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ABSTRACT

Are Risk Aversion and Impatience Related to Cognitive Ability?

Is the way that people make risky choices, or tradeoffs over time, related to cognitive ability? This paper investigates whether there is a link between cognitive ability, risk aversion, and impatience, using a representative sample of the population and incentive compatible measures. We conduct choice experiments measuring risk aversion, and impatience over an annual time horizon, for a randomly drawn sample of roughly 1,000 German adults. Subjects also take part in two different tests of cognitive ability, which correspond to sub-modules of one of the most widely used IQ tests. Interviews are conducted in subjects' own homes. We find that lower cognitive ability is associated with significantly more impatient behavior in the experiments, and with greater risk aversion. This relationship is robust to controlling for personal characteristics, educational attainment, income, and measures of credit constraints. We perform a series of additional robustness checks, which help rule out other possible confounds.

JEL Classification: C93, D01, D80, D90, J24, J62

Keywords: risk preference, time preference, cognitive ability, field experiment

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1 Introduction

Preferences and cognitive ability are usually assumed to be crucial determinants of economic decision-making. This is confirmed empirically by studies showing that individual measures of risk aversion and impatience predict a wide range of important economic outcomes,[1] and by the literature showing that higher cognitive ability is associated with better labor market outcomes.[2] Cognitive ability, risk aversion, and impatience are also typically thought of as independent traits. This assumption, however, has received relatively little attention in the empirical literature.

It could be true that risk aversion and impatience are unrelated to cognitive ability. On the other hand, it could be that cognitive ability does have an impact on the way that individuals make decisions over time, or decisions under risk. For instance, higher cognitive ability could facilitate an understanding of how individual risky choices aggregate to form a larger portfolio, or could facilitate the integration of present and future considerations in decision making. Another possibility is that cognitive ability proxies for the resources an individual has for resisting emotional impulses, such as fear of risks or an urge for immediate consumption. This explanation is in line with "two-system" models of decision making, which incorporate both cognitive reasoning and emotional impulses.[3] Alternatively, causality could even go the other way, such that patience or willingness to take risks affect an individual's accumulation of cognitive skills.

This paper tests whether risk aversion and impatience are related to cognitive ability. We use a sample of more than 1,000 adults living in Germany, randomly drawn so as to be representative of the population. Subjects made choices in paid experiments, which provide incentive compatible and controlled measures of risk aversion and impatience. The measure of risk aversion involved choices over real-stakes lotteries, and the measure of impatience involved making tradeoffs between payments available immediately and payments available in one year. Subjects also took two different tests of cognitive

[1] For example, see Barsky et al. (1997); Dohmen et al. (2005); Bonin et al. (2006); Grund and Sliwka (2006); Stango and Zinman (2006); Jaeger et al. (2007); Ventura (2003); Kirby and Petry (2004); Borghans and Golsteyn (2005); Eckel et al. (2005).

[2] See Herrnstein and Murray (1994); Murnane et al. (1995); Cawley et al. (2001); Bowles et al., (2001); Heckman et al. (2006).

[3] Examples include Thaler and Shefrin (1981); Metcalfe and Mischel (1999); Bernheim and Rangel (2004); Benhabib and Bisin (2005); Fudenberg and Levine (2006).

ability, each based on a different sub-module of one of the most widely used IQ tests. A questionnaire collected information on various personal and background characteristics, to serve as controls in the empirical analysis. The questionnaire and experiments were conducted in subjects' own homes.

Our main finding is that risk aversion and impatience are systematically related to cognitive ability. Individuals with higher cognitive ability are significantly more patient over the year-long time horizon studied in the choice experiments. Higher cognitive ability is also associated with significantly greater willingness to take risks in the lottery experiments. These results are robust to controlling for exogenous personal characteristics, such as age, gender, and height, which could be related to cognitive ability and could also have an impact on attitudes towards risk and intertemporal choice. The baseline results are also robust to using different estimation methods.

To further investigate the robustness of the main findings, we control for characteristics such as schooling, income, and credit constraints. Adding these controls helps address the question of whether there is a direct relationship between cognitive ability, risk aversion, and impatience, or whether cognitive ability is related to these traits only indirectly, through the channel of fostering greater educational attainment, or higher income. We find that the results are still strong when we include these additional controls, suggesting that cognitive ability does not operate solely through these indirect channels.

Another question is whether low cognitive ability could be unrelated to the traits of interest, but could cause people to have trouble understanding the incentives faced in our choice experiments, in a way that happens to look like, e.g., risk aversion. We check whether the results are robust to using a very simple survey question to measures willingness to take risks, for which there is little scope for such confusion. We find a significant relationship between cognitive ability and the survey measure of willingness to take risks, suggesting that the results based on the experimental measures are not due to confusion. A different concern arises in the case of the intertemporal choice experiment if people with higher cognitive ability adopt a strategy of arbitrage between high returns from the experiment and lower market interest rates. However, we asked subjects whether they thought about market interest rates during the experiment, and find that the relationship between cognitive ability and impatience is robust to excluding those individuals who thought about interest rates. We also find no indication that the baseline correlations are spurious, due to an impact of risk aversion or impatience on the way individuals take tests. For example, risk averse people might adopt an overly-cautious test-taking strategy, and impatient people might adopt an overly-hasty test-taking strategy. We find, however, that there is no significant relationship between these traits and error rates in our tests of cognitive ability.

An interesting question is whether measures of cognitive ability may partly proxy for personality traits measured by the "Big Five" scale from psychology, such as *conscientiousness*, rather than intelligence (Segal, 2006; Borghans et al., 2007). If this were the case, our results could be interpreted as showing a link between risk aversion, impatience, and personality traits studied in psychology, which would itself be an important finding. We do find that personality type is related to risk aversion and impatience in ways that are intuitive: openness to new experiences, and extroversion, are positively correlated with willingness to take risks, and impatience, respectively. Controlling for personality traits does not, however, eliminate the strong and significant correlation between test scores and risk aversion or impatience.

Finally, we explore whether the results for impatience could be explained by a link between cognitive ability and curvature of utility, rather than a direct relationship between cognitive ability and time preference. In the canonical case of Expected Utility Theory (EUT), greater concavity of utility can lead to more impatient choices, for the same annual discount rate. Given that we find greater risk aversion for people with lower cognitive ability, which is equivalent to concavity in EUT, this could potentially be a mechanism underlying the negative correlation between cognitive ability and impatience observed in the data. In other words, the link between cognitive ability and concavity could be doing double duty, explaining both the results on risk aversion and the results on impatience. This would not change the importance of our finding that people with low cognitive ability exhibit more impatient *behavior*, because of the important implications for investment decisions, but it would shed a different light on the underlying mechanism. In an empirical test, however, where we allow concavity to affect choices in the intertemporal choice experiment, we find very similar results to our baseline case. Thus, the evidence suggests that cognitive ability is in fact related to time preference, in the sense of an annual discount rate, a distinct mechanism from the link between cognitive ability and concavity of utility.

In summary, this paper documents a systematic relationship between cognitive ability, risk aversion, and impatience: people with higher cognitive ability are significantly more patient, and are significantly more willing to take risks. There are a number of previous studies, mainly from psychology, which have also explored these relationships.[4] The emerging picture from this interesting literature is supportive of our findings, although the evidence is somewhat mixed: some of these studies find that IQ measures or math SAT scores are positively related to patience, but other studies find no significant relationship. There are also two previous studies that look at risk as well as time preference; these find that higher cognitive ability leads to a greater tendency towards risk neutrality, or towards less risk averse behavior in general, respectively (see Benjamin et al., 2006, and Frederick, 2006, for evidence and a review of the literature). Different from this paper, the previous evidence has focused exclusively on young children or students as subjects (with the exception of the study by Monterosso et al., 2001, on impatience of cocaine addicts, which finds no relationship with cognitive ability). In most cases, findings are correlations without controls for important background characteristics such as education or income (for an exception see Benjamin et al., 2006), and in many cases measures of risk aversion and impatience are not incentive compatible. In addition to adding more controls, and conducting additional robustness checks, this paper makes a significant contribution relative to previous studies by being the first to present evidence based on incentive compatible measures and a large representative sample of adults.

The findings in this paper are potentially relevant for the specification of economic models that incorporate both cognitive ability and time or risk preferences as fundamental parameters. Typically, structural models of this type do not explicitly allow for the dependency identified by our results. There are some exceptions, including Heckman et al. (2006), who allow for cognitive ability to affect the discount rate, and vice versa, in a formal model explaining labor market and behavioral outcomes. However, they do not observe the discount rate directly, so when they estimate the model they cannot identify the impact of cognitive ability on time preferences separately from its impact on other unobserved variables such as human capital productivity, and direct market productivity. Our findings provide an empirical basis for the flexible approach adopted by Heckman

[4] For psychological evidence on the relationship between intelligence and the ability to delay gratification see, e.g., Funder and Block (1989), Shoda et al. (1990), Kirby et al. (2005), Parker and Fischoff (2005).

et al. (2006), and shed light on the specific nature of the relationship between cognitive ability and preferences regarding risk and time.

The paper also points to a different interpretation of reduced form models that have been estimated in the literature on cognitive ability and labor market outcomes. These models have typically included a measure of cognitive abilities, but not risk aversion or impatience, as explanatory variables (e.g., Herrnstein and Murray, 1994; Murnane et al., 1995; Neal and Johnson, 1996; Cawley et al., 2001). Outcomes such as educational attainment or wages may by affected by risk aversion and impatience, and thus part of the impact of cognitive ability may reflect the correlation with these traits. In other words, our findings point to a potentially important source of omitted variable bias in this type of estimation.

Given that cognitive ability is known to be transmitted from parents to children (Bouchard and McGue, 1981; Plomin et al., 2000), our findings could also be relevant for the literature on intergenerational transmission of preferences and socio-economic status. For example, Dohmen et al. (2006) show that attitudes towards risk are strongly correlated between parents and children, and Knowles and Postlewaite (2005) find an intergenerational correlation in attitudes towards saving. Also, a large literature on social mobility documents strong intergenerational correlations in important economic outcomes that are plausibly related to risk attitudes, or patience, such as wealth, income, occupation, and education (Kerckhoff *et al.*, 1985; Solon, 1992; Mulligan, 1997 and 1999; Charles and Hurst, 2003; Black *et al.*, 2005; Long and Ferrie, 2005). To the extent that cognitive ability affects risk aversion and impatience, consistent with our findings, the transmission of cognitive ability could be one channel explaining intergenerational correlation in traits such as risk aversion and impatience, which in turn could help explain persistence of economic outcomes. Alternatively, if risk aversion and impatience affect cognitive ability, then transmission of these attitudes across generations could be part of the mechanism through which cognitive ability is passed from one generation to the next.

Our findings are also potentially relevant for the literature investigating the relationship between the distribution of cognitive ability and inequality in economic outcomes (e.g., Leuven et al., 2004; Blau and Kahn, 2005). If people who have high cognitive ability are more patient, and thus more likely to make investments, and if they earn a risk premium from being less risk averse, this would exacerbate differences in inequality associated with differences in cognitive ability. Reduced form models that include cognitive ability but do not control for differences in risk aversion or impatience across countries may deliver biased estimates of the impact of cognitive ability on inequality. Also, for a given distribution of cognitive ability, the degree of inequality in economic outcomes is likely to be greater than if there was not a link with risk aversion and impatience.

If risk aversion and impatience are linked to cognitive ability, this could also be relevant for policy interventions. For example, some policy interventions are designed to improve cognitive ability, typically focusing on young children due to evidence that early childhood environment has a strong impact on cognitive skills (see, e.g., Heckman, 2006; Knudsen et al., 2006). If higher cognitive ability leads to greater patience and greater willingness to take risks, this is an important, additional effect of such interventions, with far-reaching implications for a child's future economic outcomes. Of course the direction of causality is important in this case. Instead of cognitive ability affecting preferences, it could be that patience and willingness to take risks cause children to develop knowledge and skills more quickly in life. In this case there would be different policy implications, e.g., a reason to focus attention on designing interventions that affect patience and risk preferences of children.

