Federal Reserve Bank of Chicago

Cognitive Abilities and Household Financial Decision Making

Sumit Agarwal and Bhashkar Mazumder

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Sumit Agarwal
Federal Reserve Bank of Chicago

Bhashkar Mazumder
Federal Reserve Bank of Chicago

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Abstract

We analyze the effects of cognitive abilities on two examples of consumer financial decisions where suboptimal behavior is well defined. The first example features the optimal use of credit cards for convenience transactions after a balance transfer and the second involves a financial mistake on a home equity loan application. We find that consumers with higher overall test scores and specifically those with higher math scores are substantially less likely to make a financial mistake. These mistakes are generally not associated with the non-mathematical component scores.

Keywords: Household finance, Credit Cards, Home Equity, AFQT Scores
JEL Classifications: D1, D8, G2

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1. Introduction

Individuals commonly make financial decisions that would be considered suboptimal according to standard consumer finance theory (e.g. Agarwal et al, 2009; Bertrand and Morse, 2011; Choi et al, 2011). Financial decision-making behavior has potentially wide ranging ramifications on society. For example, the boom and bust in U.S. housing markets that helped precipitate the recent economic downturn was likely due in part to poor household decision-making. Yet despite the growing salience of the issue, our current understanding of exactly what causes suboptimal financial decision making is limited.

The ability to process information and to make financial calculations appear to be especially important aspects of sound financial decision making and a growing literature has linked cognitive ability to financial behaviors and outcomes.[1] We present new empirical findings on the relationship between cognitive ability and financial decision making by focusing on two cases where suboptimal behavior is clearly defined. The first example features consumers who transfer their entire credit card balance from an existing account to a new card but decide to use the new card for "convenience" transactions — transactions that are fully paid for within the grace period. As we explain in the next section, it is never optimal to use the new card for such purchases, since it leads to finance charges that could be avoided by simply using the old card. We refer to this as a "balance transfer mistake" and describe the point at which a consumer discovers the optimal strategy as experiencing a "eureka" moment.

The second example features individuals who apply for a home equity loan or line of credit and who are provided with a pricing schedule that shows how the APR for their loan will depend on the loan to value ratio (LTV). Individuals are asked to estimate their home price and the bank separately calculates an estimate of the value of the home. If the individual's estimated home price is sufficiently different from the bank's estimate, then the individual may be penalized by being offered a higher APR than what the initial pricing schedule would have determined based on the bank's estimate of the home value. We

[1] There is growing evidence that cognitive ability is related to behavioral anomalies (e.g. Frederick, 2005; Dohmen et al, 2010; Benjamin et. al, forthcoming) and to financial market outcomes (e.g. Cole and Shastry, 2009; McArdle, Smith, and Willis, 2009; Grinblatt, Keloharju, and Linnainmaa, 2011; Christelis, Jappelli, and Padula, 2010).

classify individuals who proceed to take out the loan at the higher APR (rather than simply decline the loan and reapply for a loan elsewhere) as having made a "rate-changing mistake," or RCM.

We construct a unique dataset that links members of the US military in 1993 to administrative data from a large financial institution containing retail credit data from 2000 through 2002. Our measures of cognitive skills are based on the Armed Forces Qualifying Test (AFQT) score which contains information on both math and verbal ability. We find that consumers with higher overall AFQT scores and specifically those with higher math scores are substantially less likely to make balance transfer and rate-changing mistakes. A one standard deviation increase in the composite AFQT score is associated with a 24 percentage point increase in the probability that a consumer will discover the optimal balance transfer strategy and an 11 percentage point decrease in the likelihood of making a rate changing mistake in the home loan application process. Interestingly, we find that verbal scores are not at all associated with balance transfer mistakes and are much less strongly associated with rate-changing mistakes.

Our analysis improves upon the current literature in several respects. First, in contrast to studies that rely on broad outcomes such as stock market participation, we use clearly defined examples of financial mistakes where there is little ambiguity about whether the behavior is suboptimal. Second, we use well established measures of cognitive ability and do not rely on proxies such as age or education. Third, we study very routine behaviors concerning debt management that cover a broad swath of the population. In combination, these three aspects of our analysis provide a novel contribution to the existing literature.

Since we do not have a random sample of the national population, strictly speaking, our inferences only pertain to the population which we examine. However, we show that on many observable characteristics our matched samples are broadly similar to the universes from which they are drawn.[2]

[2] We also note that other important contributions (e.g. Madrian and Shea, 2001; Cullen, Einav, Finkelstein and Pascu, forthcoming) in the related literature have drawn inferences from the behavior of employees in a single firm. We also conduct a supplementary exercise using nationally representative data from the National Longitudinal Survey of Youth (NLSY) and find similar results when we link AFQT math scores to a measure of intertemporal decision making (see Online Appendix).

The rest of the paper is organized as follows. Section 2 describes the data and our measures. In section 3 we present our main results. In section 4 we briefly discuss the possible implications of our findings. Our conclusions are offered in section 5.

2. Data and Measures

2.1 Military data

We use all active duty military personnel in 1993 who entered the military beginning in September 1986 so that test scores are measured consistently. We use the armed forces qualifying test (AFQT) which combines two of the math scores with the two of the verbal scores.[3] In addition to test scores, we have data on sex, age, education, service branch, race, ethnicity, marital status, and zip code of residence.

2.2 Credit card data

We use a proprietary panel data set from a large financial institution that made balance transfer offers to credit card users nationally between January 2000 and December 2002.[4] The data includes the main billing information listed on each account's monthly statement as well as specific information on the balance transfer offer.[5] We also observe the FICO score as well as a proprietary (internal) credit "behavior" score. A higher score implies that the borrower has a lower probability of default. In addition, we have credit bureau data on the number of other credit cards, total credit card balances, mortgage balances, as well as age, gender, and self-reported income at the time of the account opening.

We merge the credit card data with the military data using a unique identifier. We restrict the sample to individuals who transferred their entire balance out of the existing card and who only made convenience transactions on either the new or the old card after completing the balance transfer.

[3] There are a total 10 different subtests, which cover numerical operations, word knowledge, arithmetic reasoning, mathematical knowledge, electronics information, mechanical comprehension, general science, paragraph comprehension, coding speed, and automotive and shop. We use the 1989 metric of the AFQT. A 1991 National Academy of Science study established the validity of the test as a predictor of job performance (Wigdor and Green, 1991). The test is used for enlistment screening and for assigning jobs within the military. Many previous studies have used the AFQT to measure cognitive ability (e.g. Neal and Johnson, 1996; Heckman, Stixrud, and Urzua; Warner and Pleeter, 2001).

[4] A total of 14,798 accepted the offer. Balance transfer offers were not made conditional on closing the old credit card account and in our sample, borrowers did not pay fees for the balance transfer.

[5] The monthly billing information includes total payment, spending, credit limit, balance, debt, purchases, cash advance APRs, and fees paid. The balance transfer data includes the amount of the balance transfer, the start date of the teaser rate, the initial teaser APR, and the end date of the balance transfer APR offer.

