The relationship between intertemporal choice and following the path of least resistance across choices, preferences, and beliefs

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Abstract

The degree to which individuals prefer smaller sooner versus larger delayed rewards serves as a powerful predictor of their impulsivity towards a number of different kinds of rewards. Here we test the limits of its predictive ability within a variety of cognitive and social domains. Across several large samples of subjects, individuals who prefer smaller more immediate rewards (steeper discounters) are less reflective (or more impulsive) in their choices, preferences, and beliefs. First, steeper discounters used more automatic, less controlled choice strategies, giving more intuitive but incorrect responses on the Cognitive Reflection Test (replicating previous findings); employing a suboptimal probability matching heuristic for a one-shot gamble (rather than maximizing their probability of reward); and relying less on optimal planning in a two-stage reinforcement learning task. Second, steeper discounters preferred to consume information that was less complex and multi-faceted, as suggested by their self-reported Need for Cognitive Closure, their use of short-form social media (i.e., Twitter), and their preferred news sources (in particular, whether or not they preferred National Public Radio over other news sources). Third, steeper discounters had interpersonal and religious beliefs that are associated with reduced epistemic complexity: they were more likely to believe that the behavior of others could be explained by fixed rather than dynamic factors, and they believed more strongly in God and in the afterlife. Together these findings provide evidence for a link between individual differences in temporal discounting for monetary rewards and preferences for the path of least resistance (less reflective and/or more automatic modes of processing) across a variety of domains.

Keywords: intertemporal choice, individual differences, intuition, reflection, religiosity

1 Introduction

Intertemporal choice — deciding whether to delay gratification in hopes of gaining larger future rewards — is a central topic of study in judgment and decision-making. Individuals vary in their responses to intertemporal choice, and their revealed discount rates are predictive of behavior across several other reward domains. Most notably, people who discount monetary rewards more steeply with delay, preferring smaller sums sooner to larger sums later, tend to discount delays associated with other goods, such as food (Duckworth, Tsukayama & Geier, 2010; Jarmolowicz, Cherry, Reed & Bruce, 2014), alcohol (MacKillop et al., 2010; Petry, 2001), sex (Reimers, Maylor, Stewart, & Chater, 2009), and drugs (Kirby, Petry & Bickel, 1999). These behavioral patterns have significant consequences. People who favor immediate rewards, as in the classic "marshmallow experiments", have poorer academic performance, career success, and are more likely to be incarcerated or have a drug addiction (Duckworth & Seligman, 2005; Eigsti et al., 2006; Mischel, Shoda & Rodriguez, 1989). These findings point toward a broad psychological and behavioral pattern. Might this pattern be even broader? Here we investigate the relationship between steep discounting and a more general tendency to rely less on controlled processing and/or rely more on automatic processing, that is, to take what we call the "path of least cognitive resistance".

Several lines of evidence suggest a relationship between steep discounting and a more general avoidance of reflective/effortful processing. Substance abusers collect fewer information samples than others before forming a decision about an underlying distribution (i.e., whether there are more samples of one color or another in a partially observable set); this tendency to reach premature conclusions is consistent with a construct has been called reflection/impulsivity (Clark, Robbins, Ersche & Sahakian, 2006; see Kagan, 1966). Steeper monetary discounters have also been shown to discount cognitive effort more steeply: when given the choice of performing an easy or a hard cognitive task (e.g., tasks varying in working memory load) they are more likely

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to choose the easy task (Kool, McGuire, Wang & Botvinick, 2013; Westbrook, Kester & Braver, 2013). Consistent with this, Frederick (2005) found that steeper discounters were also more likely to give automatic/intuitive but incorrect responses to the word problems that comprised his Cognitive Reflection Test (CRT), rather than engaging in the (potentially effortful) reflection process that would lead to the correct response. The CRT, as a measure of reflective cognitive style, correlates with several measures of judgment of decision-making (Stanovich & West, 1998; Toplak, West & Stanovich, 2011, 2014; West, Toplak & Stanovich, 2008).

In the present research we ask whether this connection between intertemporal choice and processing style generalizes across a wider array of cognitive and social domains than previously described. Using intertemporal choice data from thousands of subjects (responses on the Monetary Choice Questionnaire; Kirby et al., 1999), we show that preferences for more immediate gratification are associated with taking the path of least cognitive resistance across multiple manifestations: steeper discounters rely on more automatic (less reflective) strategies in a variety of choice environments assessing heuristic use and planning; they prefer less informational complexity in their daily life (as indicated by scores on the Need for Closure scale and by the complexity of their preferred news sources); and they hold interpersonal and religious beliefs that are associated with reductions in epistemic complexity (endorsing stronger psychologically essentialist beliefs that the behaviors of others are stable and predictable, and stronger beliefs in the existence of God and the afterlife).

2   Methods

2.1   Subjects

We recruited subjects to complete surveys online (N=7894, 59.2% female, M_{age}=30.2, SD_{age}=12.0) or in the laboratory (N=399, 50.9% female, M_{age}=23.7, SD_{age}=7.4). Participation took part in independent waves across which survey materials varied (total of twelve survey samples). However, subsequent tests confirmed that all results remained qualitatively similar when controlling for each individual sample, and therefore these data were aggregated for all of our analyses. Online surveys were completed by (a) volunteer subjects (N=1542), (b) students and local residents completing a prescreening survey for the Harvard University study pool (N=1876), (c) workers on Amazon's Mechanical Turk (N=4106), or (d) subjects completing a paid follow-up survey for a neuroscientific study assessing a wide array of individual differences (N=370). To provide independent validation for perceptions of different news media outlets (see News Rankings), we surveyed an independent sample of workers on Amazon's Mechanical Turk (N=257, 46.7% female).

2.2   Measures

Monetary Choice Questionnaire   . Discount rates were determined from responses to a series of delay/monetary trade-off choices (e.g., "Would you rather have $34 today or $50 in 30 days?"). All choices included a smaller option today, but the two monetary amounts and the future delay were varied. Assuming a hyperbolic discount function, these data allow one to estimate the rate at which subjects discount future rewards. See Kirby et al. (1999) for details on the measure and how discount rates were estimated from choices (essentially by identifying the discount rate that best predicted the distribution of choices for/against a delayed reward).

Discount rates were then log10-transformed to correct for skewness of the distribution (Kirby et al., 1999). Except in one case (see Appendix 1), intertemporal choices were hypothetical. Discount rates estimated based on hypothetical intertemporal choices have been shown to correspond closely to those based on equivalent incentivized choices (Johnson & Bickel, 2002; Madden, Begotka, Raiff & Kastern, 2003; Madden et al., 2004), and the predictive validity of such hypothetical-based discount rates has been multiply confirmed (e.g., Alessi & Petry, 2003; Duckworth & Seligman, 2005; Hariri et al., 2006). Further, for some survey samples the original 27-question version of the questionnaire was given, which includes nine choices each for small, medium and large reward amounts (i.e., each set of nine choices samples indifference points for the same set of discount rates, but is shifted to points higher or lower along each curve). For the remaining samples, we included only the set of nine choices at the medium reward level because (a) we were not interested in "magnitude effects" on discounting (see Frederick, Loewenstein & O'Donoghue, 2002; Kirby et al., 1999) and (b) we found that discount rates could be robustly estimated from any of the three sets of nine choices alone (and among them the medium reward magnitude provided the strongest estimate). In aggregating across samples, we therefore combine estimates based only on the medium magnitude rewards (either from surveys that only included these choices or extracting these nine choices from the longer surveys). However, all of the temporal discounting results are highly similar irrespective of incentive level or number of questions used to estimate one's discount rate.

Discount rates were not estimated for subjects who neglected to respond to two or more of the binary choices in the 9-item survey (total of 142 subjects across all surveys; when estimating the discount rate for the 27-item version, this exclusion criterion was four or more). Following Kirby et al. (1999), we also calculated a measure of choice consistency for each subject, calculated as the percentage of their nine responses that were consistent with their estimated discount rate. We exclude subjects who were less than 75% consistent in their responses (N = 64; 0.8% of total sample), but

note that all of our results hold when including all subjects, and when excluding subjects who were not 100% consistent (N = 932; 11.4% of total sample). Moreover, consistency was not significantly correlated with discount rate across our sample (r(8149) = –0.006, p = 0.60). Finally, given that smaller sooner rewards on the MCQ do not vary in their delay (i.e., all would be received 'today'), we also note that these discount rates do not distinguish between preferences for *immediate* rewards (immediacy bias) and preferences for *sooner* rewards.

Cognitive Reflection Test (CRT). The CRT comprises 3 word problems that reliably elicit automatic/intuitive responses that must subsequently be rejected in order to arrive at the correct response (e.g., "A bat and a ball together cost $1.10. The bat costs $1.00 more than the ball. How much does the ball cost?") (Frederick, 2005). We scored the CRT in two ways: based on the number of total correct responses (e.g., 5 cents in the example above) and based on the total responses that were incorrect but intuitive/automatic (e.g., 10 cents[1]). While these measures differ slightly in their sensitivity to different aspects of CRT responding (i.e., overcoming an automatic lure and/or reasoning to a correct response; Baron, Scott, Fincher & Metz, 2015; Pennycook, Cheyne, Koehler & Fugelsang, 2015), they are highly (negatively) correlated. Subjects were excluded from CRT analyses if they failed to respond to any of the questions.

We and others have recently shown that CRT scores correlate with belief in God (Gervais & Norenzayan, 2012; Pennycook, Cheyne, Seli, Koehler & Fugelsang, 2012; Pennycook, Ross, Koehler & Fugelsang, 2016; Shenhav, Rand & Greene, 2012). The CRT data reported in this paper highly overlaps the data reported in Shenhav et al. (2012) but all of the analyses reported in this paper are new.

