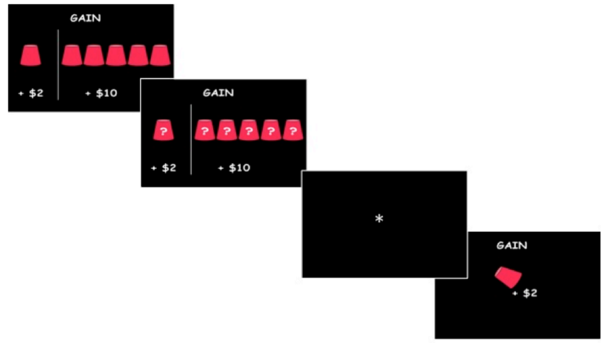
Reward and Decision Making Tasks

Roulette Task

Participants complete a total of two runs of the Roulette Game, a a task originally designed by Payne (2005) to assess probability sensitivity in risky choice. This version was simplified from the original to be comprehensible to adolescents. In this task, participants are presented with a series of "wheel" gambles with a 1/3 probability of gaining money (ranging from +$3.50 to +$8), a 1/3 probability of losing money (ranging from -$4 to -$8.50) and a 1/3 probability of receiving $0. A total of 400 trials were created and divided among 5 runs of 80 trials each; the run number and order is counterbalanced across participants, and each participant completes two runs for a total of 160 trials. After viewing the gamble for 1000 ms, participants are presented with an amount of money (ranging from $1 to $2.50) and instructed to add that amount of money to one of the three spaces on the "wheel", changing the value of that gamble. Thus, on each trial the participant makes a decision employing one of three strategies. A gain-maximizing (GMax) decision is one where the participant chooses to add money to the positive-value space on the "wheel", increasing the maximum possible amount they could win without altering outcome probabilities. A probability-maximizing (PMax) decision is one where the participant adds money to the reference ($0) space, increasing the probability from 1/3 to 2/3 chance of winning some amount of money without altering the range of values. Finally, a loss-minimizing (LMin) decision is one where the participant adds money to the negative-value space, reducing the value of the potential loss without altering outcome probabilities. Because the probabilities of each space were equal, the expected value of the gamble remained unchanged regardless of participant decision; therefore, no one strategy can be considered optimal, and different strategies may be seen as reflecting different but equally valid approaches to risk-taking.

