Who is "Behavioral"? Cognitive Ability and Anomalous Preferences

Daniel J. Benjamin[*] Harvard University
Jesse M. Shapiro University of Chicago

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Abstract

Short-term discounting and small-stakes risk-aversion have been argued to be fundamental in understanding a wide range of economic behaviors. Knowing how these deviations from normative decision-making are distributed in the population is crucial both for understanding their causes and for evaluating their economic impact. Using the NLSY, we show that real-world behaviors that have been connected with these biases—low levels of financial market participation, low levels of asset accumulation, obesity, and smoking—are negatively related to cognitive ability, controlling for labor income and family fixed effects. In two laboratory studies, we show directly that cognitive ability is associated with more standard time and risk preferences. We also show that reverse causality is not a likely explanation for our results, and that cognitive ability is *not* reliably related to preferences that lack a normative benchmark. We find that experimentally reducing the cognitive resources available for deliberative processing does *not* affect expressed time and risk preferences, suggesting that cognitive ability improves decision-making through better acquired heuristics, rather than through superior on-the-spot reasoning.

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1 Introduction

An enormous literature in psychology argues that cognitive constraints force people to rely on fallible heuristics (Kahneman, Slovic and Tversky, 1982; Kahneman 2003), resulting in systematic deviations from the predictions of standard decision theory. For example, short-term discounting and small-stakes risk-aversion have been argued to be fundamental in understanding a wide range of consumption and financial market behaviors (e.g., Angeletos et al, 2001; Benartzi and Thaler, 1995). Despite intensifying interest in the role of such deviations in the economy, surprisingly little attention has been paid to the question of *which* economic agents are most susceptible to these biases.[1]

Knowing how such psychological biases are distributed in the population is crucial for evaluating their economic impact because outside of the laboratory not all decision-makers carry the same weight (Friedman, 1953). For example, the market for payday lending and check-cashing is especially sensitive to the biases of those with limited assets (Caskey, 1994; Bertrand, Mullainathan and Shafir, 2004), whereas the behavior of aggregate savings is disproportionately sensitive to the biases of those with substantial wealth (Saez and Kopczuk, forthcoming).[2]

In this paper, we examine the relationship between cognitive ability and two deviations from standard decision theory that have been widely studied by economists, short-term discounting and small-stakes risk-aversion. We focus on cognitive ability rather than other possible predictors of bias for two reasons. First, many authors have argued that deviations from the predictions of economic theory arise from bounded cognition (e.g., Thaler 1992). A natural implication of this view is that individuals with greater cognitive ability—those whose cognition is "less bounded"—will behave in a way that is more consistent with normative decision theory. Second, despite growing interest in the cognitive foundations of economic preferences (e.g., McClure et al, 2004; Breiter et al, 2001), little is known about how cognitive differences among individuals relate to differences in their time and risk behavior.

We motivate our study with evidence from the National Longitudinal Survey of Youth 1979 (NLSY) on the relationship between cognitive ability and a set of real-world behaviors—low levels of asset accumulation, obesity, smoking, and low levels of financial market participation—that have been argued to arise from some form of small-stakes risk aversion or short-run impatience. In all

[1] See Lillard and Willis (2001); Kézdi and Willis (2002); Bernheim, Garrett and Maki (2001); Ameriks, Caplin and Leahy (2003); and Lusardi (2003) for recent work that also examines heterogeneity in decision-making.

[2] The presence of heterogeneity also affects the potential for sorting into activities, which in turn may either attenuate or exacerbate the role of biases in the marketplace (Haigh and List, 2005; Lazear, Malmendier and Weber, 2004).

cases, we find a negative relationship between cognitive ability and the presence of the anomalous behavior, with mathematical ability playing an especially important role. These relationships survive extensive controls for income and family fixed effects (implemented using sibling groups).

These findings show that cognitive ability is correlated with the behaviors of interest, consistent with the hypothesis that cognitive ability is correlated with the preference anomalies—short-run impatience and small-stakes risk aversion—that have been hypothesized to generate those behaviors. In principle, however, our findings could be interpreted as evidence of a relationship between cognitive ability and other determinants of these behaviors.[3]

In light of these difficulties with survey evidence, we conducted a laboratory study of the small-stakes risk preferences and short-run impatience of students in a Chilean high school. These students' standardized test scores range from the 45th to the 99th percentile. We constructed our elicitation procedures so that risk-averse or impatient behavior in our study cannot be consistent with standard economic models without assuming an absurdly high degree of risk-aversion or discounting (Rabin, 2000; Rabin and Thaler, 2001; Rabin, 2002). We find that higher cognitive ability is predictive of much lower levels of small-stakes risk aversion and short-run impatience. Mathematical ability has a much larger and more reliable relationship with these preference anomalies than verbal ability. For example, we calculate that a one-standard-deviation increase in measured mathematical ability is associated with an increase of about 14 percentage points in the probability of behaving in a risk-neutral fashion over small stakes (as against a mean probability of about 10%) and an increase of about 18 percentage points in the probability of behaving patiently over short-run trade-offs (with a mean of about 28%). We also find that cognitive ability can account for much of the correlation between small-stakes risk aversion and short-run impatience.

Of course, the direction of causation may run from preferences to cognitive ability, with more patient individuals investing more in cognitive skills.[4] Although it is not clear how this view accounts for the correlation of cognitive ability with risk preference, we take the concern seriously. Taking advantage of the fact that most of the participants in our laboratory study have been at the same school since the first grade, we show that elementary-school grade point averages predict decision-making in the 12th grade just as well as 12th grade ability does. While this finding does not conclusively rule out a role for reverse causality, it does mean that if reverse causality were the whole story, differences in investment in skills must have occurred entirely in pre-school ages.

[3]For alternative possible determinants of these behaviors, see, e.g., Lakdawalla and Philipson (2002); Becker, Grossman and Murphy (1994); Constantinides, Donaldson and Mehra (2002).

[4]This is the argument of Shoda, Mischel and Peake (1990), who show that preschoolers' ability to delay gratification is positively related to subsequent high school performance on the SATs.

Additionally, the fact that the individuals in our sample have had essentially identical classroom experiences throughout their lives casts doubt on explanations based on heterogeneity in schooling quality or in in-school training in decision-making.

Having established a link between cognitive ability and anomalous preferences, we next ask whether cognitive ability is related to non-anomalous preferences. In a study of Harvard undergraduates, we find a relationship between cognitive ability and risk-neutrality, and a weaker but still discernible relationship with discounting, but we do *not* find a statistically reliable relationship between cognitive ability and fairness preferences, as measured by Dictator Game behavior. Nor do we find a relationship between cognitive ability and idiosyncratic preferences, like choice of candy bar. These negative results suggest that cognitive skills are most robustly related to preferences that have a normative benchmark.

Our study of Harvard undergraduates also allows us to investigate the causal mechanism underlying the correlation between ability and normative decision-making. Broadly speaking, there are two reasons why more cognitively able individuals might exhibit more normative preferences. On the one hand, they may be able to bring superior cognitive resources to bear on a given decision problem and thus be more likely to compute the optimal action. Alternatively, they may devote the same resources to a given current problem, but have acquired heuristics for decision-making that lead to better choices. In the parlance of cognitive psychology, the question is whether cognitive ability affects "controlled" processes (conscious, intentional, resource-intensive) or "automatic" processes (unconscious, highly-practiced, cognitively-efficient) (Wegner and Bargh 1998; see also Kahneman, 2003).

To tease these possibilities apart, we employ a "cognitive load" manipulation, a technique commonly used in psychology studies to disable controlled processing (e.g., Baddeley and Hitch, 1974; Gilbert and Silvera, 1996). If cognitively able individuals behave differently due to greater cognitive resources, then cognitive load should lead to more impatient and more risk-averse choices. We subjected randomly chosen participants in our Harvard study to cognitive load, by having them listen for sequences of tones while making their decisions. This manipulation interfered with participants' ability to solve SAT-like math problems, suggesting that it successfully reduced the cognitive resources available for controlled, deliberative processing. But cognitive load had no effect on our measures of short-run impatience[5] and small-stakes risk aversion. Though tentative, these

[5]But see Hinson, Jameson, and Whitney (2002), who found that cognitive load increases impulsivity in choice problems similar to ours, and Shiv and Fedorikhin (1999), who found that cognitive load increases impulsivity when rewards are vividly tempting (but not otherwise). Both papers operationalized cognitive load by requiring participants to remember strings of numbers. In pilot tests using the same method, we were unable to replicate these results.

results suggest that people with greater cognitive ability have acquired instinctual reactions that lead to more normative decision-making.

Our work makes several contributions to a large psychology literature that shows that cognitive ability is correlated with success in a wide range of real-world life outcomes (see Jensen, 1998, for a review). First, we extend this work into the economic realm by focusing on a set of behaviors—expressed risk and time preferences—that are central for real-world economic decision-making. In fact, to the extent that risk and time preferences play an important role in behaviors and outcomes like crime, delinquency, health, longevity, and accident-proneness, our findings help to make sense of the real-world correlations documented in the psychology literature (Jensen, 1998). Second, in our studies of field evidence, we control for socioeconomic status and educational background to a much greater extent than the existing literature. Finally, our laboratory work takes steps toward understanding the mechanism by which cognitive ability is related to better decision-making.