Convenience transactions are those that are fully paid for during the grace period. Balance transfer amounts exceeded $2000 on average. Our sample includes a total of 480 individuals who were matched to the military data and who had non-missing data on the key variables of interest. Online Appendix Table A1 presents summary statistics and compares a common set of covariates to the full military sample in Panel A. The comparison shows that for the most part our sample is reasonably representative of the full military.[6] Panel B of Table A1 compares this matched sample to the full sample of borrowers and here we find differences that in some cases are due to differences in the age distribution of the samples.[7]

2.3 Balance Transfer Mistake

When a borrower makes a balance transfer to a new card they pay substantially lower APRs on the balances transferred to the new card for a six- to nine-month period (a "teaser" rate). However, *new* purchases on the new card typically have high APRs. The catch is that payments on the new card first paid down the (low interest) transferred balances, and only subsequently paid down the (high interest) debt accumulated from new purchases. The CARD act of 2009 now requires card issuers to apply payments above the minimum to the balance with the highest rate first. For borrowers who have transferred the entire balance from an existing credit card and who subsequently only make "convenience" transactions, that is transactions that the consumer intends to pay off in full within the grace period, the optimal strategy during the teaser-rate period is for the borrower to only make new purchases on the *old* credit card.[8] The borrower should make no new purchases with the new card to which balances have been transferred (unless she has already repaid her transferred balances on that card).

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[6] For example, test scores, education and age at entry are very similar. The most noticeable difference is with respect to race. The matched sample overrepresents blacks (25.3 percent versus 19.8 percent) compared to the full military sample.

[7] The majority of our matched sample are in their 30s in the 2000–02 period when the balance transfer occurred compared with an older sample in the general population of borrowers. The average matched sample borrower has higher income but is also riskier as reflected by lower FICO and behavior scores. The balance transfer APR for the matched sample of borrowers is slightly higher (77 basis points) than for the full sample but the purchase APR for matched sample borrowers is much lower (649 basis points). This is most likely due to the fact that the account age of these borrowers is less than half of the full sample borrowers and so they still have favorable lending terms. It s also possible that individuals could have received more favorable terms if they were still in the military in 2000-02.

[8] We restrict the sample to individuals who transfer their *entire* balance because we want to ensure that they have the ability to use the old card for convenience use and incur no finance charges. This allows us to unambiguously identify cases where the optimal strategy is to use the old card.

This ensures that the borrower will pay no interest irrespective of the interest rates on each account.

Some borrowers will identify this optimal strategy immediately and will not make any new purchases using the new card. Some borrowers may not initially identify the optimal strategy, but will discover it after one or more pay cycles as they observe their (surprisingly) high interest charges. Those borrowers will make purchases for one or more months, then experience what we refer to as a "eureka" moment, after which they will implement the optimal strategy. Some will never identify the optimal strategy.

We track the use of the balance transfer card for a six-month period for consumers who continue to use at least one card for a convenience purchase. Our main dependent variable, is an indicator variable which is equal to one if a person discovers the optimal strategy at some point during the six-month period. That is if they either never make the mistake or, if they do make the mistake at some point in this period, they cease to make the mistake for the remainder of the sixth-month window. A second outcome tracks how many months it takes for the consumer to adopt the optimal strategy and to stop using the balance transfer card for new purchases.[9] Figure 1, which plots the distribution of AFQT scores by whether the consumer ever has a eureka moment, provides a preview of the main results. We find that among those with AFQT percentile scores above 70, everybody ultimately identifies the optimal strategy. In contrast, the majority of cases with a score below 50 will not identify the optimal strategy.[10] In section 3.1 we estimate the effects using a linear probability model while including demographic and financial controls.

2.4 Home Equity Loans and Lines Data

We also use a proprietary panel dataset obtained from a national financial institution to study financial mistakes with respect to home equity loans and lines of credit.[11] Between March and December of 2002, the lender offered a menu of standardized contracts for home equity loans or lines of credit with 5 year maturities. Consumers chose the following: (a) either a loan or a credit line; (b) either a first or

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[9] About one-third implement the optimal strategy immediately, slightly more than one-third never implement the optimal strategy and the remaining third implement the optimal strategy at some point after the first month.

[10] A full set of differences in the mean characteristics of those who experience eureka versus those that who don't are shown in Online Appendix Table A3. Of particular note is that blacks make up a much larger fraction of the "no eureka" subsample. As we show later, however, our results are robust to dropping blacks.

[11] This company did not specialize in subprime loans or any other segment of the market.

second lien; and (c) an incremental loan amount corresponding to a loan-to-value ratio (LTV) of less than 80 percent (80-), between 80 and 90 percent (80-90), or 90 percent and greater (90+). In essence, the lender offered twelve different contract choices, each having an associated APR.

For 75,000 out of 1.4 million such contracts who took up the loan or line of credit, we observe the contract terms, borrower demographic information (job and home tenure), financial information (income and debt-to-income ratio), and risk characteristics (FICO score and LTV). We also observe borrower estimates of their property values and the loan amount requested. We merge this data with the military dataset using a unique identifier producing a sample of 1,393 borrowers who took out a home equity loan or line of credit and for whose home we have non-missing values on the key variables.

Panel A of Table A2 in the online Appendix presents summary statistics comparing the matched sample to the overall military sample. In this case we find that test scores are generally a little bit higher in our matched sample. This is likely due to the fact that our matched sample is selected on those who own homes.[12] Panel B compares the matched sample to the full home loan sample. Borrowers in the matched sample have higher FICO scores, have longer job tenure, have higher income, have higher home values and loan amounts and pay a lower APR.

2.5 Rate-Changing Mistake

In determining the APR for a home equity loan or line of credit, the amount of collateral offered by the borrower, as measured by the LTV, is a key determinant. Higher LTVs imply higher APRs, since the fraction of collateral is lower. At the financial institution that provided our data, borrowers first estimate their home values, and ask for a credit loan or credit line falling into one of three implied borrower-generated LTV categories described earlier (80-, 80-90, 90+). The financial institution then independently verifies the house value using an industry-standard methodology and determines their own estimate of the LTV. The institution's LTV can therefore differ from the borrower's LTV.[13]

[12] Our matched home equity sample contains a larger share of whites and a smaller share of males, although neither difference is statistically significant.
[13] Agarwal (2007) and Bucks and Pence (2008) present evidence showing that borrowers often do not know their house value or mortgage terms.

Loan pricing (APR) depends on the LTV *category* that the borrower falls into and not on the specific LTV within that category.[14] If the borrower has overestimated the value of the house, so that the financial institution's LTV is higher than the borrower's LTV (e.g., the borrowers' LTV category is 80-, while the banks LTV category is 80-90), the institution will direct the buyer to a different loan with a higher interest rate corresponding to the higher LTV. In such circumstances, the loan officer is also given discretion to depart from the financial institution's normal pricing schedule to offer *an even higher* interest rate than the officer would have offered to a borrower who had correctly estimated her LTV.[15] If the borrower has underestimated the value of the house (e.g., the borrowers' LTV category is 80-90, while the banks LTV category is 80-), the financial institution need not direct the buyer to a loan with a lower interest rate corresponding to the financial institution's LTV; the loan officer may simply choose to offer the higher interest rate associated with the borrower's LTV (80-90), instead of lowering the rate to reflect the financial institution's lower LTV (80-).[16]

We define a rate-changing mistake to have occurred when the borrower LTV category differs from the bank LTV category *and the borrower proceeds with the loan*—for instance, when the borrower estimates an LTV of 85 percent but the bank calculates an LTV of 95 percent (or vice versa).[17] It is important to note that borrowers who make RCMs (regardless of whether it is due to overestimating or underestimating) are presented with sufficient information to make them aware of their mistake at the time that they are presented with the APR for the loan and before they agree to the loan. These individuals are given both the full menu of prices for each LTVcategory (in the absence of a mistake) as well as their actual offered APR. For borrowers who have been penalized, it is suboptimal to proceed with the loan, since they can simply reapply for a loan from the same lender or a different lender armed