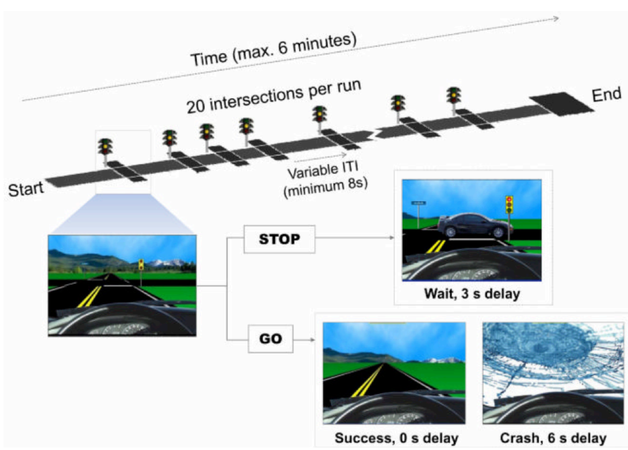
The Cups Task



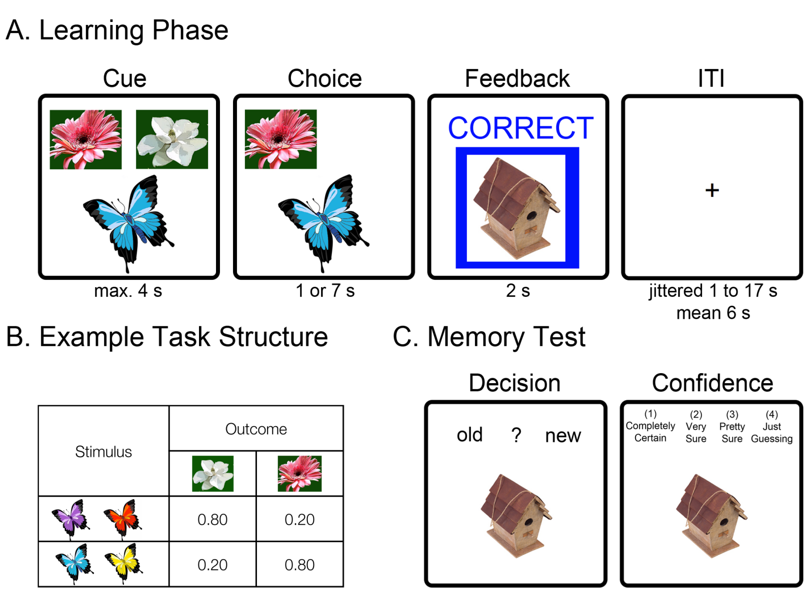
The Cups Task (Levin & Hart, 2003) measures decision-making under uncertainty, as adolescents often make decisions under uncertain and stressful conditions. Participants are presented with two task frames (Frame): a frame where they have the opportunity to gain money (Gain Frame), and one where they can lose money (Lose Frame). Depending on the frame, participants are asked to choose between a certain gain (or loss) and an uncertain gain (or loss). The certain option is to win (or lose) $2, while the uncertain option could lead to a probability (.20, .33, or .50) of a larger win (or loss) ($4, $6, or $10), or win/lose nothing. There are three trial types (n = 36/trial type) that differ on expected value (EV = value x probability). The advantageous EV trials (ADV), in which the EV is greater than $2 in the gain frame or less than $2 in the loss frame, consists of the 50%-$6, 50%-$10, and 33%-$10 trials in the gain frame and 33%-$4, 20%-$4, and 20%-$6 trials in the lose frame; in these trials, the uncertain choice yields better EV than the certain choice. The disadvantageous EV trials (DIS), in which the EV is less than $2 in the gain frame and greater than $2 in the lose frame, consisted of the 33%-$4, 20%-$4, and 20%-$6 trials in the gain frame and the 50%-$6, 50%-$10, and 33%-$10 trials in the lose frame; in these trials, the uncertain choice yielded a worse EV than the certain choice. In the equal EV trials (EQEV), in which the EV is $2, consisted of the 50%-$4, 33%-$6, and 20%-$10 trials in both gain and lose frames; in these trials, the uncertain choice yields the same EV as the certain choice. Participants are instructed to consider each choice carefully and to earn as much money as possible in the game because at the end of the game, the computer randomly selects an outcome and that outcome is be added to or subtracted from their study compensation; thus, participants could earn between $2 and $10 in addition to study compensation.

The Stoplight Task

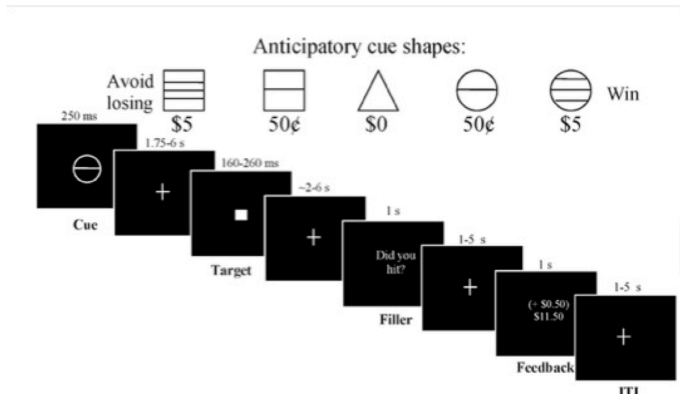
The Stoplight task is a simple driving task in which subjects control the progression of a vehicle along a straight track, from a driver's point of view. Subjects complete four rounds of the task; two in the first social condition and two in the second social condition. Each round uses a track with 20 intersections (treated as separate trials), which take under 6 minutes to traverse (dependent on subjects' choices and providence). At each intersection subjects render a decision (by button press) about whether or not to brake as the vehicle approaches a changing traffic signal (which cycles from green to yellow to red). As the vehicle approaches the intersection, the traffic signal turns yellow, and the subject decides whether to chance a possible crash in the intersection (GO decision), or to brake and wait for the light to return to green (STOP decision). Importantly, both the timing of the traffic signals and the probability of a crash in the associated intersections are varied so as to be unpredictable by the participant. Risk taking (i.e. not braking for the yellow light) is encouraged by offering monetary incentives for completing the course in a timely fashion. Successfully traveling through an intersection without braking saves time, whereas braking and waiting for the signal to turn green again is associated with a time delay. However, if the participant does not brake and a crash ensues, the loss of time is even greater than if the participant were to brake and wait for the light.



