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Reward-related episodic future thinking and delayed gratification in children ☆

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ABSTRACT

Cuing adults to imagine their personal futures enhances prudent choice in delay discounting tasks. However, it has not been established that such cueing also reduces discounting in children. We assessed the effect of episodic future thinking (EFT) on delay of gratification in children using EFT cues specifically related to the rewards on offer. One hundred and thirty-nine 8–12-year-olds were assigned to one of three conditions: (i) EFT (imagine spending money in the future), (ii) Imagine Place (imagine being in a certain place), or (iii) No Cue. They were cued on each trial of two tasks: a delay discounting task with hypothetical monetary rewards and a real delay choice task involving choices between real rewards over real delays (coins that could be swapped for treats). In the delay discounting task, the Imagine Place group showed significantly higher discounting than the other two groups. In the real delay choice task, the Imagine Place group made significantly fewer delayed choices than the EFT group. However, the EFT group did not differ from the No Cue group in either task. The lack of a difference between the EFT and No Cue conditions supports previous findings suggesting children struggle to benefit from EFT cues. Poorer performance of the Imagine Place group suggests that cued imagination is cognitively taxing for children, using up cognitive resources required to delay gratification.

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Introduction

The links between delay of gratification (DoG) abilities and important outcomes ranging from educational success to health-related behavior (e.g., Bickel, Koffarnus, Moody, & Wilson, 2014; Mischel, Shoda, & Rodriguez, 1989) are well established, leading to great interest in interventions that enhance DoG (Rung & Madden, 2018). Episodic future thinking (EFT), as defined by Atance and O'Neill (2001), involves projecting oneself into the future to pre-experience a personal event. Boyer (2008) has influentially argued that the adaptive value of EFT is to improve decision making by enhancing levels of emotional engagement with one's future: through imagining the emotional consequences of future rewards, the tendency to ignore or devalue such rewards is reduced, supporting prudent choice. Consistent with this claim, EFT manipulations have been robustly shown to enhance DoG in adults (Rösch, Stramaccia, & Benoit, 2021; Ye et al., 2021). EFT manipulations in DoG tasks involve cueing people to project themselves into the future to pre-experience personal events before choosing between a smaller sooner or larger later reward. Cues are typically provided before each trial and are often generated from participants' previously-provided descriptions of future events (e.g., Lin & Epstein, 2014).

However, the same beneficial effects of EFT cueing, or indeed other types of future thinking manipulations, have not been observed in children below the age of around 12 years (Burns, Atance, O'Connor, & McCormack, 2022; Burns, McCormack, O'Connor, Fitzpatrick, & Atance, 2021; Chernyak, Leech, & Rowe, 2017). Future thinking manipulations have included participants describing future events (Bromberg, Lobatcheva, & Peters, 2017; Burns, McCormack et al., 2021; Burns, O'Connor, Atance, & McCormack, 2021), book reading manipulations (Leech, Leimgruber, Warneken, & Rowe, 2019) and conversations about the future (Chernyak et al., 2017). Of these studies, only those involving participants older than 12 years old have found significantly increased preference for delayed rewards (Bromberg et al., 2017; Burns et al., 2022; Daniel, Said, Stanton, & Epstein, 2015). The reasons for the lack of success of such manipulations in children are unclear. One potential explanation is that engaging in EFT is too cognitively taxing for children and therefore cueing such thinking may impair, rather than enhance performance on DoG tasks. This is plausible given that the influence of concurrent cognitive tasks is linked to children's impaired performance on DoG tasks (Martinelli, Mostofsky, & Rosch, 2017), and may explain the findings of Burns, McCormack et al. (2021), who found that cueing preschoolers to imagine non-current events, whether past or present, impaired performance on a DoG task.

However, to date, studies of EFT and DoG in children have used cues that are unconnected to the rewards on offer in the DoG task: children have been cued to imagine unrelated personal future events occurring during the same time period as the delayed reward. When imagined future events are unconnected to reward-relevant personal goals, EFT cueing may potentially act as an effortful concurrent task rather than a mechanism to enhance prudent choice. Indeed, in their recent meta-analysis of EFT cueing, Rosch et al. (2021) concluded that, even for adults, specifically imagining the pay-off of the delayed reward was more effective than unrelated EFT cues. The current study focused on the possibility that reward-related, unlike unrelated, EFT cues might prove effective in children.