The rest of the paper is organized as follows. Section 2 describes the measures of cognitive ability and preferences. Section 3 presents our main results. Section 4 presents a series of additional robustness checks and results. Section 5 concludes, and discusses directions for future research.

2 Data Description

2.1 Design of the Study

The data were collected as part of a study run between June 9th and July 4th, 2005. We conducted the study using the same professional surveying company that administers the German Socio-Economic Panel (SOEP), a large panel data set for Germany (for a detailed description of the SOEP see Haisken-DeNew and Frick, 2003; Schupp and Wagner, 2002; Wagner et al., 2007). Sampling was done according to the same procedure used to generate the SOEP sample, and individuals were visited by interviewers in their own homes.[5] Our sample was constructed so as to be representative of the adult population, age 17 and older, living in Germany. In total our data include interviews with 1,012 participants.

Participants in our study went through a computer assisted personal interview (CAPI) conducted with a laptop. The interview consisted of two parts. First, subjects answered a detailed questionnaire. The items in the questionnaire were presented in the standard format used by the SOEP. Topics included demographic characteristics, financial situation, health, and attitudes. The full questionnaire, in German and translated into English, is available upon request. The questionnaire also contained two tests of cognitive ability. At the end of the questionnaire, subjects were invited to participate in the second part of the interview, which consisted of a paid experiment. A random device in the CAPI software determined whether a subject was invited to participate in a lottery experiment designed to measure the extent of risk aversion, or an intertemporal choice experiment designed to elicit impatience over an annual horizon. Neither the interviewer nor the participant had an impact on the selection of the type of the experiment. We deliberately designed the study such that an individual could only take part in one experiment so as to avoid order effects. Of all 532 subjects who were invited to take part in the discount rate experiment 500 participated, while 452 out of 480 potential participants took part in the lottery choice experiment.

2.2 Measures of Cognitive Ability

Each of the two tests of cognitive ability in our questionnaire is similar to a different module of the Wechsler Adult Intelligence Scale (WAIS), one of the most widely-used intelligence tests worldwide (see Tewes, 1991).[6] The Wechsler test has 11 modules, 6 verbal and 5 non-verbal. One of our tests, the *symbol correspondence test*, is similar to a sub-module in the non-verbal section of the WAIS, which asks subjects to match as many numbers and symbols as possible in 90 seconds according to a given correspondence. Our other test, the *word fluency test* is similar to one of the verbal sub-modules of the WAIS,

[5] For each of 179 randomly chosen primary sampling units (voting districts), an interviewer was given a randomly chosen starting address. Starting at that specific local address, the interviewer contacted every third household and had to motivate one adult person aged 16 or older to participate. For a detailed discussion of the random walk method of sampling see Fowler (1988).

[6] We used the German version of the test, which is known as the *Hamburger-Wechsler Intelligenztest für Erwachsene (HAWIE-R).*

in which subjects are given a timed vocabulary test. Our tests were designed to capture the aspects of intelligence measured by these sub-modules, while also being suitable for implementation in the field as part of a CAPI interview, rather than in the usual paper and pencil format of the WAIS. Previously, the symbol correspondence test and word fluency test used in our study have been shown to be strongly correlated with the corresponding modules of the German version of the WAIS, as well as with the remaining modules, and with scores on other prominent intelligence tests (Lang et al., 2005; Lang et al., 2007).

The symbol correspondence test presented subjects with nine unfamiliar symbols, each paired with one of the digits 1 through 9. After brief instructions, subjects were presented with a screen that had this same mapping from numbers to symbols at the top. A symbol, with a blank box beneath it, was presented in the center of that screen. Subjects had to type the correct corresponding number into the box. Once a number was entered, a new screen with another symbol appeared. Subjects had 90 seconds to find as many correspondences between symbols and numbers as they could, using the correct number for each symbol. Thus, speed and accuracy in applying the given correspondence under time pressure determine how well an individual does on the test. A total of 105 persons refused to participate, and procedural problems arose in some cases, so we have non-missing symbol-correspondence scores for a total of 902 subjects.

The word fluency test asked subjects to verbally list as many animals as they could in 90 seconds. After each naming, the interviewer pressed one of three keys, to indicate a correct animal name, a name repetition, or the statement of a wrong or unclear name, respectively.[7] Before the test started, subjects were asked whether they wanted to participate, and 87 subjects refused to take part. Some of the participants who had agreed to participate changed their minds just after the experiment began, and stopped. In a few other cases, procedural problems arose, mostly because interviewers made input errors, for example forgetting to press a key after the interviewee had named an animal. In total, we have word fluency scores for 848 individuals.

Figure 1 shows the resulting distributions of cognitive ability in our data. The upper

[7] Lang et al. (2005) assessed the error-proneness of this procedure in a laboratory experiment in which they tape-recorded the tests and then compared the correct test results with those resulting from interviewers' entries. On average interviewers were slightly off, recording 0.4 fewer correct answers than the true total. Ceteris paribus this recording error makes the word fluency test a more noisy measure than the symbol correspondence test, where there is no scope for recording error, due to computerization of the procedure.

graph in the figure is the histogram of correct answers on the symbol correspondence test. Overlaid is a graph of the smoothed density function of the distribution of symbol correspondence test scores, estimated using a Gaussian kernel.[8] A normal density function is also plotted in the graph, with the same mean and variance as the estimated density. The figure shows that the estimated density function for the symbol correspondence test is close to the normal density, or a "bell-shaped curve", consistent with the usual finding from the literature on cognitive ability. The lower graph of the figure shows the histogram of the number of correct recalls in the word fluency test. Graphs of the smoothed density function are estimated in the same way as in the upper graph, and a normal density is included in the same way as well. The estimated density for the word fluency test is also close to normal.

To ease the interpretation of our results, we use standardized measures of the test scores in our analysis. The upper graph in Figure 2 shows separate kernel density estimates of the standardized distributions of the symbol correspondence test, for the participants in the lottery experiment and the intertemporal choice experiment, respectively. A standard normal distribution is overlaid on the graph. One important observation is that the distribution is very similar across sub-samples. The hypothesis that the distribution of scores is the same for both sub-samples cannot be rejected using a Kolmogorov-Smirnov test (p-value= 0.487). Also, for both sub-samples we cannot reject the hypothesis that the estimated distribution is normal at the five-percent level, using a joint test of skewness and kurtosis. The lower graph in the figure makes a similar comparison based on the word fluency test. Again, the distributions are not significantly different across the sub-samples for the lottery and intertemporal choice experiments (p-value= 0.396). Although the distributions look close to normal for both sub-samples, in the case of the word fluency test we reject normality at the five-percent level. Our results are robust if we instead use the non-standardized measures.[9]

2.3 Experimental Measures of Risk Aversion and Impatience

We used paid experiments to measure willingness to take risks and impatience. As described above, it was randomly determined whether a subject was invited to participate

[8] The bandwidth is chosen to minimize the mean integrated squared error if the data were Gaussian.

[9] Results with the non-standardized measures are available upon request.

in the lottery experiment or the intertemporal choice experiment. The exact script and instructions used in the experiments are presented in Appendix B below, translated from German into English.

For both experiments, the first step in the procedure involved the experimenter presenting subjects with an example choice table. The experimenter explained the types of choices that the subject would make in the table, and how payment would work. In particular, subjects were informed that the experiment would involve multiple choices, one for each row of the table, and that one table row would be randomly selected after all choices had been made, and that the choice in this row would potentially be relevant for their payoff. Subjects also knew that at the end of the experiment a random device would determine whether they were actually paid, with the probability of being paid equal to 1/7. This procedure gives subjects an incentive to choose according to their true preferences in each row, and thus is incentive compatible. After explaining the nature of the experiment and the rules for payment, the experimenter asked subjects whether they were willing to participate. Subjects who agreed to participate were given further instructions, and then allowed to ask questions. Once there were no more questions, the experiment began, and subjects were asked to make their actual choices, referring to the choice table.

We elicited willingness to take risks using choices between a paid lottery and different safe payments. Participants made choices in a table with 20 rows. In each row they had to decide whether they preferred a safe option or playing a lottery. In the lottery they could win either 300 Euros or 0 Euros, each with 50 percent probability (1 Euro $\sim$ \$ US 1.2). In each row the lottery was exactly the same but the safe option increased from row to row. In the first row the safe option was 0 Euros, in the second it was 10 Euros, and so on up to 190 Euros in row 20.

If subjects have monotonous preferences, they prefer the lottery up to a certain level of the safe option, and then switch to preferring the safe option in all subsequent rows of the choice table (see also Holt and Laury, 2002, who use a similar choice-table procedure) In our procedure, subjects were asked for their choices one row at a time, starting from the top of the table. Once a subject expressed a preference for the safe option instead of the lottery, the experimenter asked if the subject would also prefer all higher values of the safe option as well. If the answer was affirmative, the experimenter filled in the rest of the choices accordingly. Otherwise the subject could continue making choices in the table. In all cases, subjects responded in the affirmative. The switching point in the lottery experiment is informative about a subject's willingness to take risks. Since the expected value of the lottery is 150 Euros, weakly risk averse subjects should prefer safe options that are smaller than or equal to 150 Euros over the lottery. Only risk loving subjects should opt for the lottery when the offered safe option is greater than 150 Euros.

To create an incentive compatible index for how impatient an individual is, we posed subjects with choices between receiving different payments at different times. As in the lottery experiment, subjects were presented with a choice table and asked to make a choice in each row. The decision in the intertemporal choice experiment was always between 100 Euros "today" and a larger amount Y that would be received 12 months in the future. Moving down the table, the early payment was always 100 Euros but the size of the delayed payment Y increased in each subsequent row. The value of Y in the first row gave a return of 2.5 percent, assuming semi-annual compounding, and each subsequent value of Y implied an additional 2.5 percentage point increase in the annual rate of return.[10] Observing the value of Y (or equivalently, the implied annual rate of return) necessary to induce the individual to wait 12 months, we obtain an index of impatience.

Subjects were asked for their decisions one row at a time, starting from the first row. The first time that a subject switched from 100 Euros to the delayed payment, the subject was asked whether he or she also preferred to wait for any larger payment, which all subjects agreed upon. As in the lottery experiment, subjects knew that one row would be randomly selected at the end of the experiment, and that their decision in that row could be relevant for their payoff. Subjects also knew that all payments would be sent by mail following the interview, in the form of a check. Checks for "today" could be cashed immediately, but checks for payments in 12 months would be cashable only in 12 months.

Our focus in this paper is on the relationship between cognitive ability and impatience, rather than estimating the average level of impatience in the population, but our design does address an important challenge that arises when trying to precisely measure the level of impatience. The potential problem is that subjects could be skeptical that

[10] We chose semi-annual compounding of the annual interest rate because this is a natural compromise between the two types of compounding German subjects are most familiar with: quarterly compounding on typical bank accounts, and annual reports on the rate of return from savings accounts, pension funds, or stock holdings. Using semi-annual compounding also helps avoid prominent round numbers in the choice table, which could potentially influence switching choices.

the experimenters will deliver on a promise to make a monetary payment available in the future. This could cause them to place a premium on payments that are available immediately at the time of the interview, and thus choose in a way that makes them appear more impatient than they truly are. In our design, however, there is little scope for credibility concerns. Subjects know that even the early payment is not available immediately, but rather is sent by mail shortly after the interview in the form of a check. The timing of the mailing is thus the same as if the subject is due to receive a check that can only be cashed in one year's time. This feature of the design helps make the early and delayed payments equally credible or "incredible", and thus mitigates the problem of overstating the level of impatience.[11]

The upper graph of Figure 3 shows the histogram of switching values in the lottery experiment, which are equivalent to subjects' certainty equivalents. The main message of the figure is that there is substantial heterogeneity in willingness to take risks. It is also noteworthy that the majority of individuals are risk averse. The modal certainty equivalent is 100 Euros, well below the lottery's expected value of 150 Euros, and the median certainty equivalent is 80 Euros. These values are in line with previous evidence from laboratory experiments and field experiments that measure the degree of risk aversion.[12] Overall, the majority of subjects (77.8 percent) exhibit risk aversion in the lottery experiment, preferring a certainty equivalent strictly smaller than the expected value of the lottery to playing the lottery. The fraction of risk-seeking subjects is small (9.1 percent). As is typical in choice experiments, there is also some evidence that subjects tend to choose prominent numbers more often (e.g., 50, 100, 150). In the analysis we use estimation techniques that correct for the fact that willingness to take risks is measured in intervals, and thus is left- and right-censored, and we check robustness of our results to using broader intervals that

[11] Furthermore, experiments and payments were administered by the professional surveying agency used for the SOEP, which is highly credible and well known to the public because of its role in conducting election polls for German public television. Interviewers also left their contact details at the end of the experiment, making it easy for subjects to contact the institute. There were no reports, from any of the interviewers, about subjects expressing concerns regarding credibility of payments. Thus, it is very unlikely that subjects perceived either future or immediate payments in the experiment as being less than fully credible.

