Check for updates

Original Article

QJEP

Quarterly Journal of Experimental Psychology
1–17
© Experimental Psychology Society 2022
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/17470218221086637
qjep.sagepub.com
SAGE

Imagining emotional events benefits future-oriented decisions

Braedon C Ballance[1], Young Ji Tuen[1], Aria S Petrucci[1], William Orwig[1], Omran K Safi[1], Christopher R Madan[2] and Daniela J Palombo[1]

Abstract

How does imagining future events—whether positive or negative—influence our choices in the present? Prior work has shown the simulation of hypothetical future events, dubbed episodic future thinking, can alter the propensity to engage in delay discounting (the tendency to devalue future rewards) and does so in a valence-specific manner. Some research shows that positive episodic future thinking reduces delay discounting, whereas negative future thinking augments it. However, more recent research indicates that both positive and negative episodic future thinking reduce delay discounting, suggesting an effect of episodic future thinking that is independent of valence. In this study, we sought to replicate and extend these latter findings. Here, participants ($N = 604$; $N = 572$ after exclusions) completed an online study. In the baseline task, participants completed a delay discounting task. In the experimental task, they engaged in episodic future thinking before completing a second delay discounting task. Participants were randomly assigned to engage in either positive, neutral, or negative episodic future thinking. In accordance with Bulley et al., we found that episodic future thinking, regardless of valence, reduced delay discounting. Although episodic future thinking shifted decision-making in all conditions, the effect was stronger when participants engaged in positive episodic future thinking, even after accounting for personal relevance and vividness of imagined events. These findings suggest that episodic future thinking may promote future-oriented choices by contextualising the future, and this effect is further strengthened when the future is tied to positive emotion.

Keywords

Decision-making; delay discounting; emotion; episodic future thinking; intertemporal choice

Received: 11 August 2021; revised: 5 November 2021; accepted: 28 December 2021

Imagination plays a central role in human cognition. Episodic future thinking refers to a form of imagination wherein one can simulate, in their mind's eye, hypothetical future scenarios that are constructed *de novo* based on the building blocks of prior experiences (Schacter & Addis, 2007). This remarkable human feat—often referred to as mental time travel (Atance & O'Neill, 2001; Schacter et al., 2017; Suddendorf & Corballis, 2007; Szpunar, 2010; Tulving, 2001)—occupies a considerable portion of our daily thoughts (D'Argembeau et al., 2010).

Episodic future thinking has become an important topic in the field of cognition and behavioural economics, particularly in the context of intertemporal choices, a form of decision-making that is ubiquitous in humans. It is well known that humans have a tendency, known as delay discounting, to discount future rewards in favour of immediate ones (Berns et al., 2007; Kirby, 1997). For example, when given a choice between $70 now versus $85 in 2 months, individuals tend to choose the smaller, immediate reward. This inclination towards delay discounting demonstrates that individuals will devalue the larger, future reward because of the delay in receiving it (Green & Myerson, 2004; Kirby, 1997; Mazur, 1987). However, recent

[1]Department of Psychology, The University of British Columbia, Vancouver, British Columbia, Canada
[2]School of Psychology, University of Nottingham, Nottingham, UK

Corresponding author:
Daniela J Palombo, Department of Psychology, The University of British Columbia, 2136 West Mall, Vancouver, British Columbia V6T 1Z4, Canada.
Email: daniela.palombo@ubc.ca

empirical work has shown that engaging in episodic future thinking before choosing between immediate and future rewards can attenuate delay discounting (Benoit et al., 2011; Bulley et al., 2016; Peters & Büchel, 2010; Rösch et al., 2021; Rung & Madden, 2018; also see Schacter et al., 2017 for discussion). This effect holds regardless of whether the episodic future thinking is related to the reward (Benoit et al., 2011) or a general, unrelated future event (Cheng et al., 2012). Consistent with Boyer's (2008) proposal that episodic future thinking acts as a motivational "brake" to counter myopic decisions, these findings suggest that episodic future thinking may prompt individuals to assign greater value to future rewards, thereby reducing the urge to opt for immediate gratification (Benoit et al., 2011; Gilbert & Wilson, 2007; Peters & Büchel, 2010; Rösch et al., 2021). As detailed below, in this article, we build on previous work by examining how the emotional valence of episodic future thinking influences delay discounting.

Regarding the relevance of emotional valence to episodic future thinking, Boyer (2008) postulated that episodic future thinking can alter the subjective value of the future by enabling individuals to "pre-feel" the emotional state of the future. When pre-feeling a positive future experience, the imagined emotional state overrides the pleasure tied to the present reward (also see the studies by Benoit et al., 2011; Palombo et al., 2015b; Peters & Büchel, 2010). Thus, when individuals simulate positive future events, episodic future thinking may prompt them to invest in the future (Boyer, 2008).

However, although Boyer's proposal focuses on the benefits of positive valence, there are differing viewpoints in the literature on how episodic simulation of negatively valenced future events might influence decision-making. According to one view, simulating negative future events biases individuals towards immediate gratification given the unfavourable depiction of the future (Frankenhuis et al., 2016). Indeed, higher levels of worry (often encompassing thoughts about future threat) are associated with steeper delay discounting (Worthy et al., 2014). According to this view, negative episodic future thinking should augment delay discounting. Yet, an alternative viewpoint proposes that negative episodic future thinking may act as a preparatory motivation that prompts individuals to invest in the future in an effort to acquire the appropriate resources to manage the future threat (Bulley et al., 2016; Worthy et al., 2014; Bulley et al., 2019; Lempert et al., 2012). That is, negative episodic future thinking should attenuate delay discounting. Hence, episodic future thinking, irrespective of valence, may adaptively shift decision biases to suit the individual's view of the future (Rösch et al., 2021).

Along these lines, previous research has investigated the manner in which the emotional valence of the episodic forethought modulates intertemporal choices (Bulley et al., 2019; Calluso et al., 2019; Liu et al., 2013; Zhang et al., 2018). In such studies, participants are prompted to imagine episodic future events before making an intertemporal choice. Whether the participants were prompted to imagine a positively valenced (e.g., winning an award), negatively valenced (e.g., being assaulted by a stranger), or neutral (e.g., using a pencil) event differed between conditions. As expected, participants in these studies discounted the future choice less after engaging in positively valenced episodic future thinking compared to neutral imagination or "baseline" intertemporal choices with no episodic future thinking component (i.e., attenuated delay discounting; Bulley et al., 2019; Calluso et al., 2019; Liu et al., 2013; Rösch et al., 2021; Zhang et al., 2018; also see the study by Lin & Epstein, 2014).

However, results from studies where participants engaged in negatively valenced episodic future thinking were equivocal. Two of these studies found that imagining negative future scenarios biased choice towards the smaller, sooner reward (i.e., augmented delay discounting; Liu et al., 2013; Zhang et al., 2018). A major limitation of both these studies was the relatively small samples (approximately 30 participants per group in between-subjects designs). On the contrary, a third study, using the largest sample size to date ($N=301$, between-subjects design; approximately 100 participants per group), found that, much like positive future scenarios, imagining negative future scenarios biased choice towards the larger, later reward (i.e., the future-oriented reward), albeit the effect size was smaller for negative ($d=0.45$) compared to positive ($d=0.63$) events when each condition was compared to a neutral imagery control condition (Bulley et al., 2019). This pattern of results was also observed in a fourth study by Calluso et al. (2019), with a smaller sample ($N=65$; within-subjects design). Accordingly, a recent meta-analysis, which included both published and unpublished data, showed that positive episodic future thinking had a strong effect in reducing delay discounting, whereas negative episodic future thinking had no significant effect (Rösch et al., 2021). Given the inconsistent results, it remains unclear whether both positively and negatively valenced episodic future thinking have a similar (i.e., both reduce delay discounting) or different (i.e., positive reduces delay discounting while negative increases or has no effect on delay discounting) influence on intertemporal choices.

In this study, we had two primary objectives. Our first objective was to conceptually replicate the findings of Bulley et al. (2019), showing that imagining both positive and negative events attenuate discounting and do so to a greater extent relative to neutral events. Our second objective was to extend these findings by isolating the influence of the emotional valence of episodic future thinking on delay discounting. Consequently, we deviated from the design of Bulley et al. (2019) in a number of ways. First, we compared the effects of both positive and negative episodic future thinking to a condition involving neutral episodic future thinking, whereas Bulley et al. (2019) used an atemporal neutral condition (i.e., one that did not involve envisioning the future). For example, a participant in the positive condition might be prompted to imagine "seeing live music in 6 months" while a participant in the atemporal neutral condition might be prompted to imagine "leaning on a table." Second, we asked participants to imagine neutral events that were more consequential (e.g., attending a work meeting) than those used in prior studies (e.g., folding a piece of paper; Bulley et al., 2019; Liu et al., 2013; Zhang et al., 2018). We increased the personal relevance of neutral prompts by having participants generate the prompts themselves, rather than using a predetermined list of events—a method that has been employed in past work with episodic future thinking (D'Argembeau et al., 2008). In this regard, some of our design features demonstrated parallels to those of Calluso et al. (2019), wherein the authors also employed a condition involving personally relevant neutral episodic future thinking.

In line with Bulley et al. (2019), we hypothesised that prompting participants to imagine either positive or negative events would result in a shift towards more patient choices (i.e., decreased delay discounting) compared to when participants are prompted to imagine neutral events. Such findings would indicate that emotional episodic future thinking promotes future-oriented decisions independent of their valence. Regardless of our findings, this work will help resolve the uncertainty surrounding the effects of negatively valenced episodic future thinking and thus further reveal how emotionally valenced episodic future thinking influences intertemporal choices.

