Addictive Behaviors 66 (2017) 1–6

Contents lists available at ScienceDirect

Addictive Behaviors

journal homepage: www.elsevier.com/locate/addictbeh

The influence of episodic foresight on delay discounting and demand for alcohol

Adam Bulley [a,*], Matthew J. Gullo [b]

[a] The University of Queensland, St. Lucia, QLD 4072, Australia
[b] Centre for Youth Substance Abuse Research, The University of Queensland, Mental Health Centre, Royal Brisbane and Women's Hospital, Herston, QLD 4006, Australia

HIGHLIGHTS

- Imagining the future, known as episodic foresight, may attenuate impulsivity.
- Episodic foresight reduced delay discounting and alcohol demand intensity.
- The effect of episodic foresight on impulsivity may extend to alcohol decisions.

ARTICLE INFO

Article history:
Received 3 February 2016
Received in revised form 13 September 2016
Accepted 1 November 2016
Available online 3 November 2016

Keywords:
Episodic foresight
Episodic future thinking
Delay discounting
Intertemporal choice
Alcohol
Impulsivity

ABSTRACT

Background: There is a near-universal tendency to discount the value of delayed rewards relative to those available in the here and now. The rate at which future rewards become devalued over time, delay discounting, is an important individual difference variable related to impulsivity and is elevated in externalising disorders, including alcohol use disorders. Recent research suggests that vividly imagining personally relevant future events (episodic foresight) during an intertemporal choice task can attenuate the rate at which delayed rewards are discounted.
Objectives: The present study sought to extend these findings by examining the effect of episodic foresight on both delay discounting and alcohol-related decision-making.
Methods: Forty-eight college students were administered both modified intertemporal choice and hypothetical alcohol purchase tasks during which personally relevant episodic future event cues or control imagery cues were presented.
Results: Engaging in episodic foresight reduced both the rate at which delayed monetary rewards were discounted and initial alcohol demand intensity (but not other demand indices) relative to control imagery.
Conclusions: Findings suggest that the attenuating effect of episodic foresight on impulsivity may be limited to particular aspects of impulsive choice.

1. Introduction

Making adaptive decisions often requires a decision-maker to suppress impulses towards immediate gratification in the pursuit of long-term goals. Difficulty doing so has been conceptualized as a key feature of impulsivity, and is characteristic of many behavioural disorders in which immediate gratification becomes highly prioritized over the pursuit of longer-term reinforcement (Bickel & Marsch, 2001; Gullo & Potenza, 2014; MacKillop et al., 2011). Thus, while there is a near-universal tendency to discount the value of future rewards relative to those in the here-and-now, individuals with substance abuse disorders, pathological gambling, obesity, and those who exhibit other risky health behaviours have been consistently found to more rapidly devalue rewards that are delayed in their receipt than healthy controls (Bickel & Marsch, 2001; Dixon, Marley, & Jacobs, 2003; Story, Vlaev, Seymour, Darzi, & Dolan, 2014). For this reason, responses to *intertemporal choices* between rewards available immediately and those available only after a delay can act as a 'behavioural marker' of addiction-relevant outcomes including the severity, and risk of developing, dependence (for review see Bickel, Koffarnus, Moody, & Wilson, 2014).

Individual differences in discounting rate have been tied to a number of factors, including genetic heritability and early life developmental experiences (Anokhin, Golosheykin, Grant, & Heath, 2011; Mauro & Harris, 2000; Odum, 2011; Peters & Büchel, 2011). However, the rate at which future rewards are devalued can also vary widely *within* individuals, as a

* Corresponding author.
E-mail addresses: adam.bulley@uqconnect.edu.au (A. Bulley), m.gullo@uq.edu.au (M.J. Gullo).

http://dx.doi.org/10.1016/j.addbeh.2016.11.003
0306-4603/

function of the perceived certainty of a future reward, the framing of the choice question, current affect, alongside other situational or biological variables (for reviews see Gray & MacKillop, 2015; Lempert & Phelps, 2015). One critical set of psychological variables associated with variation in the discounting rate is the manner in which individuals mentally represent or imagine future rewards and the context of their receipt (Bulley, Henry, & Suddendorf, 2016).

A number of recent experimental studies suggest that imagining the future, so-called *episodic foresight* (Suddendorf & Corballis, 1997, 2007) or *episodic future thinking* (Atance & O'Neill, 2001), can reduce the rate at which future rewards are discounted in the process of making intertemporal choices. In general, these studies have provided participants with modified intertemporal choice tasks (ICTs) in which a personally relevant future event cue is provided alongside the choice question (Benoit, Gilbert, & Burgess, 2011; Daniel, Said, Stanton, & Epstein, 2015; Daniel, Stanton, & Epstein, 2013a, 2013b; Kwan et al., 2015; Lin & Epstein, 2014; Liu, Feng, Chen, & Li, 2013; Palombo, Keane, & Verfaellie, 2014; Peters & Büchel, 2010). For example, in Peters and Büchel (2010), participants indicated their preference for either 20€ now, or 35€ in 45 days, while in some trials being simultaneously cued with an actual event they had planned in around 45 days time. In the episodic cue condition, preferences shifted towards longer-term rewards, and the strength of this effect was associated with individual differences in the vividness of mental imagery about the episodic future event.

The effect of episodic foresight has been shown to extend to real-world behavioural indices of impulsive choice. When tempted with unrestricted access to immediately gratifying, densely caloric food, both obese women and children consumed less if concurrently imagining personally relevant future events (Daniel et al., 2015, 2013b). This effect of episodic foresight on impulsive eating has also recently been demonstrated in college women, such that food-related episodic future thinking led to more restricted consumption of freely and immediately available snacks (Dassen, Jansen, Nederkoorn, & Houben, 2016), and in a sample of obese or overweight women in a real-world food-court experiment (O'Neill, Daniel, & Epstein, 2015).