[12] Previous studies using lottery experiments have often assumed a CRRA utility function, and utility defined over outcomes in the experiment rather than final wealth levels, in order to infer a risk preference parameter (but see Rabin, 2000, for a criticism of this approach). Applying these assumptions to our data for the sake of comparability yields mean and median coefficients of relative risk aversion that fall in the range between 0.48 and 0.43. This is similar to the range of 0.3 to 0.5 found by Holt and Laury (2002) in laboratory experiments with college students, and is reasonably close to the value 0.67 found by Harrison et al. (2005) in a field experiment with people in Denmark.

eliminate much of the lumpiness of the distribution around prominent numbers.

The lower graph of Figure 3 shows the histogram of switching values in the intertemporal choice experiment. Again, the main message of the figure is that there is substantial heterogeneity. It is noteworthy that the implied level is similar to that in other recent studies that use behavior in the field to infer impatience.[13] Note that there is a spike in the figure in the highest category of impatience; this reflects individuals who are so impatient that they prefer the early payment even in the final row of the choice table. There is again some evidence that prominent numbers affect choices: switching is slightly more common in rows where the delayed payment surpasses prominent numbers, for example 110 Euros, or 120 Euros, although this feature of choices appears less pronounced than in the lottery experiment. In the analysis we take steps to correct for left and right censoring of the impatience measure, and check robustness to using intervals that mitigate lumpiness around prominent numbers.

3 Results

We begin our empirical analysis by looking at the relationship between cognitive ability, risk aversion, and impatience in the raw data. The upper graph in Figure 4 shows the average values of our indexes of willingness to take risks, and impatience, for each decile of the distribution of cognitive ability as measured by the symbol correspondence test. The lower graph displays similar information, but using performance on the word fluency test as the measure of cognitive ability. For both measures, the average degree of impatience is clearly lower for higher deciles of the ability distribution. Also, for both measures

[13] Under certain assumptions it is possible to infer an annual discount rate from switching rows in the experiment, and to compare to annual discount rates estimated in previous studies that make similar assumptions. For example, with locally-linear utility and semi-annual compounding of the annual discount rate, the lower bound for the annual discount rate is given by the formula $100 * (1 + \underline{\delta}/2)^2 = Z$, where Z is the largest value of the delayed payment such that the individual still prefers 100 Euros today. The upper bound is calculated as $100 * (1 + \bar{\delta}/2)^2 = Y$, where Y is the value of the delayed payment in the next row of the table, i.e., the smallest delayed payment that makes the individual willing to switch to waiting one year. An individual's true discount rate δ lies within this interval, $\delta \in \left[\underline{\delta}, \bar{\delta}\right]$. The resulting median discount rate falls in the range of 27.5 to 30 percent. Harrison et al. (2002) make similar assumptions, except using quarterly instead of semi-annual compounding, and find an average annual discount rate of 28.1 percent in their field experiment with individuals in Denmark. Warner and Pleeter (2001) provide evidence on annual discount rates for a large number of individuals in the U.S. military, inferred from very high stakes choices between different voluntary separation options. They find an average annual discount rate ranging from 10 to 19 percent for officers and from 35 to 55 percent for enlisted soldiers.

the average certainty equivalent is increasing in the level of cognitive ability, indicating greater willingness to take risks. Thus, the figure provides an initial indication that both willingness to take risks and patience are systematically related to cognitive ability.

In order to assess whether these relationships are statistically significant, and whether they are robust to controlling for personal characteristics, we next regress our measures of risk aversion and impatience on cognitive ability and controls. Table 1 presents the results. The dependent variable in columns (1) to (4) is the switching row in the lottery experiment. A higher switching row indicates a higher certainty equivalent, and thus a greater willingness to take risks. The dependent variable in columns (5) to (8) is the switching row in the intertemporal choice experiment. A higher value indicates that an individual needs a higher rate of return to forgo the immediate payment and wait one year, and thus greater impatience. To account for the fact that the dependent variables are measured in intervals, and thus that all observations are right and left censored, the regressions are estimated using interval regression techniques.[14] Coefficient estimates are marginal effects; robust standard errors are reported in brackets. Unless otherwise noted, all subsequent tables in the paper also report interval regressions, and robust standard errors. In all regressions we use the standardized measures of the cognitive ability as explanatory variables.

Column (1) shows that people with better performance on the symbol correspondence test exhibit greater willingness to take risks in the lottery experiment. The effect is only slightly smaller, and is still significant at the five percent level, when we also control for personal characteristics in column (2). We find a similarly large and significant relationship between cognitive ability and risk taking if we instead use the word fluency test as the measure of cognitive ability (columns (3) and (4)). The magnitude is also economically significant: a one standard deviation increase in cognitive ability is associated with a shift of about one switching row, which corresponds to a 12.5 percent increase in the certainty equivalent for the median subject in our sample.[15]

[14] The procedure maximizes a likelihood function that is a natural generalization of a Tobit, treating each value as a left and right censored observation coming from an interval with known bounds. Error terms are assumed to be normally distributed. For more information, see the STATA reference manual on the intreg procedure listed under Tobit estimation.

[15] Notably, this result does not appear to be driven by an impact of cognitive ability on understanding of expected values, or the use of expected value as a choice heuristic. If this were the case, we would expect cognitive ability to have an impact mainly by increasing the probability of switching exactly in those rows that corresponding to risk neutrality (rows 15 and 16). We do not, however, observe an especially

Turning to impatience, columns (5) to (8) show that people with higher cognitive ability are significantly more patient, i.e., switch significantly earlier in the choice table in the experiment. This result is robust to controlling for personal characteristics. The magnitude of the coefficient, and the level of statistical significance, are slightly lower in the regressions that use word fluency as the measure of cognitive ability. This could reflect greater measurement error in the word fluency test, or could indicate that impatience is less strongly related to verbal ability. The magnitude of the effects is again economically significant: the coefficients imply that a one standard deviation increase in cognitive ability leads an individual to switch about one row earlier, corresponding to a 9 percent decrease in the rate of return needed to induce the median individual to switch to preferring the delayed payment.

The results in Table 1 are robust to using different estimation techniques. For example, in Table A.1 in Appendix A we show that results are similar if we use OLS instead of interval regression. In other regressions we try a different approach to dealing with the fact that the dependent variables are censored, and use a Cox mixed proportional hazards model. We estimate the impact of cognitive ability on the hazard of switching in the choice tables, from the lottery to the safe payment in the risk experiment, and from the immediate to the delayed payment in the intertemporal choice experiment. We find similar results in this case: the coefficient estimates show that higher cognitive ability significantly decreases the hazard of switching in the risk experiment, which corresponds to greater willingness to take risks, and increases the hazard of switching in the intertermporal choice experiment, which corresponds to greater patience. Finally, we also explore the robustness of the results to collapsing the preference measures into broader intervals around prominent numbers. This makes sense if some of the people who switch at prominent numbers in fact prefer to switch a row earlier or a row later, but are "attracted" by the prominent number and switch at that point by mistake. Table A.1 in Appendix A shows that we find similar results when we use these smoothed measures, which use intervals of 3 or 4 switching

large impact of cognitive ability on the tendency to be risk neutral. In fact, only 4 percent more subjects switch at risk neutrality among the top quartile of the symbol correspondence distribution, compared to the bottom quartile. Instead, in the data we observe that higher cognitive ability shifts the entire distribution of switching rows in the direction of greater willingness to take risks. We reach a similar conclusion if we estimate probit regressions, where the dependent variable is equal to 1 in the case of risk neutrality. Cognitive ability does not have a significant impact on the probability of being risk neutral ($p < 0.313$; detailed results available upon request). Thus, the results in Table 1 reflect a tendency for higher cognitive ability to make people less risk averse in general.

rows, rather than intervals containing single rows.

Overall, the baseline results are consistent with greater willingness to take risks, and greater patience, among those with relatively high cognitive ability. This is true controlling for personal characteristics, and using various estimation strategies. In the following sub-sections we do a series of additional robustness checks, to rule out various alternative explanations for the apparent link between cognitive ability, risk aversion, and impatience.

4 Robustness Checks

4.1 The Role of Education

In this sub-section we explore whether the baseline results are robust to controlling for education. Higher cognitive ability is typically associated with higher educational attainment (see Card, 1999). In fact, both of our measures of cognitive ability are strong predictors of educational attainment: people in our sample who have higher cognitive ability are significantly more likely to go to school longer and/or to obtain advanced schooling degrees. Results from a multinomial Logit estimation, with different degree categories as the dependent variable, and cognitive ability and personal characteristics as explanatory variables, show that high cognitive ability increases the likelihood of acquiring an advanced degree.[16] One could hypothesize that education, in turn, might affect preferences, in particular discount rates (see, e.g., Becker and Mulligan, 1997). In order to see whether cognitive ability has a direct impact on preferences, or whether it operates only indirectly through the channel of education, it is desirable to investigate whether the baseline results change if we control for education.

There is also another rationale for controlling for education, namely the potential for education to determine cognitive ability. Previous evidence suggests that educational attainment affects performance on the AFQT (Hansen et al., 2004; Cascio and Lewis, 2006). This is less likely to be the case for our measures of ability, which are not as dependent on accumulated knowledge or experience. However, to the extent that our measures of cognitive ability are partly a proxy for education, some of the impact of

[16] Results available upon request.

cognitive ability in Table 1 could reflect the impact of education, which was omitted from the regressions.

Table 2 presents the same regressions as in Table 1, but adding dummy variables for different educational degrees. This is a better measure of educational attainment for Germany than years of schooling, because of the structure of the German educational system (see Card, 1999, p. 1806). In teenage years, German students select into different types of high schools, some focusing on vocational training, others intended to prepare students for college. Thus, an equal number of years of education can mean very different things depending on the type of degree. Columns (1) and (3) show that the impact of both types of cognitive ability on risk preference is only slightly smaller, and remains significant, once we control for schooling degree. In columns (2) and (4), where we also control for personal characteristics, both measures of cognitive ability are still significant, although for the symbol correspondence test significance drops to the ten percent level. Interestingly, more advanced degrees are significantly positively correlated with willingness to take risks, as shown by the coefficient on the dummy variable for "Abitur", which is the degree completed at the end of a college track high school. In columns (5) to (8), we see that the symbol correspondence test remains a strong and significant predictor of impatience, controlling for education and for personal characteristics. The word fluency test is still significant at the ten percent level when we control for education, but becomes insignificant (p-value=0.142) once we control for education and exogenous characteristics simultaneously. Interestingly, however, education is also not significantly correlated with discount rates, in any of the specifications. In summary, the baseline results are largely unchanged if we control for education, suggesting that the relationship between cognitive ability, risk aversion, and impatience does not work solely through the indirect channel of education.

4.2 The Role of Income and Credit Constraints

Another possibility is that cognitive ability could have an indirect effect through the channel of income or credit constraints. Higher cognitive ability is associated with higher income, and higher income could affect willingness to take risks, or willingness to be patient. For example, someone with higher income may be less worried about taking a risk and winning nothing, all else equal, because higher income provides a cushion against bad shocks. It could also be the case that for people with low income, choosing the early payment in the intertemporal choice experiment is a necessity because they are credit constrained and need the 100 Euros immediately, in order to cover some important expense. To see whether cognitive ability has a direct impact on the way that people make choices under uncertainty, or over time, above and beyond these indirect channels, we add income and a measure of credit constraints to our baseline specifications.