In addition to our primary objectives, an exploratory goal of this study was to examine whether symptoms of anxiety and depression influence the relationship between emotionally valenced episodic future thinking and delay discounting. Researchers have found that individuals with higher trait anxiety or depression are more likely to imagine negative events when engaging in episodic future thinking (Miloyan et al., 2014; Miloyan & Suddendorf, 2015; Roepke & Seligman, 2016) and may display a different trend towards immediate- or future-oriented choices (Bulley et al., 2016). Other work shows that individual differences in stress appraisal interacts with acute stress to influence delay discounting (Lempert et al., 2012). Individuals with higher anxiety and/or depression may be biased towards negative interpretations of the future, even in positive or neutral conditions. To address this goal, this study also included self-report measures of anxiety and depression so that symptom severity scores could be correlated with the shift in delay discounting due to episodic future thinking. Given the exploratory nature of this analysis, we did not hypothesise the directionality of this relationship.

Methods

Participants

A total of 604 participants were recruited through the University of British Columbia's Human Subject Pool and randomly assigned to a positive, neutral, or negative emotional valence condition. As per our pre-registration, we opted to collect responses until we reached $N=650$ or until our sign-up deadline. In determining the sample size for this study, we did not perform a power analysis, but rather set out to recruit at least as many participants as in the study by Bulley et al. (2019; $N=297$). To our knowledge, our study represents the largest sample to date investigating this topic. All participants were fluent in English, provided informed consent, were given the option to withdraw from the study at any time, and were compensated in the form of course credit for undergraduate psychology courses (note that participants were not necessarily majoring in psychology). The protocol for this study was reviewed and approved by the University of British Columbia Behavioural Research Ethics Board. This study was pre-registered.

In accordance with our pre-registration plan, participants were excluded from analysis if they answered three or more (out of five) comprehension questions incorrectly. We also excluded participants if three or more of their imagination prompt descriptions did not describe their thoughts or events and if they did not enter five self-generated imagination prompts. For example, a participant would be excluded based upon their imagination event prompts or written descriptions if they skipped through written sections by entering "NA" or nonsensical characters, or copy/pasted their written responses from prior responses. The latter two exclusion criteria were not pre-registered. Based on these exclusion criteria, 32 participants were excluded from the analysis (5.3%), leaving a final sample size of 572 participants (Positive = 194, Neutral = 185, Negative = 193; see Supplementary Materials). The mean age (*SD*) for participants in the positive, neutral, and negative condition was 20.68 (2.75), 20.39 (2.30), and 20.65 (2.52), respectively.

Measures

Delay discounting task. The intertemporal choice task used in this study was modified from the 27-item Monetary Choice Questionnaire (MCQ; Kirby et al., 1999) and was used to calculate the proportion of larger, later choices for each participant. The questionnaire was administered twice, once to establish a baseline and a second time in conjunction with episodic future thinking event prompts, subjective ratings (vividness, emotionality, personal relevance), and narrative descriptions, as described in detail below (see Procedures). Note that the inclusion of a baseline is a departure from the study by Bulley et al. (2019) and helps to establish the ability of episodic future thinking to modulate choice behaviour at the intra-individual level.

In each item of the modified MCQ, participants were instructed to indicate their preference between a hypothetical reward available immediately (e.g., $25 now) or

Table 1. Intertemporal choices, including rewards and delays.

Immediate reward ($)	Delayed reward ($)	Delay (in weeks)	LL proportion at baseline
20	55	1	0.99
31	85	1	0.98
11	30	2	0.96
15	35	2	0.95
33	80	2	0.98
25	60	3	0.93
14	25	3	0.71
41	75	3	0.88
27	50	3	0.85
24	35	3	0.60
54	80	3	0.84
34	50	6	0.60
19	25	6	0.35
55	75	6	0.60
40	55	6	0.48
25	30	6	0.24
49	60	6	0.48
69	85	6	0.55
54	60	12	0.19
54	55	12	0.07
67	75	12	0.29
22	25	12	0.11
80	85	12	0.12
47	50	12	0.12
78	80	12	0.10
28	30	12	0.10
34	35	12	0.06

LL: larger later.

a larger reward (e.g., $60) available after an indicated delay. The order of intertemporal choices was randomised across trials. See Table 1 for a full list of choices. Using the choices that participants made across different reward values and delays, we calculated the proportion of larger, later choices across the 27 trials for each participant. In this modified version of the questionnaire, monetary values from the original questionnaire were retained but the delays were changed such that there were only five unique delays (1, 2, 3, 6, and 12 weeks) instead of a range of delays. Our purpose in modifying these delays was to synchronise the time scales between intertemporal choices and episodic future thinking trials. For example, participants would be prompted to imagine an event that occurs in 6 weeks and then decide between an immediate reward or a reward available in 6 weeks.

Self-report measures

Demographics and health history. Basic demographic information was assessed in Qualtrics (2005) with a set of questions regarding age, gender, and education. Participants also completed a health history questionnaire, which included questions about drug use, vision and hearing, major health events, and current or past history of neurological and psychiatric concerns. Data derived from these questions were not used in any analyses in this study.

State-Trait Anxiety Inventory. To measure symptoms of anxiety, we used the State-Trait Anxiety Inventory (STAI), which consists of two scales measuring state and trait anxiety, respectively (Spielberger et al., 1983). State anxiety (STAI-S) describes the current level of anxiety (how anxious a participant is feeling at that moment), whereas trait anxiety (STAI-T) describes general anxiety (how anxious the participant usually feels). Both scales consist of 20 questions that are rated along a 4-point scale (1 = *not at all*; 4 = *very much so*). Anxiety-absent items were reverse coded. Total scores within each subscale range from 20 to 80, with higher scores indicating greater levels of state or trait anxiety, respectively. Both scales have demonstrated good reliability ($\alpha = .90$ for STAI-T; $\alpha = .92$ for STAI-S; Spielberger et al., 1983).

Centre for Epidemiologic Studies Depression Scale. To measure symptoms of depression, we used the Centre for

Figure 1. Episodic future thinking delay discounting trial design. This figure depicts the order of events in a single trial of the episodic future thinking delay discounting task. Each participant completed 27 of these trials presented in a randomised order, where one of the five self-generated events was input into each trial.

Table 2. Example future event lists provided in positive, neutral, and negative conditions.

Positive future events	Neutral future events	Negative future events
Winning a scholarship that I applied for	Printing off my completed assignment	Falling ill with food poisoning
Going to see my favourite musician	Attending a meeting at work	Falling and injuring my back
Visiting my loved ones	Packing my bag with everything I need for the day	Getting into a traffic accident
Relaxing at the beach in my dream vacation spot	Peer-reviewing an in-class presentation	Contracting an infection

Not included in this table, we provided an equal number of "bad examples." These "bad examples" were vague events (e.g., "having a bad day," "holding a pencil," "having my morning coffee") that would not be conducive to rich imagination. The table provides four representative examples, but participants were provided with a more exhaustive list.

Epidemiologic Studies Depression Scale (CESD; Radloff, 1977). The CESD consists of 20 items representing various symptoms of depression. Participants rate how often they have experienced each symptom "during the past week" using a 4-point scale (0 = *not at all* or *less than 1 day*; 3 = *most* or *all of the time*, *5–7 days*). Depression-absent items were reverse coded. Total scores range from 0 to 60, with higher scores indicating greater frequency of depressive symptoms. The CESD has shown to be a reliable measure of depression in the general population ($\alpha = .85$; Radloff, 1977).

Procedure

In this online study, participants provided informed consent before being randomly assigned by Qualtrics to one of three conditions (positive, negative, or neutral future episodic thinking). Participants then completed the two-part delay-discounting task (see Figure 1 for a visual representation of this task) followed by self-report measures; For the first part of the delay-discounting task, participants completed a baseline iteration of the modified MCQ (question order randomised), which did not involve an episodic future thinking component.

Participants then answered a series of questions regarding their demographics and health history. Next, participants were asked to generate five prompts describing possible future events that they could envision reasonably occurring in their lives within the next 4 months. By having participants generate these prompts themselves, we aimed to maximise the personal relevance of imagined events across conditions. Specifically, participants were asked to generate specific, novel events (i.e., events they had not already experienced in their past) lasting no longer than 24 hr. Depending on condition, participants generated positive, neutral, or negative future events. To assist with event selection, a list of suitable (and unsuitable) example events was provided for each condition (Table 2). Suitable events were specific and novel, while unsuitable examples were vague and/or familiar.

Participants then completed the second iteration of the modified MCQ (question order randomised). Prior to each trial, participants were randomly prompted to imagine themselves experiencing one of the five self-generated events as vividly as possible while concentrating on details of the experience (e.g., where they are, what they are doing, how they feel); there was no time limit for this. Before beginning this iteration of the modified MCQ, participants saw a guided example illustrating the amount of detail they should include when imagining these events. We specified that participants should imagine these events prior to each intertemporal choice question, but that responses to those questions did not need to be related to the event. For each trial of the modified MCQ, participants responded to an intertemporal choice question and then rated how vivid (1 = *not vivid at all*; 7 = *very vivid*), emotional (1 = *intensely negative*; 4 = *neutral*; 7 = *intensely positive*), and personally relevant (1 = *not relevant at all*; 7 = *very relevant*) they considered the event they had imagined just prior to their decision. To affirm that participants were performing the task as instructed, they were asked to provide a written, detailed description of the event they imagined on five randomly selected trials (see Figure 1). For these written descriptions, there was a 50-character minimum count that participants had to reach before they were allowed to move on to the next trial.

Throughout the survey, participants were asked to answer five, two-option comprehension questions after reading the instructions pertaining to each task. These questions were designed to test whether the participant properly understood the instructions for each task (baseline delay discounting, future event generation, and post-episodic future thinking delay discounting). If participants answered a question incorrectly, another prompt would appear summarising the key points to correct their understanding.

