**Study 4: Does priming children to think about the future improve performance on delay of gratification and delay discounting tasks.**

In this study we investigated whether cueing children aged 9-to-11 years to think about events in their personal future will promote increased patience on intertemporal decision making tasks. Participants were assigned to one of three conditions: future, past or control and completed four tasks:

* An interview in which they generated episodic memory or episodic future thinking cues that would be used in the subsequent tasks. Participants in the control condition simply talked about their favourite TV programmes and youtube channels.
* A delay of gratification task with real rewards.
* A delay discounting task using hypothetical rewards.
* a novel measure of children’s subjective judgement of how far away future time points feel (referred to below as future time perception).

**Participants**

One hundredseventy-seven children were recruited for this study: eighty-five 8-9-year-olds and ninety-one 10-11-year-olds. Children were randomly assigned to one of three conditions: 56 to the past condition, 57 to the future condition and 64 to the control condition.

**Measures**

**Interview task.** All children completed an interview task. Children in the past condition were asked to describe five positively valenced events from their personal past. For each event participants were instructed that the event should fall within a specific time window: yesterday, a few days ago, a week ago, a few weeks ago and a few months ago. Participants in the future condition were also asked to generate positively valenced events, however, they were asked about events that were likely to happen to them within specific future windows: tomorrow, a few days from now, a week from now, a few weeks from now and a few months from now. Children in the control condition were asked to describe 5 of their favourite tv programmes or YouTube channels. Whenever children in the past and future conditions described an event they were asked to make three ancillary judgements about the event. 1. a speed judgement regarding how quickly the event came to mind (Figure 1), 2. a clarity judgement regarding how clear in their mind the event looked to them as they recalled it / imagined it (Figure 2) and 3. an emotion valence judgement (how did it make them feel thinking about the event, Figure 3). After each event had been narrated, the experimenter made a cue card with the help of the participant on which they displayed a brief sentence summarising the event. The cue card was used in the subsequent tasks to remind participants about the generated events.

**Delay of Gratification.** This was task comprised of 12 trials on which participants were offered a choice between a low value reward available immediately and a higher value reward available after a specified delay. Three delay periods were used, 1 day, 1 week and 3 weeks, with 4 trials at each delay. On each trial one of four reward pairs (once at each delay) were offered: trading cards (1 vs. 2), erasers (1 vs. 2), pens/pencils (1 vs. 2) and sweets (1 vs. 2). Participants in the future and past conditions were cued to think about the yesterday / tomorrow event prior to the 1 day delay trials, the last week / next week event prior to the 1 week delay trial and the few weeks ago / few weeks from now event prior to the 3 week delay trials.

Participants sat at a table across from the experimenter, with two trays, one labelled ‘now’ and one labelled ‘later’, placed in front of them. The experimenter showed children 3 types of trading card, each from a different theme (Football players, Star Wars characters and Despicable Me cards for the males; Disney Princess, Shopkins and Trolls cards for the females) and two types of novelty erasers (Lego shaped and emoji). Each child’s preferred trading card and eraser was used in the subsequent delay choice trials. On trials on which the trading card was the reward the cards were placed inside a small opaque envelope to hide the characters on the cards, ensuring that the specific cards used did not affect children’s choices. There were two orders of presentation of the trials, which was counterbalanced between participants. Participants were scored a 0 on a trial of they chose the immediate reward, and a 1 if they chose the delayed reward.

**Future time perception task*.*** This task (e.g. Kim & Zauberman; 2009, 2013) involved participants making judgements regarding the subjective distance of various time points in the future. Children made estimates of the subjective distance of four different time-points, with estimates being made twice for each time-point, and all children made these estimates in the same order (3 Days, 3 Months, 1 week, 3 weeks, 3 days, 3 weeks, 1 week , 3 months). Estimates were made using a specially constructed wooden box, with an aperture in the front of it and a metal pole with a handle on the end running through the side of the box. Inside the box was a 100m reel of 3mm Para Cord. The Para Cord was fed through the front aperture such that it could be pulled to unravel the cord. A specially constructed mechanism inside the box measured the cord length as it was pulled through the aperture. A screen on the rear of the box displayed the measurement in millimetres.