In Table 3 we estimate the same regressions as in Table 1, but add controls for income and credit constraints. The income variable is current household monthly income, net of taxes and benefits (for more details see the table notes). The dummy variable for credit constraints is based on a question in our questionnaire, which asked the following: "If you suddenly encountered an unforeseen situation, and had to pay an expense of 1,000 Euros within the next two weeks, would it be possible for you to borrow the money?" Columns (1) to (4) show that both measures of cognitive ability still have a strong impact on willingness to take risks, significant at the five percent level, if we control for income, credit constraints, and personal characteristics. Results in columns (5) to (8) indicate that cognitive ability measured by the symbol correspondence tests is a significant predictor of impatience, controlling for income and credit constraints. The coefficients for the word fluency measure are also statistically significant, except in column 8, where we add all controls at once and the coefficient is no longer significant (p-value=0.131). Notably, in all specifications income has a significant positive correlation with willingness to take risks, and a significant negative correlation with the degree of impatience.

The results are also similar if we control for education and income simultaneously. The symbol correspondence test has a statistically significant impact on willingness to take risks and impatience, in all specifications, and the point estimates are largely unchanged. The word fluency measure is also significant when controlling for both education and income, except in the fullest specification where it is not quite significant once we control for personal characteristics as well.[17] Thus, the relationship between cognitive ability, risk aversion, and impatience is not explained entirely by different levels of education, income, or degree of credit constraints.

[17] These results are available upon request.

4.3 Are the Results Explained by Confusion in the Choice Experiments?

Because we rely on choice experiments to measure willingness to take risks and impatience, a potential concern is that low cognitive ability could be associated with confusion about incentives faced in the experiments, in a way that happens to be observationally equivalent to greater risk aversion, or greater impatience. Confusion is unlikely, given that the experiments are relatively simple. Also, it is not clear why confusion should be systematic in a way that would appear as greater risk aversion or impatience.[18] In the case of willingness to take risks, however, we are able to address this potential confound directly. Our data include a very simple survey question about risk attitudes that is immune to problems of confusion about incentives, filling out tables, etc.. The question simply asks an individual to rate his or her own "willingness to take risks, in general" on a scale from 0 to 10, where 0 is "completely unwilling" and 10 is "completely willing." In previous research, this particular question has been shown to be a good predictor of a wide variety of risky behaviors, including holding stocks, being self-employed, smoking, migrating, and participating in sports (see, for example, Dohmen et al., 2005; Bonin et al. (2006); Jaeger et al., 2007).

Table 4 presents regressions where the dependent variable is the response to the survey question about willingness to take risks. Columns (1) to (4) use the same specifications as in our baseline regressions. The coefficient estimates show that in every case, higher cognitive ability is associated with greater willingness to take risks. Coefficients on cognitive ability are always significant at the one percent level. This shows that the positive relationship between cognitive ability and willingness to take risks is present even if we use a very simple, survey measure of risk preference. Thus, our baseline results are unlikely to be explained by confusion about incentives in the choice experiments.

4.4 Arbitrage Between the Experiment and the Credit Market

A potential confound that is specific to the intertemporal choice experiment arises if people with high cognitive ability are more likely to engage in a specific kind of arbitrage behav-

[18] In the case of the intertemporal choice experiment, for example, confused individuals could well appear more patient. For instance, suppose that subjects ignore the time delay, and think that one of the two columns in the table is randomly selected, rather than one row. Given that payments are always larger in the second column, which gives the delayed payments, confused subjects would tend to choose delayed payments and thus appear more patient.

ior. In particular, it could be that some highly impatient subjects adopt a sophisticated strategy of arbitrage. They might make patient choices in the experiment in order to take advantage of the above-market rates of return, and then borrow outside of the experiment at market interest rates to finance their desire for immediate consumption. If use of this strategy is more likely for individuals with high cognitive ability, then intelligent people could be just as impatient as those with low ability, but simply appear more patient in the experiment because they have figured out a less expensive way to finance immediate consumption.

To identify individuals who engaged in arbitrage, we asked at the end of the experiment whether a subject had thought about market interest rates at all during the experiment. Of all participants, roughly 37 percent say that they thought about an interest rate. This suggests that most subjects are not engaging in arbitrage at all. Interestingly, however, thinking about market rates of return is significantly more likely for subjects who score higher on either measure of cognitive ability.[19] Thus, it is important to assess whether our results are driven by the minority who do think about interest rates.

Table 5 presents our baseline regression specifications for impatience, but including on the right hand side a dummy variable equal to 1 if an individual thought about market interest rates and 0 otherwise. Thinking about interest rates does lead to a large and statistically significant decrease in the discount rate observed in the experiment. This is consistent with those who think about interest rates engaging in arbitrage. The more important finding for our purposes, however, is that higher cognitive ability is still associated with a significantly lower degree of impatience, even controlling for thinking about market interest rates.

4.5 Preferences and Test-Taking Strategy

Another potential confound would arise if risk aversion and impatience are not related to true cognitive ability, but instead influence the type of test-taking strategy that subjects adopt, in a way that leads to lower *measured* cognitive ability. For instance, suppose that risk averse individuals take more time to provide answers in the tests of cognitive ability

[19] This result is based on a probit regression with a binary indicator for thinking about the interest rate as the dependent variable and cognitive ability as the explanatory variable. These results are available upon request.

because this preference partly reflects a desire to avoid losses, or mistakes. This would lead to a lower error rate on the test, but potentially also to a lower score because subjects answer fewer questions within the time limit. We test the hypothesis that risk aversion has an impact on the error rates in the tests. It is less plausible that impatience would affect the way that an individual approaches the tests of cognitive ability. The tests take 90 seconds, regardless of effort, so there is no incentive for an impatient individual to rush through the cognitive ability exercises. Nevertheless, we also check whether impatient individuals have higher error rates on the tests of cognitive ability.

In OLS regressions, we regress the error rates in the tests of cognitive ability on willingness to take risks and impatience, with and without controls for personal characteristics.[20] The error rate is defined as the number of incorrect answers divided by the total number of answers given by an individual. For both tests of cognitive ability, there is no significant impact of the risk aversion or impatience on error rates, in any specification.[21] Thus, there is little indication that the baseline results reflect an impact of risk aversion or impatience on test-taking strategy.

4.6 Are the Tests of Cognitive Ability a Proxy for Personality Type?

In this sub-section we investigate an interesting possibility, which is that performance on cognitive tests could partly measure aspects of a subject's personality, rather than cognitive ability. For example, conscientiousness, one of the five personality traits known as the "Big Five" in psychology, has been shown to predict performance on tests of cognitive ability (Segal, 2006). If our measures of cognitive ability in fact proxy for personality type, then our findings could be interpreted as revealing a link between fundamentally important traits in economics (risk aversion and impatience) and personality traits. If this were the case, it would be an interesting finding, with important implications.[22] In our questionnaire we included standard measures of the Big Five, so we can test whether cognitive ability has an impact on risk aversion and impatience, controlling for conscientiousness and other dimensions of personality.

[20] Results are available upon request.

[21] Point estimates are essentially zero, and none are close to significant. These results are available upon request.

[22] See Heckman et al. (2006) for a discussion of the importance of investigating the link between economic preferences and non-cognitive skills or personality traits.

Table 6 reports regressions with the same specifications as in Table 1, but adding controls for what psychologists have agreed are five key dimensions of personality: conscientiousness, extroversion, agreeableness, openness, and neuroticism.[23] The main conclusion to be drawn from Table 6 is that the coefficients on cognitive ability are still statistically significant, even controlling for personality type. Coefficients on the measures of cognitive ability are only slightly smaller than in Table 1, and are similarly significant, except in column (8) where the coefficient for the word fluency test is no longer significant. Interestingly, openness to new experience is associated with significantly greater willingness to take risks, and extroversion is associated with significantly greater impatience, although only in the regressions that use the symbol correspondence test to measure cognitive ability. In summary, although there is some interesting evidence suggesting that risk aversion and impatience are related to personality type, this does not explain the relationship between our cognitive ability measures, risk aversion, and impatience.

4.7 Concavity of Utility and Impatient Behavior

Finally, we investigate whether our results on impatience indicate a link between cognitive ability and pure time preference, or whether they could also partly be driven by a tendency for people with lower cognitive ability to make choices as if they have more concave utility functions (i.e. a faster rate of diminishing marginal utility of income). Note that, regardless of whether concavity plays a role or not, it is important that we find a robust tendency for people with lower cognitive ability to exhibit more impatient *behavior*, because of the far-reaching implications for the many economic outcomes that are linked to investment behavior. Nevertheless, this investigation is conceptually interesting because it is informative about the mechanisms underlying the observed pattern in behavior.

The issue of concavity arises if one considers our results in light of, e.g., standard Expected Utility Theory (EUT). We find that many people are risk averse in the lottery experiment. In the context of EUT, risk aversion is equivalent to concavity of the instantaneous utility function, and if one is willing to make particular assumptions about

[23] The Big-Five questionnaire measures personality traits by asking subjects how much they agree with different statements about themselves. We use a fifteen item version of the questionnaire where each trait is assessed based on level of agreement with three statements. The subject indicates the level of agreement on a seven-point scale, and response are added across each set of three statements to achieve a score for that personality trait. Statements are presented in random order.

the functional form of utility, it is possible to calculate risk preference in terms of a parameter describing curvature. For example, assuming CRRA utility, it is possible to use the switching point in our lottery experiment to bound an individual's CRRA coefficient. A higher CRRA parameter implies a higher degree of concavity of the utility function and therefore a higher degree of risk aversion.[24] We find that risk aversion, or concavity, is more prevalent among people with low cognitive ability. For example, coefficients in columns (2) and (4) of Table 1 imply that a one standard deviation increase in the symbol correspondence (word fluency) score is associated with a 8.16 Euro (9.08 Euro) increase in the certainty equivalent. For an individual with the median degree of risk aversion this corresponds to a decrease in the lower bound of the CRRA parameter from 0.476 to 0.434 (0.429).

The question, then, is whether cognitive ability might affect impatient behavior in the intertemporal choice experiment indirectly, through the channel of changing concavity, rather than through a direct relationship with time preference. Consider the EUT setting with exponential discounting, and assume that utility is locally linear for the stakes used in the intertemporal choice experiment. In this benchmark case, where concavity plays no role by assumption, the relationship between the observed switching row and δ (the semi-annually-compounded 12-month discount rate) is given by the indifference condition

$$\left(1+\frac{\delta}{2}\right)^2 = \frac{x_{t+\tau}}{x_t}.$$

where τ is one year, x_t corresponds to 100 Euros available today, $x_{t+\tau}$ is the delayed payment of $100 + \Delta$ available in one year. Under these assumptions, we can translate switching rows into discount rates. For the median subject, who switches in row 11, the discount rate is in the interval from 25 to 27.5 percent, and the coefficients in columns (6) and (8) of Table 1 imply that a one standard deviation increase in performance on the symbol correspondence or word fluency test is associated with a 2.98 or 2.30 percentage point decrease in the annual discount rate, respectively. Now consider how concave utility

[24] In our choice experiment, indifference between the lottery of winning 300 Euros or 0 Euros with equal probability and a safe option of y implies $.5\frac{300^{1-\gamma}}{(1-\gamma)} = \frac{y^{1-\gamma}}{(1-\gamma)}$, and therefore $\gamma = 1 - \frac{(ln.5)}{(lny - ln300)}$. Using the safe option from the switching row in the experiment gives the lower bound for the interval containing γ and using the safe option in the previous row gives the upper bound. Note that this calculation uses the assumption that utility is defined only over outcomes in the experiment, rather than over final wealth levels (for a similar approach see Holt and Laury, 2002; Harrison et al., 2005). For a critique of inferring curvature from risk aversion in moderate stake lotteries, however, see Rabin (2002).