A large body of evidence suggests that problematic alcohol users tend to show steeper discounting rates than individuals who use alcohol at more moderate or less risky levels (MacKillop et al., 2011; Petry, 2001). While individuals may not be explicitly deciding between payoffs at different times when they choose whether or not to eat unhealthy foods or drink alcohol, there is commonality between the type of decision-processes tapped by the ICT, and the processes employed in such health-related consumption decisions (Yi, Mitchell, & Bickel, 2010). In both cases, the options exist to make either (i) a decision prioritizing immediate gratification (e.g. pleasure) or (ii) a decision that prioritizes longer-term gains (e.g. health). Purchase demand for alcohol is one measure than can be employed to investigate this decision-process, and is predictive of alcohol consumption (Dennhardt, Yurasek, & Murphy, 2015; Murphy et al., 2015) as well as problematic alcohol-related behaviours such as driving after drinking (Teeters, Pickover, Dennhardt, Martens, & Murphy, 2014).

Demand for alcohol can be directly assessed with hypothetical 'alcohol purchase tasks' (APTs) that ask participants to indicate their willingness to purchase hypothetical drinks at increasing costs (MacKillop et al., 2009, 2010; MacKillop & Murphy, 2007; Murphy, MacKillop, Skidmore, & Pederson, 2009). There is generally good correspondence between hypothetical tasks of this nature and tasks in which access to alcohol is provided (Amlung, Acker, Stojek, Murphy, & MacKillop, 2012). Given recent studies showing that episodic foresight can reduce not only delay discounting but also 'impulsive' eating, in the current study we aimed to explore the effect of episodic foresight on both standard monetary intertemporal choice, as well as alcohol demand using a hypothetical APT. Firstly, we hypothesized that engaging in episodic foresight during the ICT would attenuate the rate at which future rewards were subjectively devalued over time. Secondly, we hypothesized that engaging in episodic foresight would reduce 'impulsive' alcohol demand on the hypothetical APT.

2. Method

2.1. Participants

Fifty-two undergraduate students participated in the study for course credit. The study was approved by the relevant university human research ethics committee. Four (7.7%) participants were excluded because they did not attend both experimental sessions. This left a final sample of 48 participants (33 females, 68.8%). The mean age of the sample was 20.67 years ($SD = 5.36$).

2.2. Design and procedure

Participants attended two sessions timed roughly one week apart. In both sessions, participants completed a modified ICT, in which they made a series of choices between immediate (smaller) or delayed (larger) rewards available at five future time-points, and a hypothetical APT, in which they indicated how many drinks they would consume at various price intervals. During both tasks, participants were presented with cues to engage in either (i) episodic foresight or (ii) control imagery before each decision point, with the order of this manipulation counterbalanced between sessions.

The episodic or control cues were generated at the start of the respective session, and were drawn from either (i) personally relevant events that participants listed they were looking forward to in the future (episodic), or (ii) events from a story with vivid imagery that they were instructed to read (control). Participants also completed the Alcohol Use Disorders Identification Test (AUDIT). At the end of each session, participants rated dimensions of their mental imagery during the tasks. Demographic information was collected at the start of the first session, and participants underwent a funnel debriefing procedure at the end of the second session.

2.3. Manipulations

2.3.1. Episodic foresight

At the start of the episodic foresight session, participants were asked to imagine and list personally relevant future events that they were "looking forward to" over the next year. Specifically, they were asked to provide two events for each of the time delays corresponding to the reward delays in the ICT, and to rate the vividness, positive emotionality, and personal relevance of these events on a scale from 1 (*not at all*) to 6 (*very*). For each time point (today, two-days, 30-days, 180-days, and 365-days), the events with the highest average rating across these scales were selected as cues for the episodic foresight manipulation. These episodic cues were inserted into the code of the computerized ICT, to be presented before each decision in a manner that synchronized the temporal distance to both the possible future event and the delayed reward. For example, participants would be presented with a cue to imagine an event they were looking forward to in around 180 days before making a choice about a reward that was delayed by that same amount of time. The episodic cues were also presented in the APT, though because this task lacks a temporal component, the cues appeared before each decision in an arbitrary order.

2.3.2. Control imagery

At the start of the control imagery session, participants read the first two chapters of "Pinocchio" (Collodi, 1995), which contains many highly vivid events (e.g. "Geppetto turned the colour of a red pepper"). The story was split into five pages, and participants were instructed to list two events from each page that they enjoyed and to rate the vividness, positive emotionality, and personal relevance of these events on a scale from 1 (*not at all*) to 6 (*very*). The events with the highest average

ratings were selected as cues for the control imagery manipulation. Because the story events were fictitious rather than specific temporal events, the control cues were inserted into the ICT and APT in an arbitrary order. This control imagery task was based on a previous study by Daniel et al. (2013a) and meant that participants were engaging in mental imagery (and thereby constructing a mental scenario as per the episodic condition), but that these simulations differed from the episodic foresight imagery inasmuch as they were (i) fictitious (ii) not prospective, (iii) not personally relevant events.