After completing the second iteration of the modified MCQ, participants completed the STAI and CESD. Participants were then asked to answer questions about the task, including "What did you think about the study?," "What did you think the study was about?," and "Do you have any comments about the study?." Finally, they were debriefed in full. As detailed in Supplementary Materials, the second question was used to determine the extent to which demand characteristics were relevant to this study.

Statistical analysis

All analyses were conducted using *R* (R Core Team, 2019). Pre-registered analyses are explicitly stated (https://aspredicted.org/ex5gp.pdf). For all analyses, our a-priori alpha level was set at .05, and Bonferroni corrections were used to adjust reported *p*-values for multiple comparisons where stated.

To confirm that episodic future thinking event prompts elicited the appropriate emotional responses, we conducted a one-way analysis of variance (ANOVA) to compare emotionality ratings across conditions (positive, negative, or neutral), per our pre-registration plan. In addition, we conducted two more one-way ANOVAs to determine whether vividness and personal relevance ratings differed between positive, neutral, and negative conditions. All of the rating scores included in these analyses reflect a within-participant average.

From both the baseline and imagination delay discounting tasks, we calculated the proportion of larger, later choices to smaller, sooner choices. These proportions were taken as our primary dependent variable and labelled "LL proportion" (larger later proportion). We compared the effect of positive, neutral, or negative episodic future thinking on LL proportions by conducting a 3×2 mixed ANOVA where the between-subjects factor was emotional valence of episodic future thinking (positive, neutral, or negative) and the within-subjects factor was phase (baseline or post-episodic future thinking delay discounting), per our pre-registration plan. When needed, significant interactions or main effects were decomposed using one-way ANOVAs and post hoc *t*-tests.

In addition, we calculated a difference score between delay discounting trials (episodic future thinking LL proportion minus baseline LL proportion; hereafter referenced as LL proportion difference scores) for each participant, which we used in additional post hoc analyses to compare the magnitude of effects between conditions (using *t*-tests). Finally, to account for the role of vividness and personal relevance in observed condition differences (which differed across conditions), we conducted an analysis of covariance (ANCOVA) with personal relevance and vividness as covariates. These latter analyses were not clearly specified in our pre-registration plan.

We also examined Bonferroni corrected correlations between ratings (emotionality, vividness, personal relevance) and the shift in choices between episodic future thinking and baseline delay discounting tasks in each condition (LL proportion difference scores) but this was not pre-registered. Given the skewness of some ratings, we focus on Spearman correlations but report Pearson correlations as well.

We additionally examined delay discounting using a hyperbolic discounting function. Bulley et al. (2019) used the standard 27-item MCQ (Kirby et al., 1999) and fit *k* values based on a hyperbolic discounting function using the scoring method of Kaplan et al. (2016). As we modified the MCQ to align with our imagined future event methods more closely (see Supplementary Materials), we could not use this approach. Here, we used a hierarchical Bayesian estimation method to model hyperbolic discounting parameters for each of the three groups using Vincent's (2016) delay discounting toolbox; model fitting was conducted using Markov-chain Monte-Carlo (MCMC) as implemented in JAGS (Plummer, 2003). This approach involves fitting parameters at the trial, participant, and group levels, somewhat similar to mixed-effect models. In Supplementary Materials, we report the comparison of this approach being applied and the *k* values estimated in the study by Bulley et al. (2019). As both methods were relatively consistent and Vincent's (2016) toolbox is more flexible, we applied the latter to our data. This analysis was not pre-registered but was conducted to align our findings with the literature.

Subsequent exploratory analyses were performed to determine whether anxiety and depression symptoms were correlated with shifts in choices between episodic future thinking and baseline delay discounting tasks in each condition, per our pre-registration. To this end, we computed Pearson and Spearman correlations between LL proportion difference scores and STAI-T, STAI-S, and CESD scores.

Results

All data from this study have been made publicly available and can be found at: https://osf.io/m2xv4/. Note that some of our measures demonstrated violations of normality. Moreover, we also observed inhomogeneity of variance across conditions for some measures (i.e., delay discounting measures and ratings). However, we determined that

Table 3. Summary statistics in positive, neutral, and negative conditions.

	Neutral (N=185)	Positive (N=194)	Negative (N=193)
Baseline DD			
Mean (*SD*)	0.52 (0.21)	0.52 (0.21)	0.53 (0.22)
Median [Min, Max]	0.52 [0.07, 1.00]	0.48 [0.04, 1.00]	0.52 [0.04, 1.00]
EFT DD			
Mean (*SD*)	0.56 (0.21)	0.63 (0.22)	0.60 (0 .25)
Median [Min, Max]	0.56 [0.11, 1.00]	0.63 [0.07, 1.00]	0.63 [0.00, 1.00]
Emotionality			
Mean (*SD*)	4.15 (0.51)	5.66 (0.77)	2.56 (1.16)
Median [Min, Max]	4.07 [1.07, 6.96]	5.67 [3.19, 7.00]	2.22 [1.00, 6.26]
Vividness			
Mean (*SD*)	5.05 (1.13)	5.43 (0.91)	5.34 (0.96)
Median [Min, Max]	5.07 [1.00, 7.00]	5.48 [1.96, 7.00]	5.52 [2.37, 7.00]
Personal relevance			
Mean (*SD*)	4.90 (1.14)	5.83 (0.82)	5.33 (1.08)
Median [Min, Max]	4.85 [1.07, 7.00]	5.96 [2.78, 7.00]	5.44 [1.67, 7.00]
STAI-State			
Mean (*SD*)	43.54 (12.32)	42.81 (11.94)	46.35 (13.10)
Median [Min, Max]	42.00 [20, 72]	42.00 [20, 75]	47.00 [20, 80]
Missing (*N*)	2	1	1
STAI-Trait			
Mean (*SD*)	45.94 (11.19)	46.45 (11.91)	47.18 (11.02)
Median [Min, Max]	45.00 [21, 73]	47.00 [23, 75]	47.00 [22, 72]
Missing (*N*)	0	2	0
CESD			
Mean (*SD*)	19.01 (11.58)	19.27 (11.16)	20.33 (10.97)
Median [Min, Max]	17.00 [1, 50]	17.00 [1, 52]	20.00 [0, 47]
Missing (*N*)	1	1	0

DD: delay discounting; *SD*: standard deviation; EFT: episodic future thinking; STAI: State-Trait Anxiety Inventory; CESD: Centre for Epidemiologic Studies Depression Scale.
Baseline and episodic future thinking (EFT) variables represent the proportion of larger, later choices in either baseline or EFT delay discounting tasks, respectively.

ANOVA was still suitable due to its robustness to violations of these assumptions when using large samples and close to equal sample sizes per group.

Summary statistics

Table 3 summarises the primary variables of interest in this study. These variables include LL proportions (for baseline and post episodic future thinking delay discounting trials), vividness, emotionality, personal relevance ratings, CESD scores, and STAI scores. Episodic future thinking event ratings were computed by averaging the responses for each participant across the 27 trials of the baseline or episodic future thinking discounting task. CESD and STAI scores were computed by summing the relevant item responses for each participant. Participants with missing data were not excluded (see below).

Episodic future thinking event ratings

We first checked whether episodic future thinking event prompts inspired the appropriate emotional response (positive, neutral, or negative) by comparing emotionality ratings across conditions using a one-way ANOVA (manipulation check). As expected, ratings differed across conditions ($F(2, 569)=625.39$, $p<.001$, $\eta p^2=.69$), such that participants rated that they felt more positive when imagining events in the positive condition compared to the neutral ($p<.001$, Cohen's $d=2.29$) or negative condition ($p<.001$, $d=3.14$; see Figure 2a). Similarly, participants in the negative condition reported feeling significantly more negative after imagining events compared to participants in the neutral condition ($p<.001$, $d=1.76$; see Figure 2a). These results indicated that the event prompts used in each of the episodic future thinking discounting trials evoked the expected emotional response in each condition (positive, neutral, or negative), yielding large effect sizes.

We next compared vividness ratings across conditions with a one-way ANOVA. We found that vividness ratings differed between conditions ($F(2, 569)=7.32$, $p<.001$, $\eta p^2=.03$), such that participants in the positive ($p<.001$, $d=0.37$) or negative ($p=.02$, $d=0.27$) conditions reported their imaginations to be significantly more vivid than those