Measuring DoG in children

DoG studies with young children have frequently used delay maintenance tasks, such as the marshmallow task, where children can choose at any time to terminate a wait for a larger reward, over a period of seconds or minutes (Garon, 2016). However, adult studies typically involve multiple trials and binding choices between smaller sooner or larger later rewards; these usually encompass longer time periods (days to months) over which EFT might be expected to become important. EFT studies in adults commonly use computerized delay discounting tasks with hypothetical monetary rewards (e.g., would you prefer $10 now or $100 in 1 month?). These tasks allow the calculation of indifference points (i.e., the point at which the individual is equally likely to choose the immediate or delayed reward) that are fitted by mathematical models, producing temporal discounting functions that capture how reward value varies as a function of time. Previous child-friendly versions of this task have produced meaningful data in children as young as 8 years old (Burns et al., 2020), and we employed such a task in the current study. However, these tasks necessarily involve dozens of trials and may be taxing for some children. Therefore, we also used a much simpler real delay choice task in which children completed a small number of trials and were offered differing amounts of tokens that could be exchanged for real rewards over shorter time periods.

The current study

Our study used reward-related EFT cues in an attempt to improve DoG in children as measured by a real delay choice task and a computerized delay discounting task with hypothetical monetary rewards. In the delay discounting task, in the EFT cueing condition children were cued to imagine spending (hypothetical) money in the future in their preferred retail outlets. In the real delay choice task, children were offered tokens (toy coins) that could then be exchanged for real rewards. This made the task comparable to the delay discounting task, as children in the EFT condition were asked to imagine spending their tokens prior to each trial. We also included two control conditions: a No Cue condition and an Imagine Place condition. In the latter condition children were cued to imagine being in another place but not in the future and with no mention of rewards. This served to examine the effects on DoG of cued imagination that was neither reward-relevant or future-oriented, allowing us to test whether the effect of cued imagination varied depending on the temporal location and reward-relevance of the imagined events. In summary, then, the three conditions (reward-relevant EFT, Imagine Place, and No Cue) enabled us to address the twin aims of the study, which were to operationalize an EFT manipulation that had maximal chances of being effective in a child population, and to examine whether cued-imagination per se can actually impair DoG in children. Based on previous results with both children and adults we predicted improved DoG performance in the reward-relevant EFT condition, but hypothesized that performance may be impaired in the Imagine Place condition, because of the cognitive load of a concurrent task that involved imagining irrelevant events.

Method

Participants

One hundred and thirty-nine children (43.17% males) aged 8–12 years (*M* = 10.62, *SD* = 0.73) were recruited from three schools in the country of the first author. The intended age range was 8–11 but there were five 12-year-olds in the classes the sample was taken from. The minimum sample size of 113 to achieve .8 power was determined using the 'pwr' package in R (R Core Team, 2021) based on a small effect size and an alpha level of .05. Due to local demographics, 98% of children were white and of low to middle socio-economic status. The latter was given by the region's deprivation index which falls in the category of 'marginally below average' (Haase & Pratschke, 2017), albeit in the context of a relatively affluent European country. Written parental consent was obtained for all participants and children assented to their participation through the use of a red/green traffic light assent procedure. Children were randomly assigned to one of three experimental conditions. Demographic information split by experimental condition is available in the supplement.

Materials and procedure

Delay discounting task

The delay discounting task was programmed in PsychoPy (Peirce et al., 2019) and presented on a 13 inch touchscreen laptop. Prior to the main task, in the EFT condition, children were presented with six images of retail outlets where they could spend money (e.g, the sport shop, the toy shop) and were asked to pick the three places they would most like to spend their money. They were then prompted to imagine going to these places to spend money sometime soon, with each image shown in turn accompanied by a voiceover providing detailed imagination prompts (see supplement). For each of the three chosen places, the voiceover providing the cue ran for approximately 30 seconds, with each prompt separated by six seconds. Participants could then move on to the next stage in their own time by pressing the spacebar on the laptop. Participants were not asked to verbalize their thoughts. The Imagine Place condition followed the same procedure but children picked three places they would like to visit (e.g., the forest, the playground) and were asked to imagine being in each of these places with no reference to time. In the No Cue condition children were shown six colors and asked to pick their three favorite colors.