2.4. Measures

2.4.1. Intertemporal choice task (ICT)

Participants were presented with a series of computerized choices between a small, immediate amount of money (e.g. $2) and a larger, consistent amount ($10) that was variably delayed in its receipt by 0, 2, 30, 180 or 365 days (Richards, Zhang, Mitchell, & de Wit, 1999). Participants were instructed to answer as if they were really going to receive the rewards after the designated delay. A screen displayed the choice question and two response buttons, an episodic or control event cue in bold red lettering, and a prompt instructing the participant to imagine the event. Participants were instructed before the task that when an event cue was presented they should take a few moments to vividly imagine the event, including as many sensory and emotional details as possible, before making their decision. The instruction to explicitly imagine the events differed from one previous study in which participants were merely cued with future events (Peters & Büchel, 2010), but closely resembled other studies that have given similarly explicit instructions (Daniel et al., 2013b; Lin & Epstein, 2014).

Participants were also told they did not need to imagine spending the money during the event, meaning the imagination component of the task was ostensibly unrelated to the decision-making component. A titrating adjusting-amount procedure converged on the 'indifference point' for each of the delays at which point the subjective value of the immediate (smaller) and future (larger) reward was indistinguishable. The program was set to terminate after converging (or making a substantial number of attempts to converge) on an indifference point for each delay. The indifference points for each delay produced by the ICT were used to generate area under the indifference curve (AUC) values, with higher AUC values representing lower delay discounting. For more information on this calculation see (Myerson, Green, & Warusawitharana, 2001; Reed, Kaplan, & Brewer, 2012). Because participants completed two intertemporal choice tasks (once with episodic cues, once with control cues), we calculated AUC values separately for both iterations of the ICT.

2.4.2. Alcohol purchase task (APT)

Alcohol demand was assessed with a state-oriented hypothetical APT modelled after MacKillop et al. (2010), which requires participants to list how many drinks they would purchase and consume at various prices. The APT instructions specified that drinks had to be consumed, not stockpiled, and that 'a drink' was defined as standard sized beer, wine, or shot of liquor (straight or mixed). Participants were presented with nineteen price intervals, one by one, alongside a text-box wherein they entered the number of drinks they would buy at that price. The price intervals were zero (free), 1¢, 5¢, 13¢, 25¢, 50¢, $1, $2, $3, $4, $5, $6, $11, $35, $70, $140, $280, $560, and $1120. The approximately doubling interval spacing is common in demand tasks and is based on a progressive-ratio operant schedule (Jacobs & Bickel, 1999; MacKillop et al., 2010). Before each price interval screen a separate display appeared with an event cue (episodic or control), alongside instructions asking the participant to take a few moments to imagine this event. Once participants had imagined the event for a few moments, they were free to respond.

The APT produces five 'demand indices' that reflect different aspects of alcohol purchasing behaviour (MacKillop et al., 2009; Murphy & MacKillop, 2006). *Intensity* of demand is the number of drinks requested at zero cost (when drinks are free). *Breakpoint* is the price at which the requested drinks equal zero (the price that first suppresses consumption to zero demand). 'O_{max}' is the highest observed *expenditure* on alcohol across the price intervals (the most amount of money spent at any one price). 'P_{max}' is the price at which O_{max} occurs (i.e. the price point at which the most money is spent on drinks). *Elasticity*, which is derived from demand-curve modelling, indicates the rate of decrease in consumption as a function of cost (Murphy et al., 2009).

2.4.3. Alcohol use

Alcohol use patterns were assessed with the AUDIT, which is a 10-item self-report questionnaire with questions about drinking amount, frequency, dependence, and drinking-related problems (Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). The AUDIT is a screening instrument for problematic drinking patterns. It has good internal reliability and test–retest reliability across various populations (e.g., university students, emergency room patients) (Daeppen, Yersin, Landry, Pécoud, & Decrey, 2000; Dawe, Loxton, Kavanagh, & Mattick, 2002). Scores on the AUDIT correlate with other measures of risky or harmful drinking (O'Hare & Sherrer, 1999), and can effectively classify dependent and non-dependent drinkers (Saunders et al., 1993).

2.4.4. Cue ratings

At the end of each session, participants rated the vividness, positive emotionality, and personal relevance of each event cue on scale from 1 (*not at all*) to 6 (*very*). Participants also rated how frequently each event cue evoked their imagination during the tasks, from 1 (*never*) to 6 (*every time*).

3. Results

3.1. Drinking behaviours of the sample

The mean AUDIT score was 5.73, with 14 (29%) participants scoring above the 8 + cut-off for hazardous drinking specified by Saunders et al. (1993). When asked how often they have a drink containing alcohol, approximately 17% of the sample responded with 'never', 38% with 'monthly or less', 31% with '2–4 times a month', 13% with '2–3 times a week' and 2% with '4 or more times a week'. When asked how many standard drinks they have on a typical day when they are drinking, approximately 56% responded with '1 or 2', 20% with '3 or 4', 20% with '5 or 6', none with '7 to 9' and 2% with '10 or more'.

3.2. Cue ratings

One participant was missing data from the control session cue-rating questionnaire and as such these data were estimated with Expectation Maximisation (Dempster, Laird, & Rubin, 1977). Paired-samples t-tests revealed that participants rated the personal relevance of the episodic imagery significantly higher ($M = 5.34$, $SD = 0.54$) than the personal relevance of control imagery ($M = 3.06$, $SD = 1.2$), $t\ (47) = 12.14$, $p < 0.001$, and that participants rated the positive emotionality of episodic imagery ($M = 5.39$, $SD = 0.52$) significantly higher than control imagery ($M = 3.89$ $SD = 0.92$), $t\ (47) = 9.78$, $p < 0.001$. As in previous studies (Daniel et al., 2013a, 2013b), a general 'imagery' score was calculated by averaging the self-reported vividness and frequency of imagery during the tasks. Overall, participants rated the combined frequency and vividness of their imagery significantly higher in the episodic condition ($M = 5.06$, $SD = 0.54$) than in the control condition ($M = 4.61$, $SD = 0.84$), $t\ (47) = 3.92$, $p < 0.001$. Hence, the difference between the imagery in the two conditions was entered as a covariate in subsequent analyses.