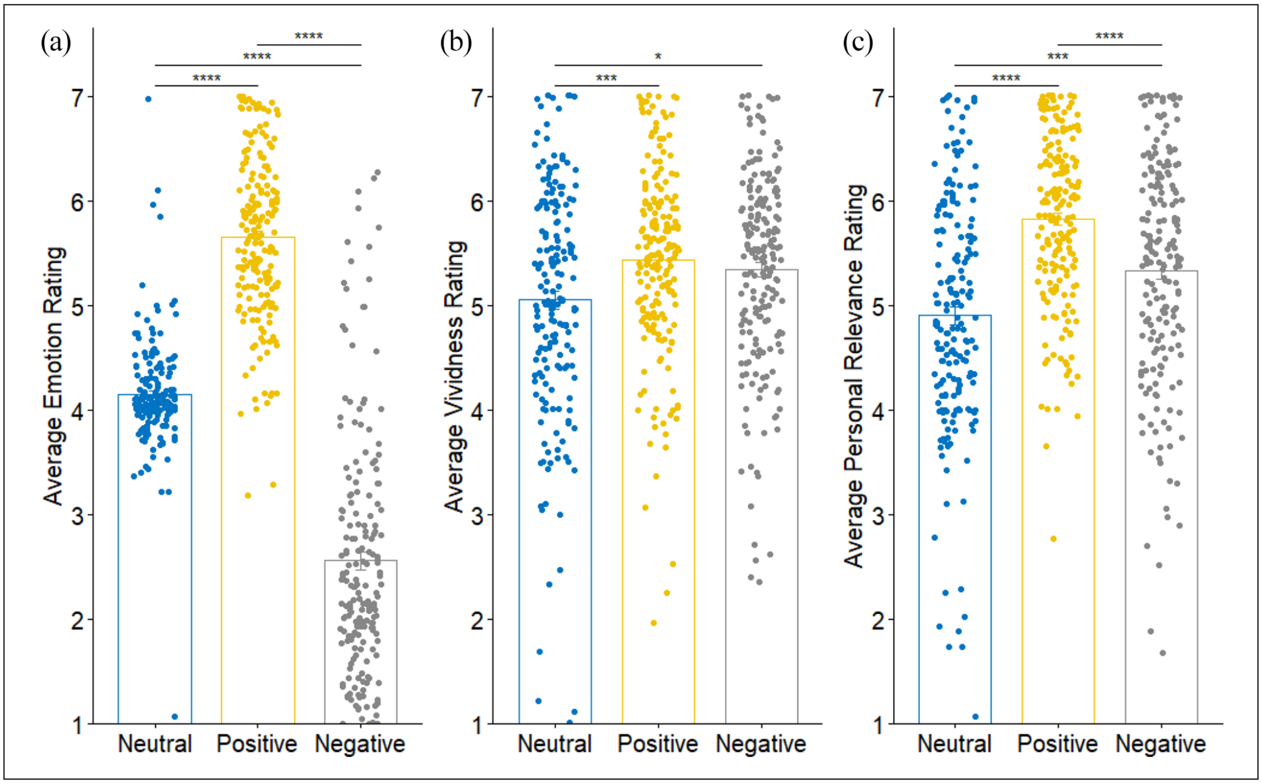

Figure 2. Average ratings of episodic future thinking events in each condition. This figure displays the (a) average emotionality, (b) vividness, and (c) personal relevance ratings from the episodic future thinking delay discounting trials. Bars indicate the mean (±*SE*) of each rating for neutral, positive, or negative conditions. Individual data points for each participant are jittered.

in the neutral condition (see Figure 2b). However, there was no significant difference in vividness ratings between participants in the positive versus negative condition ($p = 1.00$, $d = 0.10$). As expected, these findings suggest that participants are more easily able to generate vivid imaginations of positive or negative events (compared with neutral) but there is no difference in the vividness of imaginations between positive and negative events.

Using a third one-way ANOVA, we compared personal relevance ratings across conditions. We found that personal relevance ratings significantly differed between conditions ($F(2, 569) = 39.18$, $p < .001$, $\eta p^2 = .12$), such that participants in the positive condition rated their imaginations as significantly more personally relevant than those in the neutral ($p < .001$, $d = 0.94$) or negative conditions ($p < .001$, $d = 0.52$; see Figure 2c). In addition, participants in the negative condition also rated their future events as significantly more personally relevant than those in the neutral condition ($p < .001$, $d = 0.39$; See Figure 2c). These results indicate that the personal relevance of episodic future thinking differs significantly depending on the emotional valence of the events.

Given the significant differences in vividness and personal relevance between conditions, we added both variables as covariates in later analyses to determine whether they influenced results.

Effects of emotionally valenced episodic future thinking on delay discounting

Our primary objective was to determine whether positive, neutral, or negative episodic future thinking would influence delay discounting differently. To examine this, we conducted a mixed ANOVA with phase (baseline or future thinking) entered as the within-subjects factor, condition (positive, negative, or neutral) entered as the between-subjects factor, and LL proportion as the dependent variable. We observed a significant main effect of phase ($F(1, 569) = 118.79$, $p < .001$, $\eta p^2 = .17$), but not condition ($F(2, 569) = 1.50$, $p = .23$, $\eta p^2 = .005$). Critically, the difference in LL proportion between baseline and episodic future thinking delay discounting depended on condition, as evidenced by a significant phase × condition interaction ($F(2, 569) = 7.65$, $p < .001$, $\eta p^2 = .03$). Note that the interaction was significant even after controlling for personal significance and vividness ($p = .003$, $\eta p^2 = .02$).

To determine the nature of this interaction, we first investigated the effect of condition at each phase (baseline or episodic future thinking) using two one-way ANOVAs with LL proportion as the dependent variable. As expected, the effect of condition was significant only in the episodic future thinking phase ($F(2, 569) = 4.26$, $p = .015$, $\eta^2 = .02$), but not the baseline phase ($F(2, 569) = 0.18$, $p = .84$, $\eta^2 = .001$).

Next, we conducted Bonferroni adjusted post hoc comparisons to compare baseline and episodic future thinking LL proportions within each level of condition. We found that participants in the positive ($p < .001$, $d = 0.76$), neutral ($p < .001$, $d = 0.32$) and negative ($p < .001$, $d = 0.35$) conditions made more larger, later choices in the episodic future thinking delay discounting trials than in the baseline delay discounting trials (Figure 3). These results suggest that engaging in episodic future thinking of any valence (positive, neutral, or negative) promotes larger, later choices.

To break down the above-mentioned interaction between phase and condition, we computed a difference score within each condition and conducted a final set of post hoc comparisons, reporting *p*-values with Bonferroni adjustment. Here, our dependent variable was LL proportion difference scores. Critically, given the significant differences in vividness and personal relevance ratings between conditions, we also ran these analyses using an ANCOVA, where personal relevance and vividness ratings were added as covariates, although the pattern of results without these covariates did not change.[1] When controlling for personal relevance and vividness, we found that positive episodic future thinking significantly shifted decisions towards larger, later choices compared to neutral ($F(1, 375) = 14.21$, $p < .001$, $\eta p^2 = .04$), and negative ($F(1, 383) = 4.74$, $p = .03$, $\eta p^2 = .01$) episodic future thinking. By contrast, there was no significant difference between the neutral and negative conditions ($F(1, 374) = 1.73$, $p = .19$, $\eta p^2 = .005$). Note that we re-ran the analyses (not pre-registered) with two statistical outliers (difference score, neutral condition; greater than 3 × interquartile range) removed and the pattern of results did not change (either with or without covariates).

A mixed ANOVA of phase and condition using estimated log(k) values produced similar results to the comparable as the initial ANOVA based on LL proportion. There was a significant main effect of phase ($F(1, 569) = 141.20$, $p < .001$, $\eta p^2 = .20$), but not condition ($F(2, 569) = 2.75$, $p = .06$, $\eta p^2 = .01$). As with LL proportion, there was a significant phase × condition interaction ($F(2, 569) = 9.39$, $p < .001$, $\eta p^2 = .03$). Due to these consistencies, we did not repeat the subsequent one-way ANOVAs and separate ANCOVAs again for the log(k) values. Hyperbolic discounting functions for the groups and phases are shown in Figure 4.

Finally, for completeness, we also report correlations between LL proportion difference scores for each condition and ratings of emotionality, vividness, and personal relevance to determine whether the magnitude of the shift towards larger, later choices after episodic future thinking was correlated with the phenomenological characteristics of the imagined events. Given the skewness of some ratings, we focus on Spearman correlations but report Pearson correlations as well (See Supplementary Materials). These analyses (Bonferroni corrected) show that emotionality was correlated with LL proportion difference scores in the positive condition only (positive $\rho = .19$, $p = .03$; negative $\rho = -.02$, $p = 1.00$; neutral $\rho = .09$, $p = .73$) and vividness was correlated with LL proportion difference scores in the neutral and positive conditions (positive $\rho = .22$, $p = .005$; negative $\rho = -.01$, $p = 1.00$; neutral $\rho = .21$, $p = .01$). None of the personal relevance correlations were significant.

Exploratory analyses

A peripheral goal was to explore whether higher levels of trait anxiety (measured by the STAI-T scale), state anxiety (measured by the STAI-S scale), and depression (measured with the CESD) were correlated with the shift towards larger, later choices after episodic future thinking in each condition. To do so, we calculated Spearman (and Pearson) correlation coefficients between these scores and LL proportion difference scores in the positive, neutral, and negative condition (note that STAI-S, STAI-T, and CESD data were missing for $N = 4$, $N = 2$, and $N = 2$ participants, respectively). We did not observe any significant correlations between trait anxiety, state anxiety, or depression symptoms with LL proportion difference scores in the positive, neutral, or negative episodic future thinking conditions, even with no correction for multiple comparisons. Note that scores from the STAI-T, STAI-S, and CESD scales were highly correlated, $r > .70$. For interested readers, we also note that the correlations between STAI-T, STAI-S, and CESD and baseline LL proportion were not significant (see Supplementary Materials; these analyses were not pre-registered).[2]

Discussion

In this study, we sought to replicate and extend the work of Bulley et al. (2019), which demonstrated that both positive and negative episodic future thinking attenuated delay discounting. The findings of our study indicate that engaging in any form of episodic future thinking (whether positive, negative, or neutral) promotes patient choices. However, valence did influence this relationship insofar as the magnitude of change in delay discounting (from baseline) was larger for positive episodic future thinking than neutral or negative episodic future thinking; there was no difference in magnitude between negative and neutral episodic future thinking. This pattern held even after controlling for differences in personal relevance and vividness, which covaried with emotion. These findings corroborate past research evidencing the robust ability of positive episodic future thinking to reduce delay discounting (Bulley et al., 2019; Liu et al., 2013; Rösch et al., 2021; Zhang et al., 2018; also see the studies by Daniel et al., 2013; O'Donnell et al., 2017; Stein et al., 2018). Critically, the present findings are