Our paper is most closely related to independent work by Frederick (2005), who shows that performance on a range of cognitive tests correlates negatively with impatience and risk-aversion. Our work differs from his in several ways. For one thing, we investigate the correlation between cognitive ability and real-world behaviors. Also, our Chilean high school study allows us to address concerns about reverse causality. Finally, the cognitive load manipulation in our Harvard study enables us to tease apart competing causal explanations. We are aware of some other existing work examining the relationship between cognitive ability and impatience (Funder and Block, 1989; Shoda, Mischel, and Peake, 1990; Parker and Fischhoff, 2005)[6] but none that addresses risk-aversion.[7] A recent body of psychological laboratory evidence argues that individuals with greater cognitive skills display fewer biases in judgment and decision-making (such as the sunk-cost fallacy, gain-loss framing, and the conjuction fallacy) in hypothetical choice scenarios (Stanovich, 1999; Stanovich and West, 1998). Like us, Brandstätter and Güth (2002) fail to find a reliable relationship between cognitive ability and Dictator Game giving.

The remainder of the paper is organized as follows. Section 2 presents motivating evidence from survey data. Section 3 lays out our laboratory procedures. Section 4 presents the results from our study of Chilean high school students. Section 5 presents robustness checks drawn from

[6]Kirby, Winston, and Santiesteban (2005) focus on the relationship between GPA and short-term impatience for undergraduates at two colleges, but they also obtained SAT scores from the registrars. In their data, SAT scores and GPA correlate negatively with short-term impatience.

A related literature finds that reduced frontal-lobe function correlates with impulsivity (e.g., Damasio 1995; Whitney, Jameson, and Hinson, 2004).

[7]Donkers, Melenberg, and Van Soest (2001) find that risk-aversion is negatively correlated with education (in hypothetical choices).

the Chile study and from our laboratory study of Harvard undergraduates. Section 6 analyzes the cognitive load results from our Harvard study and discusses potential causal mechanisms to explain the relationship between cognitive ability and normative preferences. Section 7 concludes.

2 Motivating Evidence from the NLSY

In this section we present survey evidence that will serve as motivation for our laboratory study. We will investigate the connection between measured cognitive ability and a set of behaviors—low levels of asset accumulation, obesity, smoking, and low levels of financial market participation—that have been explicitly connected in the economics literature with either small-stakes risk aversion or short-term time preference. We restrict our set of dependent measures in this way to lessen concerns about bias due to the selective inclusion or exclusion of behaviors from the set we consider.

2.1 The National Longitudinal Survey of Youth

The National Longitudinal Survey of Youth 1979 (NLSY) is compiled from repeated interviews of a nationally representative sample of 12,686 Americans. All respondents were between the ages of 14 and 22 in 1979, the first survey year. Interviews were conducted annually through 1994 and biennially thereafter.

In 1980, 94% of survey respondents were administered the Armed Services Vocational Aptitude Battery (ASVAB), which consists of 10 exams designed to measure different areas of knowledge and ability.[8] On the basis of each respondent's ASVAB results, data processors constructed an approximation to the respondent's percentile in the Armed Forces Qualifying Test (AFQT), a measure developed by the U.S. Department of Defense.[9] Each constructed score was then compared to the overall distribution of scores for respondents age 17 and over to yield a percentile score ranging from 0.01 to 0.99. This percentile score will serve as our primary measure of cognitive ability in this section.[10]

[8] These areas are: general science, arithmetic reasoning, word knowledge, paragraph comprehension, numerical operations, coding speed, auto and shop information, mathematics knowledge, mechanical comprehension and electronics information.

[9] In particular, for each respondent a score was calculated by summing the raw scores from arithmetic reasoning, word knowledge, and paragraph comprehension, plus one-half of the score from the numerical operations exam.

[10] The AFQT score has a correlation of over 0.94 with the first principal component of the scores on the ten sections of the ASVAB, which cognitive psychologists believe to be a good measure of "general cognitive ability." This principal component is highly correlated with SAT scores (Frey and Detterman, 2004), which we use as a measure of cognitive ability in our own laboratory work (see Section 3). Moreover, SAT scores in turn have a very strong correlation with scores on a Raven's Matrices Task, another common tool for measuring general cognitive ability (Frey and Detterman, 2004).

We will also be interested in separating the effects of mathematical and verbal ability. We have therefore computed a mathematical ability score as the sum of performance on the arithmetic reasoning, numerical operations, and mathematical knowledge sections of the ASVAB and a verbal ability score as the sum of performance on the word knowledge and paragraph comprehension sections.

We will estimate the relationship between AFQT score and our dependent measures—financial market participation, asset accumulation, obesity, and smoking—using linear probability models. Since respondents were at different ages when taking the ASVAB, we will include dummies for age in 1979 in all specifications. We also include a dummy for gender in all models.[11] For all outcomes measured in multiple years, we include dummies for survey year to control for time trends. We also adjust standard errors for within-individual correlation in the error structure whenever we have repeated measures for a given individual.

As a proxy for human capital wealth, we will control for the log of family income in every available survey year from 1979 to 2000 (18 years of data in all), with dummies proxying for missing data. Though such controls will not perfectly capture permanent income, the availability of so many years of data allows for much richer specifications than would be possible in purely cross-sectional data.

To account for family background characteristics that may be correlated with cognitive ability, we will take advantage of the fact that many of the respondents in the NLSY are siblings (53.8% have at least one sibling who is also a respondent). We will therefore be able to estimate our models with "sibling group" fixed effects to difference out family-specific factors that might be correlated with both cognitive ability and our dependent measures.

2.2 Cognitive Ability and Behavior in the NLSY

Asset accumulation. Bernheim (1991) argues that Americans have anomalously low levels of retirement savings, a phenomenon that Angeletos et al (2001) attribute to short-run impatience. To measure asset accumulation, we code a dummy equal to one if the respondent said that she would have "something left over" in response to the following question:

> Suppose you [and your spouse] were to sell all of your major possessions (including your home), turn all of your investments and other assets into cash, and pay all of your

[11] Controlling for gender does not meaningfully affect our results, since gender and AFQT score are statistically unrelated in our sample. When we split the sample by gender, in most cases the estimated effect of AFQT score is similar for male and female respondents.

debts. Would you have something left over, break even, or be in debt?

The first column of Table 1 shows the strong, statistically significant, and positive relationship between AFQT score and the propensity to have positive net assets. As specification (3) shows, even within a group of siblings and after controlling for family income from all available survey years, an additional 10 percentile points of AFQT is associated with an increase of about 1.5 percentage points in the propensity to have positive net assets.[12] This is economically nontrivial when compared to the mean of about 66 percent. Moreover, while the introduction of income controls between specifications (1) and (2) decreases the estimated relationship with AFQT score significantly, the introduction of sibling group fixed effects in specification (3) has a relatively small impact on the AFQT coefficient despite increasing the R^2 of the model from 0.17 to 0.44. In specification (4) we attempt to separate the AFQT coefficient into mathematical and verbal components. The estimated coefficient on verbal ability is essentially zero, whereas the relationship with mathematical ability is statistically strong and on the same order of magnitude as the overall AFQT coefficient.

Smoking. O'Donoghue and Rabin (1999) and Gruber and Köszegi (2001) have argued that short-run impatience plays an important role in the decision to begin smoking and in the difficulty of quitting (see also O'Donoghue and Rabin, 2000). We create a dummy equal to one if the respondent is a daily smoker, as reported in the answer to the survey question, "Do you now smoke daily, occasionally, or not at all?" The second column of Table 1 presents our estimates of the relationship between AFQT score and the propensity to smoke regularly. After including income and sibling group controls, we estimate that an increase of ten percentile points in the AFQT score is associated with a decrease of about 1.3 percentage points in the probability of smoking, relative to a baseline of about 28 percent. As with asset accumulation, while including income controls does reduce the estimated AFQT coefficient considerably, including sibling group fixed effects has much less impact. Indeed, in this case the coefficient on AFQT actually increases slightly between specifications (2) and (3). In specification (4), we report that the estimated coefficient on mathematical ability is much larger than the coefficient on verbal ability, consistent with the findings for asset accumulation.

[12] Since one might question the wisdom of significant saving in early adulthood, we have confirmed that our results are robust to restricting attention to respondents who are 35 and over. Moreover, it might be argued that standard economic models prescribe not only *more* asset accumulation among middle-aged individuals but also *less* asset accumulation (or even borrowing) among younger individuals. In fact, when we include an interaction between age and AFQT score in the regression, the interaction is positive and strongly statistically significant. This suggests that higher AFQT respondents are more likely to have the profile of low saving in early adulthood and high saving later on, in accordance with the prescriptions of life-cycle savings models.

Obesity. Cutler, Glaeser, and Shapiro (2003) argue that the rise in obesity in the last several decades has resulted from an interaction between falling time costs of eating and consumers who display short-run impatience. In some survey years, NLSY respondents were asked to report their weight in pounds and their height in inches. We calculate the respondent's average reported height and then, for each response to the weight question, we calculate the respondent's body mass index (BMI) as the ratio of her weight in kilograms to the square of her height in meters. We then follow standard practice and define an obesity dummy equal to one if the respondent's BMI exceeds 30.