In the task, participants were instructed that they were to think about how far away different times felt to them in the future, and that they would pull out the string to indicate how far in the future each time felt. The experimenter firstly demonstrated how to complete the task with two practice trials (“I’m thinking about a time very soon, so I pull it out a short bit. Now I’m thinking about a long time from now, so I’ll pull it out a long way”), in which the experimenter pulled the string out for ½ of a revolution for the ‘very soon’ trial, and pulled the string out for 2 revolutions for the ‘long time’ trial. Participants completed this task twice; on day 1, they completed the task as outlined (we refer to this as the Uncued condition). On day 2, children in the past and future conditions were given cues from the EFT task which corresponded to the four time-points used in this task (Cued condition). Before children made each subjective time estimate, they were asked to think about the event they had generated for that particular time-point before making their subjective time estimate. Children in the control condition completed the Uncued version of the task twice.

The mean value of the two estimates that children produced at each delay length was used in the subsequent fitting of subjective time functions. We first identified participants that failed to produce estimates that monotonically increased with actual distance of the time point in the future. Two specific criteria were applied, 1. Participants were who produced an estimate for a time point that was more than 20% shorter in length than the time point preceding it in calendar time, were identified as unsystematic 2. Participants whose estimate to furthest time point (in calendar time) was not greater at least 50% greater in length than their estimate to the shortest time point were also identified as unsystematic. For each participant we first transformed future time estimates into subjective units by setting the median string length across all participants for the shortest 1-day estimate equal one unit of subjective time. All time estimates were transformed into subjective units by dividing them by this number. We then used the least square method to fit power and linear functions to each participant’s data.

***Delay discounting task.*** This was a computerised task programmed in E-prime (Psychology Software Tools, Pittsburgh, PA) and administered on a 15inch Dell laptop with touchscreen. The task involved hypothetical monetary rewards: the immediate reward varied in value from £1 to £31, while the delayed reward was fixed at £32. On each trial the delayed reward was available at one of four delays (3 days, 1 week, 3 weeks and 3 months). Participants completed five trials at each delay and trials within a delay were block presented (participants completed the blocks in chronological order from shortest delay (3 days) to longest delay (3 months)). For participants in the past and future conditions, before they began each block of five trials for each delay, they were presented on screen with the cue they had generated in the interview task corresponding to that particular delay. Children were asked to think about the cued event whilst they completed the delay discounting task. Children in the control condition completed the task without any cues. On each trial in a delay block the value of the immediate reward was set as the mean value of two parameters H and L, i.e. immediate reward = (H + L) / 2. On the first trial H was set to £32 and L is set to 0 such the immediate reward was £16. If the participant chose the immediate reward then H was adjusted down to take the value of the immediate. If the participant chose the delayed reward then L was adjusted upwards to take the value of the immediate reward. After 5 trials the values of H and L converge such that the difference between them is £1. The midpoint between the final values of H and L is the participant’s indifference point for that delay. Unsystematic discounters were identified using a rule recommended by Johnson and Bickel (2008). For the remaining participants, their delay discounting data was analyzed in a two-step process. First, a number of discount functions were fitted to each participant’s data. These discount functions were selected based on their normative (exponential discount function) or putative descriptive status (hyperbolic and quasi-hyperbolic discount functions). A fourth ‘noise’ model, a y-intercept model based on the mean indifference point that captures insensitivity to variations in delay was also fitted. The best fitting model for each participant was determined on the basis of Bayesian Information Criterion scores (BIC; Schwarz, 1978). In step two we derived model-based Area Under the Curve (model AUC), by applying integral calculus to the fitted function (Gilroy & Hantula, 2018). Model AUC scores are scaled to the interval 0-1 by dividing them through by the total area of the graph.

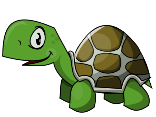


Figure 1. Scale used for speed judgements in the interview task.