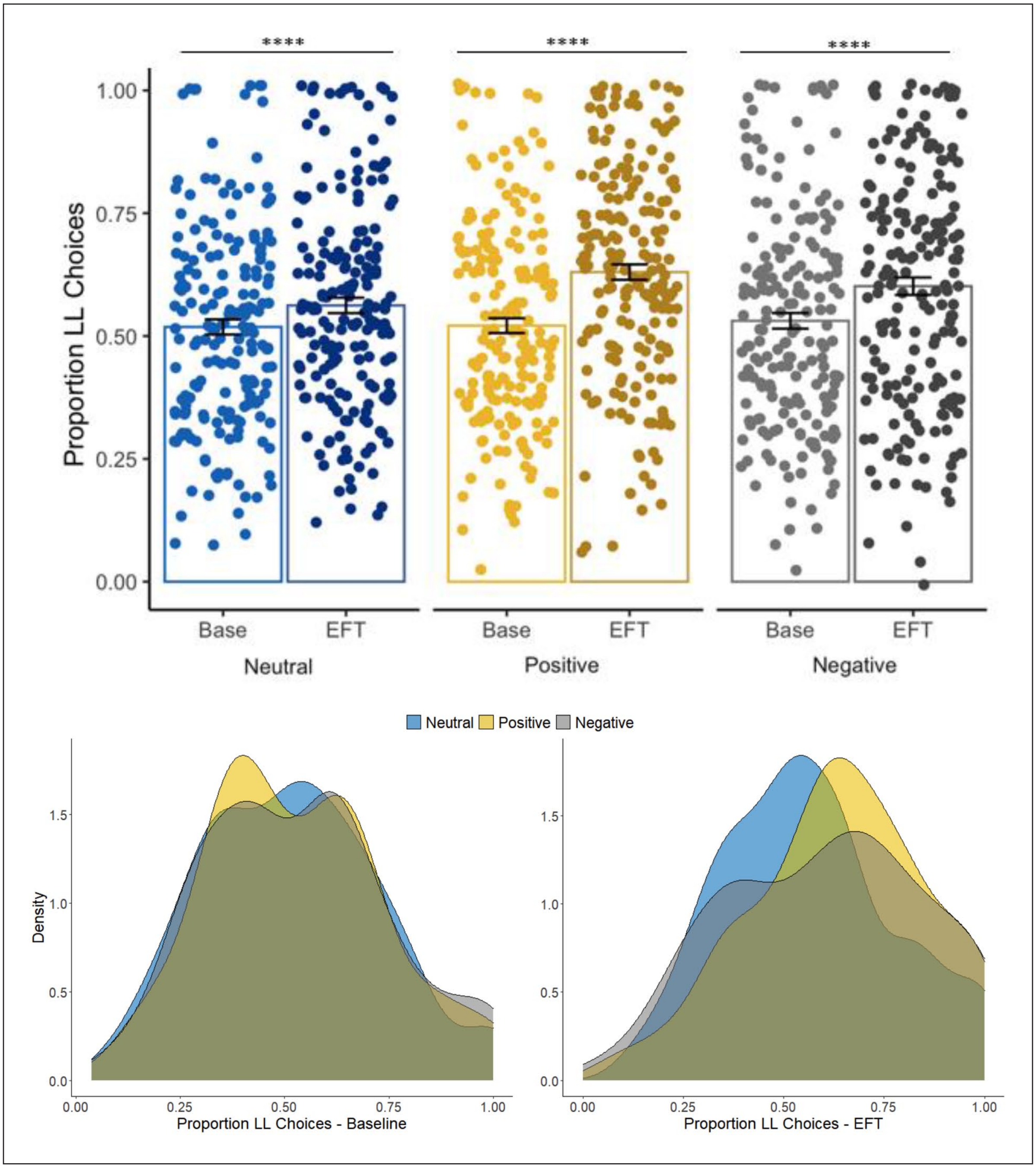

Figure 3. Comparing proportion of larger, later choices in baseline and episodic future thinking phases in each condition. The top panel of this figure displays the proportion of larger, later (LL) choices in baseline or episodic future thinking (EFT) for the positive, neutral or negative conditions. Bars indicate the mean (±*SE*) proportion LL choices for baseline or EFT delay discounting trials in the neutral, positive, and negative conditions. Individual data points for each participant are jittered. The bottom panel shows density plots for the two experimental conditions.

in line with recent studies (Bulley et al., 2019; Calluso et al., 2019) showing negative episodic future thinking promoted patient choices (i.e., reduced delay discounting), rather than immediate choices (i.e., increased delay discounting) as in prior reports (Liu et al., 2013; Zhang et al., 2018), which has important implications for understanding how humans make decisions when facing unfavourable situations or stress. This work makes a valuable contribution because it brings needed clarity to an equivocal finding in the literature pertaining to how valence may interact with episodic future thinking to affect delay discounting. Our work also emphasises the importance of replication,

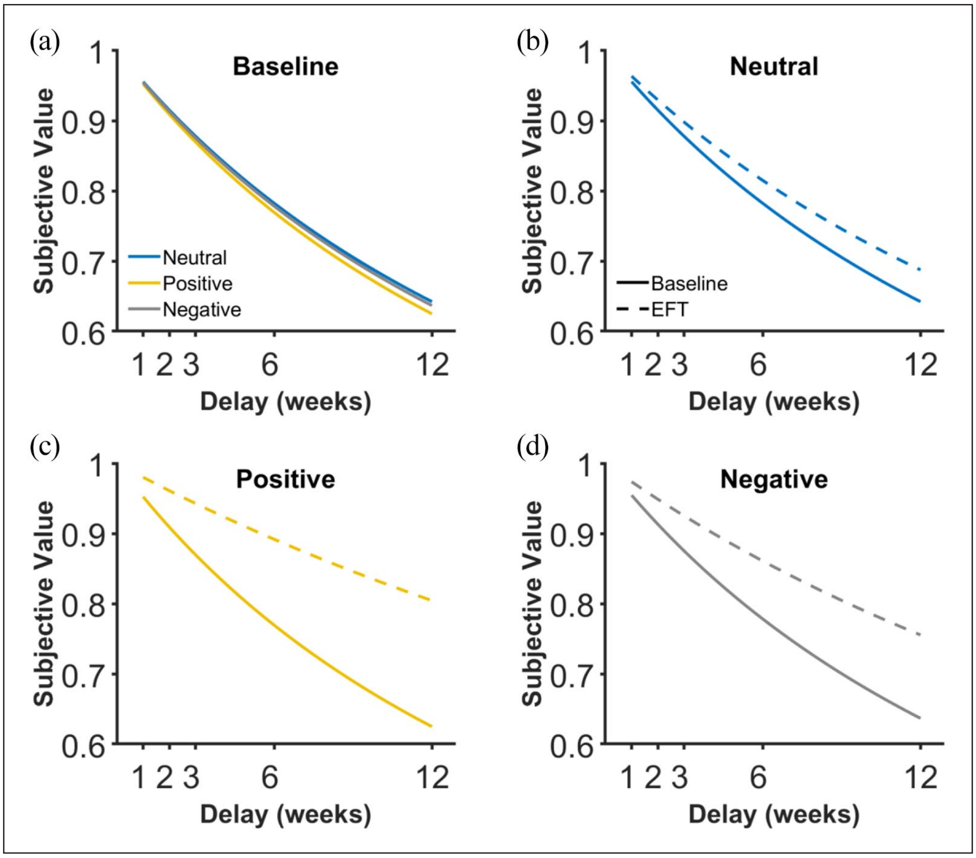

Figure 4. Comparing hyperbolic discounting functions for baseline and episodic future thinking delay discounting in each condition. This figure displays the estimated hyperbolic discounting function for baseline or episodic future thinking (EFT) delay discounting trials for positive, neutral, or negative conditions. (a) Shows the baseline discounting functions as being nearly identical for all three groups. (b to d) Show the baseline (solid line) and EFT (dashed line). Note that the shallower discounting overall in our paradigm is likely related to the shorter delays chosen in our study; our maximum delay was 84 days (12 weeks), whereas the 27-item MCQ has a maximum delay of 189 days (11 of 27 questions in the MCQ have delays longer than 84 days).

particularly in the context of literature with small sample sizes.

Why does episodic future thinking bias individuals towards patient choices? A number of ideas have been put forth in the literature. In one proposal, episodic future thinking manipulations change the perceived temporal distance until the reward is received. That is, perhaps episodic future thinking makes the future feel closer in subjective time to the present, bolstering its imminence (Boyer, 2008) and thus promoting future-oriented choices. Another possibility, albeit not necessarily mutually exclusive, is that episodic future thinking might alter the concreteness of the future. This idea is based on Construal Level Theory (Trope & Liberman, 2010), which posits that temporally distant events are psychologically more distant, so individuals construe them more abstractly than immediate events. Along these lines, episodic future thinking prompts individuals to simulate abstract, distant events, and represent them more concretely (Cheng et al., 2012; Kurth-Nelson et al., 2012; Lempert & Phelps, 2016; also see H. Kim et al., 2013, in which people discounted less when now and later options were equated in level of construal). In doing so, individuals may be better equipped to resist the tendency towards delay discounting and instead opt for the future-oriented choice over the immediate one. Such a proposal is consistent with our findings that all episodic future thinking (regardless of emotional valence) shifted participants towards more patient decisions, although vividness of events (potentially a proxy for concreteness) was only associated with this shift in the positive and neutral conditions (also see Peters & Büchel, 2010). Although we did not include a group without an episodic future thinking manipulation, other studies have used repeated administrations of a delay discounting task within the same experimental session and demonstrated no change in discounting values (Bulley et al., 2021; Naudé et al., 2018; intermixed format). This finding, coupled with observed correlations between the change in discounting following episodic future thinking and phenomenological ratings, make it less likely that participants selected more patient choices in the second iteration of the delay discounting tasks simply due to repeated testing.