Children were then cued with one of three images they had chosen on each trial of a delay discounting task with hypothetical rewards. A picture first appeared on the screen of one of the retail outlets/places participants had previously chosen. Then pictures of the monetary rewards and text describing the delays were displayed with an accompanying audio description (e.g., "Imagine going to the sweetshop with. . .€5 now. . .or. . .€10 in 3 weeks"); see supplement for further details and sample display. The delayed reward was €10 offered at one of four delays: 1 day, 1 week, 3 weeks, and 3 months. The immediate reward ranged from €0 to €10 and varied in 50 cent increments. An iterative adjusting amount procedure was used to home in on indifference points at each delay (Richards, Zhang, Mitchell, & De Wit, 1999). The task terminated after an indifference point was reached for all delays and also included a set of check trials to monitor understanding. The choices offered in check trials were: €10 now or €0 in 1 week, €10 now or €8 in 3 months and €0 now or €10 in 1 week. If a participant chose the smaller amount of money on more than one of these trials their data was excluded from the analysis. The mean number of test trials was 52 (range = 20–87).

Delay Choice task

The delay choice task was carried out immediately after the delay discounting task. It comprised of 6 trials involving three delay periods (1 day, 1 week, 3 weeks), with two trials at each delay (1 coin now v 2 later; 1 coin now v 3 later), with trial order counterbalanced. Toy coins could then be exchanged for items from a 'gift shop.' After hearing task instructions, children were asked the following check questions to ensure task comprehension: "If you choose this one coin when will you get the treats you buy with it?" and "If you choose these two coins when will you get the treats you buy with them?" Before each trial in the EFT condition, children were presented with an image of the 'gift shop' and verbally prompted to imagine spending their coins in the shop. In the Imagine Place condition, children were presented with an image of one of the places they had chosen to visit prior to the delay discounting task. Children were then verbally prompted to imagine being in that place. In the No Cue condition children were shown one of their chosen colors. On each trial, participants pointed to the option they would prefer. Participants scored 0 on a trial if they chose the immediate reward, and 1 if they chose the larger delayed reward, producing a total score from 0 to 6. When children chose to delay gratification, they chose the rewards they wished to buy with their coins after the task; these were then kept by the researcher and delivered to the child's classroom after the appropriate delay.

Data processing

For the delay discounting task the first criterion outlined by Johnson and Bickel (2008) was used to identify unsystematic discounters (i.e., those who produced an indifference point increase from one delay to the next that was greater than 20% of the delayed reward) who were subsequently removed from all delay discounting analyses. For the remaining participants, delay discounting data were processed in two stages. First, following Burns et al. (2020), three discount functions were fitted to each participant's data (hyperbolic, quasi-hyperbolic, exponential), alongside a fourth 'noise' model based on the mean indifference point that best reflected the responding of participants who were insensitive to variations in delay. The best-fitting model for each participant was determined by selecting the model with the best overall Bayesian Information Criterion score (Schwarz, 1978). Next, integral calculus was used to calculate the area under the curve produced by the fitted function (model-based AUC; larger values indicate less steep discounting as a function of time). Model fitting and AUC calculations were carried out using the Discounting Model Selector software (Gilroy & Hantula, 2018). To correct for positive skew, log transformed AUC values were used in analyses. For the delay choice task, the total number of delayed choices (0–6) was used as the outcome variable.

The main data analyses were carried out in R (R Core Team, 2021). To examine the influence of condition (EFT, Imagine Place, No Cue) on DoG while controlling for age (days), a hierarchical multiple regression was run for each task with age entered at step 1 and condition at step 2.