Cognitive Ability (Intelligence) Measures. Subjects in one of our samples (N = 321) completed the Shipley Vocabulary Test (Shipley, 1986) and the Wechsler Adult Intelligence Scale Matrix Reasoning test (Wechsler, 1997), standard measures of crystallized and fluid intelligence, respectively (for additional details, see Shenhav et al., 2012).

Probability Matching Task. We used a measure of probability matching behavior as an additional test of heuristic reasoning. The test, designed by Koehler & James (2010; see Vulkan, 2000) involves showing subjects ten cups each of two different colors (in this case blue and orange). They are told that five-dollar bills are hidden under 10 of the 20

cups, seven under blue cups and three under orange cups. Previous studies have shown that some subjects behave suboptimally on this task by choosing 7–8 blue cups and 2–3 red cups, referred to as *probability matching*, whereas others will behave more optimally by instead choosing 9-10 of the blue cups, referred to as *probability maximizing*. Matching versus maximizing behavior on this task is believed to be driven by greater or lesser reliance on heuristic reasoning, an assertion supported by the finding that more intuitive responders on the CRT were more likely to match than maximize (Koehler & James, 2010).

Two-Step Task. Adapted from Daw and colleagues (2011), the two-step task assesses reliance on forms of reasoning that are referred to as model-based and model-free. The task involves navigating an environment consisting of two stages and three possible states (an initial state and two possible states in the second stage), and trying to maximize rewards (game points). For ease of exposition, we will refer to these states as Rooms 1, 2A, 2B, but in the actual task these were represented in more abstract and symbolic terms. Each trial begins in Room 1. In Room 1 subjects can choose actions A or B which will lead them probabilistically to Room 2A or 2B – that is, choosing A landed the subject in Room 2A most of the time (and otherwise in room 2B), and the reverse was true for Room 2B. These room-to-room transition probabilities were fixed over the course of the session such that choosing A led to Room 2A 72% of the time and Room 2B 28% of the time (and vice versa when choosing B). Subjects were instructed that these transitions were not deterministic and that the transition probabilities had to be learned through experience (this included learning which rooms were more associated with choices A and B since these rooms weren't labeled in any way that connected them to their Room 1 choices).

Once in either of the second rooms (2A or 2B), the subject makes a second choice (2Ax or 2Ay in Room 2A, 2Bx or 2By in Room 2B), and wins or loses points based on that choice. The rewards associated with these four choices (2Ax, 2Ay, 2Bx, 2By) must also be learned, and they also change over the course of the experiment such that sometimes choosing 2Ax might be the most rewarding and other times choosing 2By might be. Achieving the best reward on a given trial therefore requires not only selecting the appropriate choice in the second room (x or y) but also planning ahead and making the choice in Room 1 that maximizes one's likelihood of ending up in the second room with the most rewarding option (either 2A or 2B).

For example, a subject selects Choice A in Room 1, arrives in Room 2A (the *common* room-to-room transition), then selects choice 2Ax, and receives a large reward. On the next trial, she may choose to repeat the choice of A in Room 1 and the choice of 2Ax in Room 2A in order to again reach that reward. Now consider a second example: the subject

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[1] Because a subset of subjects responded to the specific problem above with the response 0.10 or 0.05 (suggesting that they missed the instruction to give the answer in cents), we assumed in these cases that they intended to respond 10 or 5 and counted those responses accordingly. However, all of our findings are qualitatively unchanged if we instead treat these responses as though they were intended in cents rather than dollars.

selects Choice A in Room 1, arrives in Room 2B (the *rare* transition), then selects 2By, and receives a large reward. If the subject considers only the rewards associated with their recent actions, referred to as *model-free* learning, she will once again choose to repeat her previous Room 1 choice (A) in hopes of arriving at the same large reward. However, if the subject considers the previous actions, rewards, and the likelihood of transitioning between rooms (i.e., the underlying world model), referred to as *model-based* learning, then she will switch her previous Room 1 choice and instead choose B in order to maximize her likelihood of returning to the room with the high reward (in this example, Room 2B). An individual's overall tendency towards model-free versus model-based learning/reasoning can therefore be ascertained by the degree to which their Room 1 choices are guided only by the Room 2 reward on the previous trial (i.e., win-stay, lose-switch) versus a combination of previous reward and previous transition probability (i.e., common-win-stay, common-lose-switch, rare-win-switch, rare-lose-stay).

The two-step task findings we describe are based on a reanalysis of unpublished data collected and provided to us by Fiery Cushman. Subjects in this study performed a web-based version of the two-step task. The task consisted of 25 practice trials followed by 125 main trials[2]. Their goal was to maximize points won over the course of the experiment. To assess the degree to which behavior on this task was characterized by model-based planning, we used a regression approach previously used to relate this task to individual differences in performance on cognitive control tasks and in devaluation sensitivity (Gillan, Otto, Phelps & Daw, 2015; Otto, Skatova, Madlon-Kay & Daw, 2015). Specifically, we performed a mixed-effects logistic regression analysis over Room 1 choices to predict whether subjects would stay with or switch from their previous Room 1 choice given (i) the reward received in Room 2 of the previous trial, (ii) whether the specific Room 2 from the previous trial resulted from a common or rare transition from Room 1, and (iii) the interaction of A and B. For reasons described above, and as has been done in previous studies of this task, we used this final interaction term as an index of model-based planning on this task: a strong interaction between the reward and transition type (common/rare) on the previous trial suggests that the subject applied greater model-based reasoning whereas a weak interaction suggests that the subject applied less model-based reasoning. Note that these model-based influences on behavior are separate from (and may serve to attenuate) the influence of a basic win-stay/lose-switch strategy (which is indexed by the main effect of reward [term (i) above]). This mixed-effects regression included random intercepts and slopes for each subject.

We report findings from two closely related analyses that examine whether terms in the regression above correlate with individual differences measures (e.g., discount rate). In keeping with previous approaches to analyzing individual differences in behavior on this task (e.g., Gillan et al., 2015; Otto et al., 2015), our primary analysis utilized a mixed-effects regression that included the relevant individual differences measure (e.g., discount rate) as a fixed effect in the regression above, interacting with the two main effects and their interaction. These interactions between discount rate and the task variables effectively test for the relationship between the individual difference measure of interest and the influence of that variable (or interaction between variables) on choice. This regression approach enabled us to test for the relationship between discount rate and one task variable (e.g., the model-based planning index), while simultaneously accounting for the relationship between discount rate and the remaining task variables. However, in order to visualize the relationship between discount rate and model-based planning, we separately display and report the bivariate relationship between these two variables based on the random effect estimates in the reduced regression described above (i.e., including task variables but not discount rate).

To ensure sufficient within-subject variance for reliable analysis, we exclude subjects who made the same Room 1 stay/switch decision (i.e., consistently chose to stay or consistently chose to switch) on more than 95% of trials (our results are, however, robust to including these subjects).

News Ranking. To investigate preferences for sources of more vs. less complex information, subjects in some surveys were asked to rank their top 3 networks from the following list, according to how much they rely on each for their news: ABC, CNN, FOX News, NPR, CBS, NBC, MSNBC. We analyzed the frequency with which each was given the top ranking across subjects.

To provide independent validation for the perceived complexity of each network, we surveyed a separate group of subjects through AMT (N=257, 46.7% female, M_{age} = 34.1, SD_{age} = 12.2) to assess how much they associate each network with the following terms: 'intuitive,' 'easy to consume,' 'informative,' 'complex/multifaceted,' ('entertaining' was included as a foil and excluded from our analysis). For each subject and news network, these four ratings were combined together into a composite *complexity index*, after reverse-coding the first two items. We tested whether the average complexity of a given network (as rated by these 257 subjects) was related to the discount rates of those (in the main sample) who indicated this as their top-ranked news source.

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[2]Due to occasional bottleneck issues with the web server, some trials were not recorded. Additional trials were missing due to a few incomplete sessions. We excluded four subjects with fewer than 100 main task trials (out of 125). The remaining subjects had an average of 122 trials available for analysis (SD = 3.8).

Psychological Essentialism. The Psychological Essentialism Scale (derived from Bastian & Haslam, 2006) measures the degree to which subjects perceive individuals as (i) reducible to basic traits versus (ii) complex and nuanced in their thoughts and behavior. In particular, we consider two 8-item subscales developed by these authors: 'informativeness' (e.g., "Generally speaking, once you know someone in one or two contexts it is possible to predict how they will behave in most other contexts") and 'discreteness' (e.g., "The kind of person someone is, is clearly defined; they either are a certain kind of person or they are not").[3] Overall scores were normalized within each of three different experimental samples before the samples were aggregated, with higher scores indicating greater endorsement of psychological essentialism. The results reported are robust to controlling for differences between samples.

Religious Belief. Following our previous work (Shenhav et al., 2012), we primarily used two items to assess religious belief: (A) a continuous scale indicating belief in God on a 9-point scale from 'confident atheist' to 'confident believer' (B) a binary response indicating whether the individual has "had an experience that convinced [him/her] that God exists." In addition to these, we included 9-point items to indicate family religiosity during childhood; whether the subject had become a much more confident atheist/believer since childhood; and to indicate strong disagreement to strong agreement with the following statements: "I spend a considerable amount of time on religious practices" and "I believe that when someone dies a part of them continues on to some form of afterlife." Of these, the measure of afterlife beliefs was treated as a primary dependent variable, alongside the continuous and binary measures of belief above; the other three items were analyzed individually for secondary analyses (e.g., to test whether discount rate is more closely tied to belief than practice).