As the third column of Table 1 shows, the negative relationship between AFQT score and obesity becomes statistically insignificant when we control for sibling group fixed effects in specification (3). We do, however, estimate a marginally statistically significant relationship with mathematical ability in specification (4), in contrast to a point estimate of about zero on verbal ability. The coefficient on mathematical ability implies that an increase of ten percentile points in mathematical ability reduces the probability of being obese by about half a percentage point (about 16 percent of our sample are obese).

Financial market participation. A large literature on the equity premium puzzle (Mehra and Prescott, 1985) documents that "even though stocks appear to be an attractive asset—they have high average returns and a low covariance with consumption growth—investors appear very unwilling to hold them" (Barberis and Thaler, 2003). Some authors have contended that myopic loss aversion—which predicts risk aversion over small stakes—can explain this reluctance to participate in financial markets (Benartzi and Thaler, 1995; Barberis, Huang and Thaler, 2003).

We measure financial market participation using respondents' answers to the following question:[13]

> Not counting any individual retirement accounts (IRA or Keogh) 401K or pre-tax annuities...Do you [or your spouse] have any common stock, preferred stock, stock options, corporate or government bonds, or mutual funds?

The fourth column of Table 1 shows the strong positive relationship between AFQT score and financial market participation. As specification (3) shows, even after controlling for sibling group fixed effects and family income from all survey years, we estimate that an increase of 10 percentile points in AFQT score is associated with an increase of two percentage points in the probability of owning a financial asset, as against a sample mean of about 20 percent. Specification (4) shows that

[13] Myopic loss aversion predicts less investment in equities relative to bonds, so it would be better for our purposes if this question did not include "corporate or government bonds." We do not believe this inclusion meaningfully affects our results.

the relationship with math and verbal ability is similar, with the verbal ability coefficient slightly higher.

Summary. In all cases we find that the AFQT-behavior relationship has the expected sign, and in all but one case (that of obesity), the estimated coefficient on AFQT score is strongly statistically and economically significant even when we control extensively for income and only compare individuals within sibling groups. Moreover, we find in all but one case (that of financial market participation) that mathematical ability has a stronger relationship with the behavior than verbal ability, although in general we cannot distinguish the two coefficients statistically.

3 Laboratory Procedures

3.1 Interpreting Measured Preferences

In the studies reported below, we will investigate the connection between cognitive ability and small-stakes risk-aversion and short-term impatience. In this subsection, we describe the decision problems we used in our laboratory studies, and we use existing calibration theorems to argue that any risk-aversion or discounting displayed in the laboratory cannot be a result of agents maximizing standard preferences with reasonable parameters (Rabin, 2000; Rabin and Thaler, 2001; Rabin, 2002). Instead, we interpret such behaviors as resulting from decision procedures that people apply when faced with similar real-world choices.

Small-Stakes Risk Preference. We elicited expressed risk preferences with five questions of the following form:

> Please circle either Choice A or Choice B.
> (A) You get \$0.50 for sure.
> (B) If the die comes up 1, 2, or 3, you get X. If the die comes up 4, 5, or 6, you get nothing.

where X was \$0.95, \$1.05, \$1.15, \$1.25, and \$1.35.[14] In each case, (A) is the safe bet, and (B) is the risky bet.

In this problem, any reasonable expected-utility preferences imply perfectly risk-neutral behavior: choosing the safe bet for $X = \$0.95$ and choosing the risky bet for all other values of X. Rabin's (2000) calibration theorem implies that participants who rejected the gambles we offered

[14] These dollar amounts actually correspond with those used in our Harvard study, discussed in Section 6. In our Chile study, (A) paid 250 pesos for sure. For (B), X was 400, 550, 700, 850, and 1000 pesos. At the then-exchange rate of 632 pesos/\$, the stakes were of comparable magnitude in the two studies. Calibrations based on the Chile amounts lead to the same qualitative conclusion that expressed risk-aversion is not plausibly explained by maximization of a stable expected utility function.

them could not plausibly have been behaving in accordance with standard expected utility theory, the normative benchmark. If a participant's risk-aversion in our studies were truly explained by expected utility theory, then that participant's utility function would have to be so concave that the person would turn down a gamble that gives a 50% chance of losing \$5 and a 50% chance of winning an infinite amount of money! (Put another way, an expected-utility maximizer with a constant relative risk-aversion utility function and lifetime wealth of \$100,000 would make this decision only if the coefficient of relative risk-aversion exceeded 15,000!) The reason is that risk-aversion over such small stakes requires non-negligible local concavity that, when extrapolated, leads to extraordinary risk-aversion over larger stakes. Because this behavior over larger-stakes gambles is obviously implausible, the risk-averse choice of the safe bet when $X = \$1.05$ is quantitatively inconsistent with standard expected utility theory. Making the risk-averse choice of the safe bet when X is larger than \$1.05 implies even more extreme risk-aversion over larger stakes and is therefore even more questionable.[15]

Note that participants who choose the safe bet are not only exhibiting small-stakes risk-aversion but also "narrow bracketing," considering the current gamble in isolation from ongoing risks and other changes in wealth (Barberis, Huang and Thaler, 2003; Read, Loewenstein, and Rabin, 1999). We take risk-averse behavior as the outcome of interest and do not take a position on whether heterogeneity in expressed risk attitudes results from differences in framing or differences in respondents' assessments of gains (but see footnote 34).

Short-Term Time Preference. We measured time preferences with six questions of the form:

> Please circle either Choice A or Choice B.
> (A) You get \$5.00 right now.
> (B) You get X a week from now.

For the six questions, X was \$5.05, \$5.35, \$5.55, \$5.75, \$5.95, and \$6.15.[16] The impatient choice is always (A), and the patient choice is (B).

Taking time-consistent exponential discounting as the normative standard, an impatient choice is non-normative in the sense of implying an absurdly high discount rate. For example, a person indifferent between receiving \$5.00 now and \$5.05 in one week is, under constant discounting,

[15] The risk-seeking choice of the risky bet for $X = \$0.95$ is similarly suspect. Even if risk-loving preferences are considered acceptable over larger stakes, they are inappropriate in this context of small stakes. Assuming a convex utility function, an argument analogous to Rabin's (2000) calibration theorem would show that the risk-seeking choice of the risky bet for $X = \$0.95$ is quantitatively inconsistent with standard expected utility theory. Such a choice for an expected-utility maximizer would imply a counterfactual degree of risk-seeking over somewhat larger stakes. Therefore, we take risk neutrality as the normative benchmark in our studies.

[16] In the Chile study, (A) paid 500 pesos right now. For (B), X was 450, 550, 650, 750, 850, and 950 pesos. Making an impatient choice with these stakes similarly implies an implausibly high discount rate.

implicitly discounting cash flows at a rate of $52 \times \ln\left(\frac{\$5.05}{\$5.00}\right) \approx 52\%$ per annum![17] Someone who makes the impatient choice for larger values of X is implicitly discounting at an even higher rate. Such high discount rates imply virtually no regard for the future, which seems unlikely to be the correct explanation of a participant's impatient choice in this decision problem.

Although our approach is a standard laboratory tool for measuring time preference (Frederick, Loewenstein and O'Donoghue, 2002), there are a number of reasons why this procedure may not actually measure impatience. For one thing, participants may not trust that they will actually receive the delayed reward if they make the patient choice. In our study, we promised to pay participants in cash in a week if they made the patient choice, and in cash the next day if they made the impatient choice. At the very end of the experimental procedure, we asked them, "Did you believe that you would actually get paid in a week if you chose to take the money in a week?" Of our 92 participants, 90 said they believed they would get paid in a week. Additionally, the two participants who did not believe they would receive the money in a week actually had higher-than-average mathematical ability, suggesting that heterogeneity in trust is not likely to bias our results toward finding that more able individuals are more patient.[18]

Most fundamentally, according to economic theory, questions involving monetary rewards should not measure impatience, since people can (in principle) borrow or lend money at the market rate of interest regardless of how they discount future utility (Fuchs, 1982).[19] Therefore, participants who behaved impatiently in our experiment may have been exhibiting *both* short-run impatience *and* a misunderstanding about the fungibility of money. Although our procedure may not accurately recover a "deep" preference parameter, variation in discounting measured in a manner similar to the one we employ here predicts variation in behaviors such as drug addiction (e.g., Kirby, Petry, and Bickel, 1999; Kirby and Petry, 2004), cigarette smoking (Fuchs, 1982; Bickel, Odum, and Madden 1999), excessive gambling (Petry and Casarella, 1999), use of commitment savings devices (Ashraf, Karlan, and Yin, 2004), and rapid exhaustion of food stamps (Shapiro, 2005).

[17] Imputing an exact discount rate over utility flows from this indifference requires assumptions about the utility function. However, Arrow (1971) and Rabin (2000) imply that, for participants with a reasonable amount of lifetime wealth, utility should be approximately linear over the small-stakes choices we offer. Within the standard model, the discount rate over small cash flows therefore approximates the discount rate over utility flows.