Results

In the delay discounting task, 6 participants were excluded for failing more than one check question, 13 for responding unsystematically, and 5 for failing more than one check question and responding unsystematically. After exclusions, the final sample consisted of 120 children (EFT = 40, Imagine Place = 40, No Cue = 40). In the delay choice task, 2 participants were removed from the analysis because they failed to answer check questions after two attempts, leaving a final sample of 137 (EFT = 46, Imagine Place = 45, No Cue = 46). Performance on both tasks is depicted in Fig. 1, which shows that performance was weakest in the Imagine Place condition with similar performance in the other two conditions. Collapsing between conditions, scores on the delay choice task and AUC scores were significantly correlated, $r = .56$, 95% CI $[.42, .67], t(118) = 7.33, p < .001$.

Table 1 shows the results of a hierarchical regression on delay choice and AUC scores. An interaction term between age and condition was not included, because initial analyses indicated this was not significant. Age was a significant predictor of performance on the delay discounting task and the addition of condition significantly improved the model fit, $F(2,116) = 5.21$, $p = .007$, $\eta_p^2 = 0.08$. Children in the Imagine Place condition ($M = 0.49$, $SD = 0.30$) had significantly lower model-based AUC scores compared to those in the EFT condition ($M = 0.64$, $SD = 0.25$), $b = -0.16$, $p = .010$. When the reference category was changed from the EFT condition to the No Cue condition, participants in the Imagine Place condition showed significantly higher discounting than those who were not cued at all ($M = 0.66$, $SD = 0.28$), $b = -0.18$, $p = .004$. The difference in performance between EFT and No Cue conditions was not significant.

Age was also a significant predictor of number of delayed choices. The addition of condition did not significantly improve the model, $F(2,133) = 2.83$, $p = .063$, $\eta_p^2 = 0.04$, although there was a trend in the direction similar to that observed in the AUC data, with participants in the Imagine Place condition ($M = 3.09$, $SD = 1.61$) scoring significantly lower than those in the EFT condition ($M = 3.74$, $SD = 1.25$), $b = -0.68$, $p = .019$. There was no significant difference between performance in the No Cue ($M = 3.48$, $SD = 1.39$) and EFT conditions, or between the No Cue and Imagine Place Condition.

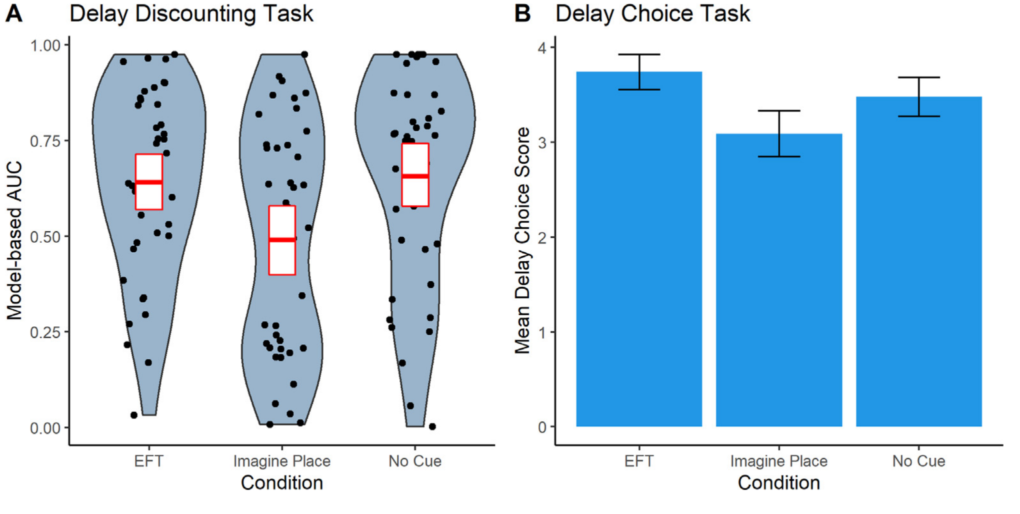

Fig. 1. Panel A: Mean Model-based AUC score by condition. Points are individual scores (jittered within groups to reduce overlap) with violin illustrating distribution; red lines indicate median; the lower and upper hinges correspond to the first and third quartiles. Panel B: Mean score (out of 6) on delay choice task by condition with error bars representing standard error.