To better compare our findings with previous findings that stand in tension with our hypotheses (Carter, Mccullough, Kim-Spoon, Corrales & Blake, 2012; DeWall et al., 2014) (see Appendix 2), subjects in one of our samples (N = 1022) also responded to the Religious Commitment Inventory (Worthington et al., 2003), the primary measure of religious belief/practice from those studies (example item: "I often read books and magazines about my faith").

Demographic Variables. We performed secondary analyses that included a range of demographic variables as co-

variates. In addition to gender and age (log-transformed to correct for positive skew), these covariates included education variables (both one's own education level and the highest education level reached by each parent), socioeconomic status (current income level and family income level during childhood), and political affiliation/conservatism (US party affiliation and scalar measures of self-reported social and fiscal conservatism). Subjects indicated the highest education level obtained (at present) by themselves and by their biological parents using the following options: less than a high school degree, high school diploma, vocational training, attended (or currently attending) college, bachelor's degree, graduate degree, unknown. We assessed immediate family income level during childhood with a Likert-type rating along a subjective scale ranging from 'low' to 'average' to 'high.' The subject's own income in the previous year was reported on an 8-point scale ranging from '$15,000 or less' to 'over $100,000.' Subjects separately rated their social and fiscal conservatism on 9-point scales ranging from 'Very liberal' to 'Very conservative.' For one sample (the prescreen survey, N=1876), we used an item asking "How would you describe your family's social class position?" (with responses 'Poor,' 'Working class,' 'Middle Class,' 'Upper middle class,' and 'Upper class') as the measure of socioeconomic status. Education level, current income, and family social class were treated as (discrete) ordinal variables, gender and party affiliation as nominal variables, and the remaining demographic measures were treated as continuous variables.

Note that samples varied in which of these variables were collected, and thus not all analyses included the same set of covariates.

3 Results

Subjects (N=8293, 58.8% female) completed the Monetary Choice Questionnaire (MCQ; Kirby et al., 1999), a standard measure of temporal discounting consisting of a series of binary forced-choice questions between a given amount of money today or a larger amount received some days in the future. From the responses to these binary choices we can estimate each subject's overall preference for sooner over delayed rewards, summarized as a single value: her discount rate. (See Methods.) Higher discount rates reflect a *steeper* discount function and thus greater overall preference for smaller sooner rewards over larger delayed rewards; conversely, lower discount rates reflect a *shallower* discount function and therefore greater weight on larger delayed rewards (see Figure 1A, right; note also that our analyses will always refer to discount rates that have been log-transformed in order to correct for skew, as is standard). The average discount rate (raw: $M_{geom} = 0.0076$, SD = 0.05; log: M_{arithm} = −2.1; SD = 0.8) and the proportion of an individual's choices consistent with their discount rate (M = 0.98; SD

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[3]Of the 883 subjects who completed this measure, 137 also completed a third 'biological basis' subscale (e.g., "The kind of person someone is can be largely attributed to their genetic inheritance"); we omit this subscale from our analyses, and did not have the other subjects complete it, because it is only weakly correlated with the other two subscales and had the potential to introduce biases related to scientific authority and evolutionary theory. We also note that one sample (N=348) completed a shortened scale consisting of 5 representative items across the two subscales.
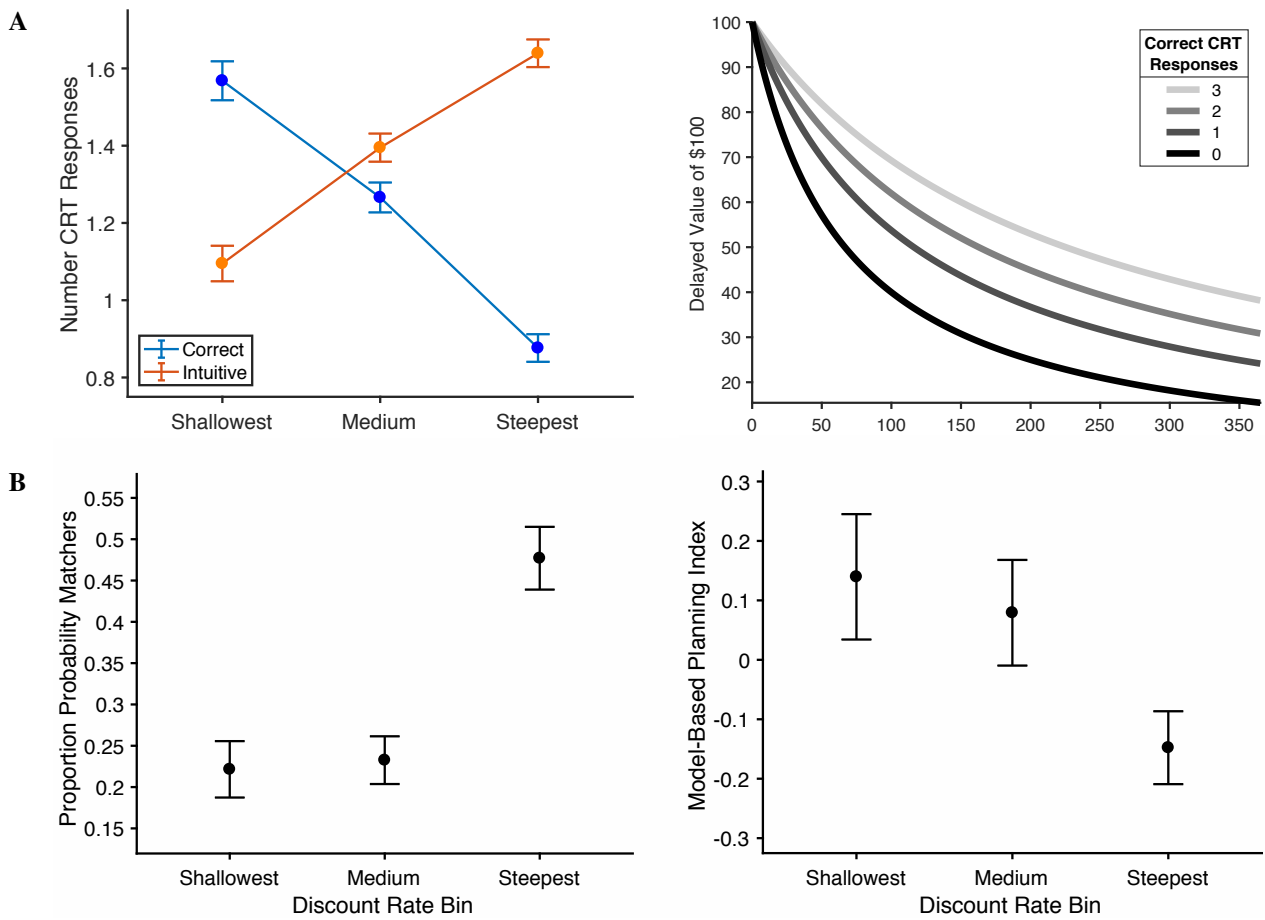
FIGURE 1: Temporal discounting and choice behavior. **A) Left:** Steeper discounters give fewer correct and more intuitive responses on the CRT. Average numbers of correct/intuitive responses are shown for individuals with discount rates in the lowest, mid, and highest tertiles of our sample. Higher versus lower discount rates reflect steeper versus shallower discounting functions. (Note that a continuous measure of discount rate is used for all statistics in the main text, but these values were binned for ease of display in figures.) **Right:** For illustrative purposes we show projected discounted value of $100 over the course of a year for subjects who gave 0–3 correct CRT responses. **B)** Steeper discounters are more likely to apply a probability matching rather than a probability maximizing strategy in a one-shot probabilistic gamble. **C)** Steeper discounters are less likely to use a model-based strategy in the two-step task. Higher model-based index values reflect a stronger interaction between previous reward and previous transition probability when making a stay/switch decision on Stage 1 of the current trial. (Note that values on the y-axis represent random effect estimates from a mixed-effects regression. Zero therefore represents the fixed-effect slope across the group – which is significantly greater than zero – rather than representing no effect of this interaction.) Error bars represent s.e.m.

= 0.05) were similar to those previously reported using the MCQ[4] (Kirby et al., 1999).

Steeper temporal discounting, as estimated from these intertemporal choices, has been associated with greater impulsivity related not only to monetary rewards (reflected, e.g., in gambling behavior; Alessi & Petry, 2003), but also to food, nicotine, and other drugs (reflected, e.g., in body mass index (BMI) and smoking; Baker, Johnson, & Bickel, 2003; Duckworth et al., 2010; Jarmolowicz et al., 2014; Kirby et

al., 1999; Reimers et al., 2009). Similarly, we found that steeper monetary discounting was associated with significantly higher BMI ($r(5092) = 0.08$, $p<0.0001$) and greater likelihood of being a current smoker ($r_{point-biserial[pb]}(1836) = 0.17$, $p<0.0001$).[5] These results help to validate our estimated discount rates by showing that they are correlated with impulsivity for other extrinsic rewards beside money, in a manner consistent with previous research.

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[4]Kirby and colleagues found that healthy controls in their study were 99% consistent in their responses to the 9-item subsets of the MCQ.

[5]Both of these effects hold when including age and gender as covariates (BMI: $r_{partial}(5022) = 0.06$, $p<0.0001$, smoking: $r_{pb\_partial}(1763) = 0.16$, $p<0.0001$).

