in the United States, MTURK users are generally representative of the population (Burnham et al., 2018), results may not generalize to participants with problems that were exclusionary. We selected participants in Study 2 to target those with DD deficits and to limit the influence of comorbidities, so results should be replicated with individuals with exclusionary conditions, such as those with substance use issues. Still, individuals struggling with obesity and/or diabetes may benefit from this procedure as neither were excluded in the present sample and both conditions relate to deficits in DD (Reach et al., 2011).

Additionally, we designed the manipulation to specifically prompt highly vivid and positive memories and future thinking cues. The downside of this manipulation is that it does not allow for meaningful between-group comparisons based on these phenomenological characteristics. The non-identity self-report phenomenological variables were intended as manipulation checks, rather than as dependent variables, and because the manipulation was implemented as planned, these variables are at or near ceiling in all groups and did not differ. Future research could differentially manipulate vividness, positivity, and other phenomenological variables in memory and EFT to examine how these variables impact combined memory and EFT effects on delay discounting like the effects observed here.

Although we hypothesized that identity-related variables influential to memory's effects would differ between groups and may explain observed effects, this was not the case because those in groups performing EFT did not differ in rating the identity-related content of their EFT cues. These variables represent motivational pressures on constructing one's identity (identity motives; Study 1) and the degree to which degree to which one feels their autonomy, competence, and relatedness needs are met in the events recalled or generated (psychological need satisfaction; Study 2). If an identity-based explanation for effects on DD is accurate, future studies may wish to examine other aspects of identity or use a qualitative approach in assessing identity within EFT events; however, as both studies failed to demonstrate any meaningful differences in self-reported identity variables, we feel other explanations for observed effects are

more likely. As the non-salient memory-EFT group (EPT-EFT) performed more poorly in the delay discounting task than the self-defining memory-EFT group (SDM-EFT), but temporal difference of memories did not differ between groups, it is not likely that SDM recall allowed access to a more expansive temporal window from which to draw content in creating EFT cues. Future research will need to examine other SDM qualities that might affect EFT. If these can be identified, it is possible they could be more effectively targeted through memory prompts and lead to even greater effects on DD.

Finally, no significant difference in DD was observed between the working memory-EFT (WM-EFT) and self-defining memory-ERT (SDM-ERT) groups in Study 2. This may be explained by the fact that our prior EFT studies have not included memory tasks before EFT/ERT procedures, and in order to accommodate the added cognitive burden, we reduced the number of EFT/ERT cues participants were asked to generate from our normal EFT protocols (typically five or six cues). It is likely that reducing the absolute number of EFT cues generated, and thus the overall exposure to prospection, could have lessened the EFT effect to some degree, leading to non-significance for this effect in Study 2. Our interpretation is that people demonstrating high discounting may require more EFT rehearsal to think more prospectively and realize the full DD reduction if not first performing SDM. This interpretation comports well with some of our results in clinical research (Epstein et al., 2022). Future studies could examine if there is a differential dose response to EFT depending upon one's inherent degree of DD.

Despite these limitations, the studies discussed above present the first evidence that a past-plus-future thinking procedure can synergistically influence event-cued delay discounting measures beyond EFT alone, demonstrating that memory recall can influence prospection and promote decisions with longer-term benefits. For those struggling to change behaviors known to relate to DD and make better future-oriented decision, a targeted cognitive approach involving both memory and future thinking may complement known behavior change strategies and be a useful tool that can motivate one to make better decisions in the present to maintain behavior over the long term.

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**Data Availability** The datasets generated and analyzed during these studies are publicly available in the Open Science repository at https://osf.io/qwz39/.

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