3.3. Episodic foresight during intertemporal choice

Some participants lacked sufficient data on the ICT due to repeatedly inconsistent responses in either the control (n = 7; 15%) or episodic (n = 4; 8%) session. In each case, the program's adjusting-amount procedure was unable to converge on an indifference point for one of the delays after a number of convergence attempts. Response inconsistency is not uncommon in studies employing ICTs (Isen, Sparks, & Iacono, 2014; Jonhson & Bickel, 2008; Olson, Hooper, Collins, & Luciana, 2007). Because of the repeated measures design, the participants with incomplete data from either of the two ICTs were excluded from the subsequent discounting analyses, in line with previous studies using the same procedure (e.g. Isen et al., 2014). The excluded cases did not differ significantly in terms of gender, general imagery scores, AUC values, or AUDIT scores (*ps* > 0.05).

A one way repeated measures ANCOVA was run with condition (episodic vs. control) as the within-subjects factor and AUC as the outcome, controlling for imagery differences. Gender was also included as a covariate because of previous studies suggesting a relationship between gender, delay discounting and episodic thinking (Seinstra, Grzymek, & Kalenscher, 2015). This ANCOVA revealed a significant difference in discounting between the episodic and control conditions, $F(1, 34) = 8.42$, $p = 0.006$, $\eta_p^2 = 0.198$, such that engaging in episodic foresight increased AUC values ($M = 0.71$, $SD = 0.26$) compared to control imagery ($M = 0.54$ $SD = 0.30$). Because higher AUC values represent less steep discounting of future rewards, this suggests that episodic foresight reduced impulsivity on the task relative to control imagery (see Fig. 1). No significant interactions emerged between condition and any covariate (*ps* > 0.05), and as such the assumption of homogeneity of regression was not violated.

3.4. Episodic foresight during alcohol purchase task

Two participants did not complete the APT because they indicated they would abstain from drinks regardless of circumstances (they were non-drinkers), so these participants were removed from subsequent APT analyses. Data were initially screened as per previous studies utilizing an APT (Amlung & MacKillop, 2012; Amlung & Mackillop, 2014; MacKillop et al., 2010). We were tolerant of violations of the assumptions about the directional change in consumption across price increments (e.g. bounce/preference reversals) because in both iterations of the task participants underwent an imagination manipulation whose influence on choice patterns or consistency could not be predicted (see Stein et al., 2015). Four participants were excluded for non-consumption (zero demand) on the APT. Raw demand data were examined for outliers with a criterion of Z = 4 to retain maximum data (as per MacKillop et al., 2010). A small number of high-magnitude outliers were detected in the raw demand data, all of which were recoded to the next highest non-outlying value. After screening the price-level data and computing the behavioural economic demand indices, the demand indices were also examined for outliers with a standard criterion of Z > 3.29. These demand index outliers were recoded as one unit higher than the next highest value (Tabachnick & Fidell, 2007). The distributions of all demand indices were examined for normality with histogram plots, which indicated that O_{max}, P_{max}, intensity and breakpoint were positively skewed. These indices were therefore subjected to square-root transformations, which greatly improved the skewness of all distributions. As per Amlung and Mackillop (2012), elasticity of demand was derived by using a non-linear exponential demand curve equation from Hursh and Silberberg (2008), and was subsequently subjected to a logarithmic transformation on account of its skewness. Because actual alcohol use behaviours have been found to be associated with APT responses (Amlung et al., 2012), analyses of the demand indices included AUDIT scores as a covariate.

Results of repeated measures ANCOVAs with condition (episodic vs. control) as the within-subjects factors and each of the demand indices as the outcomes, controlling for imagery differences, AUDIT scores and gender (on account of potential demand differences between males and females; Gray & MacKillop, 2014) revealed a small but significant effect of condition on intensity of demand, which was significantly lower in the episodic condition relative to the control condition (see Table 1). No significant differences between the conditions were found for O_{max}, P_{max}, breakpoint or elasticity. In none of the models was there a significant interaction between condition and any covariate (*ps* > 0.05), and as such the assumption of homogeneity of regression was not violated.

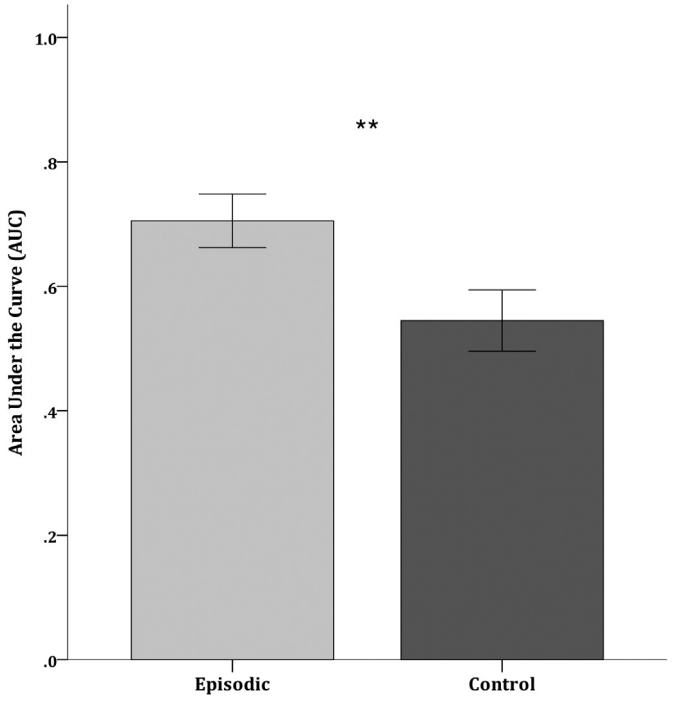

Fig. 1. Area under the curve values in the episodic and control imagery conditions. N = 37, **p < 0.01. Error bars represent ± 1 SEM.