Learning and Memory Task Design: Probabilistic Feedback Learning Paradigm
In this task, participants learn associations between pairs of stimuli by trial and error. Response-contingent feedback follows choices, and over many trials participants use this feedback to learn which choice is the optimal one for each of the four cue stimuli. On each trial in the learning phase, participants see one of four different butterflies and predict which of two flowers the butterfly is more likely to feed from. Participants have up to four seconds to make a response, and are encouraged to respond as quickly as possible. Each butterfly is associated with one flower on 80% of trials and with the other flower on 20% of trials (**Figure 1A**). This means that most of the time choosing the optimal flower for a particular butterfly results in "correct" feedback, but 20% of the time choosing the optimal flower results in "incorrect" feedback. This allows us to observe learning rates over the course of time in the task as well as seek out prediction error signals in the brain for these infrequent and surprising feedback outcomes and gauge trial-by-trial expectations. Feedback is visually presented on the screen (the word "correct" in blue or "incorrect" in red) for two seconds, followed by a fixation-cross for a jittered inter-trial interval. Within participant, the cue butterfly and associated target flower remains fixed with 0.8/0.2 probability over the entire task, but this is fully counterbalanced across participants (**Figure 1B**). The test phase immediately follows the learning phase. Participants continue to make choices for the same butterfly-flower associations, but no longer receive feedback for these choices. Participants are instructed to continue choosing based on the associations that they had learned over the previous trials. This provides a measure for how well the associations have been learned for each of the 4 butterfly stimuli, in the absence of continued reinforcements.