[14] We have verified this empirically in our data.
[15] We have verified that this occurs by talking to loan officers.
[16] Even if the financial institution's estimate of the true house value is inaccurate, that misestimation will not matter for the borrower's decision to accept the loan as long as other institutions use the same methodology.
[17] An example where misestimation does not lead to a higher APR is if the borrower's estimated LTV is 60 percent, but the true LTV is 70 percent. In this case the borrower would still qualify for the highest quality loan category (LTV<80) and would not suffer an effective interest rate penalty.

with an accurate estimate of their home value that would allow them to avoid such a penalty.[18] We find that, on average, making an RCM increases the APR by 269 basis points which is clearly a costly mistake. Online Appendix Table A4, Panel B highlights the significant differences between the borrowers with and without an RCM. The FICO score for the RCM borrowers is 25 points lower, their income is $20,357 lower and their debt-to-income ratio is 6 percentage points higher.

To preview our results with respect to the effects of cognitive ability on making an RCM, Figure 2 shows that there are no cases of rate-changing mistakes among those with percentile scores above 69. In contrast, RCMs are concentrated in the lower half of the AFQT distribution.[19] We present more detailed statistical results based on estimating linear probability models in section 3.2.

3. Results

3.1 Balance Transfer Mistakes and AFQT Scores

In Table 1 we show the results of our first set of estimates that use the composite AFQT test score to predict whether consumers learn the optimal behavior after a balance transfer, i.e., experience a eureka moment. In all of our estimations, we have standardized all the test score variables to have a mean of zero and a standard deviation of one. In column (1) where we don't include any controls, the estimated effect of a one standard deviation increase in AFQT scores is to raise the probability of a eureka moment by about 23 percentage points. The effect is highly significant with a t-statistic over 12. In column (2) we add financial controls from our credit card dataset and find that this has almost an imperceptible effect on the AFQT score coefficient. Further, we find that most of the financial controls have no effect on the probability of a eureka moment. Perhaps not surprisingly, the one exception is the behavior score –where higher values indicate greater credit worthiness based on the borrower's payment and purchase behavior.

In column (3) the effect rises slightly to 0.24 when we include our demographic controls. Perhaps surprisingly, there is no effect of education, though this may be an imperfect measure since it may only

[18] We have no information on the subsequent behavior of borrowers who choose not to accept a loan. Therefore, we cannot distinguish the reasons why a borrower declined a loan or determine if they received a loan elsewhere. There are also no pecuniary costs if te borrower decides to decline the loan.
[19] Online Appendix Table A4 provides more detailed summary statistics separately for those who experience an RCM versus those who don't.

capture completed schooling by the time of enlistment or early in one's military career. Those that were married at the time they were in the military are significantly less likely to have a eureka moment. Interestingly, we find that the effect on being black is actually positive conditional on AFQT scores and education. This finding is interesting in light of the theoretical model developed by Lang and Manove (2011) who argue that blacks of similar ability to whites may need to signal their productivity to employers by acquiring more education.[20] They cite studies suggesting that blacks are not rewarded the same as whites in the labor market for equivalent AFQT scores. It is possible that the increased likelihood of discovering the optimal balance transfer strategy among blacks who have the same measured ability as whites, reflects their greater investments along other dimensions of human capital.

In column (4) we include both sets of controls and again find that doing this has no effect on our main finding. In columns (5) through (8) we use the four component scores (arithmetic reasoning, math knowledge, paragraph comprehension, and word knowledge) that are used to calculate the AFQT score. In all four specifications, the two math scores are both highly significant, suggesting that quantitative skills are critical for avoiding suboptimal behavior. In contrast, we estimate that the effects of the two verbal test scores are a fairly precisely estimated 0. For example, the largest point estimate for a verbal score suggests that a one standard deviation increase in word knowledge would only increase the incidence of eureka moments by a little more than a tenth of a percentage point. We also find that once we include all of the covariates using this specification, we no longer find any of the demographic controls to be significant.

In other specifications (not shown) we also estimated the effect of AFQT scores on whether a borrower *immediately* adopts the optimal strategy. In these cases the coefficient on the AFQT score is consistently around 0.18. This suggests that about two-thirds of the 0.24 effect of cognitive skills shown in Table 1 is due to an immediate effect and about a third of the effect is due to borrowers who learned the optimal strategy after initially making a financial mistake. We also found that when we used this

[20] Lang and Manove (2011) find that there are significant black-white wage differences conditional on education and AFQT suggesting the possibility of labor market discrimination.

dependent variable, that none of the financial or demographic controls were ever significant.

To illustrate the effects of AFQT scores on the speed at which individuals learn, we plot in Figure 3 the unadjusted mean AFQT scores for borrowers based on how many months it took them to discover the optimal strategy. The chart shows that AFQT is monotonically decreasing in the number of months it takes borrowers to learn. We estimate that a one standard deviation increase in AFQT scores is associated with a 1.5 month reduction in the time it takes to achieve optimal behavior speed. This analysis suggests that cognitive skills also affects the "intensive" margin of optimal financial decision making behavior.

3.2 Rate-Changing Mistakes and AFQT Scores

In Table 2 we report the effects of AFQT scores on the probability of making a rate-changing mistake for home equity loans or lines.[21] The first four columns use the overall AFQT score and utilize the following: no controls in column (1), financial controls from the home equity data in column (2), demographic controls from the military data in column (3), and both sets of controls in column (4). The key finding is that a one standard deviation increase in AFQT lowers the probability that a borrower will make a rate-changing mistake by between 10 and 11 percentage points. Since the average probability of making a rate-changing mistake is 14 percent in our sample, the implied effect size is over 70 percent.

Among the financial covariates, taking out a loan versus a line raises the likelihood of an RCM by about 10 percentage points as does a one percentage point increase in the APR. The debt-to-income ratio has a small but perceptible effect. The FICO score also has a small effect but it is not economically meaningful. Turning to demographic controls, education actually has a positive sign but the effect is reduced once we condition on financial variables. As before, blacks are significantly less likely to make an RCM conditional on AFQT scores, while women are slightly more likely to make one (not shown).

When we use the four subtests that make up the AFQT (columns 5 to 8), we again find that both math scores have large and significant negative effects on RCM. Among the verbal scores, paragraph comprehension has no effect but we do see a negative statistically significant effect of word knowledge.

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[21] For these regressions we pool home equity loans and lines of credit together, but include a dummy variable for home equity loans. We also control for not having a first mortgage and LTV bucket.

A one standard deviation increase in word knowledge lowers the probability of an RCM by about 2 to 3 percentage points.

Finally, to highlight the importance of RCMs, we estimated the effect of AFQT scores on the APR for consumers who *do not make an RCM* and found no statistically significant or quantitatively meaningful effect. When coupled with our main findings, this suggests that cognitive ability only affects loan pricing through the rate-changing mistake.