Although episodic future thinking promoted greater patience in general, the relatively greater difference score of positive episodic future thinking (compared with neutral or negative) suggests that emotional valence also plays a role. This might occur via a larger change in construal level, whereby positive episodic future thinking tethers a positive feeling to the future choice. That is, episodic future thinking provides a vehicle for value assignment, through which humans can determine if something in the future will feel good or not based on how it makes us feel when we envision it. When such simulations are of positive value, they can most effectively combat the allure of immediate gratification to increase one's fitness goals (Benoit et al., 2011; Boyer, 2008; Palombo et al., 2015b; Peters & Büchel, 2010). In light of this idea, it is interesting that it was only within the positive condition that we observed an association between the magnitude of the shift in decision-making following episodic future thinking and degree of emotionality associated with future events (in addition to the vividness association noted above), supportive of this "pre-feel" notion. Yet, it is also important to consider the fact that our emotional conditions may differ in the extent to which they are decoupled from the potential reward (e.g., a larger, later reward might be more useful when envisioning oneself at a bar versus recovering from an illness or completing an assignment).

At first blush, it is somewhat surprising then that negative episodic future thinking also promoted future-oriented choices. From the ideas presented above, it would follow that the construal-level changes driven by negative episodic future thinking would reduce the subjective value of the future. Our findings suggest that a different mechanism may come into play when imagined events are negative (also see the studies by Bulley et al., 2019; Calluso et al., 2019). Specifically, negative episodic future thinking may compel individuals to select the larger, later reward in an effort to gather resources to combat the effects of an otherwise bleak future (i.e., preparatory motivation; Bulley et al., 2019). This is in line with the idea that the emotional content of episodic future thinking can act as an adaptive motivator to sway present behaviour in whatever direction provides the most biological value (Miloyan & Suddendorf, 2015). Still, it is important to consider that the effect of negative episodic future thinking was statistically comparable to neutral episodic future thinking in our study. As such, if preparatory motivation is involved in promoting future-oriented choices, it may work in conjunction with another mechanism driven by episodic future thinking. Alternatively, it might be that negative (and neutral) emotion operates to affect delay discounting via one of the more general mechanisms discussed above, namely by altering construal-level or perceived temporal distance, whereas the content of the simulations per se is less relevant.[3]

Although our results are in accordance with both Bulley et al. (2019) and Calluso et al., (2019), it remains a puzzle why some studies have observed an opposite pattern of results: that negative episodic future thinking augments temporal discounting (Liu et al., 2013; Zhang et al., 2018). A content analysis of the types of events produced in studies that observe increased versus decreased temporal discounting following negative episodic future thinking could illuminate whether certain types of negative events are more likely to promote patience (see Supplementary Materials for sample narratives from this study). One idea is that some types of negative simulations, such as those pertaining to serious illness or death, may be especially potent in pulling one towards more myopic choice behaviour (Bulley et al., 2016). When episodic future thinking increases the salience of one's shortened time horizon or risk of mortality, delaying gratification becomes a less sensible choice. Related to this idea, the degree of controllability of the negative event may play a role; events with a more malleable outcome may be more effective in promoting farsighted behaviour, as doing so could attenuate the degree to which the future yields harm (see the studies by Bulley et al., 2019; Bulley & Schacter, 2020; Griskevicius et al., 2011 for discussions of this idea). Somewhat at odds with this sentiment, a greater preference for larger, later rewards was observed following a manipulation of mortality salience, namely thinking about death (Kelley & Schmeichel, 2015; but also see the study by Griskevicius et al., 2011, for nuances associated with individual differences). It will be important for future work to consider the nature of the experiences and potentially the types of emotions elicited in episodic future thinking manipulations (e.g., fear, sadness, anger, disgust) as different experiences and/or emotions may be associated with different future goal states. In considering alternative interpretations for these incongruous results, it is possible that other study design features are at play, including sample size, which was notably smaller in the studies by Liu et al. (2013) and Zhang et al. (2018) relative to the other studies.[4]

In this study, we developed a neutral condition that involves engaging in episodic future thinking tied to more meaningful events as opposed to the imagery tasks used in prior studies, which involved envisioning more menial tasks like "sitting on a chair" (see the study by Lin & Epstein, 2014). Although we were unsuccessful in fully matching personal relevance between conditions, which was higher for emotional versus neutral events, we note that it may be difficult to do so as high personal relevance may be part and parcel of emotional events (indeed the two ratings were correlated in all three conditions; all *p*-values $< .001$). Nevertheless, differences in personal relevance could not explain any effects we observed here; the significant difference between positive and neutral episodic future thinking (as well as positive versus negative episodic future thinking) were observed after controlling for personal relevance. This point is relevant in comparing our results to the study by Bulley et al. (2019). In their study, negative episodic future thinking reduced delay discounting in comparison to a neutral imagery control condition; whereas in our study it did so in comparison to a baseline version of the task, but not in comparison to neutral episodic future thinking. Hence, it is important to consider results from studies in light of the control tasks used. Indeed, other work has highlighted the importance of goal-relevance on the magnitude of the influence of episodic future thinking on delay discounting, showing that highly goal-relevant events have a larger effect than low goal-relevant events (O'Donnell et al., 2017).

In our exploratory analyses, we found no significant correlation between anxiety (or depression) levels and the effect of episodic future thinking on intertemporal choices in any condition. Previous research has shown that individuals with trait anxiety and depression are more prone to imagine negative events when engaging in episodic future thinking (Miloyan et al., 2014; Miloyan & Suddendorf, 2015; Roepke & Seligman, 2016). Given this negative bias, researchers have suggested that individuals who display higher levels of trait anxiety or depression might be more prone to selecting immediate intertemporal choices after engaging in episodic future thinking (see Bulley et al., 2016). Yet, our finding that negative episodic future thinking promotes patient choices suggests that even individuals prone to envisioning negative future events would shift their decisions towards future-oriented choices. In any case, our data suggest that the relationship between episodic future thinking and intertemporal choices is not affected by depression or trait (or even state) anxiety. A caveat is that this study used a general (not clinical) undergraduate population and as such, further research is needed to definitively determine whether such relationships would manifest in those with clinical levels of anxiety (or depression). Indeed, even when examining baseline discounting in association with trait (or even state) anxiety or depression, we failed to observe significant associations, whereas such associations do, at times, emerge in clinical samples. For example, in a study by Steinglass et al., 2017, although there was no evidence of an association between trait anxiety and discounting in the control group (also see Jenks & Lawyer, 2015; Patt et al., 2021), such associations did emerge in some of their clinical samples (higher trait anxiety in individuals with Obsessive Compulsive Disorder and Social Anxiety Disorder was associated with discounting less steeply). Although we did observe a large range of scores on all clinical measures in our sample, it is possible that a relationship between discounting and aspects of anxiety or depression only manifests at a higher level of symptoms. A comprehensive review of this literature goes beyond the scope of this article, but it is important to note that relationships between anxiety or depression and delay discounting are likely complex and depend on the nature of the population sampled (Amlung et al., 2019).

In this study, we considered the possible presence of demand characteristics namely, that participants were able to guess the correct study hypothesis, which could have driven the effect of episodic future thinking on intertemporal choices. Given that episodic future thinking involves shifting participants' focus towards the future, it is possible that participants could deduce the purpose of this manipulation and alter their decisions accordingly. However, researchers have found that the effects of episodic future thinking on delay discounting are not significantly different between those who could correctly identify the hypothesis versus those who could not (Rung & Madden, 2019; also see Stein et al., 2018). Indeed, a recent meta-analysis similarly suggests that demand characteristics do not play a role in the effect of episodic future thinking on delay discounting (Rösch et al., 2021). In this study, we observed little evidence for the involvement of demand characteristics (see Supplementary Materials). Moreover, when we re-ran all our analyses without the small subset of participants who correctly guessed the manipulation, our results did not change. Thus, it seems that the effect of episodic future thinking on delay discounting is not driven by demand characteristics.

Limitations and future directions

This study has limitations that merit consideration. First, unlike previous research in this area, this study was administered online rather than in-person. As such, this study lacked experimenter control over the environment in which the experiment took place. Although participants who expressed deviating from task instructions were excluded (see Methods), it is possible that some participants deviated from instructions but did not report doing so. If anything, these deviations would introduce noise into our paradigm, and we nevertheless observed significant effects in this study. Moreover, we note that a recent meta-analysis found no difference in effect sizes between online and in-person studies using episodic future thinking (Rösch et al., 2021).

A second important limitation is that we used hypothetical rewards, wherein participants did not receive any real payout for their choices. To increase ecological validity, some researchers have turned to more incentive-compatible approaches (i.e., "potentially real rewards," wherein a single trial is randomly selected for payout) due to the prohibitive costs of real rewards (i.e., payment on every trial). Although hypothetical and potentially real rewards have been shown to have concordance in patterns of discounting behaviour in a number of studies (Johnson & Bickel, 2002; Lagorio & Madden, 2005; Madden et al., 2004) as well as in terms of neural correlates (Bickel et al., 2009), it is not yet clear how either of these approaches correspond to temporal preferences made during real-world decisions. In both cases, there is the added concern that the process involved differs from more experiential paradigms, as in those typically used in non-human animals (see Palombo et al., 2015a). Improving the ecological validity of delay discounting tasks is an important goal for future research (also see Patt et al., 2021).

A final limitation of this study is that we did not distinguish between valence and arousal, and future research should consider the extent to which arousal may contribute to the effects observed here. Both subjective (i.e., self-report) and objective (i.e., skin conductance) measures could be considered for examining this further (see Greening et al., 2021).