[18] A second reason why the acceptance of the immediate reward may not reflect impatient behavior is that receiving the delayed reward may require incurring greater transaction costs. In our Chile study, however, participants knew they would receive cash whether they chose the immediate or the delayed amount of money. Participants were also told that if they missed school on the payment day, their homeroom teacher would hold their payment envelope until they came to school. Two participants who chose the immediate reward were absent in school the next day and received their payment the following day. All participants who chose the delayed reward were present in school when they were paid the next week.

[19] Of course, the student populations who participated in our studies were likely liquidity-constrained. They probably could not borrow at the market rate of interest. But if the students were liquidity-constrained both today and in a week, then choices over monetary rewards would in principle measure discount rates.

3.2 Study of Chilean High School Students

Participants were seniors at a semi-private high school in Santiago, Chile. Most participants entered the school for kindergarten at age 4 or 5. Some students were admitted because older siblings had attended, but most were admitted on the basis of adequate performance on an entry exam. Most students (more than 80%) had received their entire formal education at the school. Therefore, these participants had had a similar schooling experience. The school gave us grade point averages for grades 1 through 11 for all students participating in our study for whom such data were available.

At the end of their senior year, Chilean high school students take a national standardized test, the Prueba de Selección Universitaria (PSU), which has three obligatory sections—Math, Verbal, and Chilean History and Geography—as well as specific subject-area sections. The math section is very much like the SAT I Math Section, while the verbal section covers literary concepts, reading comprehension, logical paragraph organization, and vocabulary. For many Chilean universities, the PSU score together with GPA are the sole determinants of admission. Because performance on the exam is so important, seniors at this school take monthly practice tests. We obtained 5 practice test scores (for April through August, 2004) from the school for each participant.

3.2.1 Participants

Participants were the 92 out of 160 members of the senior class of a Chilean high school who turned in parental consent forms. None had received any formal training in economics. We held a single 30-minute experimental session on August 24, 2004, with participants sitting in widely-separated desks in the school gym.

3.2.2 Procedure

After handing out a questionnaire booklet to each participant, an experimenter guided participants through the questionnaire in unison by reading instructions aloud. The questionnaire was divided into sections (with neutral labels such as “Choices” and “More Choices”), each of which elicited a type of preference. The questionnaire contained a section that elicited small-stakes risk preferences, a section that elicited short-term time preferences, another section that specifically examined loss aversion, and a final section that asked a few demographic questions.

Participants were paid in cash for their choices in the risk-preferences and loss-aversion sections, as well as paid a participation fee of 1250 pesos (about \$2.00 at the then-exchange rate of 632 pesos/\$), during lunch break the following day. Participants who chose to be paid “now” in the time-preference section were also paid in cash for that section at the same time. Participants who chose to be paid "a week from now" in the time-preference section were paid in cash during lunch break one week after the experiment.

Small-Stakes Risk Preference. The section of the questionnaire that elicited risk preferences comprised five questions exactly like those described above, except denominated in pesos. Option (A) (the safe bet) paid 250 pesos, and option (B) (the risky bet) paid X, where X was 400, 550, 700, 850, and 1000 pesos. To make sure that participants understood the choices they were making, we gave them an example question in the instructions for this section. We also informed participants that they would answer five questions of the above form. Finally, we gave participants the opportunity to ask any questions about the instructions. There was no stated time limit for answering the questions, but we waited about 6 minutes for all participants to finish before moving on. We then rolled a die five times to determine their payment for this section.

The questionnaire contained all five questions on the same page, with X in ascending order. This presentation made salient to participants the strategy of choosing (A) (the safe bet) for small X and (B) (the risky bet) for large X. In fact, 70 out of 92 gave monotonic responses, choosing (A) below some threshold value of X and (B) above it.[20] For these participants, the threshold measures the level of risk-aversion.[21]

Short-Term Time Preference. We measured time preferences with six questions as described above. For each question, the participant chose between 500 pesos today and X a week from today. All six questions were on the same page, with X in ascending order: 450, 550, 650, 750, 850, and 950 pesos. We ordered the questions this way to make obvious to participants the strategy of choosing (A) (the immediate payoff) for small X and (B) (the delayed payoff) for large X. As it turned out, 87 out of 92 participants chose (A) below some threshold value of X and (B) above it.

In the instructions for this section, the experimenter gave participants an example question, told them that a die roll would select the question to be implemented, and gave them a chance to ask questions. Participants took about 6 minutes to answer the six questions. The instructions explained that participants would receive cash to pay them for this section. The cash would be paid at lunchtime the next day if the participant had chosen (A) for the relevant question, or at lunchtime in a week if the participant had chosen (B).

[20] In all cases, we present statistical results for the whole sample of subjects but note that our results are substantively unchanged if we restrict attention to only those subjects whose responses were monotonic.

[21] We also collected information on loss aversion. Since the results for small-stakes loss aversion closely parallel those for risk-aversion, we present our findings on loss aversion in Appendix Table 2 and focus in the body of the paper on risk and time preferences.

3.3 Study of Harvard Undergraduates

3.3.1 Participants

Participants were 60 undergraduates (virtually all Harvard students), recruited through on-campus posters and e-mail solicitations. We promised students $5 for participating in a 45-minute experiment, with the possibility to earn more "depending on your responses [in the experiment]." We allowed only non-economics majors to participate because we were concerned that economics students would be familiar with our preference elicitation procedures. In total, we held six sessions, on February 8, 21 and 22 and May 14, 15 and 16, 2004.[22]

3.3.2 Procedure

An experimenter guided participants through the questionnaire in unison by reading instructions aloud. The questionnaire contained four preference-elicitation sections: small-stakes risk preferences, short-term time preferences, fairness preferences, and idiosyncratic consumption preferences. The order of the sections differed across sessions; this order had no effect on the results, so we do not discuss it further.

At the end of the questionnaire, after all the preference-elicitation questions, we asked participants for their major, year in school, and gender. Most importantly for our analysis later, we asked participants for their highest Math and Verbal SAT I scores. We also asked participants for ACT or other standardized test scores, but virtually all participants had taken the SAT, and virtually none had taken the ACT or other standardized test. We therefore focus our analysis on SAT scores, which are available for 57 of our 60 participants. As a check on the accuracy of the self-reported SAT scores, we included a section of SAT-like math questions near the end of the questionnaire (after participants had responded to all the preference-elicitation sections). The correlation between performance on the SAT-like math questions and self-reported Math SAT score was 0.33, which is significantly different from 0 ($p = 0.012$). Given that our math test contained six questions and the Math SAT contains about 50, this correlation is not especially low and seems to indicate that students' self-reported scores contain valid information.

We paid all participants $5 in cash for their participation immediately at the completion of the

[22] We actually conducted the study with Harvard College students before the study with Chilean high school students. We discuss them in reverse order for expositional reasons. To make sure that analogous parts of the questionnaires from the two studies were comparable, those parts were translated from the Harvard questionnaire by a native Spanish speaker from Santiago. To be sure that the translation was accurate, we asked a different native Spanish speaker to back-translate the questionnaire into English. The back-translated questionnaire closely matched the original.

session. We also paid participants (by check) for their choices so that our preference-elicitation procedures were incentive-compatible. As described below, for some sections we paid participants immediately after the experiment. For other sections, we mailed checks to participants within a week of their participation.

Small-Stakes Risk Preference. The procedure for measuring risk preferences was the same as in the Chile study. Each question offered the choice between \$0.50 for sure and a gamble that gave a 50% chance of winning \$0 and a 50% chance of winning X, where X took the values \$0.95, \$1.05, \$1.15, \$1.25, and \$1.35. We gave participants an example question in the instructions and the opportunity to ask questions. Participants had 15 seconds to answer the five questions. 51 out of 60 gave monotonic responses, choosing (A) below some threshold value of X and (B) above it. Seventeen participants behaved in a way that is consistent with perfect risk-neutrality, rejecting the bet for $X = \$0.95$ and accepting the bet for all other values of X.

Participants knew from the instructions that after they made a selection for each question, we would roll a die five times to determine their payment for this section. We asked a participant to roll the die to maximize our credibility. We paid participants for this section in the check that we mailed within a week of the participant's participation.

Short-Term Time Preference. We measured time preferences the same way as in the Chile study. After an example question and an opportunity to ask the experimenter about the instructions, participants chose between \$5.00 today and X a week from now, where X was \$5.05, \$5.35, \$5.55, \$5.75, \$5.95, and \$6.15. We ordered the questions this way to make salient the strategy of choosing (A) (the immediate payoff) for small X and (B) (the delayed payoff) for large X. As it turned out, 53 out of 60 participants chose (A) below some threshold value of X and (B) above it. Among the 57 participants for whom SAT scores are available, 6 did not answer all of the time preference questions (5 of whom were subjected to cognitive load, described below). These participants have been omitted from our analysis.[23]

After giving participants 15 seconds to answer the six questions, we asked a participant to roll the die that would select the question to be implemented. The instructions explained that participants would receive a check to pay them for this section. That check would be post-dated by a week if the participant had chosen (B) for the relevant question. We gave participants their check immediately after the session.