TABLE 1: Summary of correlations between intertemporal choice and key variables of interest. Each row reflects the zero-order correlation between discount rate and a given variable. The correlation with the model-based index is based on individual random effect estimates from the mixed-effects regression reported in the main text. † denotes point-biserial correlation between discount rate and binary variable. All other correlations are Pearson's r values. See also Table A1 for correlations of these variables with each item from the discounting measure separately.

Variable	N	Corr (r)	p-value
BMI	5094	0.078	<.0001
Smoker	1838	0.175†	<.0001
Intuitive CRT responses	2286	0.200	<.0001
Correct CRT responses	2286	−0.252	<.0001
Probability matcher	538	0.233†	<.0001
Model-based planning	265	−0.183	0.003
Need for closure	1833	0.073	0.0019
Twitter use	1005	0.077	0.015
Reddit use	1005	−0.018	0.568
Complexity of preferred news	1282	−0.139	<.0001
Essentialism	881	0.106	0.0016
Genetics of race & behavior	1788	0.088	0.0002
Belief in God	7577	0.104	<.0001
Convinced of God	6454	0.097†	<.0001
Belief in afterlife	6454	0.083	<.0001

Having provided this validation, we now use these revealed discount rates to test the hypothesis that temporal discounting is related to a tendency toward less reflective (or more automatic) processing across four domains: problem-solving strategies, decisions about information consumption, beliefs about others, and beliefs about the divine. As described above, the data presented here are the aggregation of a series of different datasets, such that each subject completed only a subset of the measures related to one or more of these domains. Therefore, analyses presented below include all subjects who completed the measure under consideration (see Table 1 for summary statistics for each result). Furthermore, the covariates that were collected varied across datasets, and so correspondingly our secondary analyses vary in which covariates they include.

3.1 Discounting and problem-solving

We first tested whether steeper discounters were more likely to use simplifying strategies when problem-solving. We tested this using three indices of such behavior: intuitive (versus reflective) responding to mathematical word problems (CRT), probability matching (versus maximizing) on a one-shot probabilistic gamble, and model-free (versus model-based) decision-making in a repeated multi-stage choice task. First, replicating previous findings using different measures of temporal discounting, we found that steeper temporal discounters were significantly more likely to give intuitively compelling but incorrect responses, and less likely to give correct responses, on the CRT (Figure 1A; $r_{correct}(2284) =$ −0.25, $r_{intuitive}(2284) = 0.20$, $p<0.0001$). We also extended this prior work by showing that the relationship between discounting and CRT is still present (N=321; $r_{correct}(319)$ = −0.16, $r_{intuitive}(319) = 0.15$, $ps<0.01$) within a subset of our sample in which measures of cognitive ability were collected and found to be uncorrelated with discount rate (fluid IQ: $r(318) = $ −0.026, $p = 0.64$; crystallized IQ: $r(313) =$ −0.066, $p = 0.24$). These results suggest that general cognitive ability cannot account for the correlation we observed between discount rate and CRT.

Second, we tested whether discount rate correlated with use of a probability matching heuristic (Koehler & James, 2010; Vulkan, 2000). As noted earlier, when individuals allocate resources between two options that have different (and complementary) probabilities of winning (e.g., 70% versus 30%) they will occasionally rely on a heuristic of splitting their resources in a way that approximates these probabilities (e.g., 70% to the first option, 30% to the second; i.e., *matching*) rather than placing all of their resources with the higher probability option (i.e., *maximizing*). We had subjects perform a single one-shot decision task that differentiated these two types of behavior (see Methods) and found that steeper discounters were more likely to engage in probability matching (Figure 1B; $r_{pb}(536) = 0.23$, $p<0.0001$). Performance on this task was previously shown to correlate with performance on the CRT (Koehler & James, 2010). We replicate this finding (CRT accuracy: $r_{pb}(532) = −0.32$, CRT intuitive: $r_{pb}(532) = 0.32$, $p<0.0001$). Both discount rate and CRT were significantly correlated with probability matching in combined models containing discount rate and either CRT measure (CRT accuracy: $r_{pb\_partial\_CRT} = −0.29$, $r_{pb\_partial\_MCQ} = 0.13$; CRT intuitive: $r_{pb\_partial\_CRT} = 0.28$, $r_{pb\_partial\_MCQ} = 0.148$, $ps<0.0001$).

Third, we tested whether discount rate was correlated with decision-making approaches in a more complex choice environment. Using a modified version of the well-validated "two-step" task (see Methods), we assessed preferences for deliberating based on a rich internal model of one's environment (*model-based* decision-making) versus choosing one's actions based only on recent reward history (*model-free* decision-making). Using our index of model-based decision-making, we found that steeper discounters were significantly less model-based in their decisions (N = 265, coeff = 0.20, SE = 0.07, z = 3.08, $p=0.002$; Figure 1C). While this correlation is consistent with our predictions, we note that steeper

discounters were also less sensitive to payoff levels (coeff = –0.10, SE = 0.04, $z = –2.39$, p=0.02), which we did not predict and may suggest that these subjects were to some degree less attentive. Discount rate did not, however, correlate with overall rates of staying with versus switching from a previous choice (coeff = –0.06, SE = 0.07, $z = –0.77$, p=0.44) or with the sensitivity of choices to the transition probability of the previous trial (i.e., whether or not it was an uncommon transition; coeff = 0.04, SE = 0.04, $z = 1.03$, p=0.30).

3.2 Discounting and information consumption

These results so far suggest that steep reward discounters tend to rely on simplifying or more cognitively impulsive strategies in different problem-solving and decision-making domains. To assess whether these tendencies translated into preferences for simplicity in their consumption of information, we tested for a correlation between discount rate and a 15-item version of the Need for (Cognitive) Closure scale (Roets & Hiel, 2011; example item: "I dislike it when a person's statement could mean many different things"; NFC; Webster & Kruglanski, 1994). This self-report measure of cognitive disposition has been used to explain variation in ideological extremism, particularly for political or otherwise group-centered ideology. Consistent with our prediction, we found a significant positive correlation between discount rate and NFC score (Figure 2A; $r(1831) = 0.073$, $p < 0.002$): steeper discounters report a greater preference for information/solutions to be provided to them in simpler, more immediate, and more predictable form rather than in a more complex or ambiguous form.

Given the relationship between discount rate and NFC, we might also expect individual differences in temporal discounting to predict how people prefer to acquire new information. Specifically, we predicted that steeper discounters prefer information that is presented in a less complex fashion and is thus faster/easier to consume (and perhaps provides sooner epistemic gratification). We tested this in two ways. First, we examined whether discounting was correlated with use of the social media platform Twitter, given its emphasis on short-form messaging. Subjects indicated how often they use Twitter on a six-point scale ranging from "never" to "at least once an hour." For comparison, we asked how often those same subjects visited the longer-form blog site, Reddit. We found that steep discounters did in fact spend more time using Twitter ($r(1003) = 0.08$, $p < 0.02$) but not Reddit ($r(1003) = –0.02$, $p = 0.57$), and the difference between these correlations was significant ($z = 2.13$, p=0.03; Figure 2B).[6]

Second, we asked subjects to rank their preferred media for obtaining news, including major broadcast and cable television networks and public radio (all U.S.-based news sources). We found an association between discount rate and subjects' choice of top-ranked news source (Figure 2C; (6, 1282) = 29.8, p<0.0001), with the shallowest discounters being most likely to prefer National Public Radio.[7]

To provide evidence that the pattern we observed for news preferences corresponded to the complexity of information offered by these different news sources, we surveyed an independent group of subjects (N=257, 46.7% female, M_{age} = 34.1, SD_{age} = 12.2) regarding their associations for each network. Specifically, we generated a composite *complexity index* based on how much each network was positively associated with being 'informative' and 'complex/multifaceted' and negatively associated with being 'intuitive' and 'easy to consume.' We then tested for variation in this index as a function of news outlet, while including as covariates demographic and political variables, average time investment in TV/internet/radio/podcasts, familiarity with and reliance on each network, and how much subjects felt that the individuals on that network shared their views. We found that the news networks significantly varied in complexity ($F(6,1310)$ = 25.3, p<0.0001; Figure 2C), with a pattern similar to that observed for discount rate. In particular, NPR was associated with significantly greater complexity than any other network, and MSNBC/CNN were further associated with greater complexity than the remaining networks (Tukey's HSD ps < 0.03).[8] Furthermore, we found that the discount rates of subjects in the previous sample significantly (negatively) correlated with the average network complexity of those subjects' top-ranked news source (ordinal logistic regression, χ^2 (6, 1297) = 18.1, p<0.0001; $r_{spearman}(1280)$ = –0.12, p<0.0001); as predicted, steeper discounters preferred news sources that were less complex and easier to consume. While these findings support the hypothesis that informational complexity played a role in steeper discounters preferring certain news sources to others, they are qualified by the fact that our measure of complexity was based on subjective ratings (from an independent set of raters) rather than more objective analyses of news content.

= –0.06, $p = 0.054$). The correlation between discounting and Twitter use also remained significant in a model that included age, gender, education and weekly internet use as covariates ($r_{partial}(995) = 0.10$, $p < 0.005$).

[7]A secondary analysis showed that this association between discount rate and network preference was also significant in a model that included covariates for age, gender, and measures of education, socioeconomics, political affiliation/conservatism, religious belief, and average time spent watching TV and browsing the internet (χ^2 (6, 977) = 15.9, p<0.02).