Table 1
Hierarchical multiple regression analyses for delay choice scores and model-based AUC scores.

Predictor	*b*	*b* 95% CI	Sr2	Sr2 95%CI	Fit	Difference
Delay Choice Scores						
(Intercept)	−2.69	[−6.08, 0.70]				
Age	0.00**	[0.00, 0.00]	.09	[.02,.19]		
					R^2 =.087** 95% CI[.02,.19]	
(Intercept)	−2.47	[−5.82, 0.88]				
Age	0.00**	[0.00, 0.00]	.09	[−.00,.18]		
Imagine Place	−0.68*	[−1.24, −0.11]	.04	[−.02,.10]		
No Cue	−0.31	[−0.87, 0.25]	.01	[−.02,.04]		
					R2 =.124** 95% CI[.03,.22]	ΔR^2 =.037 95% CI[−.02,.10]
Model-based AUC scores						
(Intercept)	−0.44	[−1.18, 0.30]				
Age	0.00**	[0.00, 0.00]	.06	[.00,.16]		
					R^2 =.061** 95% CI[.00,.16]	
(Intercept)	−0.45	[−1.17, 0.27]				
Age	0.00**	[0.00, 0.00]	.07	[−.02,.15]		
Imagine Place	−0.16*	[−0.27, −0.04]	.05	[−.02,.12]		
No Cue	0.02	[−0.10, 0.14]	.00	[−.01,.01]		
					R2 =.139** 95% CI[.03,.24]	ΔR^2 =.077** 95% CI[−.01,.17]

Note. b represents the unstandardized regression weights. Sr2 represent the semi-partial correlation values. * indicates p <.05. ** indicates p <.01.***indicates p <.001. For the Delay Discounting task, co-efficients of the Imagine Place and No cue Conditions reflect performance in comparison to the EFT condition

Discussion

Contrary to our prediction, for both DoG tasks, performance in the EFT condition was not significantly better than that in the No Cue control condition. However, performance in the Imagine Place Condition was significantly poorer than in either of the other two conditions in the discounting task and than in the EFT condition in the real delay choice task. Performance was predicted by age on both tasks, and was correlated between the tasks.

The latter findings support the use of a delay discounting task with hypothetical monetary rewards with children of this age range, although findings also indicate this must be done with caution. Despite using audio and visual representations of rewards and choices, and check questions to ensure children understood the task, unsystematic performance was observed in around 13% of children, whose data was excluded from analysis. The fact that a proportion of children did not properly engage with the task was expected (Burns et al., 2020), and our findings reinforce the importance of checking for unsystematic data when using this type of task with children. Nevertheless, the strong correlation between this task and the real delay choice task implies that, for the remaining sample, the data were meaningful.

Why is EFT cueing not effective?

Our attempt to demonstrate an EFT cueing effect using reward-related EFT was not successful, aligning with previous null findings in relation to future thinking manipulations and DoG in children (Burns et al., 2022; Burns, McCormack et al., 2021; Chernyak et al., 2017), and contrasting with the robust demonstrations of the effect in participants older than 12 years (Bromberg et al., 2017) and adults (Rösch et al., 2021). There are a number of possible reasons why EFT cueing is ineffective in children, even when it is reward-related, three of which we will now consider. First, children might lack the future thinking skills required to benefit from such manipulations, in line with findings suggesting EFT continues to improve past late childhood (Gott & Lah, 2014). However, we note that there is limited evidence that EFT is predictive of DoG performance in this age range (Burns, O'Connor et al., 2021). Moreover, if this suggestion is correct, we might expect to see a relation between EFT skills in children and whether they benefit from EFT cueing. Burns, O'Connor et al. (2021) report failing to find such a relation.