Fairness Preference. In order to test whether cognitive ability is related to more *normative*

[23] The conclusion that cognitive load does not significantly reduce measured time preference is robust to including these participants and coding them as non-patient.

preferences, we included a placebo Dictator Game section. Since there is no generally-accepted normative standard for fairness behavior, we did *not* expect to find a relationship between cognitive ability and Dictator Game giving. We informed participants that they had been randomly assigned to another participant in the same session, but that no one would ever find out who had been assigned to whom. Moreover, to rule out simple reciprocity concerns, the experimenter made it clear that the other person had, in turn, been assigned to a different participant. As a result, each participant would affect the payoff of another participant but would not be affected by that other participant.

Participants were told they had been given \$1.00, and they had the opportunity to give away \$0.00, \$0.25, \$0.50, \$0.75, or \$1.00 to another participant. Participants were given 15 seconds to make a decision.

Idiosyncratic Preference. As a second placebo section, we asked participants five binary preference questions that have no normative standard. To maximize power, we chose questions for which we anticipated that roughly half the participants would choose each option. We asked them whether they preferred chocolate or coffee ice cream, red or silver-colored cars, cats or dogs as pets, Pepsi or Coke to drink, and Butterfinger or Kit Kat as a candy to eat. We informed participants that they would actually receive their preferred candy as part of their payment.

Cognitive Load Manipulation. In order to understand the causal mechanism behind the correlation between cognitive ability and normative behavior, we subjected half the participants to "cognitive load" during each section of the questionnaire. During each of the preference-elicitation sections of the questionnaire and during the SAT-like math questions, participants heard a CD of piano notes while they filled out the section. In each section, half the participants were required to remember the number of times they heard a specific sequence of musical tones. The sequence to be remembered varied across questionnaires. To incentivize participants in the cognitive load condition to pay attention to the tones, we made payment for that section contingent on correct recall of the number of repetitions of the sequence of tones.

4 Cognitive Ability and Anomalous Preferences

In this section, we ask whether expressed risk and time preferences are related to cognitive ability. To address this issue, we focus on our sample of Chilean high school seniors, whose standardized test scores range from the 45th percentile to the 99th percentile (conversions from raw scores to population percentiles based on Universidad de Chile, 2004). For each participant, we calculated the average score on the math and verbal sections of the five practice PSU exams for which we have data. We then standardized these measures by dividing each by the standard deviation in the entire Chilean test-taking population so that coefficients can be interpreted as marginal effects of a one-standard-deviation increase in the independent variable.[24]

Small-Stakes Risk Preference. Column (1) of Panel A of Table 2 presents probit estimates of the effects of mathematical ability on the participant's propensity to display perfect risk-neutrality. Coefficients can be interpreted as marginal effects evaluated at the mean of the independent variables. We estimate that a one-standard-deviation increase in measured mathematical ability is associated with a 14 percentage point greater likelihood of risk-neutrality, a statistically and economically significant effect given the base rate of 11%.

Column (2) presents joint estimates of the effects of mathematical and verbal ability. Because the two are highly related (with a correlation coefficient of 0.46), it is difficult to separately identify the effects of each of these measures. The point estimates do suggest that mathematical ability plays a larger role, although the large standard errors on the effect of verbal ability make it impossible to statistically reject the equality of these coefficients.

In column (3) we investigate whether including controls for some obvious confounds reduces the estimated importance of cognitive ability. The individuals in our sample are similar in age and have mostly been in the same school for their entire lives; thus many important sources of heterogeneity are not present in this group. Nevertheless there are some measurable demographic differences among these students that we can control for. First, we include a dummy for gender (about 63 percent of our sample is male). We find that males are slightly more likely to behave risk-neutrally, but the point estimate is small and statistically insignificant. Next, we include a dummy for whether the participant is over 17 years old, which is true for 37 percent of our sample (all but two of the over-17 participants are 18 years old). Older participants are slightly more likely to be risk-neutral, but again the effect is statistically insignificant.[25]

Perhaps most importantly, we include a control for the average income in dollars in the participant's municipality, as measured from the 2000 Chilean Census. We standardized this variable so an increase of one unit can be interpreted as an increase of one standard deviation in municipal average income.[26] Though crude, this proxy for income has a statistically significant positive

[24] Appendix Table 1 shows that our results are similar when we use ordered probit models with categorical measures of the number of risk-neutral or patient choices made by the subject as the dependent variables.

[25] Results are also robust to including a dummy for whether a respondent has chosen a quantitative (high school) major.

[26] For the five participants with unavailable data on income in municipality, we impute their income at the sample mean. Results are robust to dropping these observations.

correlation of 0.22 with a participant's math score ($p = 0.03$). Nevertheless, we find it corresponds *negatively* to the propensity to be risk-neutral. The estimate is fairly precise—we have enough power to strongly reject positive effects of income that are on the same order of magnitude as the effect of mathematical ability.

The inclusion of these controls results in an increase in the estimated effect of mathematical ability. While we cannot include the detailed controls possible in the NLSY, the homogeneity of the sample population and the fact that our proxy for income enters negatively in the determination of risk-neutrality lend credence to the view that mathematical ability is important even among a group of respondents who are similar along other dimensions.

Short-Term Time Preference. Results are similar when we examine the relationship between cognitive ability and patience in columns (4) through (6). As column (4) shows, there is an economically large and statistically significant positive effect of mathematical ability on the propensity to display perfect patience. A one-standard-deviation increase in mathematical performance raises the propensity to be patient by 18 percentage points, relative to a base of 28%. The model in column (5) estimates the effects of mathematical and verbal ability jointly. As with risk preference, there is insufficient power to distinguish the effects statistically, but the point estimates indicate a much larger effect of mathematical ability than of verbal ability.

In column (6) we include our set of demographic controls. We find that male participants are slightly less patient and older participants are slightly more patient. We also find that participants from richer municipalities are more likely to be patient than those from poorer municipalities, but the differences are statistically insignificant despite being reasonably precisely estimated. Including these controls roughly doubles the goodness-of-fit of the model and *increases* the estimated coefficient on mathematical ability, again providing some confidence that omitted characteristics cannot fully explain our findings.[27]

Correlation between risk and time preferences. The low R^2's in our models indicate that cognitive ability explains only a small share of the variation in expressed preferences. Of course, this may be due in part to measurement error in our preference measures.[28] However, cognitive ability may still explain much of the correlation *between* expressed risk attitudes and time preference. In our sample, the correlation between a dummy for perfect patience and a dummy for perfect

[27] Participants with higher measured cognitive ability are somewhat (but not statistically significantly) less likely to choose the middle option for both the risk and time preference questions, consistent with Stanovich's (1999) finding that people with higher ability are less susceptible to framing effects. Nonetheless, the results are similar when participants who chose the middle option are dropped from the analysis.

[28] But see Cutler and Glaeser (2005), who argue that the share of variation explained by individual-specific factors is small in general.

risk-neutrality is only 0.1075. After regressing both dummy variables on mathematical ability and extracting residuals, the correlation between the residuals drops to 0.0092. Thus, to the extent that these two preferences are driven by a common mechanism, cognitive ability seems to explain most of the variance in that mechanism.

5 Robustness

In this section, we describe a number of tests of the robustness of our basic finding. First, we address reverse causality concerns using data on early-life achievement to proxy for long-standing differences in cognitive ability. Next, we ask whether our results are specific to preferences with a non-normative or anomalous character, or whether all types of preferences seem to be correlated with cognitive ability. We find that behaviors, such as Dictator Game giving, that do not violate standard decision theory are not related to cognitive ability, suggesting that our claims may indeed be specific to anomalous or "non-normative" behaviors.

5.1 Early-life Achievement and Reverse Causality

Thus far we have shown that individuals with greater measured cognitive ability are more risk-neutral over small-stakes gambles and more patient over short-run trade-offs than those with less cognitive ability. We have argued that these findings are not likely to be due simply to differences in socioeconomic status or schooling quality. A remaining concern is that the estimates result from reverse-causality—i.e., that patient individuals are more likely to invest in acquiring cognitive skills. On this view, heterogeneity in time preferences is driving heterogeneity in cognitive ability, rather than vice versa. It is not clear how this view explains the relationship between cognitive ability and risk preferences, or the fact that cognitive ability explains most of the correlation between time and risk preferences. Nonetheless, we address the reverse-causality concern in this subsection by showing that, in our sample of Chilean high school seniors, differences in cognitive ability arising early in life are strongly predictive of decision-making later on. While this fact does not completely rule out the reverse-causality explanation, it does mean that any differences in investment in cognitive skills arising from differences in time preference must have occurred at very young ages.

To measure early-life achievement we calculate for each student the mean grade point average (GPA) in mathematics and language over all years in elementary school.[29] Among the 84 partic-

[29] We follow Wolff, Schiefelbein and Schiefelbein (2002) in defining elementary school to consist of grades 1 through 6. Results are similar when we define elementary school as consisting of grades 1 through 5.

ipants for whom these data are available, the correlation between the average elementary-school GPA in mathematics and our measure of current mathematical ability is 0.65. The analogous correlation between GPA in language and verbal ability is 0.57. Thus early-life achievement is strongly, but not perfectly, related to cognitive ability as measured in grade 12.