[8]In addition to accounting for variance associated with political and other variables, which has it limitations (Westfall & Yarkoni, 2016), we separately tested whether these top rankings varied by political party affiliation. We found that the average complexity ratings of subjects affiliated with the Democratic and Republican parties yielded identical rankings of the top three networks (NPR, MSNBC, CNN), suggesting that these particular network rankings were not politically motivated.

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[6]This finding could not be accounted for by average time spent using the internet – which was positively correlated with discount rate ($r(2668)$ = 0.07, $p < 0.001$) – as overall internet use was negatively associated with an individual's relative use of Twitter versus Reddit (i.e., people who spent more time on the internet used Reddit more frequently than Twitter; $r(1003)$
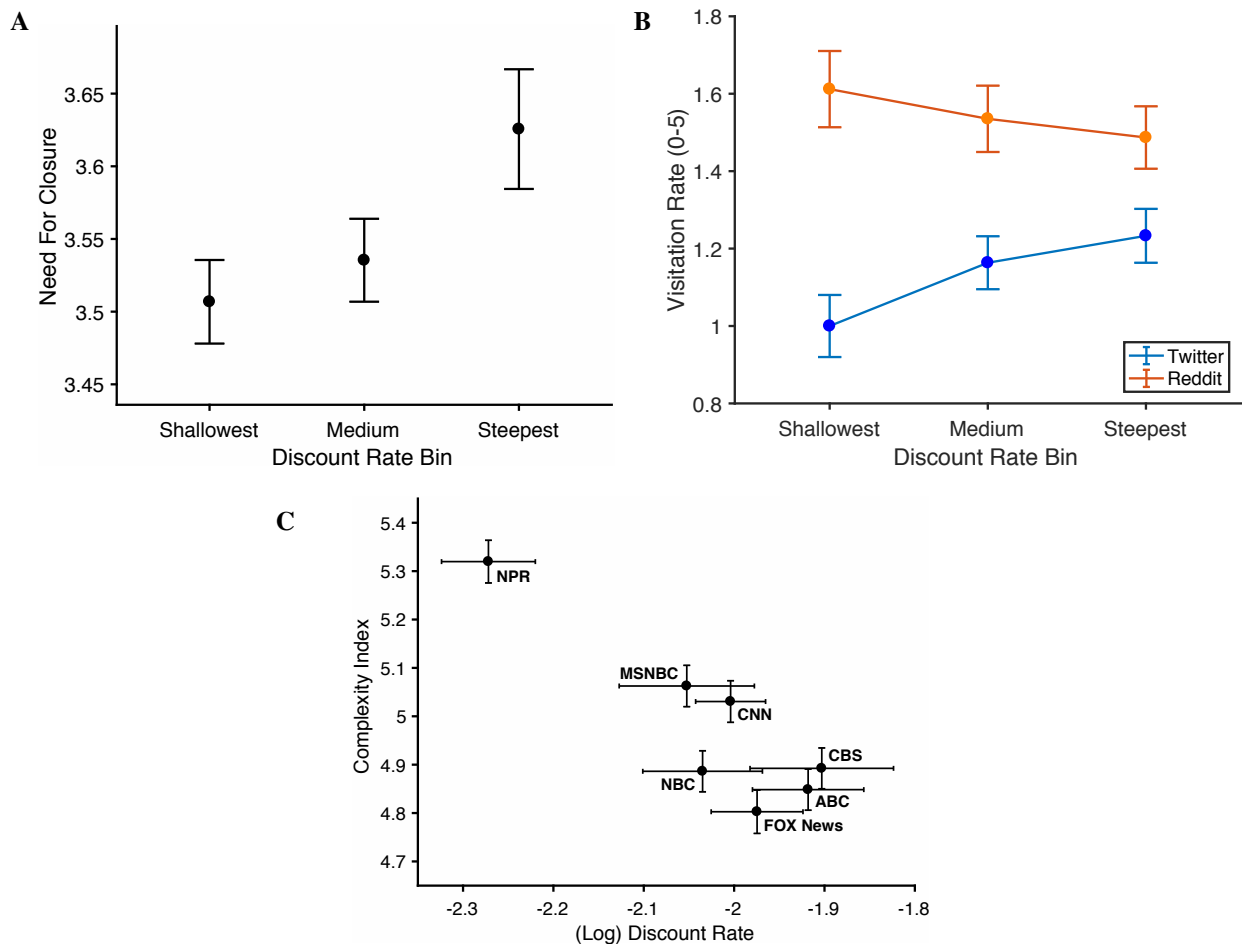
FIGURE 2: Temporal discounting and preference for reduced epistemic complexity. **A)** Steeper discounters score higher on the Need for Closure scale. **B)** Steeper discounting is also positively correlated with frequency of checking Twitter (blue) but not Reddit (orange; which only reveals a non-significant negative trend in the opposite direction). **C)** Discount rate (x-axis) accounts for significant variance in individuals' choices of news media outlet, with the shallowest discounters reporting the greatest preference for NPR as their primary source of news. Similar patterns are found when assessing how complex/informative (versus intuitive/easy to consume) a given network is (y-axis), with NPR again standing out as significantly different than the remaining networks. Values on the y-axis represent average ratings on a composite complexity index, after controlling for potential confounds (e.g., related to familiarity and political leaning); these complexity ratings were given by a different sample of subjects from the discount rates. Error bars represent s.e.m.

3.3 Discounting and simplifying beliefs

We next asked whether steep discounting correlates with adherence to beliefs that reduce epistemic complexity regarding our surroundings, including the individuals that inhabit it. A classic example of this from research on person perception is the belief that a person's character is stable and allows for generalization of their behavior across varying contexts (Gelman, 2003). Such "psychologically essentialist" beliefs can help to reinforce our automatic tendency to perceive others through the lens of broad categories/stereotypes rather than engaging in the effort of correcting for the individual's own history and current situation (Fiske & Taylor, 1991; Gilbert & Hixon, 1991; Gilbert, Pelham & Krull, 1988). We therefore tested whether discount rate was correlated with the degree to which people endorse a psychologically essentialist perspective. We found that subjects' scores on a scale of psychological essentialism (Bastian & Haslam, 2006) were significantly positively correlated with their discount rate (Figure 3A; $r(879) = 0.11$, $p < 0.002$). In a separate sample we examined responses to the question "Are behavioral differences between racial groups due more to genetic factors or environmental factors?" (where responses were given on a 7-point scale ranging from "completely due to genetic factors" to "equally due to genetic factors and environmental factors" to "completely due to environmental factors"; our
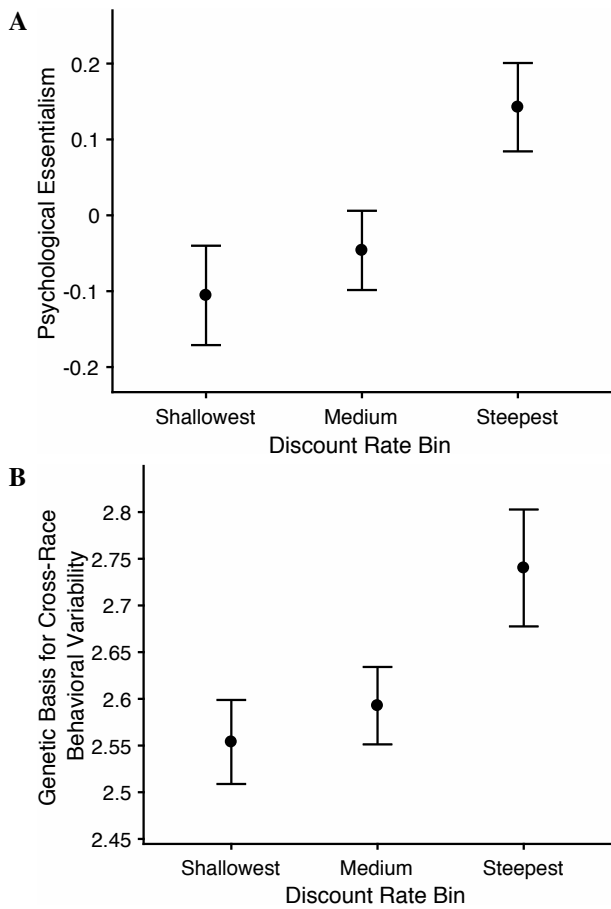
A

B

FIGURE 3: Temporal discounting and beliefs about others. Steeper discounters **A**) score higher on a (z-scored) measure of belief in psychological essentialism and **B**) attribute behavioral differences between races to a combination of causes favoring genetic factors more and environmental factors less.

analyses reverse-score this item so that higher values favor genetic influences). Consistent with the essentialism result, we found that steeper discounters were also more likely to attribute cross-race behavioral differences to genetic rather than environmental factors (Figure 3B; $r(1786) = 0.09$, $p < 0.0002$). Essentialism and the measure of racial differences were positively correlated with both social and fiscal conservatism ($rs > 0.10$, $ps < 0.002$).[9]

Given that steeper discounters hold stronger beliefs in essentialism, we sought to test whether the predicted relationship would hold for a different set of beliefs related to belief in the divine. Previous work suggests that these too have the ability to provide simple explanations for complex phenom-