4. Discussion

This experiment investigated the impact of episodic foresight on intertemporal choices and alcohol demand. In line with our initial hypotheses, results demonstrated that imagining personally relevant future events during the monetary ICT attenuated the rate at which delayed rewards were discounted. Furthermore, cued episodic future thinking during the APT led to a small reduction in demand 'intensity' (demand at zero cost). However, contrary to our hypotheses, all alcohol demand indices aside from intensity were unaffected when participants engaged in episodic foresight during the APT. Collectively, these findings demonstrate a causal influence of cued future thinking on choice

Table 1
Comparisons between alcohol demand indices in the episodic and control imagery conditions.

	Control		Episodic				
	M	SEM	M	SEM	F (1, 38)	p	η_p^2
O_{max}	36.64	6.46	28.51	3.19	2.53	0.12	0.06
P_{max}	29.27	6.69	17.24	2.79	2.37	0.13	0.06
Intensity	6.76	0.8	5.29	0.73	4.11	0.0497*	0.1
Breakpoint	32.04	4.26	34.16	5.08	1.16	0.29	0.03
Elasticity	0.01	0.002	0.01	0.002	0.47	0.5	0.01

* Indicates significant at p < 0.05. N = 42. Non-transformed mean values reported for interpretability. Analyses controlled for sex, AUDIT scores and between-condition imagery differences.

impulsivity generally, but suggest that this influence may only extend to certain aspects of alcohol-related decision-making.

Craving for alcohol plays an important role in impulsive alcohol use behaviours, and existing research on the cognitive and motivational aspects of this craving process place mental imagery central to potential intervention outcomes (Connor et al., 2014; Kavanagh, Andrade, & May, 2005; Kemps & Tiggemann, 2007; May et al., 2014). In line with recent recommendations for clinical innovation (Kavanagh et al., 2014), the current results suggest that encouraging prospective (future-oriented) imagery may bolster the effectiveness of mental imagery in reducing impulsive behaviours. However, the small effect size and marginal significance value of the 'intensity' index mean these results should be interpreted with caution. Additionally, none of the other four APT demand indices were attenuated in the episodic foresight condition relative to the control imagery condition.

The specific mechanisms underlying the effect of episodic foresight on intertemporal decision-making remain unclear (for a review see Bulley et al., 2016). It is worth noting that the episodic cues used in this experiment were general future events and ostensibly not related to the reward-domain at hand. One possibility is that engaging in episodic foresight serves to shift time horizons towards the future, thereby increasing the salience of future goals and outcomes and informing about the utility of future rewards (Boyer, 2008; Lin & Epstein, 2014). More research remains to be done in order to determine how the specific reward content of imagined future events might influence intertemporal choice processes (see Dassen et al., 2016), as well to discern the relative contributions of episodic and semantic processing in this personal event cuing effect (see also Kwan et al., 2015; Palombo, Keane, & Verfaellie, 2015; Thom & Clayton, 2015).

There are some limitations to the current study. Firstly, rewards in both the ICT and APT were hypothetical. While choice patterns on both of these tasks have been found to correspond with actual monetary rewards and alcohol, respectively (Amlung et al., 2012; Lagorio & Madden, 2005), it would nevertheless be informative to determine whether the effect of episodic foresight operates comparably when real access to alcohol is provided. Secondly, the current study was conducted with a relatively small college student sample that endorsed relatively low levels of problematic drinking. Future research will therefore be needed to determine the generalizability of these results to populations with higher rates of problematic alcohol use. Indeed, a recent study by Snider, LaConte, and Bickel (2016), found that cued episodic future thinking reduced both delay discounting in a monetary choice task and intensity of demand in an alcohol purchase task in a sample of alcohol dependent individuals.

In conclusion, the present study demonstrates a causal influence of cued episodic foresight in reducing delay discounting, and suggests a potential role for episodic foresight in attenuating alcohol demand intensity. By coming to better understand the circumstances in which engaging in episodic foresight modifies intertemporal and impulsive choice patterns, researchers and practitioners may be able to develop novel, prospective imagery-based intervention strategies for behavioural disorders characterized by the prioritization of immediate over long-term rewards.

Role of funding source

MJG is supported by a National Health and Medical Research Council of Australia Early Career Fellowship (1036365).

Contributors

AB and MJG conceived the study. AB collected data and ran the analyses, with input from MJG. AB wrote the first draft of the paper, and MJG provided critical revisions. Both authors approved the final manuscript.

Conflict of interest

No conflict declared.

References

Amlung, M., & MacKillop, J. (2012). Consistency of self-reported alcohol consumption on randomized and sequential alcohol purchase tasks. *Frontiers in Psychiatry*, *3*(July), 1–6. http://dx.doi.org/10.3389/fpsyt.2012.00065.

Amlung, M., & Mackillop, J. (2014). Understanding the effects of stress and alcohol cues on motivation for alcohol via behavioral economics. *Alcoholism: Clinical and Experimental Research*, *38*(6), 1780–1789. http://dx.doi.org/10.1111/acer.12423.