Table 3 shows the results of probit models of risk-neutral and patient decision-making as a function of elementary-school achievement. We have standardized the independent variables so that a one-unit increase can be interpreted as an increase of one sample standard deviation. As the first column shows, a one-standard-deviation increase in elementary-school mathematics GPA is associated with a 9% greater probability of making risk-neutral choices. This effect is both statistically significant and economically large, although it is somewhat smaller than the estimated effect of cognitive ability estimated in Table 2. Again consistent with the prior evidence, column (2) includes measures of both mathematics and language GPA and suggests that the effects of mathematical achievement are greater than those of achievement in language. Columns (4) and (5) report similar results on the relationship between early-life achievement and impatience: Mathematical achievement has a statistically significant and economically large effect, and the effects of language achievement are smaller and statistically weaker. As columns (3) and (6) show, when we include both early-life and current ability measures in the model, the effects of the two are similar in magnitude and statistically indistinguishable.

The relationship between current preferences and early-life cognitive ability is similar to the relationship between current preferences and contemporaneously-measured ability. This does not conclusively reject all reverse-causality explanations, but it does imply that skills acquired endogenously during middle and secondary schools are not responsible for our finding of a relationship between measured preferences and cognitive ability.

5.2 Is the Relationship Specific to Anomalous Preferences?

We have shown evidence of a correlation between cognitive ability and preferences that are anomalous with respect to standard models of decision-making. But we have not demonstrated that this correlation arises *because* these preferences are anomalous. Indeed, it is possible that cognitive ability is correlated with all sorts of preferences, not merely those that violate the normative principles of decision theory. In this subsection we provide preliminary evidence against this view, drawing on our laboratory study of Harvard undergraduates. In particular, we will argue that in this sample the relationship between cognitive ability and anomalous preferences—namely, small-stakes risk aversion and short-run time preference—is much stronger than that with preferences that have no normative benchmark, such as Dictator Game giving.

Our primary measure of cognitive ability is the participant's Math SAT score. Participants' Math SAT scores were all between 600 and 800, with a mean of about 750 and a median of 760. Almost a quarter of our respondents reported a perfect score of 800. The nationwide average Math SAT score was about 500 during the time period in which our participants took the exam (College Board, 2001), suggesting that our sample of Harvard undergraduates is not representative of the general population. Since we are only observing the upper tail of the distribution of scores, our sample selection is likely to bias us against finding evidence of a role for cognitive ability in determining preferences. Since the distribution of Math SAT scores is highly non-normal, we conduct our analysis by comparing participants with below-median Math and Verbal SATs to participants with above-median scores.[30]

Table 4 shows the results of a probit analysis of the relationship between SAT scores and measured preferences. Column (1) confirms the result from the Chile study that individuals with greater mathematical ability are more likely to express risk-neutral preferences. We find that participants with above-median Math SAT scores have a 24 percentage point greater chance of behaving risk-neutrally, which is economically large and statistically significant at the 10% level.[31] In column (2) when we include measures of both Math and Verbal SAT score, the estimated effect of an above-median Math SAT score increases and becomes significant at the 5% level, whereas we find a statistically insignificant negative effect of having an above-median Verbal SAT score. As in our Chile study, then, mathematical ability seems to play a greater role than verbal ability in determining expressed preferences. Our estimates in columns (3) and (4) of the effect of SAT scores show positive (though not quite statistically significant) effects of mathematical ability on patience and a small and insignificant negative effect of verbal ability. These results are less precise than the analogous findings in the Chile study, possibly due to smaller sample sizes and a smaller amount of variation in cognitive ability. Nevertheless, our study of Harvard undergraduates broadly confirms the finding that more cognitively able individuals are more likely to be patient over short time

[30] When we instead use specifications that are linear in SAT score, the estimated coefficients are comparable in sign and magnitude, but less statistically precise and in general not statistically distinguishable from zero.

[31] To address the possibility that these results arise from differences in participants' ability to compute expected values rather than differences in intended choices, we conducted a follow-up Internet survey in which we asked a sample of Harvard undergraduates to select the option on the questionnaire with the highest expected value. Roughly 90 percent answered all five questions correctly, as compared to the 30 percent who chose the risk-neutral option in our laboratory study. In a hypothetical version of our risk-aversion questionnaire, the relationship between risk-neutrality and math SAT scores is only slightly weaker among those who answered the expected value questions perfectly than in the full sample, although the risk aversion data are noisier than in our laboratory study (possibly due to the hypothetical stakes).

horizons and risk-neutral over small stakes.[32]

We turn next to a behavior that does not constitute an anomaly from the perspective of normative decision theory: giving in the Dictator Game. If the relationship between preferences and cognitive ability is specific to preferences with a normative character, we should not observe a relationship with cognitive ability in this case. As columns (5) and (6) show, we indeed find no evidence of a relationship between Math SAT score and "selfishness" (defined as keeping 100% of the dollar available for splitting). (We also find no relationship between cognitive ability and our incentivized idiosyncratic preference—choice of Kit Kat vs. Butterfinger candy bar.)[33] The point estimate indicates that more cognitively able individuals are slightly less likely to behave selfishly, but this estimate is statistically indistinguishable from zero. We should note that small samples mean that our power to reject non-zero alternatives is limited in this case, so we cannot say with confidence that there is *no* relationship between Dictator Game behavior and cognitive ability. Nevertheless, the findings from this exercise are at least consistent with the hypothesis that the relationship with cognitive ability is strongest for preferences that violate a normative benchmark.[34]

6 Evidence on Causal Mechanisms

In this section, we address the question of why individuals with greater cognitive ability express greater risk-neutrality and patience. We test two competing hypotheses. One hypothesis is that greater cognitive resources make an individual more able to make the optimal choice in a particular decision problem. In that view, cognitive ability measures the quantity of scarce attentional

[32] As in our study of Chilean high school students, the correlation between risk-neutrality and patience is small (0.0698) and shrinks to nearly zero once we condition on Math SAT. We also find that the Harvard sample displays more patient and risk-neutral behavior on averge than the Chile sample, consistent with differences in average cognitive ability between the two groups.

[33] There is no statistically significant relationship between Math SAT score and choices in three of our four other, hypothetical idiosyncratic preferences. The sole exception is that individuals with higher Math SAT scores are statistically more likely to prefer cats over dogs as pets. Neither of us interprets this to mean that cats are better than dogs.

[34] The Dictator Game data also suggest that the differences in behavior across cognitive ability levels are *not* due to differences in choice bracketing. If an agent brackets broadly, the agent will virtually always choose to give away \$0.00 or \$1.00 in the Dictator Game, regardless of his preferences over allocations. The agent will virtually never make the "fair" choice of \$0.50. Broad bracketing means that the agent recognizes that his choice will only incrementally affect the total allocation of wealth between himself and the other person. If he has any reason whatsoever to believe that he is less wealthy than the other person by at least \$1.00, then he will promote equality of payoffs by allocating \$0.00 to the other person. On the other hand, if he somehow thinks that he is more wealthy by at least \$1.00, then the "fair" decision is to allocate \$1.00 to the other person. They *only* case in which a broadly bracketing agent who cared about fairness would consider giving \$0.50 is if he thought the his total wealth differed from the other person's by less than \$1.00—a vanishingly small possibility (Read, Loewenstein, and Rabin, 1999). If more cognitively able individuals bracket more broadly, then we should observe that they are more likely to give away \$0.00 or \$1.00 (rather than \$0.50) in the Dictator Game. In fact, we find a small and statistically insignificant negative relationship between cognitive ability and the propensity to choose an "extreme" allocation. These results suggest that the differences in behavior between more and less cognitively skilled individuals may not be due to differences in bracketing.

resources available for budgeting to alternative uses. Individuals with a larger cognitive budget can more easily allocate resources to finding the most preferred choice or to suppressing non-normative impulses. An alternative hypothesis is that individuals with greater cognitive ability have superior automatic procedures for making decisions, possibly as a result of learning.

To distinguish between these hypotheses, we discuss the results of our cognitive load manipulation. By distracting attention away from the main task, cognitive load reduces the cognitive resources available to participants for that task (e.g., Gilbert and Silvera, 1996). If cognitive resources are important for making an optimal choice, then participants under cognitive load should make less normative choices than participants whose cognitive resources have not been taxed. On the other hand, if participants' risk preference and time preference behavior is driven by automatic procedures, then cognitive load should not affect behavior.

Before estimating the impact of cognitive load on expressed preferences, it is important to verify that our cognitive load manipulation successfully interfered with controlled processing. As a manipulation check we examined performance on our six-question battery of SAT-like math questions. Column (1) of Table 5 shows the results of a comparison of scores on this test (total number correct) across cognitive load conditions. As the table shows, cognitive load reduced the number of questions a participant answered correctly by about .7 on average, and a Mann-Whitney test rejects the null of no effect at the 10% level ($p = .080$). This suggests that our manipulation was successful in reducing the amount of resources a participant had available for conscious processing.[35]

Column (2) of Table 5 presents a test of the effect of cognitive load on measured risk-neutrality. We find no evidence that a reduction in cognitive resources makes a participant less likely to be risk-neutral. Indeed, if anything cognitive load *increases* the propensity to be risk-neutral in our sample, although the effect is not statistically distinguishable from zero. In column (3) we turn to the effect of cognitive load on expressed time preference. Participants under cognitive load were slightly (and statistically insignificantly) *more* likely to behave patiently in our study. This is not consistent with a model in which individuals use scarce cognitive resources to determine (or implement) the patient action.[36] Finally, column (4) shows that cognitive load did not have a

[35] Additional tests (not shown) confirm that the cognitive load manipulation was successfully randomized—we find no evidence of a correlation between cognitive load and SAT score, gender, or year in school.