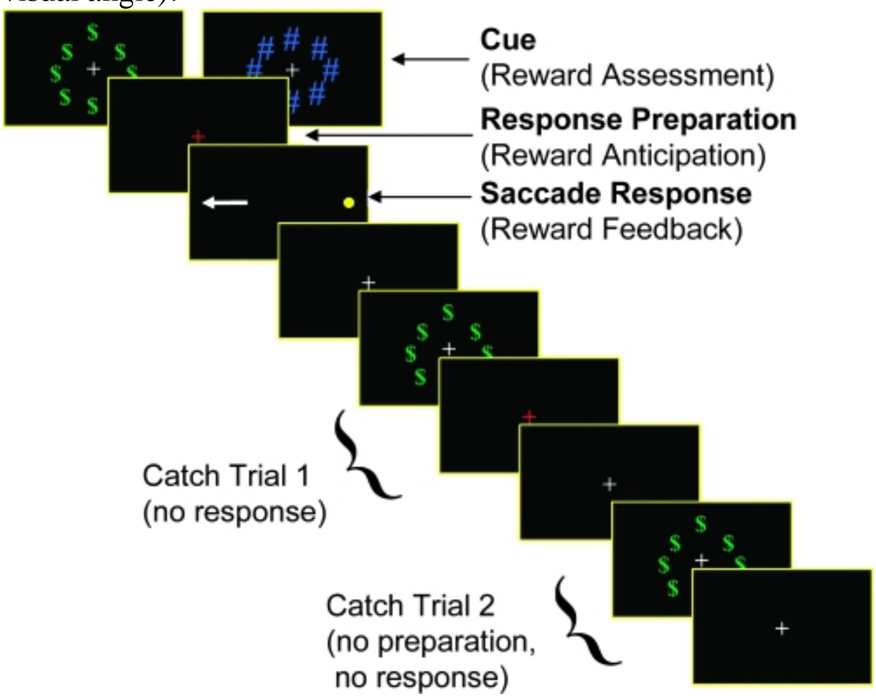
Monetary Incentive Delay Task



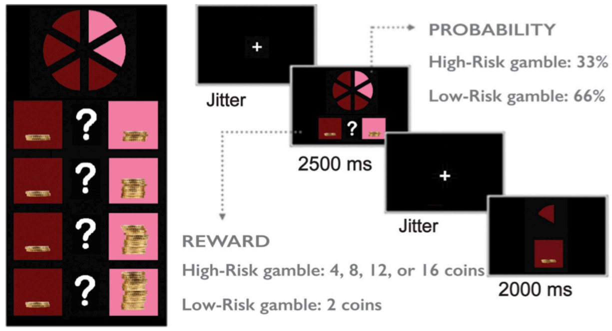
This is a widely used task used to measure reward sensitivity in the brain. The first box shows the cue types presented, with circles indicating the potential to win money (gain cue), squares indicating the potential to lose money (loss cue), and a triangle indicating no money will be won or lost (neutral cue). A cue is presented for first, followed by a fixation cross and then the target square, during which the participant is instructed to press a button as quickly as possible to win or avoid losing money. A feedback screen, in which the top number indicated the amount of money won or lost during that trial and the bottom number indicates the participant's total amount, presented at the end of each trial.

Rewarded anti-saccade task

On each AS trial, subjects are initially presented with 1ne of 2 incentive-indicating cues. A ring of green dollar bill signs ($), each subtending approximately 1° of visual angle, surrounding a central white fixation cross indicates that the subject would win money if they correctly performed the forthcoming trial. An equivalently sized, isoluminant ring of blue pound signs (#) indicates that no money is at stake on that trial. Subjects are not told exactly how much money could be earned on each trial to prevent their keeping a running tally of their performance and engaging working memory systems. However, subjects are told prior to the task that they could win up to an additional $25 contingent on their performance and that no debt would be accrued (i.e., subjects could not owe money). Next, the incentive ring disappears, and the central fixation cross changes from white to red (1.5 s), indicating to the subject that they should begin to prepare to inhibit a response. Finally, a peripheral stimulus (yellow dot) appears (75 m) at an unpredictable horizontal location (±3°, 6°, and 9° visual angle).



The Cake Gambling Task



The Cake Gambling Task, which was inspired by the Cambridge Gambling Task (Rogers et al., 1999). In this gambling task all information that is relevant for making a decision is presented to participants on each trial and no information has to be learned or retrieved over consecutive trials. On each trial, participants gamble with a round cake presented at the center of the screen. Cakes consisted of 6 wedges that could be brown or pink, and participants were told that these wedges were chocolate-flavored (brown wedges) or strawberry-flavored (pink wedges). A brown and pink square containing a number of coins, indicating the number of credits that was associated with each flavor, were presented at the foot of each cake. The proportion of pink/brown wedges (5:1, 4:2, or 3:3), and the number of credits (1, 3, 5, 7, or 9), associated with the wedges were varied systematically across trials. Importantly, 1 credit was always associated with the most likely of the two outcome possibilities, a safe choice, and 1, 3, 5, 7, or 9 credits were always associated with the least likely of the two outcome possibilities, a risky choice. Each trial started with a 500 msec fixation cross, followed by a stimulus that was presented for 5,000 msec, followed by a feedback stimulus that was presented for 1,000 msec. 3,000 msec after the stimulus appeared on the screen, a question mark was presented in between the squares at the bottom of the screen. At this point, participants were instructed to indicate by a left or right button press which color—pink or brown—the computer was most likely to select, given the fact that its choice was random, and to decide which of two possible gambles they wanted to accept. Participants had to decide between taking the risk of choosing the least likely outcome, putting a high number of credits at stake, or choosing the most likely outcome with only 1 credit at stake.

The valence of the feedback participants received always was the consequence of the combination of the computer's random choice (according to the different proportions of the two colors) for either pink or brown and the participant's decision. If these two matched, the stake associated with the participants choice was added to the total points score, if they did not match, the stake was subtracted from the total points score. Participants were instructed to try to win as many credits as possible on every trial.