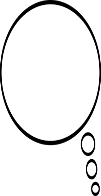
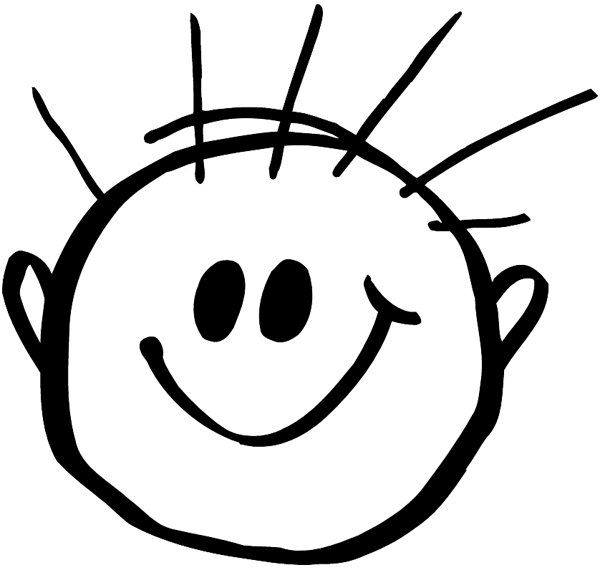
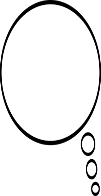
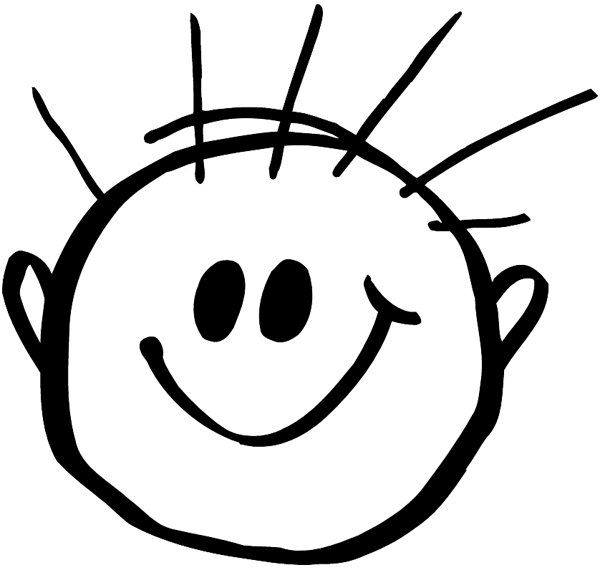
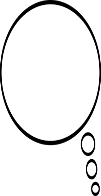
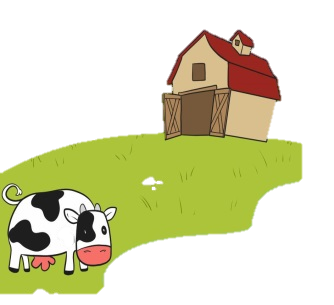
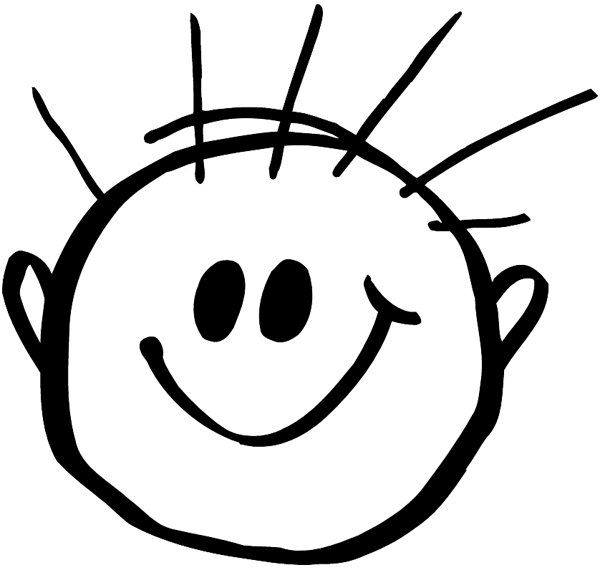
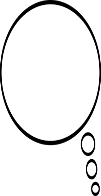
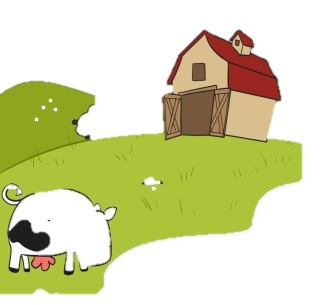
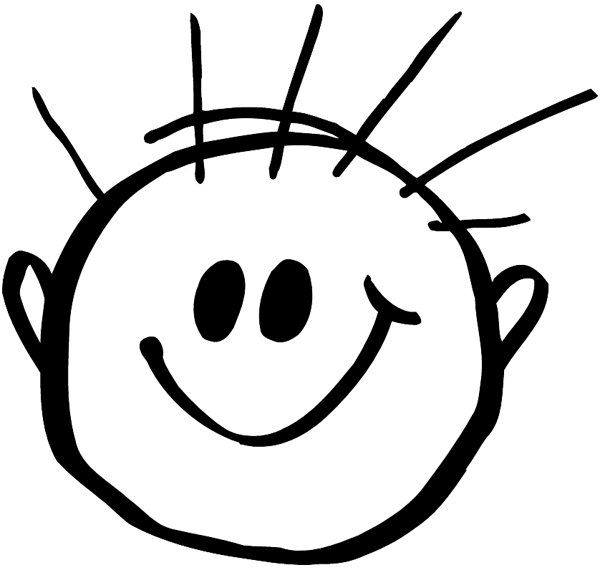