Amlung, M., Acker, J., Stojek, M. K., Murphy, J. G., & MacKillop, J. (2012). Is talk "Cheap"? An initial investigation of the equivalence of alcohol purchase task performance for hypothetical and actual rewards. *Alcoholism: Clinical and Experimental Research*, *36*(4), 716–724. http://dx.doi.org/10.1111/j.1530-0277.2011.01656.x.

Anokhin, A. P., Golosheykin, S., Grant, J. D., & Heath, A. C. (2011). Heritability of delay discounting in adolescence: A longitudinal twin study. *Behavior Genetics*, *41*(2), 175–183. http://dx.doi.org/10.1007/s10519-010-9384-7.

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences*, *5*(12), 533–539. http://dx.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. *The Journal of Neuroscience*, *31*(18), 6771–6779. http://dx.doi.org/10.1523/jneurosci.6559-10.2011.

Bickel, W. K., & Marsch, L. A. (2001). Toward a behavioral economic understanding of drug dependence: Delay discounting processes. *Addiction*, *96*(1), 73–86. http://dx.doi.org/10.1046/j.1360-0443.2001.961736.x.

Bickel, W. K., Koffarnus, M. N., Moody, L., & Wilson, A. G. (2014). The behavioral- and neuro-economic process of temporal discounting: A candidate behavioral marker of addiction. *Neuropharmacology*, *76*, 518–527. http://dx.doi.org/10.1016/j.neuropharm.2013.06.013.

Boyer, P. (2008). Evolutionary economics of mental time travel? *Trends in Cognitive Sciences*, *12*(6), 219–224. http://dx.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. http://dx.doi.org/10.1037/gpr0000061.

Collodi, C. (1995). *Pinocchio.* Hertfordshire, Great Britain: Wordsworth Editions Limited.

Connor, J. P., Kavanagh, D. J., Andrade, J., May, J., Feeney, G. F. X., Gullo, M. J., ... Tjondronegoro, D. (2014). Alcohol consumption in young adults: The role of multisensory imagery. *Addictive Behaviors*, *39*(3), 721–724. http://dx.doi.org/10.1016/j.addbeh.2013.11.023.

Daeppen, J. B., Yersin, B., Landry, U., Pécoud, A., & Decrey, H. (2000). Reliability and validity of the Alcohol Use Disorders Identification Test (AUDIT) imbedded within a general health risk screening questionnaire: Results of a survey in 332 primary care patients. *Alcoholism, Clinical and Experimental Research*, *24*(5), 659–665 (http://doi.org/0145-6008/00/2405-0659$03.00/0).

Daniel, T. O., Stanton, C. M., & Epstein, L. H. (2013a). The future is now: Comparing the effect of episodic future thinking on impulsivity in lean and obese individuals. *Appetite*, *71*(0), 120–125. http://dx.doi.org/10.1016/j.appet.2013.07.010.

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

Daniel, T. O., Said, M., Stanton, C. M., & Epstein, L. H. (2015). Episodic future thinking reduces delay discounting and energy intake in children. *Eating Behaviors*, *18*, 20–24. http://dx.doi.org/10.1016/j.eatbeh.2015.03.006.

Dassen, F. C. M., Jansen, A., Nederkoorn, C., & Houben, K. (2016). Focus on the future: Episodic future thinking reduces discount rate and snacking. *Appetite*, *96*, 327–332. http://dx.doi.org/10.1016/j.appet.2015.09.032.

Dawe, S., Loxton, N. J., Kavanagh, D. J., & Mattick, R. P. (2002). Review of diagnostic screening instruments for alcohol and other drug use and other psychiatric disorders. (August 2002). Retrieved from http://www.nada.org.au/media/14712/screening_assessment_review.pdf

Dempster, A. P., Laird, N. M., & Rubin, D. B. (1977). Maximum likelihood from incomplete data via the EM algorithm. *Journal of the Royal Statistical Society: Series B: Methodological*, *39*(1), 1–38 JOUR. Retrieved from http://www.jstor.org/stable/2984875

Dennhardt, A. A., Yurasek, A. M., & Murphy, J. G. (2015). Change in delay discounting and substance reward value following a brief alcohol and drug use intervention. *Journal of the Experimental Analysis of Behavior*, *103*(1), 125–140. http://dx.doi.org/10.1002/jeab.121.

Dixon, M. R., Marley, J., & Jacobs, E. A. (2003). Delay discounting by pathological gamblers. *Journal of Applied Behavior Analysis*, *36*(4), 449–458. http://dx.doi.org/10.1901/jaba.2003.36-449.

Gray, J. C., & MacKillop, J. (2014). Interrelationships among individual differences in alcohol demand, impulsivity, and alcohol misuse. *Psychology of Addictive Behaviors: Journal of the Society of Psychologists in Addictive Behaviors*, *28*(1), 282–287. http://dx.doi.org/10.1037/a0032766.

Gray, J. C., & Mackillop, J. (2015). Impulsive delayed reward discounting as a genetically-influenced target for drug abuse prevention: a critical evaluation. *Frontiers in Psychology*, *6*(1104). http://dx.doi.org/10.3389/fpsyg.2015.01104.

Gullo, M. J., & Potenza, M. N. (2014). Impulsivity: Mechanisms, moderators and implications for addictive behaviors. *Addictive Behaviors*, *39*(11), 1543–1546. http://dx.doi.org/10.1016/j.addbeh.2014.06.005.

Hursh, S. R., & Silberberg, A. (2008). Economic demand and essential value. *Psychological Review*, *115*(1), 186–198. http://dx.doi.org/10.1037/0033-295X.115.1.186.