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[9]While discounting continues to be significantly associated with both of these when conservatism measures are included as covariates (essentialism: $r_{partial}(859) = 0.09$, $p < 0.007$; gene-environment: $r_{partial}(1738) = 0.09$, $p < 0.0005$), this does not rule out a role for conservatism in explaining these associations. (See also discussion of the distinction between discount rate's association with fiscal versus social conservatism, below.)
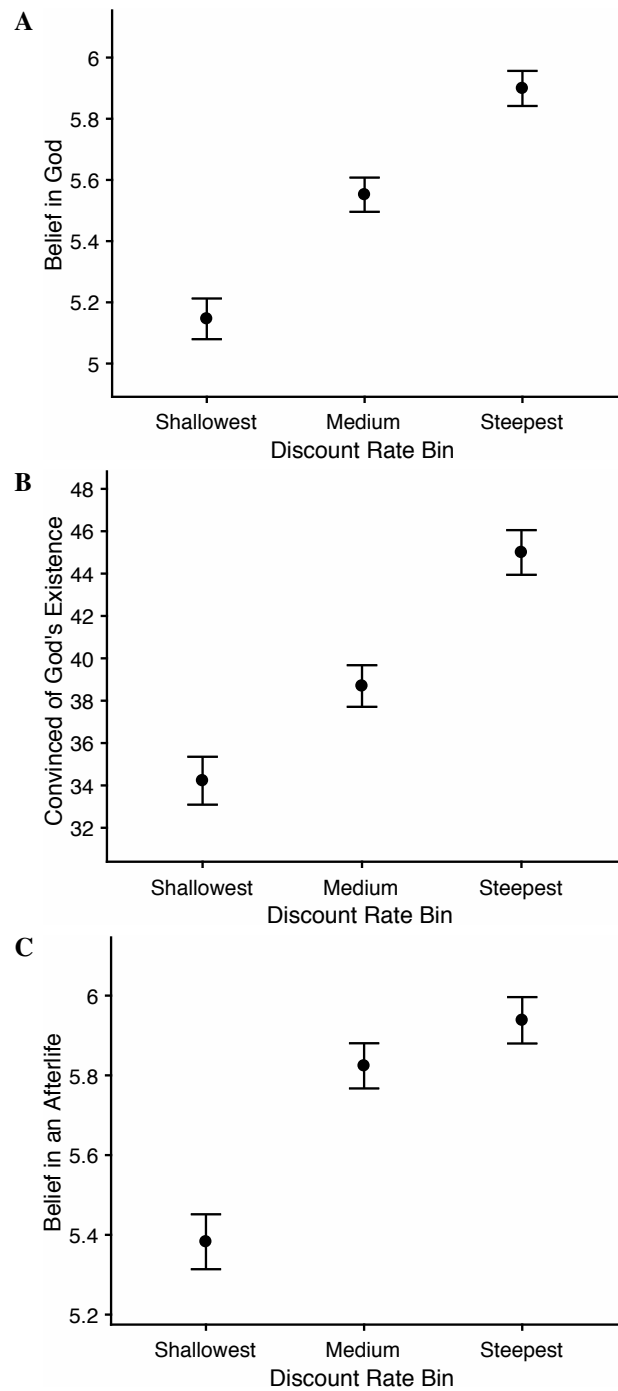
A

B

C

FIGURE 4: Temporal discounting and beliefs about the divine. Steeper discounters **A**) have stronger beliefs in God, **B**) are more likely to be convinced of God's existence through their own experience, and **C**) believe more strongly in an afterlife.

ena, and that these beliefs are closely tied to early developing beliefs and cognitive approaches that offer automatic but often incorrect insights into one's environment (e.g., anthropomorphism, dualism, and promiscuous teleology: Bloom,

2007; Kelemen, 2004; Lupfer, Tolliver & Jackson, 1996; Preston & Epley, 2005; Shenhav et al., 2012). Accordingly, we find a positive relationship between discount rate and both a Likert-scale measure of belief in God ($r(7575) = 0.10$, $p < 0.0001$) and a binary forced-choice measure of having convincing evidence of God's existence ($r_{pb}(6452) = 0.10$, $p < 0.0001$) (Figure 4A-B). Thus a greater preference for sooner reward (steeper discounting) was associated with more confident belief, while the opposite (shallower discounting) was true of more confident non-believers (atheists)[10], an association that held similarly when only testing a subsample of subjects whose discounting choices were incentivized rather than hypothetical (Appendix 1). (A subsequent analysis, also reported in Appendix 1, sought to reconcile these correlations with findings suggesting the opposite relationship between discounting and religiosity (Carter et al., 2012; De-Wall et al., 2014); using the same materials as this prior work and a larger sample, we replicated our finding of a positive relationship between belief and discount rate, failing to observe the negative relationship these studies describe.)

A natural question is whether these findings regarding divine beliefs, or those described above regarding media preferences and essentialism, are actually driven by political beliefs. Perhaps surprisingly, we found no significant relationship between discount rate and subjects' preference between the two major American parties (Democratic vs. Republican; $r_{pb}(2558) = 0.003$, $p = 0.90$).[11] This appears to be related to the fact that, while discount rate is significantly correlated with social conservatism ($r(6489) = 0.08$, $p < 0.0001$; consistent with the relationship observed between discount rate and religious belief above), discount rate is *not* related to fiscal conservatism ($r(6469) = -0.005$, $p = 0.71$).

We further found that the correlation between discount rate and belief in God was robust ($r_{partial}(5590) = 0.08$, $p < 0.0001$) to including the level of religious *practice* as a covariate, whereas discount rate did *not* significantly correlate with level of religious practice ($r_{partial}(5590) = 0.0001$, $p = 0.99$) when including belief in God as a covariate. Discount

rate also did not significantly correlate with level of religious practice when focusing only on individuals who rated themselves above the midpoint of the religious belief scale, $r(2928) = -0.01$, $p = 0.61$. Thus, we find no evidence for the hypothesis that steeper discounters are more likely to attend church or pray (e.g., as a self-regulatory strategy, attempting to rein in their impulsive tendencies), except insofar as those practices are driven by belief in God.

Similar to previous findings with CRT (Shenhav et al., 2012), we find that discount rate is correlated with change in religious belief since childhood (assessed retrospectively; $r_{partial}(5742) = 0.074$, $p < 0.0001$), such that more shallow discounters report having become more atheist over time, but that discount rate is not significantly correlated with familial religiosity during one's upbringing ($r_{partial}(5742) = 0.010$, $p = 0.43$).

In sum, the relationship between discount rate and religiosity was particularly tied to what individuals believed rather than how they acted on it, and how these beliefs were shaped over time rather than where they started out. The correlation between steep discounting and belief, but not practice, is consistent with the overarching theory that steep discounters prefer not to modify a potentially prepotent inclination towards believing in God (i.e., are less reflective; Gervais & Norenzayan, 2012; Pennycook et al., 2012; Shenhav et al., 2012) but they refrain from making the effort that religious practice requires. Subsequent analyses also revealed previously unreported relationships between lower belief in God and both lower likelihood of probability maximizing and greater model-based planning on the two-stage task described earlier (Appendix 2).

Interestingly, we also found a significant positive relationship between discounting and belief in an afterlife (Figure 4C; $r(6452) = 0.08$, $p < 0.0001$). In other words, individuals who have a stronger preference for sooner rewards are *more* likely to believe that they will continue on to a (presumably everlasting) afterlife. While perhaps surprising from a normative perspective (i.e., people who have longer time horizons and/or spend their life anticipating later reward would not be expected to sacrifice potential gains to get reward sooner), these results are entirely consistent with a psychological framework that suggests that steeper discounting biases an individual toward sooner *epistemic* gratification, which belief in God may provide.

[10]Secondary analyses showed that the correlations between discount rate and belief in God remain significant in a model that also includes age, gender, and measures of education level, socioeconomic status, and conservatism as covariates (continuous: $\beta = 0.06$, $t(2907) = 3.3$, $p=0.001$; binary: χ^2 (N=2559) = 16.1, $p<0.0001$). Follow-up analyses also showed that discount rate is significantly correlated with belief in God when covarying both measures of CRT ($r_{partial}(1950) = 0.05$, $p < 0.05$), which have previously been found to be associated with belief in God (Gervais & Norenzayan, 2012; Pennycook et al., 2012; Shenhav et al., 2012). We similarly find that discount rate is correlated with belief in God when covarying essentialist beliefs ($r_{partial}(876) = 0.15$, $p < 0.0001$) or the gene-environment item ($r_{partial}(1765) = 0.11$, $p < 0.0001$), and that the correlations between discount rate and these other variables also remain significant in those same models (essentialism: $r_{partial}(876) = 0.08$, $p < 0.02$; gene-environment: $r_{partial}(1765) = 0.07$, $p < 0.002$).

[11]When including Independent and Other as categories, the relationship between discount rate and party affiliation is almost significant (χ^2 (3, 4317) = 7.46, $p = 0.059$), apparently driven by a tendency for individuals indicating 'Other' to be shallower discounters than the remaining categories.

4   Discussion

We have shown that preferences for sooner monetary gratification are associated with more automatic and/or less reflective cognitive tendencies across domains (Table 1). When it comes to problem-solving, steeper discounters are more likely to give false but immediately appealing answers to math problems, more likely to apply a sub-optimal probabil-

ity matching heuristic in a one-shot gamble, and less likely to rely on optimal planning in a two-stage decision task. In the epistemic domain, steep discounters report greater Need for Cognitive Closure, prefer short-form social media (Twitter over Reddit), and eschew the (potentially more complex and multifaceted) news of National Public Radio relative to other new sources. Likewise, steeper discounters are more likely to hold simplifying, essentialist beliefs about the causes of human behavior. Finally, in the domain of religion, steeper discounters are more likely to believe in God — a belief that is arguably highly simplifying (Bloom, 2007; Lupfer, Tolliver & Jackson, 1996; Preston & Epley, 2005; Shenhav et al., 2012) — and are more likely to have increased their belief in God since childhood. And yet, steep discounters are not more likely to engage in religious practice per se.