Conclusion

Episodic simulation allows humans to play out the future and optimise intertemporal choices—a ubiquitous form of decision-making in humans (Bulley & Schacter, 2020). The present findings demonstrate that episodic future thinking, regardless of the emotional valence of simulated content, promotes patient choices and this effect is enhanced for those imagining positive events. These results replicate prior work and bring into sharper focus the adaptive value of episodic future thinking. In conclusion, uncovering the mechanisms that underlie the effects of episodic future thinking on intertemporal choices provides useful insight into how the domains of imagination and decision-making interact and manifest in human behaviour.

Acknowledgements

The authors thank Kate Checknita and Leor Elizur for research assistance, and Dr. James Enns for his guidance and feedback during early revisions.

Author contributions

B.C.B., Y.J.T., and D.J.P. designed the study; all co-authors analysed the data; and B.C.B. wrote the article with input from all co-authors.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work is supported by an Insight Development Grant awarded to D.J.P. from SSHRC [430-2020-00372]. D.J.P. is also supported by a Natural Sciences and Engineering Research Council of Canada Discovery Grant [RGPIN-2019-04596] and a Canadian Foundation for Innovation John R. Evans Leaders Fund Grant [38817].

ORCID iDs

Aria S Petrucci https://orcid.org/0000-0001-9051-5590
Christopher R Madan https://orcid.org/0000-0003-3228-6501
Daniela J Palombo https://orcid.org/0000-0001-8082-3522

Data accessibility statement

The data from the present experiment are publicly available at the Open Science Framework website: https://osf.io/m2xv4/

Supplementary material

The Supplementary Material is available at: qjep.sagepub.com

Notes

1. Without covariates included, we found that positive episodic future thinking significantly shifted decisions towards larger, later choices compared to neutral ($p < .001$, $d = 0.46$) and negative ($p = .03$, $d = 0.22$) episodic future thinking. By contrast, there was no significant difference between the neutral and negative condition ($p = .13$, $d = 0.15$).
2. Since these measures were administered after the delay discounting task, we also examined whether there were condition differences for scores on these measures. Although there were no significant differences for CESD and STAI-T, there was a significant difference for the STAI-S, wherein scores were elevated in the negative condition (see Supplementary Materials). These analyses were not pre-registered and were not corrected for multiple comparisons.
3. In considering other general mechanisms, it is possible that negative episodic future thinking affects discounting via stress induction. Yet, although our manipulation increased state anxiety in the negative condition, state anxiety was not correlated with the magnitude of the shift in discounting following negative episodic future thinking.
4. Indeed, it is important to note that this study and Bulley et al. (2019) examined Canadian and Australian undergraduates, respectively, and Calluso et al. (2019) examined Italian participants. By contrast, the two previous studies that have found an opposite effect of negative episodic future thinking both examined Chinese participants (Liu et al., 2013; Zhang et al., 2018). Albeit speculative, there is a possibility that cultural differences may manifest in the relationship between emotionally valenced episodic future thinking and delay discounting, which could contribute to these discrepant findings. Indeed, prior work has shown cultural differences in delay discounting more broadly (Du et al., 2002; B. Kim et al., 2012) as well as in relation to thinking about the affective value of the future (Croote et al., 2020; Lyu et al., 2019).

References

Amlung, M., Marsden, E., Holshausen, K., Morris, V., Patel, H., Vedelago, L., Naish, K. R., Reed, D. D., & McCabe, R. E. (2019). Delay discounting as a transdiagnostic process in psychiatric disorders: A meta-analysis. *JAMA Psychiatry*, *76*(11), 1176–1186. https://doi.org/10.1001/jamapsychiatry.2019.2102

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences*, *5*(12), 533–539. https://doi.org/10.1016/S1364-6613(00)01804-0

Benoit, R. G., Gilbert, S. J., & Burgess, P. W. (2011). A neural mechanism mediating the impact of episodic prospection on farsighted decisions. *Journal of Neuroscience*, *31*(18), 6771–6779. https://doi.org/10.1523/JNEUROSCI.6559-10.2011

Berns, G. S., Laibson, D., & Loewenstein, G. (2007). Intertemporal choice—Toward an integrative framework. *Trends in Cognitive Sciences*, *11*(11), 482–488. https://doi.org/10.1016/j.tics.2007.08.011

Bickel, W. K., Pitcock, J. A., Yi, R., & Angtuaco, E. J. (2009). Congruence of BOLD response across intertemporal choice conditions: Fictive and real money gains and losses. *Journal of Neuroscience*, *29*(27), 8839–8846.

Boyer, P. (2008). Evolutionary economics of mental time travel? *Trends in Cognitive Sciences*, *12*(6), 219–224. https://doi.org/10.1016/j.tics.2008.03.003

Bulley, A., Henry, J., & Suddendorf, T. (2016). Prospection and the present moment: The role of episodic foresight in intertemporal choices between immediate and delayed rewards. *Review of General Psychology*, *20*(1), 29–47. https://doi.org/10.1037/gpr0000061

Bulley, A., Lempert, K. M., Conwell, C., & Irish, M. (2021, September 23). Intertemporal choice reflects value comparison rather than self-control: Insights from confidence judgments. *PsyArXiv*. https://doi.org/10.31234/osf.io/w5zuk

Bulley, A., Miloyan, B., Pepper, G. V., Gullo, M. J., Henry, J. D., & Suddendorf, T. (2019). Cuing both positive and negative episodic foresight reduces delay discounting but does not affect risk-taking. *Quarterly Journal of Experimental Psychology*, *72*(8), 1998–2017. https://doi.org/10.1177/1747021818819777

Bulley, A., & Schacter, D. L. (2020). Deliberating trade-offs with the future. *Nature Human Behaviour*, *4*, 238–247. https://doi.org/10.1038/s41562-020-0834-9

Calluso, C., Tosoni, A., Cannito, L., & Committeri, G. (2019). Concreteness and emotional valence of episodic future thinking (EFT) independently affect the dynamics of intertemporal decisions. *PLOS ONE*, *14*(5), Article e0217224. https://doi.org/10.1371/journal.pone.0217224

Cheng, Y. Y., Shein, P. P., & Chiou, W-B. (2012). Escaping the impulse to immediate gratification: The prospect concept promotes a future-oriented mindset, prompting an inclination towards delayed gratification. *British Journal of Psychology*, *103*(1), 129–141. https://doi.org/10.1111/j.2044-8295.2011.02067.x

Croote, D. E., Lai, B., Hu, J., Baxter, M. G., Montagrin, A., & Schiller, D. (2020). Delay discounting decisions are linked to temporal distance representations of world events across cultures. *Scientific Reports*, *10*(1), 12913. https://doi.org/10.1038/s41598-020-69700-w

Daniel, T. O., Stanton, C. M., & Epstein, L. H. (2013). The future is now: Reducing impulsivity and energy intake using episodic future thinking. *Psychological Science*, *24*(11), 2339–2342. https://doi.org/10.1177/0956797613488780

D'Argembeau, A., Renaud, O., & Van der Linden, M. (2010). Frequency, characteristics, and functions of future-oriented thoughts in daily life. *Applied Cognitive Psychology*, *25*(1), 96–103. https://doi.org/10.1002/acp.1647

D'Argembeau, A., Xue, G., Lu, Z. L., Van der Linden, M., & Bechara, A. (2008). Neural correlates of envisioning emotional events in the near and far future. *NeuroImage*, *40*(1), 398–407. https://doi.org/10.1016/j.neuroimage.2007.11.025

Du, W., Green, L., & Myerson, J. (2002). Cross-cultural comparisons of discounting delayed and probabilistic rewards. *The Psychological Record*, *52*(4), 479–492. https://doi.org/10.1007/BF03395199

Frankenhuis, W. E., Panchanathan, K., & Nettle, D. (2016). Cognition in harsh and unpredictable environments. *Current Opinion in Psychology*, *7*, 76–80. https://doi.org/10.1016/j.copsyc.2015.08.011

Gilbert, D. T., & Wilson, T. D. (2007). Prospection: Experiencing the future. *Science*, *317*(5843), 1351–1354. https://doi.org/10.1126/science.1144161

Green, L., & Myerson, J. (2004). A discounting framework for choice with delayed and probabilistic rewards. *Psychological Bulletin*, *130*(5), 769–792. https://doi.org/10.1037/0033-2909.130.5.769

Greening, S. G., Lee, T., Grégoire, L., Burleigh, L., Robinson, T., Jiang, X., Mather, M., & Kaplan, J. (2021, December 18). Fear in the mind's eye: Mental imagery can generate and regulate acquired differential fear conditioned reactivity. *bioRxiv*. https://doi.org/10.1101/2021.02.04.429795

Griskevicius, V., Tybur, J., Delton, A., & Robertson, T. (2011). The influence of mortality and socioeconomic status on risk and delayed rewards: A life history theory approach. *Journal of Personality and Social Psychology*, *100*(6), 1015–1026. https://doi.org/10.1037/a0022403

Jenks, C. W., & Lawyer, S. R. (2015). Using delay discounting to understand impulsive choice in socially anxious individuals: Failure to replicate. *Journal of Behavior Therapy and Experimental Psychiatry*, *46*, 198–201. https://doi.org/10.1016/j.jbtep.2014.10.010

Johnson, M. W., & Bickel, W. K. (2002). Within-subject comparison of real and hypothetical money rewards in delay discounting. *Journal of the Experimental Analysis of Behavior*, *77*(2), 129–146. https://doi.org/10.1901/jeab.2002.77-129

Kaplan, B. A., Amlung, M., Reed, D. D., Jarmolowicz, D. P., McKerchar, T. L., & Lemley, S. M. (2016). Automating scoring of delay discounting for the 21- and 27-item monetary choice questionnaires. *The Behavior Analyst*, *39*(2), 293–304. https://doi.org/10.1007/s40614-016-0070-9

Kelley, N. J., & Schmeichel, B. J. (2015). Thinking about death reduces delay discounting. *PLOS ONE*, *10*(12), Article e0144228. https://doi.org/10.1371/journal.pone.0144228