3.3 Robustness Checks

To reinforce that it is specifically mathematical skills that seem to matter for financial decision making, we also include the other 6 subtests from the military entrance exam in Table 3. We find that the effects from the two math scores from Table 1 are unaffected by the inclusion of the other scores and continue to find few effects from non-math scores.[22] In other results (not shown) we find that our results are insensitive to using state or zip code fixed effects or to limiting the sample to only whites.[23]

We also conduct a supplementary exercise using the Health and Retirement Survey (see Online Appendix) to show that while mathematical ability predicts later life financial success, it is *not* predictive of suboptimal behavior in other aspects of life, such as failure to take medication. We further show that other forms of cognitive ability are, in fact, critically predictive of sub-optimal non-financial behaviors. This suggests that there is a correspondence in the kinds of cognitive abilities that are relevant for particular outcomes and strengthens the notion that there is something inherent in mathematical ability that lessens the likelihood of an individual making poor financial decisions.

4. Discussion

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[22] "Coding speed," which measures how quickly and accurately individuals can recognize numerical patterns is statistically significant for eureka but not for RCM. A third math test, "numerical operations" reduces the probability of a eureka moment, controlling for the other two math scores. However, the raw correlation between eureka and numerical operations is positive (0.18), but much lower than the raw correlations of eureka moments with arithmetic reasoning (0.50) or math knowledge (0.48). This relatively lower correlation suggests that numerical operations is picking up some factor that is orthogonal to the other two math scores. With RCM, we find no effect of coding speed and that numerical operations has the correct sign and is marginally significant.

[23] The RCM results are also robust to controls for contract type (loan type interacted with LTV category).

An intriguing question is why exactly math ability appears to matter for financial mistakes. While we are limited in our ability to investigate this in any definitive way, we speculate on some possibilities. In a supplementary exercise using data from the nationally representative National Longitudinal Survey of Youth (see Online Appendix), we find that a simple survey-based measure of patience based on an intertemporal decision making problem is also strongly associated with AFQT scores but once again, only with the math component of the test. One interpretation of this finding is that those with greater math ability are more patient and therefore less likely to make financial mistakes when there is an element of a time tradeoff in a financial decision such as in our examples.[24] An alternative view is that math ability is directly related to the ability to understand financial concepts, to analyze intertemporal tradeoffs and to make relevant financial calculations —all of which are arguably very important for financial decision making. However, further research is needed to better understand and interpret our empirical findings.

Since our primary aim is to demonstrate how financial mistakes are linked to cognitive ability, we have deliberately targeted very "clean" examples of suboptimal behavior, irrespective of the dollar values of the costs of such mistakes. While the costs of balance transfer mistakes are relatively small, in the case of home equity loans since an RCM increases the APR by 269 basis points this implies an increase in nearly $4000 over the life of a typical loan.[25] In any case, we think that our analysis likely only touches the tip of the iceberg in terms of the effects of poor financial decision-making due to low cognitive ability on individual and social welfare. It is highly plausible that similar types of financial mistakes have played a role in explaining loan default, foreclosures and bankruptcies. In a highly complementary paper to ours, Gerardi, Goette, and Meier (2010) find a strong association between numerical ability and mortgage

[24] In the balance transfer case the optimal strategy works when individuals can plan which card they will use for their *future* expenditures and stick with that plan. In the home loan case, it may be those who are more patient would be willing to decline the loan and to simply reapply for the loan in the *future* armed with better knowledge of how to estimate their home price in order to avoid a penalty.
[25] The increase in costs is $3771 for a 5 year $50,000 loan, assuming a change in the APR from 5% to 7.69%

delinquency and default during the recent financial crisis.[26] Future research may shed more light on the quantitative importance of cognitive ability.

Finally, it is natural to consider whether our results have implications for current efforts to improve financial literacy. To the extent that our findings represent *causal* effects of math ability on financial mistakes, and to the extent that policies exist that can affect math test scores, our results could provide support for certain interventions.[27] However, we remain cautious in interpreting the relevance of our findings for policy, since we do not yet have a definitive understanding of exactly why math scores are correlated with financial mistakes.

5. Conclusion

In the wake of the recent financial crisis, there is a clear desire among policymakers to improve the quality of household financial decision making. We add new empirical evidence to an emerging literature has begun to link financial market behaviors to measures of cognitive abilty. Specifically we use two clearly defined examples of suboptimal behavior on the part of households concerning management of debt. Our results show that consumers with higher overall AFQT scores and specifically those with higher math scores are substantially less likely to make financial mistakes in their usage of credit card balance transfer offers and on home equity loan applications. While our findings improve the quality of empirical evidence linking cognitive abilities to financial decision making, we argue that further research is needed to better elucidate the mechanisms underlying this association and to better understand the relevance of these findings for efforts to improve financial literacy in the population.

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[26] We also note that our HRS results shown in the Appendix also suggest that there are potentially very large ramifications for having poor mathematical cognitive ability on savings behavior and accumulated wealth.

[27] It is worth noting that a number of studies (e.g. Neal and Johnson, 1996; Hansen, Heckman, and Mullen, 2004; Cascio and Lewis, 2006; and Chay, Guryan and Mazumder, 2009) suggest that AFQT scores are not immutable and do not simply reflect innate intelligence.

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Table 1: Effects of AFQT on optimal behavior ("Eureka") by consumer borrowers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AFQT Score	0.228***	0.228***	0.244***	0.241***				
	(0.018)	(0.016)	(0.019)	(0.017)				
Arithmetic Reas.					0.121***	0.116***	0.133***	0.125***
					(0.022)	(0.020)	(0.023)	(0.020)
Math Knowledge					0.134***	0.141***	0.126***	0.134***
					(0.021)	(0.019)	(0.022)	(0.019)
Paragraph Comp.					0.006	-0.000	0.009	0.002
					(0.021)	(0.019)	(0.021)	(0.019)
Word Knowl.					0.008	0.008	0.014	0.013
					(0.022)	(0.020)	(0.023)	(0.020)
Financial controls								
Bal. Transfer APR		0.002		0.002		0.003		0.003
		(0.006)		(0.006)		(0.005)		(0.006)
Purchase APR		-0.004		-0.004		-0.005		-0.005
		(0.004)		(0.004)		(0.004)		(0.004)
Account Age		-0.002		-0.002		-0.000		-0.000
		(0.003)		(0.003)		(0.003)		(0.003)
Behavior Score		-0.572***		-0.560***		-0.558***		-0.552***
		(0.084)		(0.084)		(0.082)		(0.082)
Behavior Score Sq.		0.081***		0.080***		0.081***		0.080***
		(0.010)		(0.010)		(0.009)		(0.010)
Fico Score		-0.045		-0.037		-0.033		-0.025
		(0.080)		(0.080)		(0.077)		(0.079)
Fico Score Squared		-0.001		-0.002		-0.003		-0.003
		(0.007)		(0.008)		(0.007)		(0.007)
Income		-0.000		-0.000		-0.000		-0.000
		(0.000)		(0.000)		(0.000)		(0.000)
Demographic controls								
Education			0.011	0.023			0.008	0.020
			(0.028)	(0.025)			(0.027)	(0.025)
Black			0.086**	0.079**			0.052	0.044
			(0.043)	(0.039)			(0.043)	(0.039)
Other			0.050	0.102			0.034	0.083
			(0.071)	(0.063)			(0.070)	(0.062)
Female			0.007	0.007			0.030	0.026
			(0.055)	(0.049)			(0.055)	(0.049)
Married			-0.078**	-0.062*			-0.062*	-0.043
			(0.037)	(0.033)			(0.036)	(0.032)
Observations	480	480	480	480	480	480	480	480
R-squared	0.261	0.424	0.274	0.436	0.295	0.461	0.302	0.467

*** p<0.01, ** p<0.05, * p<0.1

Notes: See text for further details .