This behavioral pattern is not simply a collection of tendencies that happen to hang together. Instead, it follows naturally from a dual-process framework for understanding judgment and decision-making (Evans, 2008; Evans & Stanovich, 2013; Kahneman, 2003; Shiffrin & Schneider, 1977; Sloman, 1996, 2014). To begin, there is substantial evidence that steep discounting results from placing increased weight on automatic/intuitive processes favoring sooner rewards over more controlled/reflective processes favoring larger delayed rewards (Figner et al., 2010; McClure & Bickel, 2014; McClure, Laibson, Loewenstein & Cohen, 2004; Metcalfe & Mischel, 1999; but see also Kable & Glimcher, 2007, 2010). Likewise, CRT responses (Frederick, 2005), reliance on model-free vs. model-based valuation (Otto, Gershman, Markman & Daw, 2013; Smittenaar, FitzGerald, Romei, Wright & Dolan, 2013), probability matching vs. maximizing (Koehler & James, 2010), attributing behavior to durable traits vs. situational factors (Gilbert & Hixon, 1991; Gilbert et al., 1988), and (dis)belief in God (Gervais & Norenzayan, 2012; Pennycook et al., 2012; Shenhav et al., 2012) have all been characterized in dual-process terms. Separately, these findings indicate that, within a specific domain, there is a tension between more automatic/intuitive processes and more controlled/reflective processes (Pennycook, Fugelsang & Koehler, 2015). The present results, in concert with this literature, suggest that these cognitive tensions are related within individuals. More specifically, we find that behaviors and preferences that have been associated with a tension between automatic and controlled processes in each case are also related to the fundamental tension between smaller sooner and larger later rewards. Central to this synthesis is the idea that deploying certain kinds of problem-solving strategies, choosing certain kinds of information sources, forming certain kinds of beliefs about others, and forming certain kinds of religious beliefs may be manifestations of a more general tendency toward more immediate gratification.

Importantly, the current study cannot distinguish between two manifestations of controlled processing that have been explored in the individual differences literature. One of these focuses on an individual's propensity to overcome prepotent biases (e.g., discarding an intuitive but incorrect CRT response) whereas the other focuses on the degree to which an individual engages in reasoning or reflection in order to maximize for accuracy over speed in their response (independently of whether this is directed away from a prepotent bias; Baron et al., 2015; Kagan, 1966). Previous findings have offered reason to favor the latter (variability in reflection) in certain situations, for instance showing that belief in God is more strongly correlated with CRT accuracy than the number of intuitive responses given on this test (Pennycook, Cheyne, et al., 2015), and that utilitarian moral reasoning can be predicted by performance on CRT-like problems that lack an intuitive lure (Baron et al., 2015). In the context of the current study, these findings raise the question whether shallow discounters exhibit different patterns of behavior and preferences because of their propensity to overcome an impulse towards a more immediate (perhaps epistemic) reward *or* their propensity to engage in the kind of reflection/prospection that favors longer-term reward. Whatever the case may be, both the override of a default and reflective/prospective reasoning have been argued to reflect modes of increased control and decreased automaticity (e.g., both have been shown to be susceptible to dual-task interference) (Braver, 2012; Kurth-Nelson, Bickel & Redish, 2012; Otto et al., 2013; Otto, Taylor, & Markman, 2011). Because both mechanisms strain against more automatic modes of processing, and may thus require cognitive effort (e.g., James, 1891; Norman & Shallice, 1986; reviewed in Kool, Shenhav & Botvinick, in press; Westbrook & Braver, 2015), for convenience we have referred to their collective influences using the coarse terminology of the path of least cognitive resistance. However, future work should more carefully tease apart the relative contributions of different types of control to the current findings.

With respect to religious belief, the current work extends prior findings (Gervais & Norenzayan, 2012; Pennycook et al., 2012; Shenhav et al., 2012) confirming the dual-process prediction that belief in God will be associated with steeper discounting. The success of this prediction is significant because the opposite prediction has a clear rationale: Most religions place high value on patience and restraint, both in explicit teachings and in the provision of maximally large delayed rewards for the faithful (Carter et al., 2012). Nevertheless, the present results suggest that believing in God can be understood as the claiming of a cognitive reward in the present, rather than or in addition to being a commitment to claiming divine rewards in the future. However, while these and previous findings are consistent with the possibility that belief in God is more intuitive than disbelief (at least in American culture), as suggested above these findings are also consistent with the possibility that disbelief results from greater reflection in the absence of an automatic lure (though

the fact that reflection appears to bias belief in a particular direction would still need to be explained).

Along similar lines, we connect steeper discounting to the formation of simplifying beliefs in the domain of social cognition. Once again, people who are drawn more strongly to sooner rewards are more likely to exhibit psychological essentialism, attributing other people's behavior to stable traits rather than to dynamic situational factors. Importantly, our measure of psychological essentialism is associated with greater endorsement of racial/ethnic stereotypes (Bastian & Haslam, 2006), stigmatization of outgroup members (Howell, Weikum & Dyck, 2011), and quicker orientation toward ingroup-related cues (Bastian, Loughnan & Koval, 2011). Building on these results, we find that steep discounters are also more likely to ascribe genetic (rather than environmental) causes to the behavioral differences that differentiate races. These findings are broadly consistent with previous work showing that NFC correlates with intergroup/interracial attitudes (Roets & Hiel, 2011; Webster & Kruglanski, 1994), and indeed NFC correlated with both essentialism and this gene-environment measure in our data[12]. Understanding the relationship between reward-related impulsivity and prejudice may provide insight into alternative approaches to reducing outgroup bias. We note that political conservatism was also associated with both of these measures of essentialism, and cannot be ruled out as a partial mediator, but it is equally notable that discount rate was reliably correlated only with social rather than fiscal conservatism (and not party affiliation more generally). The latter finding underscores the connection between discount rate and belief in God, since such beliefs are also tied specifically to social conservatism.

Finally, we connect steeper discounting to people's preferred sources of information. Given the importance of having a well-informed electorate, the association between need for epistemic gratification and news consumption could have important implications for public policy, and deserves further exploration. Given the connections drawn here between steeper discounting and a broad range of distinct behaviors, it seems likely that preferring simpler news is, at least in part, a consequence of a more general preference for sooner rewards. It is also possible, however, that consuming simpler news reinforces a preference for sooner reward more generally. If the causal arrows go in both directions, this could produce a feedback cycle whereby people prone to favor sooner rewards favor news sources that deliver such rewards, which in turn strengthens the preferences for such news sources. However, it also bears emphasizing that our interpretation of news network complexity was based on sub-

jective ratings of a limited set of news organizations. While there are some benefits to using subjective rather than objective metrics (e.g., choices of news consumption are likely to be driven more by the former than the latter), these explicit ratings are susceptible to demand characteristics and other factors that may increase their noise as a proxy for perceptions of complexity. Future work should therefore compare discount rate with more direct estimates of news complexity, related to the content of the news conveyed by these and other organizations.

The ability to delay more immediate gratification and "grit" (the continued exercise of self-control in pursuit of long-term goals) have both been found to be reliable predictors of academic achievement (Duckworth & Seligman, 2005; Mischel et al., 1989). The possibility that such measures may in certain cases have predictive power over and above (or even exceeding that of) standard measures of cognitive ability (suggested by Duckworth & Seligman, 2005; but see Westfall & Yarkoni, 2016) has important implications for education policy (Tough, 2012). Other work has distinguished cognitive style and, more specifically, the reliance on heuristic thinking, from the kind of mental ability measured by traditional intelligence tests (Stanovich, 2009; Stanovich & West, 1998; West et al., 2008; for a more integrative perspective of intelligence, see Baron, 1985). The present results suggest a connection between these sets of findings and the non-intelligence factors they highlight. Answering difficult questions often requires resisting "easy answers" that promise an immediate payoff at a low cognitive cost (Epley & Gilovich, 2006; Frederick, 2005; Kahneman, 2003). Thus, the ability to delay gratification may be essential for academic achievement, not simply because academic achievement requires an extended effort, but because the pursuit of knowledge is, at a cognitive level, more like the pursuit of material rewards than one might think, with easy answers functioning like readily available marshmallows. One might naturally think of learning as a long-term goal that competes with more immediately gratifying activities — "books versus beer" (cf. Kurzban, Duckworth, Kable & Myers, 2013). However, the present results extend earlier findings suggesting that there is a parallel tension within the world of "books", including actual books such as religious texts and math textbooks, as well as other sources of ambiguous information, such as radio stations and gossip.

It is important to note that our results cannot speak directly to the nature of the correlation between intertemporal choice and the other measures examined, and it is also important to note that the strengths of the correlations themselves are small to moderate by the standards of individual differences research[13] (Gignac & Szodorai, 2016) – there is no

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[12]The correlation between discount rate and responses to the racial genetic essentialism item remained significant when covarying NFC: $r_{partial}(1779) = 0.07$, $p<0.002$. NFC and psychological essentialism were not included in the same survey, preventing a comparable analysis for the correlation between discounting and psychological essentialism while covarying NFC.

[13]While these correlations with discount rate are modest in size, they do appear to be consistent across individual items within the MCQ (Table A1), suggesting that they are not being driven by a strong correlation with responses to a subset of items.

doubt that many other factors, including upbringing and social environment, also contribute to the development of these preferences and behaviors. The correlations we observed do, however, hint at the existence of a surprisingly broad cognitive phenotype extending across a range of behaviors. Some are purely self-regarding, while others are social. Some involve inherent uncertainty while others relate to questions with clear answers. Some involve tricky laboratory tests while others concern everyday choices. Some are about this world, while others are about the next. The feature that all of these tendencies seem to share is a broader inclination to take, or resist, what we have referred to as the cognitive path of least resistance. We hope that future research sheds light on the nature of this underlying cognitive factor, and whether it represents an extension of intertemporal choice per se, or whether steep discounting simply represents one manifestation of this broader inclination.