A second possible reason that children do not benefit from EFT cueing may be that richly imagining a future reward could actually serve to increase some children's impatience. Studies using the marshmallow task have suggested that deliberately not imagining the pleasure of eating the marshmallow is a helpful strategy, and one used by children as young as 8 years (Mischel & Mischel, 1987). Although delay maintenance tasks differ structurally from the delay choice tasks used in the current study, it is possible that, for children, proactively anticipating a reward has a different effect than for adults. Rosch et al. (2021) argue that EFT can make temporally distant rewards feel more concrete, which has two affective consequences: (i) it provides a preview of the future positive affect the reward will yield, making it seem worth the wait, and (ii) it yields current positive anticipatory affect derived from the looking forward to or savoring of the future pleasant experience. Both of these affective consequences are assumed to reduce the devaluation of a delayed reward. It is possible that children do have the EFT skills required to make the future reward more concrete, but that children differ to adults in the extent to which they find anticipation pleasurable. This suggestion is speculative, and comes with the caveat that the precise means by which EFT enhances DoG is poorly understood (Ye et al., 2021). Nevertheless, examining whether the affective consequences of richly anticipating a future reward are similar in children to those in adults would provide a useful direction for research on the development of DoG.

Finally, a third possibility is that benefiting from EFT cueing requires cognitive resources that are limited in children. At the other end of the lifespan, Sasse, Peters, and Brassen (2017) found that some older adults also did not benefit from EFT cueing (see also Mok et al., 2020) and that this difficulty seemed to be linked to deficits in attentional control. Underdeveloped cognitive control abilities may contribute to children's difficulties in benefiting from EFT cues, a possibility that could be explored in future studies. Deciding to delay gratification seems to require some degree of effortful cognitive processing in children (Yu & Sonuga-Barke, 2020) and Martinelli et al. (2017) showed that children who were more impaired by increased cognitive load in a Go-/No-go task subsequently performed poorer on a DoG task. It is possible that any potential benefit of engaging in EFT is effectively 'canceled out' by the impact of the cognitive load associated with imagining the future reward. The comparatively poor performance in the Imagine Place condition, especially in comparison to the No Cue condition in the Delay Discounting task, provides some suggestive evidence for this explanation. It suggests that the processing demands of engaging in imagination per se can increase the likelihood that children choose not to delay gratification. If correct, this suggests that EFT cueing may only be effective in children with greater cognitive capacity, or that for EFT cueing to be effective, a means must be found to reduce its impact on processing resources.

All three of these possible explanations – i.e., children's limited EFT skills, the potential differential affective consequences of imagining a future reward in children, or a lack of cognitive resources - are at least compatible with the finding that EFT cueing seems to become effective from around 12 years of age. EFT is known to continue to improve into adolescence (Gott & Lah, 2014), as are cognitive resources such as working memory (Conklin, Luciana, Hooper, & Yarger, 2007), and although, to the best of our knowledge, there are no studies that have examined developmental changes in the degree of pleasure associated with the mental anticipation of rewards, a variety of measures of future orientation do increase into adolescence (Steinberg et al., 2009).

However, we also acknowledge that, there may have been some methodological issues which contributed to our failure to find an effect of reward-related EFT cueing. For example, spending their own money in a shop may be something that children had little experience of, which may have limited their ability to richly imagine the event. A further limitation of our study was that we did not assess the extent to which children were appropriately prompted by the thinking cues. While we cued children to engage in EFT, we did not record the content or episodicity of their thoughts, and an examination of these properties of their thoughts might potentially have helped shed light on why EFT cueing was ineffective.

Summary and conclusions

Our child-friendly computerized delay discounting task was significantly correlated with our novel real delay choice task and both were sensitive to developmental changes in DoG abilities. Despite some attrition owing to unsystematic responding in the delay discounting task, this suggests that both tasks are useful measures of DoG in children. Reward-related EFT cues did not improve performance in either DoG task in comparison to a No Cue condition, replicating previous null effects in children. However, it was better than performance in a condition in which children imagined being at another place. Together, these findings potentially suggest that using EFT cues may be too cognitively taxing for children and thus fails to enhance performance on DoG tasks. Further research is needed to understand exactly why children struggle to benefit from EFT cues, and to determine if EFT cueing techniques can be adapted so that they are effective in improving DoG performance.

Data availability

A link to the data/code is included in the title page.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jecp.2022.105618.

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