$u(\cdot)$, such that $u'(\cdot) > 0$ and $u''(\cdot) < 0$, affects the relationship between the switching row and the annual discount rate. The indifference condition in this case is given by

$$\left(1 + \frac{\delta}{2}\right)^2 = \frac{u(x_{t+\tau})}{u(x_t)}.$$

This expression shows that for the same δ, greater concavity in the utility function leads to more impatient behavior, in the sense of a later switching row. This follows because $\frac{u(x_{t+\tau})}{u(x_t)} < \frac{x_{t+\tau}}{x_t}$, i.e., for a given δ, the size of the delayed payment $x_{t+\tau}$ must be larger in the case of concave utility, for the indifference to hold. Put differently, as concavity of utility increases, a smaller discount rate is needed to generate the same degree of impatience in behavior (this latter point is made by Andersen et al., 2005). Given that we find that risk aversion, or equivalently concavity of utility, is more pronounced for people with low cognitive ability, this channel could thus potentially explain the results on the correlation between cognitive ability and impatience, instead of a direct link between cognitive ability and δ.

To assess empirically whether concavity is important for explaining the relationship between cognitive ability and impatient behavior, within the framework of commonly-used utility functions, we adopt the following procedure. First, for participants in the lottery experiment, we calculate CRRA coefficients from the lottery choices and then regress them on answers to the survey measure of risk attitudes. We then use the resulting estimated relationship to predict CRRA coefficients for participants in the intertermporal choice experiment, based on their responses to the survey measure of risk attitudes. With the resulting CRRA coefficients, we can then calculate the exponential discount rate implied by switching points in the intertemporal choice experiment, using the formula implied by assuming CRRA: $\left(1 + \frac{\delta}{2}\right)^2 = (x_{t+\tau}/x_t)^{1-\rho}$, where ρ is the CRRA coefficient. The estimated median implied discount rate is in the interval from 13.14 to 14.76 percent instead of the interval from 25 to 27.5 percent (Andersen et al., 2005 also find that eliciting risk preference and time preference jointly leads to lower estimates of the exponential discount rate). We regress the resulting discount rates on cognitive ability and controls, as in columns (6) and (8) of Table 1. We find that the baseline results are essentially unchanged. Cognitive ability has a similarly significant, and large impact on discount rates in this case, compared to the case where we assumed linear utility.[25] We find similar results if we instead assume CARA utility. Thus, in the case of standard utility functions, we find evidence that the results on impatience can be interpreted in terms of a link between cognitive ability and discount rates, as opposed to being driven solely by concavity.

5 Conclusion

The goal of this paper was to investigate whether risk aversion and impatience are systematically related to cognitive ability. In order to test this hypothesis, we used a large representative sample of the population, incentive compatible measures of willingness to take risks and impatience, and two tests of cognitive ability. The main finding is that people with lower cognitive ability are significantly more impatient and significantly more risk averse. This is true controlling for personal characteristics, educational attainment, income, and credit constraints. The relationship also survives a series of additional robustness checks.

One potential explanation for our findings, mentioned in the introduction, is that cognitive ability affects the ability of people to integrate choices. For example, previous research on "choice bracketing" suggests that when some people make choices, they bracket broadly and consider the consequences of all of the choices taken together, whereas others bracket narrowly and make each choice in isolation (Read et al., 1999). In the context of risky choice, this can lead people to choose to play one collection of lotteries that is first order stochastically dominated by another available collection (Tversky and Kahneman, 1981). It could potentially explain risk aversion even in small stakes lotteries, because people fail to integrate a small individual risky decision with broader considerations, e.g., regarding the expected value of future lifetime income. In the context of intertemporal choice, impatience could also reflect narrow bracketing, in the form of making choices about present consumption without considering future consequences. Further research is needed on whether narrow bracketing is more likely for people with lower cognitive ability, but one recent study provides some preliminary evidence, showing that narrow bracketing is less likely in risky choice when cognitive costs are lowered by working out the math for

[25] A one-standard deviation increase in the symbol correspondence test score (word fluency test score) is associated with a 1.5 (1.2) percentage point decrease in the discount rate.

subjects (Rabin and Weizsäcker, 2007).

Another possible explanation for our findings is that choices over time, or choices between risky and safe options, are determined by the interplay of two separate decision-making systems: an affective system that generates an impulse for immediate consumption, or a fear impulse in response to potential risks, and a cognitive system takes into account longer-term considerations, and is relatively risk neutral. Consistent with this dual-process view of decision making, brain imaging shows that greater activation of affective systems in the brain, relative to cognitive systems, increases the likelihood that someone chooses an immediate monetary reward over a larger, delayed reward (McClure et al., 2004). Research on patients with brain lesions shows that damage to affective areas of the brain increases willingness to take risks (Shiv et al., 2005). It could be that our measures of cognitive ability proxy for the resources available to individuals for suppressing affective urges, which would otherwise lead them to pursue immediate consumption, or to avoid risks.

An important topic for future research, however, is establishing the direction of causality between cognitive ability, risk aversion, and impatience. Our evidence is perhaps somewhat more supportive of an impact of cognitive ability on patience and risk aversion, rather than the other way around, given that our measures of cognitive ability capture something closer to innate ability than, say, the accumulated knowledge measured by an SAT test score. For example, one of the tests measures the speed and accuracy with which an individual matches symbols and numbers, according to a given correspondence. The correspondence is arbitrary, and has not been encountered in previous education or training settings. Thus there is relatively limited scope for performance to be explained by an impact of preferences on accumulated education or experiences.[26] The question of causality deserves further study, but the emerging picture is that cognitive ability affects preferences rather than the other way around.

Regardless of the precise mechanisms, a link between cognitive ability, risk aver-

[26] The finding from previous studies, that cognitive ability is correlated with impatience for young children, provides an additional indication that ability causes preferences and not the other way around, to the extent that young children have relatively little scope to shape their environments according to their own preferences. Also, Benjamin et al. (2006) show that preferences of high school students are significantly correlated with grades in elementary school, but do not find a statistically significant correlation with the change in grades between elementary school and high school, suggesting that preferences do not lead to faster accumulation of ability.

sion, and impatience has important implications for economic modelling. These traits are usually assumed to be independent, but the results in this paper suggest that this is a potential source of model miss-specification. In particular, it may be appropriate to allow for a negative correlation between cognitive ability and discount rates, and a positive correlation between cognitive ability and willingness to take risks. Our findings also suggest a different interpretation of reduced form models that are estimated with cognitive ability as an explanatory variable for outcomes such as educational choice or wages, but not measures of risk aversion or impatience. Our results also have potential implications for understanding social mobility, given that cognitive ability is passed from one generation to the next, and for understanding the implications of cross-country differences in cognitive ability for inequality. In terms of policy implications, this paper points to important ramifications of early childhood interventions focused on improving cognitive ability or changing preferences.

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Tables

Table 1: The Link Between Cognitive Ability, Risk Aversion, and Impatience

Dependent Variable:	Willingness to take risks (Experimental Measure)				Impatience (Experimental Measure)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Standardized symbol correspondence score	1.142***	0.816**			-1.296***	-1.193**		
	[0.277]	[0.351]			[0.448]	[0.518]		
Standardized word fluency score			1.189***	0.908***			-1.080**	-0.918*
			[0.306]	[0.313]			[0.474]	[0.481]
1 if female		1.075		1.168		2.217*		2.648**
		[0.806]		[0.826]		[1.233]		[1.262]
Age (in years)		-0.020		-0.029		0.000		0.028
		[0.021]		[0.018]		[0.031]		[0.028]
Height (in cm)		0.113**		0.099**		0.010		-0.016
		[0.045]		[0.048]		[0.069]		[0.071]
Constant	8.992***	-10.062	9.045***	-7.165	12.060***	9.174	12.006***	12.043
	[0.319]	[8.282]	[0.324]	[8.676]	[0.482]	[12.481]	[0.490]	[12.975]
log Pseudo-Likelihood	-1246.42	-1235.34	-1160.19	-1152.29	-1304.05	-1296.09	-1240.12	-1229.42
Observations	413	411	383	382	457	455	434	432

Coefficients are marginal effects from interval regressions. The dependent variable in columns (1) to (4) is an incentive compatible measure of willingness to take risks. The dependent variable in columns (5) to (8) is an incentive compatible measure of impatience over an annual time horizon. Scores on the symbol correspondence and word fluency tests are measures of cognitive ability, standardized to have mean 0 and standard deviation 1. Robust standard errors in brackets; ***, **,* indicate significance at 1-, 5-, and 10-percent level, respectively.

Table 2: Controlling for Education

Dependent Variable:	Willingness to take risks (Experimental Measure)				Impatience (Experimental Measure)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Standardized symbol correspondence score	0.823***	0.600*			-1.262***	-1.084**		
	[0.312]	[0.350]			[0.474]	[0.542]		
Standardized word fluency score			0.823**	0.675**			-0.908*	-0.729
			[0.327]	[0.325]			[0.500]	[0.497]
Abitur	2.408***	2.154**	1.975**	1.483	-0.313	-0.585	-1.552	-1.507
	[0.923]	[0.980]	[0.916]	[0.998]	[1.291]	[1.288]	[1.275]	[1.292]
Fachoberschulreife	0.677	0.547	0.868	0.408	1.398	1.003	1.209	1.067
	[0.842]	[0.902]	[0.830]	[0.915]	[1.197]	[1.200]	[1.213]	[1.230]
Other degree	-2.531**	-2.029*	-1.981	-1.569	0.032	-0.029	1.053	0.886
	[1.204]	[1.228]	[1.254]	[1.261]	[2.072]	[2.029]	[2.113]	[1.954]
No degree, still enrolled in school	0.380	-0.331	0.795	-0.469	1.063	1.166	0.816	1.892
	[1.415]	[1.655]	[1.499]	[1.743]	[2.465]	[2.660]	[2.501]	[2.691]
No degree	-2.745	-2.571	-3.841	-3.86	5.635	5.458	9.808	8.843
	[2.733]	[2.688]	[2.934]	[2.781]	[6.320]	[6.166]	[7.553]	[7.477]
1 if female		0.578		0.861		2.309*		2.833**
		[0.799]		[0.826]		[1.250]		[1.263]
Age (in years)		-0.019		-0.028		0.009		0.036
		[0.023]		[0.021]		[0.033]		[0.030]
Height (in cm)		0.079*		0.076		0.027		0.014
		[0.046]		[0.049]		[0.070]		[0.072]
Constant	8.345***	-4.633	8.415***	-3.462	11.576***	5.481	11.846***	6.286
	[0.589]	[8.482]	[0.596]	[8.909]	[0.887]	[12.773]	[0.891]	[13.197]
log Pseudo-Likelihood	-1237.80	-1228.84	-1153.99	-1148.19	-1302.17	-1294.50	-1235.92	-1225.58
Observations	413	411	383	382	457	455	434	432

Coefficients are marginal effects from interval regressions. The dependent variable in columns (1) to (4) is an incentive compatible measure of willingness to take risks. The dependent variable in columns (5) to (8) is an incentive compatible measure of impatience over an annual time horizon. Scores on the symbol correspondence and word fluency tests are measures of cognitive ability, standardized to have mean 0 and standard deviation 1. "Abitur" includes Fachabitur and indicates the most advanced pre-university degree in Germany; these degrees require the completion of an exam, which is taken at the end of university-track high-schools (Gymnasium or Sekundarstufe II of Gesamtschule). University-track education takes 12 to 13 years (depending on the federal state schooling laws). "Fachoberschulreife" is a less advanced degree, which is completed after only 10 years of schooling. It qualifies for entering advanced vocational education and for obtaining additional schooling at university-track high-schools. The reference category is "Hauptschulabschluss", which is a degree that is less advanced than Fachoberschulreife and qualifies for enrolling in basic vocational schooling. Other degrees comprise qualifications obtained at specialized schools that, for example, provide remedial education. These degrees are typically less advanced than the Hauptschulabschluss. Robust standard errors in brackets; ***, **,* indicate significance at 1-, 5-, and 10-percent level, respectively.