Isen, J. D., Sparks, J., & Iacono, W. G. (2014). Predictive validity of delay discounting behavior in adolescence: A longitudinal twin study. *Experimental and Clinical Psychopharmacology*, *18*(9), 434–443. http://dx.doi.org/10.1016/j.micinf.2011.07.011.Innate.

Jacobs, E. A., & Bickel, W. K. (1999). Modeling drug consumption in the clinic using simulation procedures: Demand for heroin and cigarettes in opioid-dependent

outpatients. *Experimental and Clinical Psychopharmacology*, *7*(4), 412–426. http://dx.doi.org/10.1037/1064-1297.7.4.412.
Jonhson, M. W., & Bickel, W. K. (2008). An algorithm for identifying nonsystematic delay-discounting data. *Experimental and Clinical Psychopharmacology*, *16*(3), 264–274. http://dx.doi.org/10.1037/1064-1297.16.3.264.An.
Kavanagh, D. J., Andrade, J., & May, J. (2005). Imaginary relish and exquisite torture: The elaborated intrusion theory of desire. *Psychological Review*, *112*(2), 446–467. http://dx.doi.org/10.1037/0033-295X.112.2.446.
Kavanagh, D. J., Andrade, J., May, J., & Connor, J. P. (2014). Motivational interventions may have greater sustained impact if they trained imagery-based self-management. *Addiction*, *109*, 1059–1065. http://dx.doi.org/10.1111/acer.12274.
Kemps, E., & Tiggemann, M. (2007). Modality-specific imagery reduces cravings for food: An application of the elaborated intrusion theory of desire to food craving. *Journal of Experimental Psychology. Applied*, *13*(2), 95–104. http://dx.doi.org/10.1037/1076-898X.13.2.95.
Kwan, D., Craver, C. F., Green, L., Myerson, J., Gao, F., Black, S. E., & Rosenbaum, R. S. (2015). Cueing the personal future to reduce discounting in intertemporal choice: Is episodic prospection necessary? *Hippocampus*. http://dx.doi.org/10.1002/hipo.22431.
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. http://dx.doi.org/10.1016/j.beproc.2005.02.003.
Lempert, K. M., & Phelps, E. a. (2015). The malleability of intertemporal choice. *Trends in Cognitive Sciences*, *xx*, 1–11. http://dx.doi.org/10.1016/j.tics.2015.09.005.
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. http://dx.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). http://dx.doi.org/10.1371/journal.pone.0081717.
MacKillop, J., & Murphy, J. G. (2007). A behavioral economic measure of demand for alcohol predicts brief intervention outcomes. *Drug and Alcohol Dependence*, *89*(2–3), 227–233. http://dx.doi.org/10.1016/j.drugalcdep.2007.01.002.
MacKillop, J., Murphy, J. G., Tidey, J. W., Kahler, C. W., Ray, L. a., & Bickel, W. K. (2009). Latent structure of facets of alcohol reinforcement from a behavioral economic demand curve. *Psychopharmacology*, *203*(1), 33–40. http://dx.doi.org/10.1007/s00213-008-1367-5.
MacKillop, J., O'Hagen, S., Lisman, S. a., Murphy, J. G., Ray, L. a., Tidey, J. W., ... Monti, P. M. (2010). Behavioral economic analysis of cue-elicited craving for alcohol. *Addiction*, *105*(9), 1599–1607. http://dx.doi.org/10.1111/j.1360-0443.2010.03004.x.
MacKillop, J., Amlung, M. T., Few, L. R., Ray, L. a., Sweet, L. H., & Munafò, M. R. (2011). Delayed reward discounting and addictive behavior: A meta-analysis. *Psychopharmacology*, *216*(3), 305–321. http://dx.doi.org/10.1007/s00213-011-2229-0.
Mauro, C. F., & Harris, Y. R. (2000). The influence of maternal child-rearing attitudes and teaching behaviors on preschoolers' delay of gratification. *The Journal of Genetic Psychology*, *161*(3), 292–306. http://dx.doi.org/10.1080/00221320009596712.
May, J., Andrade, J., Kavanagh, D. J., Feeney, G. F. X., Gullo, M. J., Statham, D. J., ... Connor, J. P. (2014). The Craving Experience Questionnaire: A brief, theory-based measure of consummatory desire and craving. *Addiction*, *109*(5), 728–735. http://dx.doi.org/10.1111/add.12472.
Murphy, J. G., & MacKillop, J. (2006). Relative reinforcing efficacy of alcohol among college student drinkers. *Experimental and Clinical Psychopharmacology*, *14*(2), 219–227. http://dx.doi.org/10.1037/1064-1397.14.2.219.
Murphy, J. G., MacKillop, J., Skidmore, J. R., & Pederson, A. a. (2009). Reliability and validity of a demand curve measure of alcohol reinforcement. *Experimental and Clinical Psychopharmacology*, *17*(6), 396–404. http://dx.doi.org/10.1037/a0017684.
Murphy, J. G., Dennhardt, A. A., Yurasek, A. M., Skidmore, J. R., Martens, M. P., MacKillop, J., & McDevitt-Murphy, M. E. (2015). Behavioral economic predictors of brief alcohol intervention outcomes. *Journal of Consulting and Clinical Psychology*, *83*(6), 1033–1043. http://dx.doi.org/10.1037/ccp0000032.
Myerson, J., Green, L., & Warusawitharana, M. (2001). Area under the curve as a measure of discounting. *Journal of the Experimental Analysis of Behavior*, *76*(2), 235–243. http://dx.doi.org/10.1901/jeab.2001.76-235.
Odum, A. L. (2011). Delay discounting: Trait variable? *Behavioural Processes*, *87*(1), 1–9. http://dx.doi.org/10.1016/j.beproc.2011.02.007.