[36] Our finding of no effect of cognitive load on time preference appears to conflict with those of Shiv and Fedorikhin (1999), who found that cognitive load made people more likely to choose chocolate cake rather than fruit salad (see also Hinson, Jameson, and Whitney, 2002). However, when participants saw photographs of the desserts rather than the actual desserts before making a choice, the effect of cognitive load on choice disappeared. A possible reconciliation of our results is that more cognitively able individuals have better instinctual responses, but in the presence of vividly tempting choices, impulse-suppressing cognitive resources also become important (see, e.g., Loewenstein and Lerner, 2002).

statistically significant effect on Dictator Game behavior.[37]

Overall, we find no support for the hypothesis that cognitive load reduces participants' expressed risk-neutrality or patience.[38] Of course, we have implemented only one of several possible cognitive load manipulations, so further work is needed to confirm the robustness of our finding.[39] But taking these results at face value, we tentatively conclude that differences in decision-making between high- and low-cognitive ability individuals result from differences in instincts or heuristics rather than from differences in instantaneous access to cognitive resources.

7 Conclusions

This paper showed that two fundamental deviations from normative decision theory—short-term discounting and small-stakes risk-aversion—are less common among more cognitively able individuals. Results from the NLSY showed that individuals with greater cognitive ability are less likely to display behaviors that have been associated with these anomalous preferences, even controlling for income and family fixed-effects. Evidence from two laboratory studies indicated that higher cognitive ability is associated with lower levels of measured short-run discounting and small-stakes risk-aversion.

So who is "behavioral"? We find that the more cognitively skilled are less biased. We therefore conclude that behavioral biases are likely to be especially important in contexts where individuals with low cognitive ability carry the most weight. Yet we also find that the most cognitively skilled are far from fully normative decision-makers. For example, in our study of Harvard undergraduates, only 36 percent of those scoring a perfect 800 on the Math SAT are risk-neutral, and only 67 percent are perfectly patient. Therefore sorting on cognitive ability alone seems unlikely to completely eliminate the effects of anomalous preferences.

[37] For all preference measures, at least 48 percent of participants got the cognitive load question right; that is, they correctly identified the number of tone sequences they had heard. When we restrict attention to participants who answered the cognitive load question correctly, we continue to find no evidence of an effect of cognitive load on preferences. Additionally, in all cases except the Dictator Game, we find that participants with above-median math SAT scores were more likely to get the cognitive load question right; this relationship is statistically significant in the case of the math quiz and the risk aversion elicitation. This provides further evidence that the cognitive load exercise required cognitive resources to complete.

[38] One potential concern with this finding is that the cognitive load manipulation also affected participants' expected payments, which could have had direct effects on patience. However evidence suggests that discount rates are if anything larger for smaller rewards (Loewenstein and Prelec, 1992), which would cause cognitive load to decrease measured patience. It therefore does not seem likely that our findings are driven by this confound.

[39] In pilot tests with Harvard students, we tried two other cognitive load procedures. We required participants to remember seven-digit numbers (as in Shiv and Fedorikhin, 1999, and Hinson, Jameson, and Whitney, 2002), and we also tried playing musical tones at a slower pace than in the actual experiment. Neither of these manipulations influenced the preferences we measured.

As a first step towards understanding why cognitive ability is correlated with more normative decision-making, we also explore the effect of an experimental reduction in cognitive resources on expressed preferences. We find that experimentally reducing available cognitive resources does *not* lead to more impatient or risk-averse behavior, casting doubt on the view that the different choices of the more cognitively able result from access to a greater budget of cognitive resources for conscious processing. The evidence therefore seems most consistent with the hypothesis that more cognitively able individuals have or develop superior heuristics (or intuitive judgments) for addressing choice problems. How individuals develop and employ such decision rules is an important topic for future research.

Our results also suggest that the overall returns to cognitive ability may be underestimated considerably by focusing solely on the labor market returns, since cognitive ability also contributes to improved consumption and financial decision-making.[40] For example, we calculate that, in a portfolio choice problem, an investor with standard expected utility preferences would be willing to give up about 5% of lifetime wealth in order to avoid having her investment decisions made in accordance with myopic loss-aversion.[41] Evidence presented in Appendix Table 2 suggests that an increase of one standard deviation in measured cognitive ability corresponds to a 10 percentage point decrease in the probability of loss aversion. Hence, if this coefficient can be interpreted as causal, we might conjecture that a one-standard-deviation increase in cognitive ability is worth about 0.5% of lifetime wealth due to improved portfolio allocation alone.[42] Since portfolio choice is only one of many important household decisions that are affected by cognitive ability, the total value of cognitive ability's effect on decision-making could be quite substantial. Though crude, such calibrations also suggest that our results may have potentially important policy implications. To the extent that education can increase cognitive ability (Cascio and Lewis, 2005), human capital policy may be an important tool for addressing biases in decision-making in a wide range of contexts.

[40] See also Haveman and Wolfe (1984), who estimate non-labor-market returns to years of schooling.

[41] We assume a constant coefficient of relative risk aversion $\rho = 5$, an exponential discount rate $\gamma = 0.08$, and log-normal portfolio returns in an infinite-horizon model. We use Campbell and Viceira's (2002, p. 104) estimates of equity and bond returns and Benartzi and Thaler's (1995) calculation that a loss-averse investor would hold around 40% equities. Details are available from the authors upon request.

[42] For comparison, Cawley, Heckman, and Vytlacil (2001) estimate that a one-standard-deviation increase in cognitive ability corresponds to an increase in wages of 10-16%.

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Table 1 *Behavior and Cognitive Ability in the NLSY*

	Controls	Dependent variable is dummy for...			
		Positive net assets	Smoking	Obesity	Financial market participation
(1)	Baseline	0.5106	-0.2453	-0.1214	0.4943
		(0.0109)	(0.0141)	(0.0092)	(0.0134)
		$R^2 = 0.10$	$R^2 = 0.03$	$R^2 = 0.07$	$R^2 = 0.13$
(2)	Income	0.2060	-0.0879	-0.0879	0.2939
	(1979-2000)	(0.0128)	(0.0178)	(0.0110)	(0.0162)
		$R^2 = 0.17$	$R^2 = 0.06$	$R^2 = 0.07$	$R^2 = 0.19$
(3)	Income	0.1481	-0.1270	-0.0305	0.2200
	+ Sibling group	(0.0267)	(0.0402)	(0.0227)	(0.0421)
		$R^2 = 0.44$	$R^2 = 0.65$	$R^2 = 0.50$	$R^2 = 0.62$
(4)	Income				
	+ Sibling group				
	Math	0.1740	-0.1296	-0.0422	0.0919
	percentile	(0.0294)	(0.0439)	(0.0234)	(0.0406)
	Verbal	0.0047	-0.0291	0.0082	0.1321
	percentile	(0.0320)	(0.0497)	(0.0254)	(0.0461)
		$R^2 = 0.44$	$R^2 = 0.65$	$R^2 = 0.50$	$R^2 = 0.62$
Mean of dep. var.		0.6609	0.2796	0.1559	0.1961
No. of observations		59166	24026	128934	15560
No. of respondents		10390	8828	11828	8293
No. of sibling groups		7419	6202	8661	5922

Notes: Data from NLSY. Standard errors in parentheses are clustered by individual. AFQT score is a percentile ranging from 0.01 to 0.99. Math score is the sum of performance on the arithmetic reasoning, numerical operations, and mathematical knowledge sections of the ASVAB, expressed as a percentile in sample distribution. Verbal score is the sum of performance on the word knowledge and paragraph comprehension sections of the ASVAB, expressed as a percentile in sample distribution. All specifications include a dummy for gender, dummies for age in 1979, and dummies in survey year. Income controls include controls for log of family income for all available years of data, 1979-1998, with dummies for missing values. Asset accumulation variable available for 1990, 1992, 1993, 1994, 1996, 1998, and 2000. Smoking variable available for 1992, 1994, and 1998. Obesity variable available for 1981, 1982, 1985, 1986, 1988, 1989, 1990, 1992, 1993, 1994, 1996, 1998, 2000, and 2002. Financial market variable participation available for 1998 and 2000.

Table 2 *Preferences and Cognitive Ability: Chilean High School Students*

Dependent variable	Risk neutral (dummy)			Patient (dummy)		
	(1)	(2)	(3)	(4)	(5)	(6)
Standardized math score	0.1358	0.1237	0.1457	0.1804	0.1665	0.2406
	(0.0489)	(0.0535)	(0.0554)	(0.0831)	(0.0933)	(0.0937)
Standardized verbal score		0.0326			0.0389	
		(0.0710)			(0.1238)	
Male			0.0121			-0.1315
			(0.0695)			(0.1154)
Age>17			0.0488			0.2043
			(0.0694)			(0.1077)
Income in municipality			-0.0319			0.0544
(standardized)			(0.0311)			(0.0510)
Mean of dependent variable	0.1087	0.1087	0.1087	0.2826	0.2826	0.2826
Pseudo-R^2	0.1480	0.1513	0.1785	0.0444	0.0453	0.0887
N	92	92	92	92	92	92

Notes: Standard errors in parentheses. Data are from laboratory study of Chilean high school students in grade 12. Demographics include dummies for gender, age, and municipality of residence. Risk neutral indicates that participant made six decisions of the following form in a way consistent with expected-value maximization:

Please circle either Choice A or Choice B.