Table 2: Effects of AFQT on rate changing mistakes (RCM) by home equity borrowers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AFQT Score	-0.096***	-0.100***	-0.107***	-0.107***				
	(0.010)	(0.008)	(0.011)	(0.009)				
Arithmetic Reas.					-0.039***	-0.044***	-0.047***	-0.049***
					(0.012)	(0.009)	(0.012)	(0.010)
Math Knowledge					-0.056***	-0.050***	-0.053***	-0.048***
					(0.011)	(0.009)	(0.011)	(0.009)
Paragraph Comp.					0.007	-0.005	0.005	-0.006
					(0.011)	(0.009)	(0.011)	(0.009)
Word Knowl.					-0.026**	-0.023**	-0.034***	-0.027***
					(0.012)	(0.009)	(0.012)	(0.009)
Financial controls								
Years on the Job		-0.001		-0.001		-0.001		-0.001
		(0.001)		(0.001)		(0.001)		(0.001)
Appraised Value		0.000		0.000		0.000		0.000
		(0.000)		(0.000)		(0.000)		(0.000)
Improvement		0.026		0.025		0.026		0.025
		(0.018)		(0.018)		(0.018)		(0.018)
Refinancing		0.017		0.018		0.018		0.019
		(0.016)		(0.016)		(0.016)		(0.016)
Equity Loan		0.103***		0.105***		0.107***		0.109***
		(0.032)		(0.032)		(0.032)		(0.032)
Income		0.000		0.000		0.000		0.000
		(0.000)		(0.000)		(0.000)		(0.000)
First Mortgage Bal.		-0.000		-0.000		0.000		0.000
		(0.000)		(0.000)		(0.000)		(0.000)
FICO Score		-0.025*		-0.025*		-0.024		-0.024
		(0.015)		(0.015)		(0.015)		(0.015)
APR		0.098***		0.097***		0.097***		0.096***
		(0.008)		(0.008)		(0.008)		(0.008)
DTI ratio		0.001**		0.001*		0.001**		0.001*
		(0.000)		(0.000)		(0.000)		(0.000)
Demographic controls								
Education			0.022*	0.006			0.020	0.005
			(0.013)	(0.010)			(0.013)	(0.010)
Black			-0.066***	-0.046***			-0.061***	-0.042**
			(0.022)	(0.018)			(0.022)	(0.018)
Other			-0.119***	-0.053*			-0.117***	-0.050*
			(0.035)	(0.029)			(0.036)	(0.029)
Observations	1380	1380	1380	1380	1380	1380	1380	1380
R-squared	0.062	0.408	0.078	0.414	0.069	0.411	0.082	0.416

Notes: Due to space limitations, coefficients on self employment , married and female are suppressed. See text for further details .

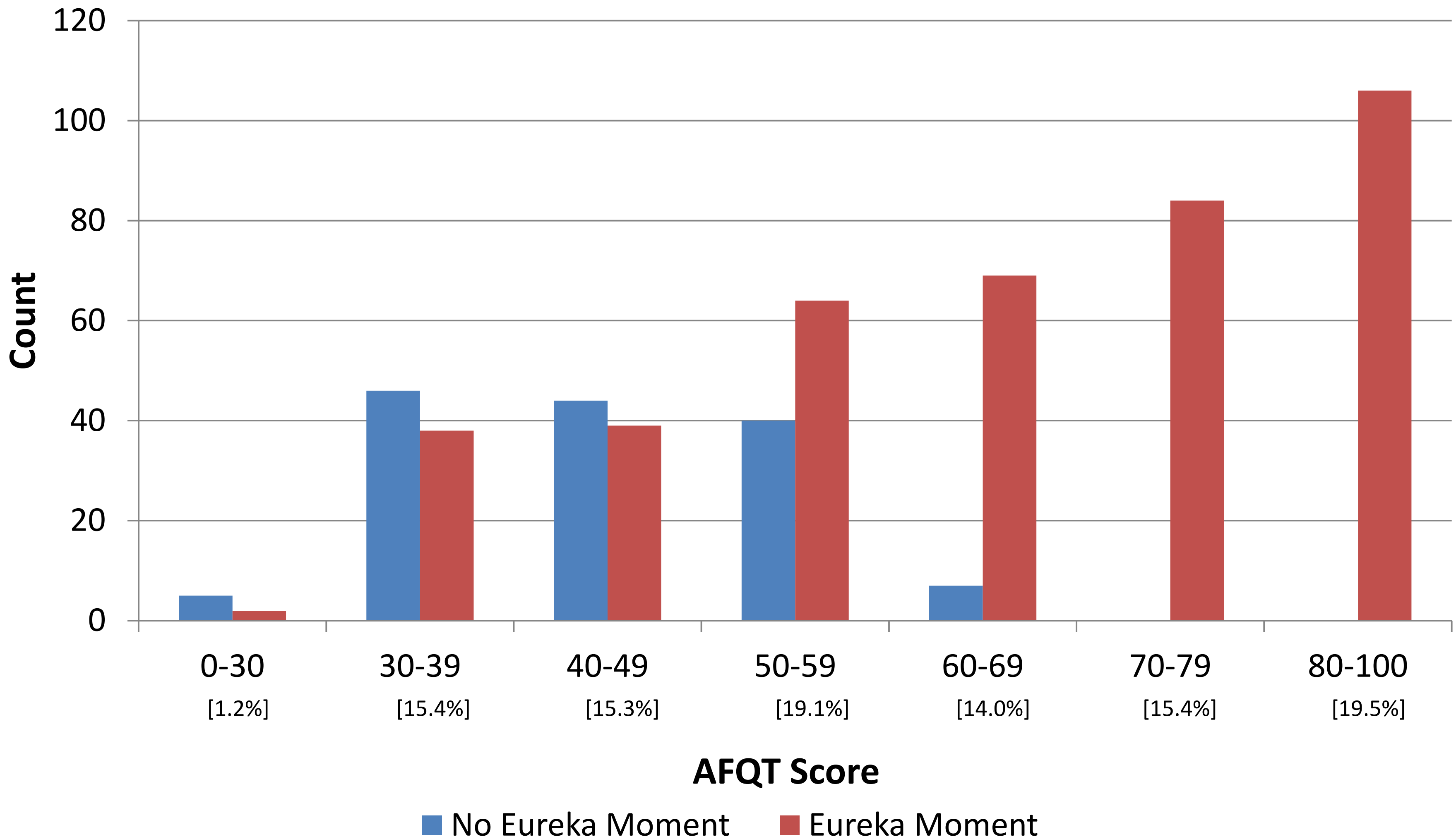
Table 3: Effects of all ASVAB tests on "Eureka" moments and Rate Changing Mistakes