O'Hare, T., & Sherrer, M. V. (1999). Validating the Alcohol Use Disorder Identification Test with college first-offenders. *Journal of Substance Abuse Treatment*, *17*(1–2), 113–119. http://dx.doi.org/10.1016/S0740-5472(98)00063-4.
Olson, E. A., Hooper, C. J., Collins, P., & Luciana, M. (2007). Adolescents' performance on delay and probability discounting tasks: Contributions of age, intelligence, executive functioning, and self-reported externalizing behavior. *Elizabeth*, *43*(7), 1886–1897. http://dx.doi.org/10.1016/j.drugalcdep.2008.02.002.A.
O'Neill, J., Daniel, T. O., & Epstein, L. H. (2015). Episodic future thinking reduces eating in a food court. *Eating Behaviors*, *20*, 9–13. http://dx.doi.org/10.1016/j.eatbeh.2015.10.002.
Palombo, D. J., Keane, M. M., & Verfaellie, M. (2014). The medial temporal lobes are critical for reward-based decision making under conditions that promote episodic future thinking. *Hippocampus*. http://dx.doi.org/10.1002/hipo.22376.
Palombo, D. J., Keane, M. M., & Verfaellie, M. (2015). How do lesion studies elucidate the role of the hippocampus in intertemporal choice? *Hippocampus*, *25*(4), 407–408.
Peters, J., & Büchel, C. (2010). Episodic future thinking reduces reward delay discounting through an enhancement of prefrontal-mediotemporal interactions. *Neuron*, *66*(1), 138–148. http://dx.doi.org/10.1016/j.neuron.2010.03.026.
Peters, J., & Büchel, C. (2011). The neural mechanisms of inter-temporal decision-making: Understanding variability. *Trends in Cognitive Sciences*, *15*(5), 227–239. http://dx.doi.org/10.1016/j.tics.2011.03.002.
Petry, N. M. (2001). Delay discounting of money and alcohol in actively using alcoholics, currently abstinent alcoholics, and controls. *Psychopharmacology*, *154*(3), 243–250. http://dx.doi.org/10.1007/s002130000638.
Reed, D. D., Kaplan, B. A., & Brewer, A. T. (2012). Tutorial on the use of Excel 2010 and Excel for Mac 2011 for conducting delay-discounting analyses. *Journal of Applied Behavior Analysis*, *45*(2), 375–386. http://dx.doi.org/10.1901/jaba.2012.45-375.
Richards, J. B., Zhang, L., Mitchell, S. H., & de Wit, H. (1999). Delay or probability discounting in a model of impulsive behavior: Effect of alcohol. *Journal of the Experimental Analysis of Behavior*, *71*(2), 121–143. http://dx.doi.org/10.1901/jeab.1999.71-121.
Saunders, J. B., Aasland, O. G., Babor, T. F., de la Fuente, J. R., & Grant, M. (1993). Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption–II. *Addiction*, *88*, 791–804. http://dx.doi.org/10.1111/j.1360-0443.1993.tb02093.x.
Seinstra, M., Grzymek, K., & Kalenscher, T. (2015). Gender-specific differences in the relationship between autobiographical memory and intertemporal choice in older adults. *PloS One*, *10*(9), e0137061. http://dx.doi.org/10.1371/journal.pone.0137061.
Snider, S. E., LaConte, S. M., & Bickel, W. K. (2016). Episodic future thinking: Expansion of the temporal window in individuals with alcohol dependence. *Alcoholism: Clinical and Experimental Research*, *40*(7), 1–9. http://dx.doi.org/10.1111/acer.13112.
Stein, J. S., Koffarnus, M. N., Snider, S. E., Quisenberry, A. J., & Bickel, W. K. (2015). Identification and Management of Nonsystematic Purchase Task Data: Toward Best Practice. *Experimental and Clinical Psychopharmacology*, *23*(5), 377–386.
Story, G., Vlaev, I., Seymour, B., Darzi, A., & Dolan, R. (2014). Does temporal discounting explain unhealthy behavior? A systematic review and reinforcement learning perspective. *Frontiers in Behavioral Neuroscience*, *8*. http://dx.doi.org/10.3389/fnbeh.2014.00076.
Suddendorf, T., & Corballis, M. C. (1997). Mental time travel and the evolution of the human mind. *Genetic, Social, and General Psychology Monographs*, *123*(2), 133–167 (Retrieved from <Go to ISI>://WOS:A1997XD90100001).
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. http://dx.doi.org/10.1017/S0140525X07001975.
Tabachnick, B. G., & Fidell, L. S. (2007). Using multivariate statistics. *Using multivariate statistics (5th ed.)980*. *http://dx.doi.org/10.1037/022267*.
Teeters, J. B., Pickover, A. M., Dennhardt, A. A., Martens, M. P., & Murphy, J. G. (2014). Elevated alcohol demand is associated with driving after drinking among college student binge drinkers. *Alcoholism: Clinical and Experimental Research*, *38*(7), 2066–2072. http://dx.doi.org/10.1111/acer.12448.
Thom, J. M., & Clayton, N. S. (2015). Translational research into intertemporal choice: The western scrub-jay as an animal model for future-thinking. *Behavioural Processes*, *112*, 43–48. http://dx.doi.org/10.1016/j.beproc.2014.09.006.
Yi, R., Mitchell, S. H., & Bickel, W. K. (2010). Delay discounting and substance abuse-dependence. *Impulsivity: The behavioral and neurological science of discounting* (pp. 191–211). http://dx.doi.org/10.1037/12069-007.