(A) You get 250 pesos for sure.

(B) If the die comes up 1, 2, or 3, you get X. If the die comes up 4, 5, or 6, you get nothing.

Patient indicates that participants made six decisions of the following form in a way consistent with the maximization of undiscounted wealth:

Please circle either Choice A or Choice B.

(A) You get 500 pesos right now.

(B) You get X a week from now.

Test scores standardized by the population standard deviation. Average GPA in elementary school (grades 1-6) standardized by sample standard deviation.

Table 3 *Preferences and Early-life Achievement: Chilean High School Students*

Dependent variable	Risk neutral (dummy)			Patient (dummy)		
	(1)	(2)	(3)	(4)	(5)	(6)
Standardized math GPA	0.0854	0.0816	0.0540	0.1481	0.1371	0.1218
(elementary school)	(0.0326)	(0.0416)	(0.0423)	(0.0560)	(0.0711)	(0.0713)
Standardized language GPA		0.0053			0.0154	
(elementary school)		(0.0363)			(0.0621)	
Standardized math score			0.0698			0.0705
(current)			(0.0654)			(0.1197)
Mean of dependent variable	0.1059	0.1059	0.1059	0.2824	0.2824	0.2824
Pseudo-R^2	0.1171	0.1175	0.1391	0.0742	0.0748	0.0777
N	85	85	85	85	85	85

Notes: Standard errors in parentheses. Data are from laboratory study of Chilean high school students in grade 12. Demographics include dummies for gender, age, and municipality of residence. Risk neutral indicates that participant made six decisions of the following form in a way consistent with expected-value maximization:

Please circle either Choice A or Choice B.

(A) You get 250 pesos for sure.

(B) If the die comes up 1, 2, or 3, you get X. If the die comes up 4, 5, or 6, you get nothing.

Patient indicates that participants made six decisions of the following form in a way consistent with the maximization of undiscounted wealth:

Please circle either Choice A or Choice B.

(A) You get 500 pesos right now.

(B) You get X a week from now.

Test scores standardized by the population standard deviation. Average GPA in elementary school (grades 1-6) standardized by sample standard deviation.

Table 4 : *Preferences and Cognitive Ability: Harvard Undergraduates*

Dependent variable	Risk neutral (dummy)		Patient (dummy)		Selfish (dummy)	
	(1)	(2)	(3)	(4)	(5)	(6)
Math SAT $\geq$ median	0.2446	0.2951	0.2549	0.2615	-0.1635	-0.1295
	(0.1222)	(0.1317)	(0.1522)	(0.1569)	(0.1421)	(0.1495)
Verbal SAT $\geq$ median		-0.1333		-0.0252		-0.1244
		(0.1335)		(0.1499)		(0.1468)
Male	0.1512	0.1279	-0.2136	-0.2158	-0.3548	-0.3781
	(0.1395)	(0.1407)	(0.1582)	(0.1586)	(0.1378)	(0.1387)
Year in school (1-4)	0.0710	0.0771	0.0817	0.0812	-0.1493	-0.1583
	(0.0715)	(0.0720)	(0.0847)	(0.0848)	(0.0827)	(0.0846)
Mean of dependent variable	0.2982	0.2982	0.5294	0.5294	0.4912	0.4912
Pseudo-R^2	0.0809	0.0952	0.0635	0.0639	0.1090	0.1180
N	57	57	51	51	57	57

Notes: Standard errors in parentheses. Data are from laboratory study of Harvard undergraduates. Risk neutral indicates that participant made six decisions of the following form in a way consistent with expected-value maximization:

Please circle either Choice A or Choice B.

(A) You get \$0.50 for sure.

(B) If the die comes up 1, 2, or 3, you get X. If the die comes up 4, 5, or 6, you get nothing.

Patient indicates that participant made six decisions of the following form in a way consistent with the maximization of undiscounted wealth:

Please circle either Choice A or Choice B.

(A) You get \$5.00 right now.

(B) You get X a week from now.

Selfish indicates that participant kept 100% of sum available for transfer to other participant in Dictator Game.

Data on SAT scores based on participants' self-reports. Median refers to sample median. Demographics include dummies for gender and year in school.

Table 5 : *Preferences and Cognitive Resources: Harvard Undergraduates*

	Math score (0-6) (1)	Risk neutral (dummy) (2)	Patient (dummy) (3)	Selfish (dummy) (4)
Mean for condition:				
No cognitive load	3.10	0.2424	0.5000	0.3704
Cognitive load	2.40	0.3704	0.5185	0.5455
Test	Mann-Whitney	Fisher exact	Fisher exact	Fisher exact
p-value	0.080	0.397	1.000	0.203
N	60	60	53	60

Notes: Standard errors in parentheses. Data are from laboratory study of Harvard undergraduates. Risk neutral indicates that participant made six decisions of the following form in a way consistent with expected-value maximization:

Please circle either Choice A or Choice B.

(A) You get $0.50 for sure.

(B) If the die comes up 1, 2, or 3, you get X. If the die comes up 4, 5, or 6, you get nothing.

Patient indicates that participants made six decisions of the following form in a way consistent with the maximization of undiscounted wealth:

Please circle either Choice A or Choice B.

(A) You get $5.00 right now.

(B) You get X a week from now.

Selfish indicates that participant kept 100% of sum available for transfer to other participant in Dictator Game.

Data on SAT scores based on participants' self-reports. Median refers to sample median. Demographics include dummies for gender and year in school.

Appendix Table 1 *Preferences and Cognitive Ability: Ordered Probit Estimates*

Dependent variable	Number of risk-neutral choices			Number of patient choices		
	(1)	(2)	(3)	(4)	(5)	(6)
Parameter estimates:						
Standardized math score	0.5355	0.4138	0.6380	0.3720	0.2577	0.5738
	(0.2086)	(0.2305)	(0.2408)	(0.2008)	(0.2260)	(0.2292)
Standardized verbal score		0.3468			0.3030	
		(0.2888)			(0.2855)	
Average marginal effects:						
Standardized math score	0.5055	0.3868	0.5990	0.4594	0.3157	0.6906
Standardized verbal score		0.3242			0.3712	
Demographics?	No	No	Yes	No	No	Yes
Mean of dependent variable	3.4565	3.4565	3.4565	4.5000	4.5000	4.5000
Pseudo-R^2	0.0268	0.0325	0.0310	0.0120	0.0158	0.0273
N	92	92	92	92	92	92

Notes: Data are from laboratory study of Chilean high school students in grade 12. Demographics include dummies for gender and age and standardized per capita income in municipality of residence. Number of risk-neutral choices counts the number of choices of the following form made in a way consistent with expected-value maximization:

Please circle either Choice A or Choice B.

(A) You get 250 pesos for sure.

(B) If the die comes up 1, 2, or 3, you get X. If the die comes up 4, 5, or 6, you get nothing.

Number of patient choices counts the number of decisions of the following form made in a way consistent with the maximization of undiscounted wealth:

Please circle either Choice A or Choice B.

(A) You get 500 pesos right now.

(B) You get X a week from now.

Test scores standardized by the population standard deviation.

Appendix Table 2 *Loss Aversion and Cognitive Ability*

Dependent variable		Loss-neutral			Number of loss-neutral choices	
Model		Probit			Ordered probit	
	(1)	(2)	(3)	(4)	(5)	(6)
Parameter estimates:						
Standardized math score	0.1013	0.1184	0.0908	0.4189	0.4503	0.4486
	(0.0490)	(0.0575)	(0.0538)	(0.2051)	(0.2327)	(0.2334)
Standardized verbal score		-0.0505			-0.0849	
		(0.0777)			(0.2942)	
Average marginal effects:						
Standardized math score	—	—	—	0.2930	0.3148	0.3122
Standardized verbal score		—	—		-0.0594	
Demographics?	No	No	Yes	No	No	Yes
Mean of dependent variable	0.1087	0.1087	0.1087	3.6087	3.6087	3.6087
Pseudo-R^2	0.0688	0.0755	0.0807	0.0200	0.0204	0.0234
N	92	92	92	92	92	92

Notes: Data are from laboratory study of Chilean high school students in grade 12. Demographics include dummies for gender and age and standardized per capita income in municipality of residence. Number of loss-neutral choices counts the number of choices of the following form made in a way consistent with expected-value maximization:

Please circle either Choice A or Choice B.

(A) You get 0 pesos for sure.

(B) If the die comes up 1, 2, or 3, you get X. If the die comes up 4, 5, or 6, you lose 250 pesos.

Loss neutrality indicates that all six choices were made in a way consistent with risk-neutral expected-value maximization. Test scores standardized by the population standard deviation.