Table 3: Controlling for Income and Credit Constraints

Dependent Variable:	Willingness to take risks (Experimental Measure)				Impatience (Experimental Measure)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Standardized symbol correspondence score	0.737**	0.687**			-1.058**	-0.955*		
	[0.337]	[0.337]			[0.519]	[0.526]		
Standardized word fluency score			0.696**	0.713**			-0.843*	-0.735
			[0.317]	[0.314]			[0.486]	[0.486]
Net monthly household income	2.223***	1.645***	2.230***	1.725***	-2.104***	-1.825**	-2.147***	-1.796**
	[0.540]	[0.542]	[0.582]	[0.579]	[0.706]	[0.727]	[0.760]	[0.787]
1 if respondent is credit constrained		-2.704***		-2.370***		2.112*		2.179*
		[0.757]		[0.772]		[1.208]		[1.216]
1 if female	1.054	1.081	1.259	1.251	2.965**	2.820**	3.115**	2.876**
	[0.799]	[0.786]	[0.823]	[0.804]	[1.262]	[1.276]	[1.283]	[1.291]
Age (in years)	-0.025	-0.037*	-0.034**	-0.044**	0.011	0.026	0.026	0.04
	[0.020]	[0.021]	[0.017]	[0.018]	[0.032]	[0.033]	[0.029]	[0.029]
Height (in cm)	0.103**	0.092**	0.096**	0.078*	0.045	0.047	0.006	0.002
	[0.045]	[0.044]	[0.047]	[0.046]	[0.069]	[0.069]	[0.071]	[0.070]
Constant	-24.843***	-17.550*	-23.302**	-15.583	18.207	14.812	24.365*	21.507
	[8.771]	[9.034]	[9.265]	[9.534]	[13.669]	[13.710]	[14.199]	[14.194]
log Pseudo-Likelihood	-1171.23	-1152.61	-1090.34	-1075.45	-1231.30	-1216.49	-1170.29	-1154.24
Observations	393	388	365	361	434	430	413	408

Coefficients are marginal effects from interval regressions. The dependent variable in columns (1) to (4) is an incentive compatible measure of willingness to take risks. The dependent variable in columns (5) to (8) is an incentive compatible measure of impatience over an annual time horizon. Scores on the symbol correspondence and word fluency tests are measures of cognitive ability, standardized to have mean 0 and standard deviation 1. The variable "net monthly household income" refers to the current monthly income in Euros of all household members, net of taxes and benefits. For less than 29 percent of responds income was only reported in 6 intervals (0 – 750; 750 – 1,500; 1,500 – 2,500; 2,500 – 3,500; 3,500 – 5,000; >5,000). In these cases we used the interval midpoints (7,500 in case of income exceeding 5,000). The indicator for credit constraints is a question that asks: "If you suddenly encountered an unforeseen situation, and had to pay an expense of 1,000 Euros in the next two weeks, would you be able to borrow the money?" Robust standard errors in brackets; ***, **,* indicate significance at 1-, 5-, and 10-percent level, respectively.

Table 4: Robustness Check: Survey Measure of Risk Preference

Dependent Variable:	Willingness to take risks (Survey Measure)			
	(1)	(2)	(3)	(4)
Standardized symbol correspondence score	0.489***	0.268***		
	[0.082]	[0.097]		
Standardized word fluency score			0.445***	0.333***
			[0.090]	[0.091]
1 if female		-0.327		-0.334
		[0.218]		[0.223]
Age (in years)		-0.021***		-0.023***
		[0.006]		[0.005]
Height (in cm)		0.018		0.015
		[0.012]		[0.012]
Constant	4.430***	2.533	4.478***	3.229
	[0.085]	[2.275]	[0.087]	[2.278]
log Pseudo-Likelihood	-2043.99	-2019.81	-1921.23	-1897.10
Observations	902	898	848	845

Coefficients are marginal effects from interval regressions. The dependent variable in columns (1) to (4) is a survey measure of willingness to take risks. Respondents rate their willingness to "take risks, in general" on a scale from 0 to 10, where 0 indicates "completely unwilling" and 10 indicates "completely willing". Scores on the symbol correspondence and word fluency tests are measures of cognitive ability, standardized to have mean 0 and standard deviation 1. Robust standard errors in brackets; ***, **,* indicate significance at 1-, 5-, and 10-percent level, respectively.

Table 5: Robustness Check: Arbitrage Between Experiment and Market Interest Rates

Dependent Variable:	Impatience(Experimental Measure)			
	(1)	(2)	(3)	(4)
Standardized symbol correspondence score	-1.178***	-0.982**		
	[0.429]	[0.494]		
Standardized word fluency score			-0.994**	-0.782*
			[0.447]	[0.455]
1 if respondent thought about interest rate	-5.894***	-5.810***	-5.725***	-5.616***
	[0.857]	[0.886]	[0.879]	[0.894]
1 if female		2.324**		2.926**
		[1.158]		[1.192]
Age (in years)		0.022		0.047*
		[0.030]		[0.027]
Height (in cm)		0.050		0.033
		[0.068]		[0.070]
Constant	14.188***	3.45	14.067***	4.745
	[0.617]	[12.198]	[0.630]	[12.693]
log Pseudo-Likelihood	-1279.94	-1272.91	-1219.79	-1209.46
Observations	455	453	433	431

Coefficients are marginal effects from interval regressions. The dependent variable in columns (1) to (4) is an incentive compatible measure of impatience over an annual time horizon. The independent variable of interest is an indicator for whether a subject reported thinking about market interest rates while making decisions in the experiment measuring impatience. Robust standard errors in brackets; ***, **, * indicate significance at 1-, 5-, and 10-percent level, respectively.

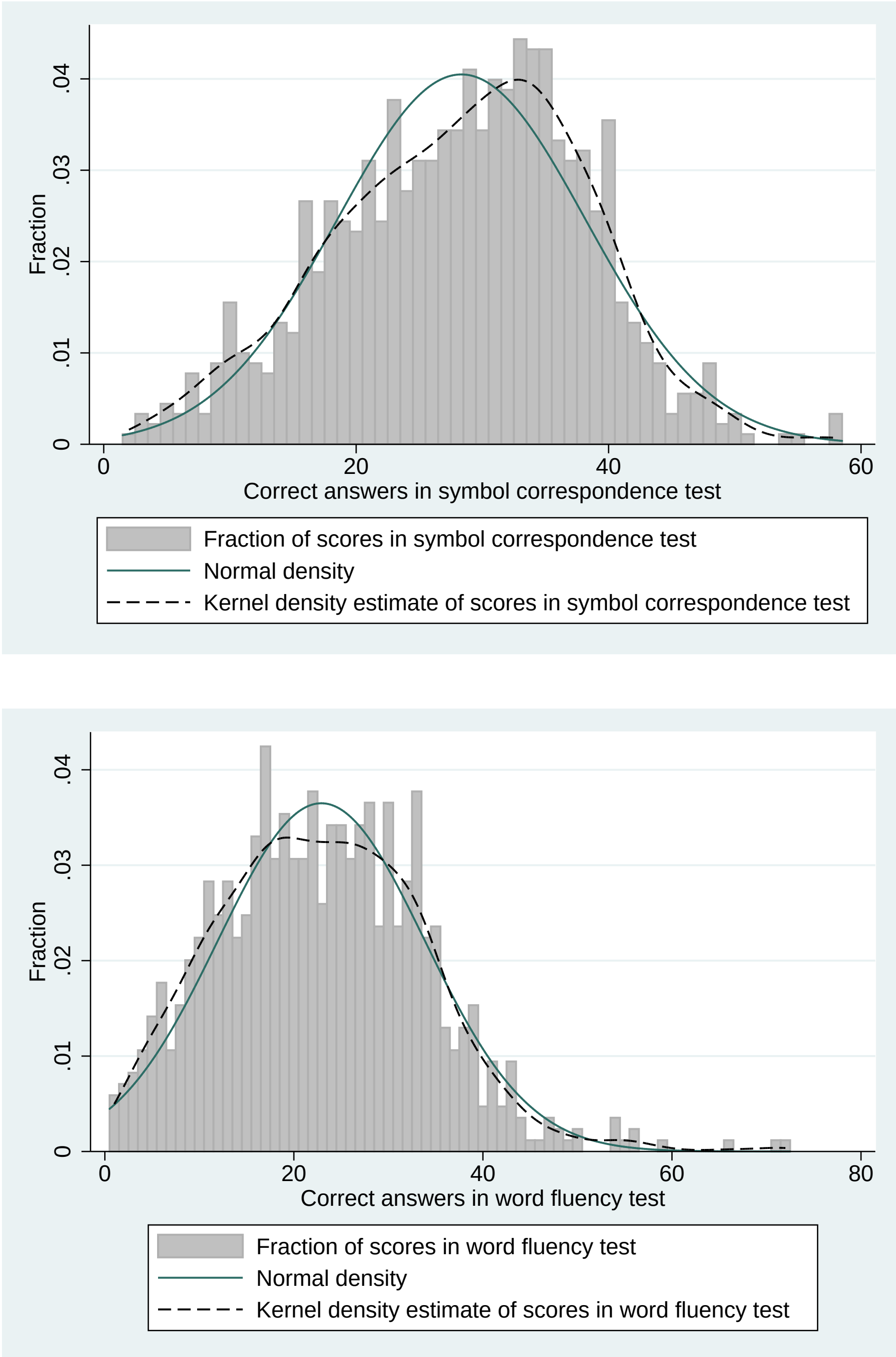
Table 6: Controlling for the Big Five

Dependent Variable:	Willingness to take risks (Experimental Measure)				Impatience (Experimental Measure)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Standardized symbol correspondence score	0.872***	0.668*			-1.172**	-1.085**		
	[0.286]	[0.346]			[0.466]	[0.525]		
Standardized word fluency score			0.959***	0.776**			-0.920*	-0.827
			[0.326]	[0.328]			[0.505]	[0.503]
Conscientiousness	-0.216	-0.085	-0.196	-0.047	0.418	0.325	0.439	0.207
	[0.325]	[0.334]	[0.331]	[0.346]	[0.483]	[0.486]	[0.495]	[0.497]
Extraversion	0.152	0.048	0.262	0.167	1.111**	0.998*	0.398	0.332
	[0.357]	[0.350]	[0.378]	[0.371]	[0.518]	[0.529]	[0.529]	[0.539]
Agreeableness	-0.2	-0.261	-0.174	-0.199	0.277	0.258	0.418	0.353
	[0.315]	[0.302]	[0.334]	[0.326]	[0.509]	[0.509]	[0.539]	[0.537]
Openness	0.923**	0.843**	0.681	0.646	-0.484	-0.575	-0.076	-0.150
	[0.409]	[0.401]	[0.430]	[0.428]	[0.531]	[0.533]	[0.515]	[0.515]
Neuroticism	-0.395	-0.324	-0.252	-0.239	0.622	0.534	0.511	0.362
	[0.324]	[0.337]	[0.341]	[0.354]	[0.472]	[0.468]	[0.513]	[0.509]
1 if female		0.957		1.048		1.908		2.230*
		[0.811]		[0.839]		[1.263]		[1.296]
Age (in years)		-0.013		-0.018		-0.006		0.019
		[0.022]		[0.019]		[0.032]		[0.029]
Height (in cm)		0.106**		0.093*		-0.003		-0.031
		[0.046]		[0.049]		[0.071]		[0.073]
Constant	8.993***	-9.215	9.098***	-6.583	11.973***	11.782	11.980***	15.256
	[0.318]	[8.338]	[0.326]	[8.812]	[0.484]	[12.837]	[0.494]	[13.365]
log Pseudo-Likelihood	-1221.39	-1211.86	-1132.65	-1126.36	-1274.73	-1267.55	-1206.50	-1197.19
Observations	406	404	375	374	447	445	422	420

Coefficients are marginal effects from interval regressions. The dependent variable in columns (1) to (4) is an incentive compatible measure of willingness to take risks. The dependent variable in columns (5) to (8) is an incentive compatible measure of impatience over an annual time horizon. Scores on the symbol correspondence and word fluency tests are measures of cognitive ability, standardized to have mean 0 and standard deviation 1. Personality traits –conscientiousness, extraversion, agreeableness, openness, neuroticism – are measured using a short version of the standard "Big Five" questionnaire from psychology. Robust standard errors in brackets; ***, **,* indicate significance at 1-, 5-, and 10-percent level, respectively.