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Appendix 1: Previous findings in conflict with reported discounting-belief correlations

We find, across several surveys, that steeper discounting is reliably associated with stronger belief in God (Figure 4). Another group recently reported the opposite finding (i.e., steeper discounters had weaker religious beliefs; Carter et al., 2012; DeWall et al., 2014). This group used the same

TABLE A1: Correlations between variables of interest and individual binary choices on the MCQ items. Individual choices of the sooner option are coded as zero (0), and choices of the delayed option are coded as one (1), so that negative correlations reflect an association with preference for the sooner reward. The consistency in the direction of these item-wise correlations for a given variable on the left-hand side suggests that correlations with overall discount rate were not driven by responses to any particular item in the MCQ.

Variable	1	2	3	4	5	6	7	8	9
BMI	−0.09	−0.09	0.05	−0.09	−0.02	−0.07	−0.04	−0.10	0.04
Smoker	−0.09	−0.09	−0.18	−0.12	−0.15	−0.12	−0.12	−0.09	−0.20
Correct CRT responses	0.03	0.08	0.20	0.20	0.20	0.16	0.22	0.12	0.19
Intuitive CRT responses	−0.04	−0.08	−0.14	−0.17	−0.15	−0.15	−0.16	−0.12	−0.10
Probability matcher	−0.01	−0.05	−0.21	−0.20	−0.29	−0.09	−0.24	−0.05	−0.21
Model-based planning	−0.00	0.03	0.20	0.08	0.17	0.10	0.17	0.04	0.11
Need for closure	−0.06	−0.06	−0.08	−0.04	−0.05	−0.04	−0.04	−0.06	−0.07
Twitter use	−0.09	−0.08	0.02	−0.06	−0.01	−0.06	−0.06	−0.09	0.03
Complexity of preferred news	0.05	0.08	0.07	0.11	0.06	0.11	0.12	0.07	0.08
Essentialism	−0.01	−0.03	−0.08	−0.08	−0.09	−0.07	−0.10	−0.02	−0.06
Genetics of race & -behavior	−0.07	−0.06	−0.09	−0.06	−0.06	−0.05	−0.05	−0.06	−0.09
Belief in God	−0.02	−0.03	−0.07	−0.10	−0.07	−0.08	−0.08	−0.06	−0.06
Convinced of God	−0.01	−0.02	−0.10	−0.08	−0.08	−0.07	−0.08	−0.03	−0.09
Belief in afterlife	−0.04	−0.04	−0.02	−0.09	−0.03	−0.07	−0.05	−0.07	−0.02

monetary choice questionnaire as we do but different measures of religious belief (the Religious Commitment Inventory [RCI]; Worthington et al., 2003; see also Kim-Spoon, Mccullough, Bickel, Farley & Longo, 2014, discussed below). They also incentivized their subjects (subjects had a 25% chance of receiving one of their intertemporal choice outcomes), whereas most of our samples used hypothetical choice. For one of our survey samples we therefore included the exact measures they include and incentivized our intertemporal choices (subjects had a 1% chance of having a randomly drawn intertemporal choice played out).

We were unable to replicate this group's findings. In our data, discount rate was positively rather than negatively correlated with RCI ($r(1012) = 0.06$, $p=0.061$), and we once again replicated our own result using the belief measures used as in the main text (continuous: $r(1012) = 0.08$, $p<0.02$, binary: $r_{pb}(1012) = 0.09$, $p<0.005$; note that this was one of the samples aggregated into the analyses reported in the main text). Because Carter and colleagues estimated discount rate from the full discounting scale, whereas we used only the medium magnitude items throughout our analyses, we repeated our analyses correlating discount rate and belief in God using overall discount rates for the full scale and highly similar results obtain. We also note that the distributions of RCI values were very similar across the two studies (our sample: M = 2.02, SD = 1.11; Carter et al: M = 2.02, SD = 1.04; DeWall et al: M = 2.01, SD = 1.03).

Follow-up analyses identified a potential source of the discrepancy between our findings and theirs. Specifically, it appears as though the relationship between discount rate and RCI may be U-shaped. The influence of discount rate on RCI scores was better explained by a combination of linear and quadratic terms (corrected Akaike Information Criterion [AICc] = 3082) rather than only a linear term (AICc = 3087) and, in this more complete model, we find a significant quadratic relationship between discounting and RCI scores in our data ($\beta_{quadratic} = 0.09$, $t(1011) = 2.60$, $p<0.01$). (The linear term in this model remains significant and slightly stronger than the linear term in the model that omitted a quadratic term; $\beta_{linear} = 0.10$, $t(1011) = 2.84$, $p<0.005$). This quadratic effect is by no means conclusive regarding whether there these variables have a U-shaped relationship (Simonsohn, unpublished), and follow-up work is needed to more thoroughly examine the range of RCI values. If such a relationship existed, however, it would suggest that there is a range of discounting values for which one might observe a negative relationship with RCI (as Carter and colleagues and DeWall and colleagues observed). Why this quadratic relationship might exist is a matter of speculation, and may have to do with the fact that average RCI scores in our sample and theirs are very low (on a scale ranging from "not at all true for me to "totally true for me"), suggesting that shallower discounters scoring more highly on RCI may simply be evincing greater uncertainty rather than more confident reli-

gious commitment. We also note that, in addition to being a larger sample (Ns=1014 vs. 277 for Carter et al and 327 for DeWall et al) our online data are collected from a geographically and demographically diverse sample of the American population (Buhrmester, Kwang & Gosling, 2011), including university-based samples, rather than only from a single university sample. This may have contributed to our sample having a higher mean discount rate (natural log-transformed medium-magnitude ks = –4.32 vs. -4.68) and greater variance (SDs = 1.75 vs. 1.48), relative to at least Carter et al[14], which may in turn have enabled us to capture a wider range of the quadratic curve described above.

Another recent finding from this group examines discount rate in a group of 106 early adolescents and compares this to their religiosity a few years later, and again finds a negative association (Kim-Spoon et al., 2014). While this latter dataset is different enough from our own (in terms of age and longitudinal approach) to preclude any direct comparison, we note that in this study, like those of Carter and colleagues and, DeWall and colleagues, the key measure of religious belief seems to focus on how one feels about faith and their religion (e.g., how often they engage with their religious group and religious material [Carter et al and DeWall et al], or how important they think it is to believe in God [Kim-Spoon et al]) rather than on the strength/confidence of their belief in the existence of God/afterlife. In our data, this difference appeared to produce a slightly weaker association between discounting and RCI than our standard belief measures (though both correlations were in the direction predicted by our other findings and contra to Carter et al and DeWall et al); whether this difference in measures helps to explain the difference between our findings and the finding by Kim-Spoon and colleagues awaits further investigation.

Finally, since these three previous studies measured discounting and religiosity in separate sessions, we sought to rule out the possibility that our findings resulted from collecting both measures in the same session. To do so, the data for one of our samples (N=1009) was collected from individuals who had previously completed the MCQ and/or a measure of belief in God[15] for other, unrelated experiments that we had performed through AMT. We had these subjects complete a new survey consisting of measures of religious belief followed by the 9-item MCQ, demographic measures, and measures of internet usage. We found that the positive correlation between belief and discounting held when measured in separate sessions as it did when measured in the same session. Specifically, we found that (a) estimates of discount rate from previous sessions (averaged over sessions for a given subject) predicted belief in God in the new survey

(Likert item: $r(987) = 0.08$, $p<0.02$; binary item: $r_{pb}(987)= 0.10$, $p<0.005$) and (b) discount rate measured by the new survey correlated with belief measured in the previous surveys, whether those surveys included intertemporal choice questions ($r(982) = 0.10$, $p<0.005$) or not ($r(358) = 0.14$, $p<0.01$).

Appendix 2: Belief in God and behavior on probability matching and two-step tasks

For completeness, we tested whether belief in God was associated not only with CRT (Shenhav et al., 2012) and intertemporal choice (main text), but also with behavior in the other choice paradigms we explored. First we tested for and found a relationship between probability matching and belief in God. Probability matchers believed more strongly in God (continuous scale: $r(537) = 0.10$, $p<0.02$) and were more likely to say they had a previous convincing experience of God's existence $r_{pb}(530) = 0.17$, $p<0.0001$).

We then tested for a similar relationship between belief in God and model-based planning in the two-step task. (We note that this survey employed a slightly different measure of belief ("How convinced are you of the existence of God" – 7-point scale ranging from 'not at all' to 'very') so these responses were excluded from cross-survey analyses of belief in God reported in the main text.) These analyses revealed a significant relationship between lower belief in God and higher model-based indices (N=263, coeff = –0.24, SE = 0.06, $z = -3.8$, $p < 0.0005$). No significant relationships were found between belief in God and either of the main effects whose interaction forms the model-based index (main effect of reward: coeff = –0.07, SE = 0.04, $z = -1.6$, $p = 0.10$; main effect of transition: coeff = 0.03, SE = 0.04, $z = 0.74$, $p = 0.46$).

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[14]These summary estimates were not provided in DeWall et al.

[15]This belief measure differed slightly from the main Likert measure used for this study. It consisted of the prompt "How strongly do you believe in the existence of a God or Gods?" and a seven-point Likert scale anchored at "very little" and "very much."