	Effects on Eureka				Effects on RCM			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Arithmetic Reas.	0.128***	0.129***	0.132***	0.131***	-0.038***	-0.046***	-0.044***	-0.049***
	(0.024)	(0.022)	(0.025)	(0.022)	(0.013)	(0.010)	(0.013)	(0.010)
Math Knowledge	0.118***	0.137***	0.113***	0.133***	-0.057***	-0.049***	-0.053***	-0.047***
	(0.023)	(0.021)	(0.024)	(0.021)	(0.012)	(0.010)	(0.012)	(0.010)
Paragraph Comp.	0.000	-0.002	0.002	-0.000	0.004	-0.007	0.003	-0.008
	(0.021)	(0.019)	(0.021)	(0.019)	(0.011)	(0.009)	(0.011)	(0.009)
Word Knowl.	-0.003	0.003	-0.000	0.004	-0.032**	-0.028***	-0.039***	-0.033***
	(0.025)	(0.022)	(0.026)	(0.023)	(0.013)	(0.010)	(0.013)	(0.011)
Numerical Oper.	-0.040*	-0.046**	-0.041*	-0.048**	-0.018*	-0.012	-0.019*	-0.012
	(0.022)	(0.020)	(0.022)	(0.020)	(0.011)	(0.009)	(0.011)	(0.009)
Electronic Info.	0.012	0.005	0.010	0.005	-0.020*	-0.010	-0.015	-0.007
	(0.024)	(0.021)	(0.024)	(0.021)	(0.012)	(0.009)	(0.012)	(0.010)
Mechanical Comp.	0.026	0.003	0.030	0.008	-0.001	0.002	-0.003	0.002
	(0.024)	(0.021)	(0.024)	(0.022)	(0.012)	(0.010)	(0.012)	(0.010)
General Science	0.012	0.003	0.016	0.005	0.025*	0.013	0.021	0.011
	(0.025)	(0.023)	(0.026)	(0.023)	(0.013)	(0.011)	(0.013)	(0.011)
Coding Speed	0.060***	0.045**	0.063***	0.046**	0.014	0.008	0.011	0.005
	(0.022)	(0.020)	(0.022)	(0.020)	(0.010)	(0.008)	(0.010)	(0.008)
Automotive/Shop	-0.046**	-0.028	-0.031	-0.016	-0.001	0.003	-0.008	0.001
	(0.023)	(0.021)	(0.026)	(0.023)	(0.012)	(0.009)	(0.012)	(0.010)
Financial Controls	N	Y	N	Y	N	Y	N	Y
Demog. Controls	N	N	Y	Y	N	N	Y	Y
Observations	480	480	480	480	1380	1380	1380	1380
R-squared	0.312	0.471	0.318	0.476	0.074	0.413	0.087	0.417

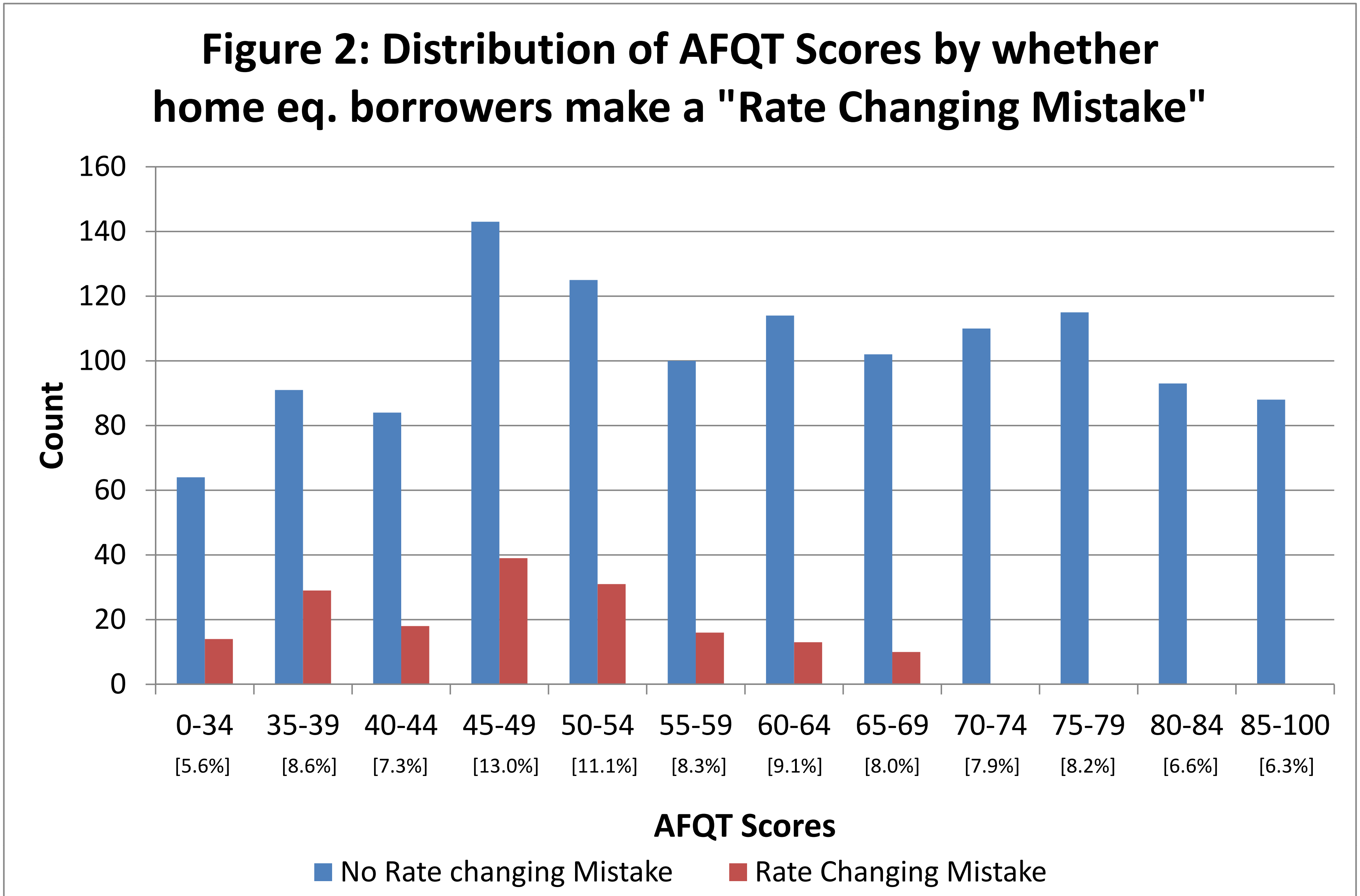
*** p<0.01, ** p<0.05, * p<0.1

Notes: See text for further details

Figure 1: Distribution of AFQT scores by whether a credit card holder has a "Eureka" moment