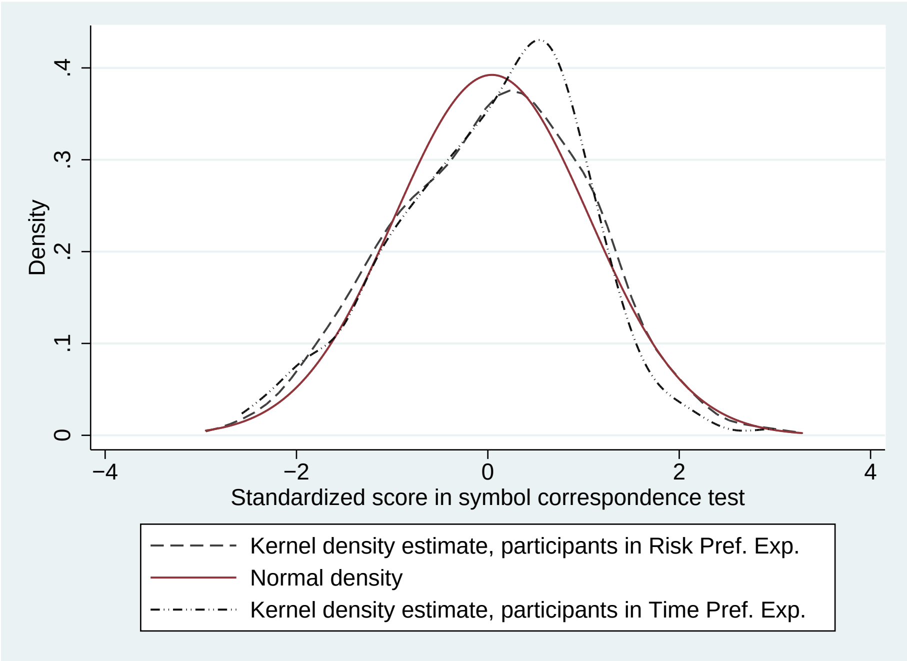
Figures

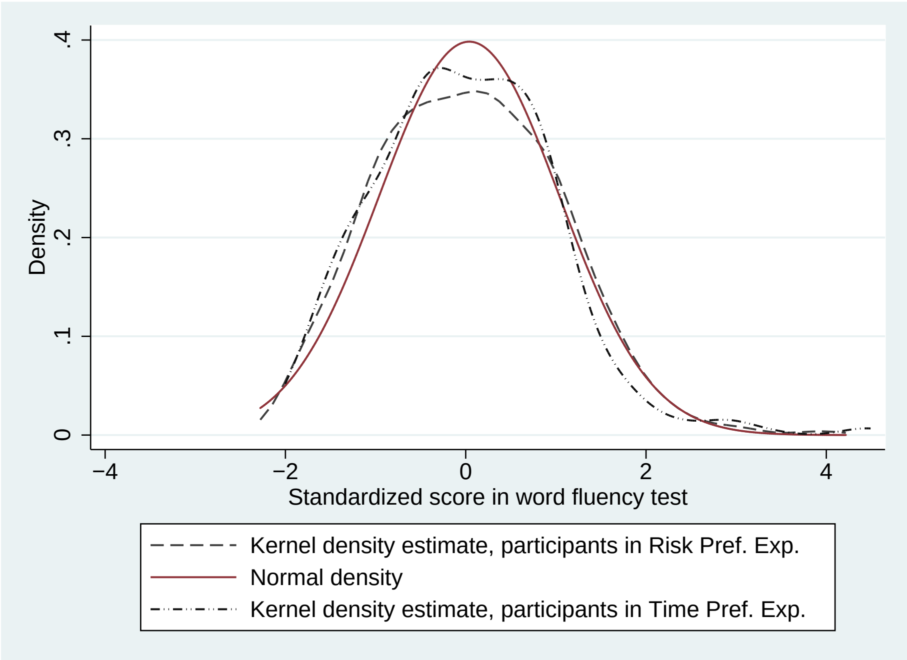
Figure 1: Distribution of Scores in the Cognitive Skills Tests



Note: The upper panel shows the histogram of correct responses in the symbol correspondence test. Overlaid is the smoothed density function of the distribution of scores, estimated using a Gaussian kernel. The bandwidth is chosen to minimize the mean integrated squared error if the data were Gaussian. A normal density is also plotted in the graph, with the same mean and variance as the estimated function. The lower panel of the figure shows the histogram of the number of correct recalls in the word fluency test. Graphs of the smoothed density function, and normal density, are estimated in the same way as in the upper panel.

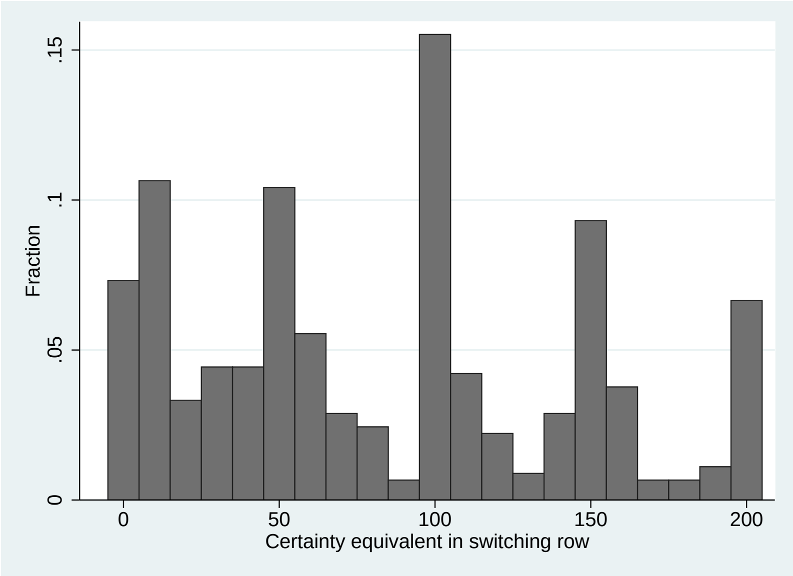
Figure 2: Comparison of Standardized Distributions of Cognitive Skills for Participants in Lottery and Intertemporal Choice Experiments

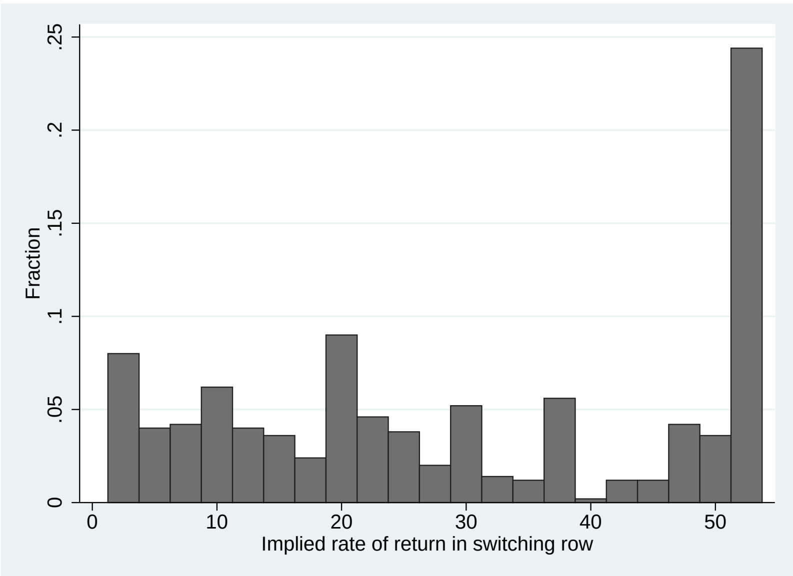




Note: The upper panel shows the smoothed density function of the distribution of standardized scores in the symbol correspondence for two sub-groups: participants in the lottery choice experiment and participants in the intertemporal choice experiment. These density functions are estimated using a Gaussian kernel with a bandwidth chosen to minimize the mean integrated squared error if the data were Gaussian. A normal density function is overlaid for comparison. The lower panel shows the analogous density functions for the word fluency test, separately for participants in the lottery experiment and participants in the intertemporal choice experiment.

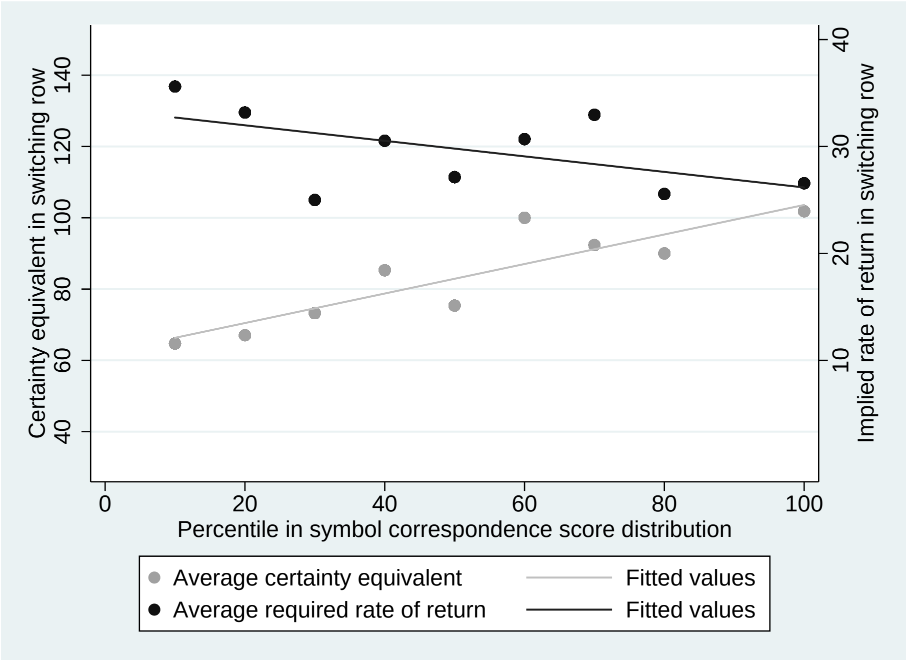
Figure 3: Distributions of Choices in the Lottery and Intertemporal Choice Experiments

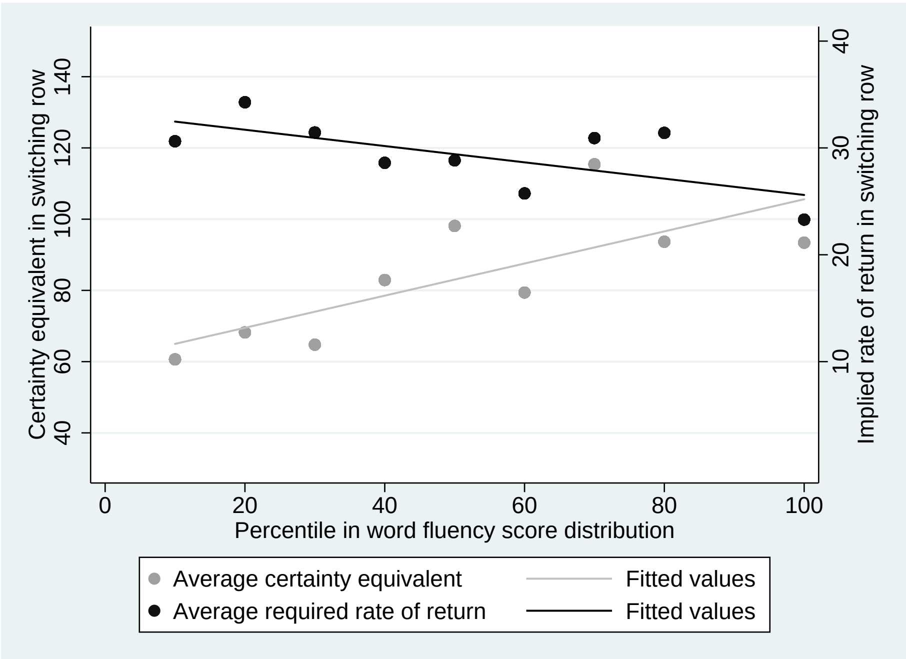




Notes: The upper panel of the figure shows the distribution of choices in the lottery experiment. Values are the safe payment necessary to induce a subject to forgo the chance to play the lottery involving 300 Euros or 0 Euros with equal probability. The lower panel shows the distribution of decisions in the intertemporal choice experiment. Values indicate the rate of return, paid one year in the future, necessary to induce a subject to forgo the chance to receive 100 Euros immediately.