Kim, B., Sung, Y. S., & McClure, S. M. (2012). The neural basis of cultural differences in delay discounting. *Philosophical Transactions of the Royal Society*, *367*(1589), 650–656. https://doi.org/10.1098/rstb.2011.0292

Kim, H., Schnall, S., & White, M. P. (2013). Similar psychological distance reduces temporal discounting. *Personality and Social Psychology Bulletin*, *39*(8), 1005–1016. https://doi.org/10.1177/0146167213488214

Kirby, K. N. (1997). Bidding on the future: Evidence against normative discounting of delayed rewards. *Journal of Experimental Psychology: General*, *126*(1), 54–70. https://doi.org/10.1037/0096-3445.126.1.54

Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin and cocaine abusers have higher discount rates for delayed rewards than alcoholics or non-drug-using controls. *Journal of Experimental Psychology: General*, *128*(1), 78–87. https://doi.org/10.1037/0096-3445.128.1.78

Kurth-Nelson, Z., Bickel, W., & Redish, A. D. (2012). A theoretical account of cognitive effects in delay discounting. *The European Journal of Neuroscience*, *35*(7), 1052–1064. https://doi.org/10.1111/j.1460-9568.2012.08058.x

Lagorio, C. H., & Madden, G. J. (2005). Delay discounting of real and hypothetical rewards III: Steady-state assessments, forced-choice trials, and all real rewards. *Behavioural Processes*, *69*(2), 173–187. https://doi.org/10.1016/j.beproc.2005.02.003

Lempert, K. M., & Phelps, E. A. (2016). The malleability of intertemporal choice. *Trends in Cognitive Sciences*, *20*(1), 64–74. https://doi.org/10.1016/j.tics.2015.09.005

Lempert, K. M., Porcelli, A. J., Delgado, M. R., & Tricomi, E. (2012). Individual differences in delay discounting under acute stress: The role of trait perceived stress. *Frontiers in Psychology*, *3*, Article 251. https://doi.org/10.3389/fpsyg.2012.00251

Lin, H., & Epstein, L. H. (2014). Living in the moment: Effects of time perspective and emotional valence of episodic thinking on delay discounting. *Behavioral Neuroscience*, *128*(1), 12–19. https://doi.org/10.1037/a0035705

Liu, L., Feng, T., Chen, J., & Li, H. (2013). The value of emotion: How does episodic prospection modulate delay discounting? *PLOS ONE*, *8*(11), Article e81717. https://doi.org/10.1371/journal.pone.0081717

Lyu, H., Du, G., & Rios, K. (2019). The relationship between future time perspective and self-esteem: A cross-cultural study of Chinese and American college students. *Frontiers in Psychology*, *10*, Article 1518. https://doi.org/10.3389/fpsyg.2019.01518

Madden, G. J., Raiff, B. R., Lagorio, C. H., Begotka, A. M., Mueller, A. M., Hehli, D. J., & Wegener, A. A. (2004). Delay discounting of potentially real and hypothetical rewards: II. Between- and within-subject comparisons. *Experimental and Clinical Psychopharmacology*, *12*(4), 251–261. https://doi.org/10.1037/1064-1297.12.4.251

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In M. L. Commons, J. E. Mazur, J. A. Nevin & H. Rachlin (Eds.), *The effect of delay and of intervening events on reinforcement value* (pp. 55–73). Lawrence Erlbaum.

Miloyan, B., Pachana, N. A., & Suddendorf, T. (2014). The future is here: A review of foresight systems in anxiety and depression. *Cognition and Emotion*, *28*(5), 795–810. https://doi.org/10.1080/02699931.2013.863179

Miloyan, B., & Suddendorf, T. (2015). Feelings of the future. *Trends in Cognitive Sciences*, *19*(4), 196–200. https://doi.org/10.1016/j.tics.2015.01.008

Naudé, G. P., Kaplan, B. A., Reed, D. D., Henley, A. J., & DiGennaro Reed, F. D. (2018). Temporal framing and the hidden-zero effect: Rate-dependent outcomes on delay discounting. *Journal of the Experimental Analysis of Behavior*, *109*(3), 506–519. https://doi.org/10.1002/jeab.328

O'Donnell, S., Daniel, T. O., & Epstein, L. H. (2017). Does goal relevant episodic future thinking amplify the effect on delay discounting? *Consciousness and Cognition*, *51*, 10–16. https://doi.org/10.1016/j.concog.2017.02.014

Palombo, D. J., Keane, M. M., & Verfaellie, M. (2015a). How do lesion studies elucidate the role of the hippocampus in intertemporal choice? *Hippocampus*, *25*(4), 407–408. https://doi.org/10.1002/hipo.22433

Palombo, D. J., Keane, M. M., & Verfaellie, M. (2015b). The medial temporal lobes are critical for reward-based decision-making under conditions that promote episodic future thinking. *Hippocampus*, *25*(3), 345–353. https://doi.org/10.1002/hipo.22376

Patt, V. M., Hunsberger, R., Jones, D. A., Keane, M. M., & Verfaellie, M. (2021). Temporal discounting when outcomes are experienced in the moment: Validation of a novel paradigm and comparison with a classic hypothetical intertemporal choice task. *PLOS ONE*, *16*(5), Article e0251480. https://doi.org/10.1371/journal.pone.0251480

Peters, J., & Büchel, C. (2010). Episodic future thinking reduces reward delay discounting through an enhancement of prefrontal-mediotemporal interactions. *Neuron*, *66*(1), 138–148. https://doi.org/10.1016/j.neuron.2010.03.026

Plummer, M. (2003, March 20–22). *JAGS: A program for analysis of Bayesian graphical models using Gibbs sampling* [Conference session]. Proceedings of the 3rd International Workshop on Distributed Statistical Computing, Vienna, Austria. https://www.r-project.org/conferences/DSC-2003/Proceedings/Plummer.pdf

Qualtrics. (2005). *Qualtrics* (Version November 2020). https://www.qualtrics.com

Radloff, L. S. (1977). The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*(3), 385–401. https://doi.org/10.1177/014662167700100306

R Core Team. (2019). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/

Roepke, A. M., & Seligman, M. E. P. (2016). Depression and prospection. *British Journal of Clinical Psychology*, *55*(1), 23–48. https://doi.org/10.1111/bjc.12087

Rösch, S. A., Stramaccia, D. F., & Benoit, R. G. (2021, January 14). Promoting farsighted decisions via episodic future thinking: A meta-analysis. *PsyArXiv*. https://doi.org/10.31234/osf.io/53ju2

Rung, J. M., & Madden, G. J. (2018). Experimental reductions of delay discounting and impulsive choice: A systematic review and meta-analysis. *Journal of Experimental Psychology: General*, *147*(9), 1349–1381. https://doi.org/10.1037/xge0000462

Rung, J. M., & Madden, G. J. (2019). Demand characteristics in episodic future thinking II: The role of cues and cue content in changing delay discounting. *Experimental and Clinical Psychopharmacology*, *27*(5), 482–495. https://doi.org/10.1037/pha0000260

Schacter, D. L., & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *362*(1481), 773–786. https://doi.org/10.1098/rstb.2007.2087

Schacter, D. L., Benoit, R. G., & Szpunar, K. K. (2017). Episodic future thinking: Mechanisms and functions. *Current Opinion in Behavioral Sciences*, *17*, 41–50. https://doi.org/10.1016/j.cobeha.2017.06.002

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Consulting Psychologists Press.

Stein, J. S., Tegge, A. N., Turner, J. K., & Bickel, W. K. (2018). Episodic future thinking reduces delay discounting and cigarette demand: An investigation of the good-subject effect. *Journal of Behavioral Medicine*, *41*(2), 269–276. https://doi.org/10.1007/s10865-017-9908-1

Steinglass, J. E., Lempert, K. M., Choo, T. H., Kimeldorf, M. B., Wall, M., Walsh, B. T., Fyer, A. J., Schneier, F. R., & Simpson, H. B. (2017). Temporal discounting across three psychiatric disorders: Anorexia nervosa, obsessive compulsive disorder, and social anxiety disorder. *Depression and Anxiety*, *34*(5), 463–470. https://doi.org/10.1002/da.22586

Suddendorf, T., & Corballis, M. C. (2007). The evolution of foresight: What is mental time travel, and is it unique to humans? *Behavioral and Brain Sciences*, *30*(3), 299–351. https://doi.org/10.1017/S0140525X07001975

Szpunar, K. K. (2010). Episodic future thought: An emerging concept. *Perspectives on Psychological Science*, *5*(2), 142–162. https://doi.org/10.1177/1745691610362350

Trope, Y., & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological Review*, *117*(2), 440–463. https://doi.org/10.1037/a0018963

Tulving, E. (2001). Origin of autonoesis in episodic memory. In H. L. Roediger, J. S. Nairne, I. Neath & A. M. Surprenant (Eds.), *The nature of remembering: Essays in honor of Robert G. Crowder* (pp. 17–34). American Psychological Association. https://doi.org/10.1037/10394-002

Vincent, B. T. (2016). Hierarchical Bayesian estimation and hypothesis testing for delay discounting tasks. *Behavior Research Methods*, *48*(4), 1608–1620. https://doi.org/10.3758/s13428-015-0672-2

Worthy, D. A., Byrne, K. A., & Fields, S. (2014). Effects of emotion on prospection during decision-making. *Frontiers in Psychology*, *5*(253), Article 591. https://doi.org/10.3389/fpsyg.2014.00591

Zhang, S., Peng, J., Qin, L. L., Suo, T., & Feng, T. (2018). Prospective emotion enables episodic prospection to shift time preference. *British Journal of Psychology*, *109*(3), 487–499. https://doi.org/10.1111/bjop.12284