Notes: Numbers in brackets represent the fraction of the sample in each AFQT bin



Notes: Numbers in brackets represent the fraction of the sample in each AFQT bin

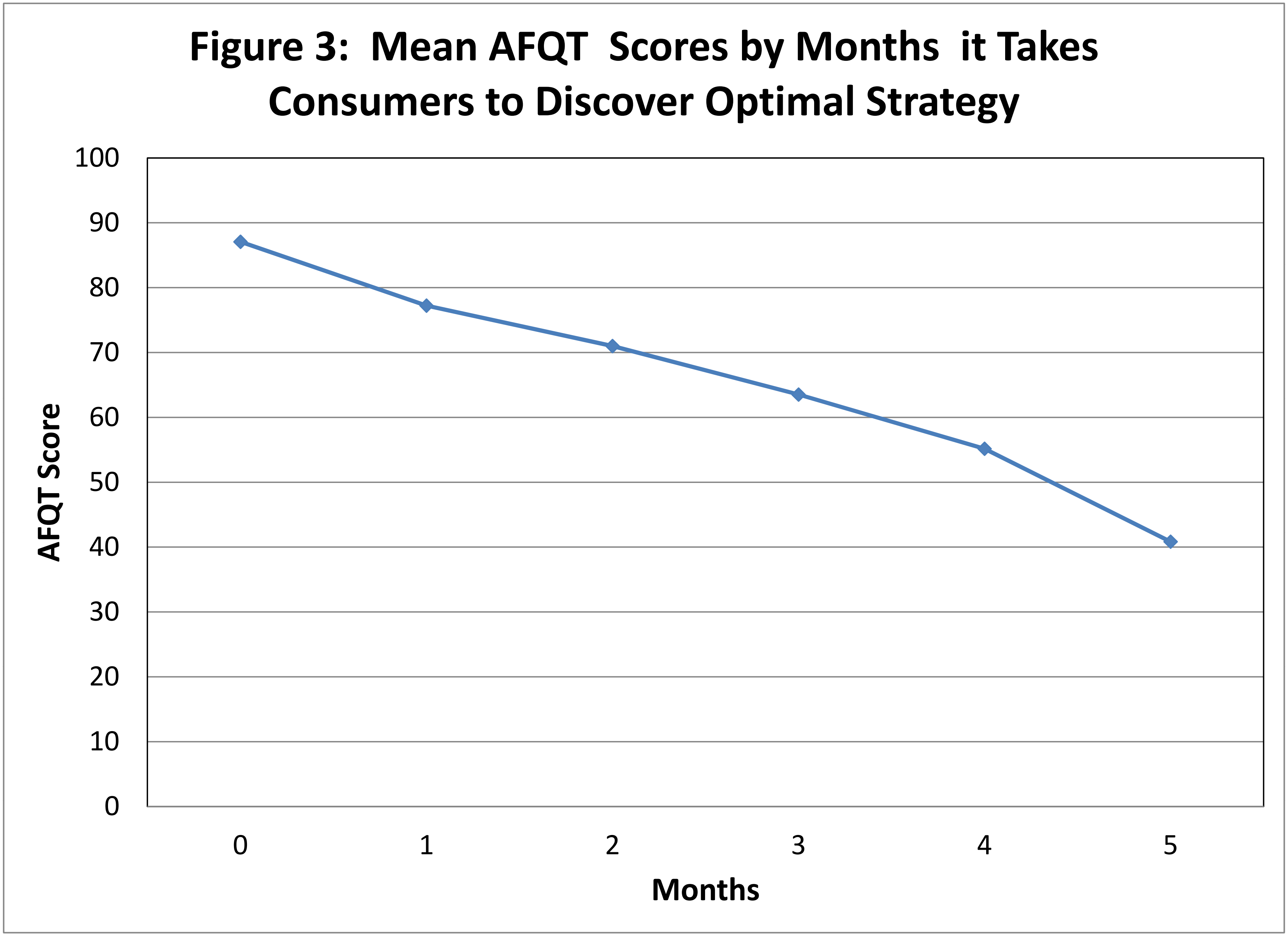


Figure 3: Mean AFQT Scores by Months it Takes Consumers to Discover Optimal Strategy
100
90
80
70
60
50
40
30
20
10
0
AFQT Score
0
1
2
3
4
5
Months

Online Appendix

"Cognitive Abilities and Household Financial Decision Making"

by Sumit Agarwal and Bhashkar Mazumder

Evidence from the NLSY: Cognitive Ability and Intertemporal Decision Making

In order to better understand the underlying mechanisms behind the link between cognitive ability and optimal financial decision making, we use the 1979 National Longitudinal Survey of Youth. The NLSY followed a nationally representative sample of individuals who were between the ages of 14 and 21 as of January 1979 into adulthood. We test whether cognitive skills are associated with lower discount rates that could reflect greater patience. In the 2006 survey, respondents were asked an experimental question designed to elicit their implicit personal discount rates. Specifically, the question read as follows: *Suppose you have won a prize of $1000, which you can claim immediately. However, you can choose to wait one month to claim the prize. If you do wait, you will receive more than $1000. What is the smallest amount of money in addition to the $1000 you would have to receive one month from now to convince you to wait rather than claim the prize now?* A response of $100, for example, would imply an annual discount rate of over 200 percent. We use a subset of responses that lie within the range of $1 to $500.[1]

We link responses to this question to respondent test scores as well as a number of other controls. Individuals in the NLSY were given the ASVAB in 1980 and their scores were used to norm the test. The use of the same scores for a nationally representative sample also may help alleviate any lingering concerns that our results on suboptimal financial behavior are driven by unrepresentative samples. Previous work by Warner and Pleater (2001) showed that AFQT scores are associated with lower discount rates as implied by a real world experiment where military personel were offered a choice of

[1] Many respondents provided answers that were clearly unreasonable, with absurdly high implied discount rates. We also have experimented with a parallel question that asks the same hypothetical over a one-year range and found similar results.

either a lump-sum payment or an annuity during separation. However, their analysis was limited to four broad intervals of the composite AFQT and could not distinguish between specific subtest scores.

In Table A5 we present the results of this analysis. In column (1) we show that a one standard deviation increase in AFQT is associated with $44 decline in the amount an individual would require to be compensated. This implies a decline in the monthly subjective discount rate of 4.4 percent. This estimate controls for several demographic characteristics (i.e., gender, race, Hispanic status, and education), which are all at least marginally significant. As a point of comparison for our AFQT results, even four additional years of schooling would only lower the discount rate by 0.8 percentage points. In column (2) we include the scores from the other six ASVAB subtests not incorporated into the composite AFQT. In column (3) we also add one's own annual earnings in 2005. These have a limited effect on our main estimates. In column (4) we utilize the fact that the NLSY contains many multiple sibling families and apply family fixed effects. This specification raises the standard errors considerably, but we still estimate a significant negative effect of about $52. In this case we have arguably greatly reduced the potential scope for omitted variables bias, since we only utilize differences in cognitive ability between siblings and sweep away all variation that is across families.

In columns (5) through (8) we run the same specifications but now show the effects of the four main math and verbal subtests of the ASVAB on our measure of patience. In all four specifications the effects are highly concentrated in the arithmetic reasoning subtest, with coefficients ranging from to -27 to -44. The other main subtests also generally have negative coefficients but are never statistically significant. One could argue that perhaps the causality runs in the reverse direction—that more impatient people tend to do worse at math—but it is unclear why impatience would not affect other cognitive abilities.

An alternative and perhaps simpler interpretation of this survey question is that it is simply picking up whether respondents are able to calculate an interest rate or fully understand the intertemporal decision problem. In this case we still think our finding for the arithmetic reasoning subtest is an important one, since the ability to calculate interest rates or understand intertemporal tradeoffs is arguably an important aspect of financial planning.

Evidence from the HRS: The Specificity of Skills

A concern in our analysis may be that math scores simply capture other unobserved characteristics of individuals who tend to avoid suboptimal behavior in *all* realms of their life, but it is not their math skills per se that matter. Suppose, for example, that certain personality traits that lead to good decision making in general are associated with strong math skills. In that case we might be falsely attributing improved financial behavior to mathematical cognitive ability when it is in fact correlates of math ability that matter. To gain further insight on this we use data from the Health and Retirement Survey (HRS) to estimate the effects of mathematical ability on sub-optimal non-financial behaviors, such as the failure to take medication or difficulty in preparing a meal. Our working assumption for this exercise is that mathematical ability does not have a direct bearing on these other behaviors. If we were to find an effect of math ability on these behaviors, comparable in magnitude to what we find with financial decision making, then such a finding might suggest that we are picking up the effects of correlates of math ability in both cases.[2]

McArdle, Smith, and Willis (2009) use the HRS to demonstrate that cognitive skills, such as numerical ability, have a significant effect on stock market participation and wealth accumulation. We begin by trying to replicate their basic findings concerning financial behavior and then extend the analysis to include non-financial behavior.