Figure 4: Distributions of Experimental Measures of Willingness to Take Risks and Impatience, by Quantiles in the Cognitive Ability Distribution





Note: The upper panel of the figure shows the average value of certainty equivalent (black dots, left vertical axis) and average annual rate of return (light grey dots, right vertical axis) necessary to induce switching, by quantiles of the score distribution of the symbol correspondence test. The lower panel of the figure shows average certainty equivalents and annual rates of return for individuals in different quantiles of the score distribution of the word fluency test.

A Appendix

A.1 Additional Tables

Table A.1: The Link Between Cognitive Ability, Risk Aversion, and Impatience: Different Estimation Methods

Risk Aversion

Dependent Variable:	Willingness to take risks (Experimental measure)							
Estimation Method:	OLS Regression		Cox Proportional Hazards Model		Interval Regression using wider intervals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Standardized symbol correspondence score	0.809**		-0.109**		0.264***		0.285***	
	[0.326]		[0.055]		[0.096]		[0.102]	
Standardized word fluency score		0.850***		-0.132**		0.250***		0.274***
		[0.290]		[0.052]		[0.081]		[0.086]
1 if female	1.014	1.107	-0.172	-0.184	0.269	0.281	0.269	0.308
	[0.729]	[0.760]	[0.118]	[0.122]	[0.213]	[0.221]	[0.219]	[0.225]
Age (in years)	-0.019	-0.029*	0.002	0.003	-0.005	-0.009*	-0.007	-0.011**
	[0.019]	[0.016]	[0.004]	[0.003]	[0.006]	[0.005]	[0.006]	[0.005]
Height (in cm)	0.112***	0.099**	-0.017***	-0.015**	0.032***	0.027**	0.030**	0.026*
	[0.041]	[0.044]	[0.006]	[0.007]	[0.012]	[0.013]	[0.012]	[0.013]
Constant	-9.381	-6.768			-3.227	-2.249	-2.389	-1.457
	[7.523]	[7.994]			[2.149]	[2.263]	[2.278]	[2.388]
R-squared - log Pseudo-Likelihood	0.06	0.06	-2030.33	-1860.31	-684.57	-638.91	-724.15	-673.82
Observations	411	382	411	382	411	382	411	382

Impatience

Dependent Variable:	Impatience (Experimental measure)							
Estimation Method:	OLS Regression		Cox Proportional Hazards Model		Interval Regression using wider intervals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Standardized symbol correspondence score	-0.844**		0.140**		-0.242**		-0.189*	
	[0.373]		[0.057]		[0.113]		[0.104]	
Standardized word fluency score		-0.630*		0.109*		-0.230**		-0.163
		[0.345]		[0.056]		[0.110]		[0.099]
1 if female	1.704*	2.044**	-0.243*	-0.265*	0.586**	0.698**	0.435*	0.561**
	[0.907]	[0.934]	[0.135]	[0.141]	[0.281]	[0.286]	[0.251]	[0.255]
Age (in years)	-0.006	0.016	-0.001	-0.003	-0.002	0.004	0.000	0.006
	[0.022]	[0.020]	[0.003]	[0.003]	[0.007]	[0.006]	[0.006]	[0.006]
Height (in cm)	-0.003	-0.020	-0.002	0.001	0.001	-0.003	0.000	-0.005
	[0.051]	[0.052]	[0.008]	[0.008]	[0.016]	[0.016]	[0.014]	[0.014]
Constant	11.611	13.272			2.231	2.696	2.995	3.448
	[9.234]	[9.566]			[2.884]	[2.950]	[2.499]	[2.535]
log Pseudo-Likelihood	0.03	0.04	-1941.34	-1832.76	-871.05	-824.00	-883.45	-834.65
Observations	455	432	455	432	455	432	455	432

The dependent variable in column (1) of the upper table is the switching row in the lottery experiment. Coefficients are from an OLS regression. The regression in column (2) of the upper table is a Cox mixed proportional hazards model, estimating the impact of the independent variables on the hazard rate of switching from the lottery to the safe payment. The dependent variables in column (3) and column (4) of the upper table are constructed using two-row and three-row intervals, respectively, rather than single switching rows for the lottery experiment. Dependent variables in columns (1) to (4) of the lower table are defined analogously, except that they are based on switching rows in the intertemporal choice experiment. Coefficients are marginal effects from interval regressions. Scores on the symbol correspondence and word fluency tests are measures of cognitive ability, standardized to have mean 0 and standard deviation 1. Robust standard errors in brackets; ***, **,* indicate significance at 1-, 5-, and 10-percent level, respectively.

Table A.2: Schooling Outcomes and Cognitive Skill Measures

Estimation Method:	OLS Regression		Multinomial Logit					
Dependent Variable:	Years of schooling		Schooling Degree					
	(1)	(2)	(3) Abitur	(4) Hauptschule	(5) No Degree	(6) Abitur	(7) Hauptschule	(8) No Degree
Standardized symbol correspondence score	0.356***		0.420***	-0.220**	-0.15			
	[0.072]		[0.113]	[0.106]	[0.380]			
Standardized word fluency score		0.305***				0.161*	-0.318***	-1.341***
		[0.064]				[0.092]	[0.101]	[0.450]
1 if female	0.07	0.016	-0.377**	-0.483***	-0.463	-0.362**	-0.407**	-0.045
	[0.122]	[0.126]	[0.180]	[0.181]	[0.646]	[0.184]	[0.189]	[0.668]
Age (in years)	-0.011***	-0.016***	0.014**	0.040***	0.031	0.008	0.044***	0.037**
	[0.004]	[0.004]	[0.006]	[0.006]	[0.022]	[0.006]	[0.006]	[0.018]
Constant	10.844***	11.116***	-0.661**	-1.741***	-4.574***	-0.332	-1.922***	-5.623***
	[0.218]	[0.200]	[0.322]	[0.328]	[1.197]	[0.288]	[0.313]	[1.170]
R-squared - log Pseudo-Likelihood	0.07	0.07		-859.65			-807.48	
Observations	856	806		809			760	

The dependent variable in columns (1) and (2) is years of schooling (excluding university education, college or vocational training) Coefficients are from an OLS regression. The remaining columns provide estimates from two multinomial regression models in which the dependent variable consists of 4 categories for schooling degree: Abitur, Realschule, Hauptschule and no degree. The omitted category is Realschule. Robust standard errors in brackets; ***, **,* indicate significance at 1-, 5-, and 10-percent level, respectively.

B Experiment Instructions and Choice Tables

In the following we present a translation of the German instructions. Instructions were presented to the interviewer on the screen of the laptop computer, and were read aloud to the subjects by the interviewer.

Screen 1

Now that the interview is over we invite you to participate in a behavioral experiment, which is important for economic science. The experiment involves financial decisions, which you can make in any way you want to. The questions are similar to those asked in the questionnaire with the exception that THIS TIME YOU CAN EARN REAL MONEY!

I will first explain the decision problem to you. Then you will make your decisions. A chance move will then determine whether you actually earn money.

Every 7th participant wins!

HOW MUCH MONEY YOU WILL EARN AND AT WHICH POINT IN TIME WILL DEPEND ON YOUR DECISIONS IN THE EXPERIMENT.

If you are among the winners, your amount will be paid by check. In this case the check will be sent to you by post.

Screen 2

Participants are now shown a choice table for the respective experiment as an example. The table is printed on a green piece of paper and is handed to participants for them to study.

The experimenter continues explaining how the experiment will work.

In the lottery experiment, the interviewer gave the following explanation:

In each row you see two alternatives. You can choose between

- A fixed amount that you get "for sure"
- and an "all or nothing" lottery, where with 50 percent probability you can win 300 Euros and with 50 percent probability you win nothing.

You start with row 1 and then you go down from row to row. In each row you decide between a safe payment (column A) and the lottery (column B). The lottery is the same in all rows. Only the amount on the safe payment (left) increases from row to row.

Which row will be relevant for your earnings will be determined by a random device later.

In the intertemporal choice experiment, the interviewer gave the following explanation:

In each row you see two alternatives. You can choose between

- A fixed amount of 100 Euro (column A "today")
- and a somewhat higher amount, which will be paid to you only "in 12 months" (column B).

Payment "today" means that the check you get can be cashed immediately.
Payment "in 12 month" means that the check you get can be cashed only in 12 months.

You start with row 1 and then you go down from row to row. In each row you decide between 100 Euro today (column A) and a higher amount (column B); please always keep the timing of the payments in mind. The amount on the left side always remains the same, only the amount on the right side increases from row to row.

Which row on one of the tables will be relevant for your earnings will be determined by a random device later.

Screen 3

As you can see, you can earn a considerable amount of money. Therefore, please carefully consider your decisions.

Can we start now?

If the participant agreed, the experiment started. If not, the experimenter said the following:

The experiment is the part of the interview where you can earn money! Are you sure that you DO NOT WANT TO PARTICIPATE?

If the participant still did not want to participate, the experiment was not conducted and the participant answered a few final questions. In case the subject wanted to participate the experiment began.

The choice table was presented to the subject on a white piece of paper. For the elicitation of willingness to take risks, the subjects were asked to make the decisions that are listed in Table A.3below:

Participants studied their table. Then the experimenter asked for the subject's decision in each row, whether they preferred the option in column A or B, starting with the first row. In case a participant preferred the fixed payment the experimenter asked:

You have decided in favor of the fixed payment. We assume that this implies that for all higher amounts you also prefer the safe payment, meaning that for all remaining rows all higher amounts will be selected (i.e., column A)

If the participant did not agree, he kept on deciding between columns A and B.

In the intertemporal choice experiment, impatience over a year-long time horizon was inferred from subjects' choices Table A.4 shown below.

A similar procedure to the lottery experiment was followed, such that the experimenter

Table A.3: Choices in the Risk Preference Experiment

	safe payment		lottery
1)	€0 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
2)	€10 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
3)	€20 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
4)	€30 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
5)	€40 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
6)	€50 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
7)	€60 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
8)	€70 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
9)	€80 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
10)	€90 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
11)	€100 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
12)	€110 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
13)	€120 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
14)	€130 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
15)	€140 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
16)	€150 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
17)	€160 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
18)	€170 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
19)	€180 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0
20)	€190 for sure	or	50 percent chance of winning €300 and 50 percent chance of getting €0

Table A.4: Choices in the Intertemporal Choice Experiment

	Column A		Column B
1)	€100 today	or	€102.5 in 12 months
2)	€100 today	or	€105.1 in 12 months
3)	€100 today	or	€107.6 in 12 months
4)	€100 today	or	€110.2 in 12 months
5)	€100 today	or	€112.8 in 12 months
6)	€100 today	or	€115.5 in 12 months
7)	€100 today	or	€118.2 in 12 months
8)	€100 today	or	€121.0 in 12 months
9)	€100 today	or	€123.7 in 12 months
10)	€100 today	or	€126.5 in 12 months
11)	€100 today	or	€129.3 in 12 months
12)	€100 today	or	€132.2 in 12 months
13)	€100 today	or	€135.1 in 12 months
14)	€100 today	or	€138.0 in 12 months
15)	€100 today	or	€141.0 in 12 months
16)	€100 today	or	€144.0 in 12 months
17)	€100 today	or	€147.0 in 12 months
18)	€100 today	or	€150.0 in 12 months
19)	€100 today	or	€153.1 in 12 months
20)	€100 today	or	€156.2 in 12 months

asked for the subject's decision in each row, whether they preferred the option in Column A or B, starting with the first row. In case a participant preferred the higher, delayed amount the experimenter asked:

You have decided in favor of the higher amount of in months. We assume that this implies that for all higher amounts you also prefer the later payment, meaning that for all remaining rows all higher amounts will be selected (i.e., Column B)

Then it was determined whether the participant was among those who would be paid. Participants could choose their "lucky number" between 1 and 7. They could then press on one out of seven fields on the computer, which represented numbers from 1 to 7. If they hit "their" number they won, otherwise they did not win. In case they won, it was determined which of the tables was selected and which row of the respective table. This was done again by pressing on fields presented to participants on the computer screen. In the end subjects who had won were informed that they would be sent the check by mail.