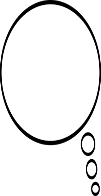
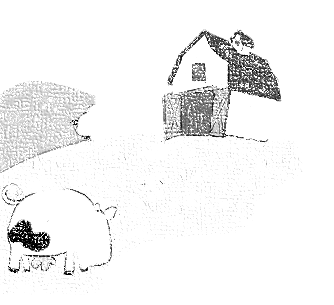
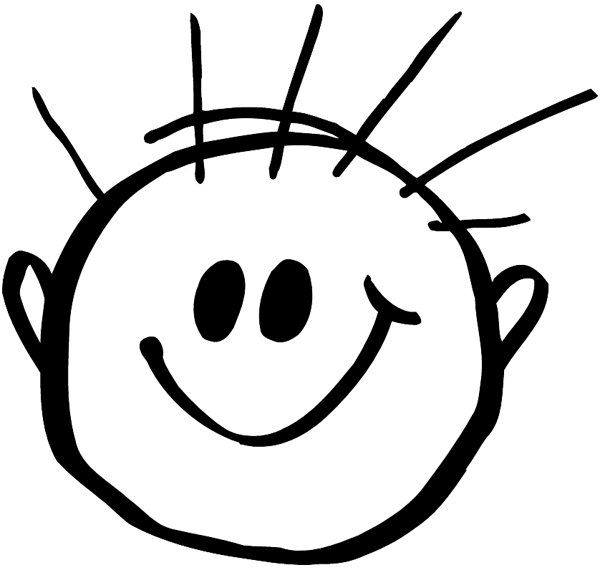
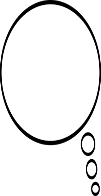
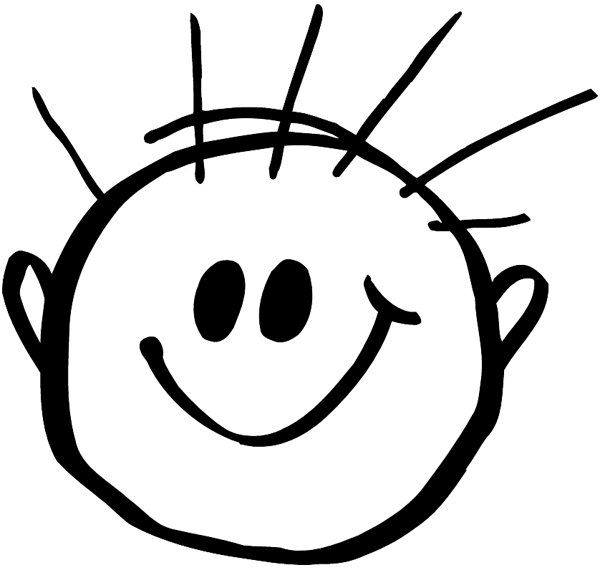


Figure 2. Scale used to elicit clarity judgements in the interview task.

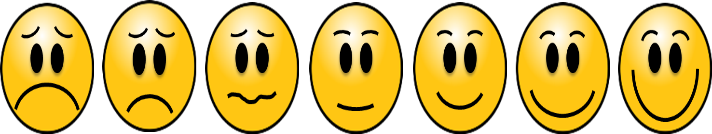


Figure 3. Scale used to elicit emotion valence judgements in the interview task.