The HRS collects information about wealth, income, cognitive abilities, and many other variables of interest bi-annually from over 22,000 Americans older than 50 years old. The measures of cognitive ability are word recall, mental status, number series, retrieval fluency, and numeracy.[3] Following

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[2] The exercise may not be illuminating if our assumption is wrong and math ability somehow helps with all aspects of life. It is also possible that math ability matters directly for financial decision making but that the correlates of math ability happen to lead to good decision making in non-financial contexts. In either of these cases, however, we might still expect some difference in the *magnitude* of the effects between the financial and non-financial contexts.

[3] For word recall, the interviewer reads a lists of 10 basic nouns and requests the participant to immediately list as many of the 10 nouns as possible. After five minutes the surveyor asks the participant to list as many of the 10 nouns as possible again. Mental status is derived from five tests. The first asks the respondent to subtract 7 from 100 and then to subtract 7 from the previous result. This is done a total of 5 times and a point is given for each proper subtraction. The second is to count backwards from 20 as quickly as possible. The next three tests ask a series of question: what is today's date, who is the President and Vice-President of the United states, what do you usually cut paper with, and what do you call the kind of prickly plant that grows in the desert. The numeracy score

McArdle, Smith, and Willis (2009), our estimated outcomes include total wealth, total financial wealth, the percent of stock ownership. We supplement these with outcomes from questions pertaining to Instrumental Activities of Daily Living (IADLs). Specifically, we have information for each individual on whether the individual has difficulty reading a map, buying groceries, taking medication, making a phone call, preparing a meal, and managing money. We restrict the sample to those individuals that indicate that they don't have trouble, do have trouble, or cannot perform the task, and we create indicators for not having trouble performing said task. These indicator variables are then multiplied by 100 so that the coefficients can be interpreted as percentage point effects.

We present the results in Table A6. In column (1) we find that each additional math question (out of a total of 3 questions) answered correctly is associated with an increase in total wealth of $100,000 and financial wealth of $66,000.[4] Similarly for the small subsample that answered the number series questions, there are significant effects on wealth—a one standard deviation increase is associated with about an $85,000 increase in total wealth. Retrieval fluency is also statistically significant. A one standard deviation increase in retrieval fluency (25 points) is associated with about a $179,000 increase in total wealth. However, no effects are found for mental status and word recall. Of course, these regressions do not necessarily reflect causal relationships, as McArdle, Smith, and Willis (2009) fully acknowledge. Nonetheless, they are strongly suggestive that improvements in cognitive skill could have substantial payoffs.

In columns (4) through (8) we present results on the new outcomes. We find that for the four outcomes that appear to require the least amount of mathematical aptitude (buy groceries, take

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is based on the number of correct answers to three mathematical questions. Number series are designed to test abstract reasoning through a series of number series puzzles. For retrieval fluency the interviewer gives the respondent a category and asks the respondent to name as many items in that category as possible in 45 seconds. Retrieval fluency and number series were part of an experimental module that was run on a randomly chosen subsample of the survey sample.

[4] These results are significantly larger than the coefficients reported by McCardle, Smith, and Willis (2009). They find an effect of $20,000 for total wealth and $7,000 for financial wealth. We attempted to construct the identical sample of 18, 382 reported by McCardle, Smith, and Willis (2009) in their results in their Table 1 and came close with a sample of 18,338. The means and standard deviations of our cognitive and demographic variables are virtually identical to their sample though we have some modest differences with some of the financial variables.

medication, make a phone call, and prepare a meal), numeracy is *not* statistically significant—and in three of four cases the point estimates are close to zero or negative. In only one case (prepare a meal) is number series statistically significant. In contrast, for these same four outcomes, the coefficients on mental status and word recall are always large and positive—and in seven of eight cases significant at the one percent level. Recall, that these measures of cognitive skill were never significant for total wealth or financial wealth. As an additional check that there is no systematic bias in the IADL questions, we do find that numeracy has a huge effect on the outcome of managing money. We find that numeracy also has a significant effect on reading a map, which arguably does require some quantitative skills.

Table A1: Summary Statistics of Credit Card Samples

Panel A: Comparison of Matched Credit Card Sample to Full Military Sample

	Matched CC Sample			Military Sample				T-Stat
	Mean	s.d	N	Mean	s.d.	N	Diff.	of diff
Variables from Military Sample								
Enlistment Age	19.7	2.31	541	19.8	2.54	828314	-0.06	-0.60
Education	12.1	0.62	541	12.0	1.26	829999	0.10	3.59
Black	25.3%	0.44	541	19.8%	0.40	829999	0.055	2.94
White	67.3%	0.47	541	69.8%	0.46	829999	-0.025	-1.24
Other	7.4%	0.26	541	10.4%	0.31	829999	-0.030	-2.66
Male	88.9%	0.31	541	87.6%	0.33	829999	0.013	0.95
Female	11.1%	0.31	541	12.4%	0.33	829999	-0.013	-0.94
Married	34.2%	0.47	541	33.9%	0.47	829999	0.00	0.14
AFQT Score	60.2	19.25	541	61.0	18.92	828819	-0.87	-1.05
Word Knowl.	28.4	4.42	541	28.4	4.46	829999	-0.07	-0.36
Arithmetic Reas.	20.9	5.23	541	21.1	5.19	829999	-0.12	-0.54
Math Knowledge	16.2	4.94	541	16.5	4.86	829999	-0.27	-1.27
Paragraph Comp.	12.5	2.00	541	12.6	2.00	829999	-0.11	-1.27
Numerical Oper.	41.0	7.30	541	41.4	7.28	829969	-0.41	-1.32
Electronic Info.	12.6	3.44	541	12.6	3.46	829797	-0.03	-0.19
Mechanical Comp.	16.7	4.28	541	16.9	4.10	829963	-0.19	-1.01
General Science	17.8	4.03	541	17.8	3.94	829994	0.01	0.06
Coding Speed	53.5	11.39	541	54.1	11.74	829983	-0.60	-1.23
Automotive/Shop	15.4	5.14	541	15.5	5.06	829935	-0.18	-0.80

Panel B: Comparison of Matched Credit Card Sample to Full Credit Card Sample

	Matched CC Sample			Full Credit Card Sample				T-Stat
	Mean	s.d	N	Mean	s.d.	N	Diff.	of diff
Variables from Credit Card Sample								
Bal. Transfer APR	7.16	2.84	541	6.38	3.93	14798	0.77	6.14
Purchase APR	7.91	5.11	541	14.40	2.44	14798	-6.49	-29.41
Account Age	15.19	9.80	541	34.83	23.02	14798	-19.63	-42.51
Behavior Score	663	157.54	541	727	81	14798	-63.91	-9.39
Fico Score	707	64.09	508	731	76	14798	-23.84	-8.19
Income	71363	70797	511	57121	114375	10227	14242	4.28

Table A2: Summary Statistics of Home Equity Samples

Panel A: Comparison of Matched Home Equity Sample to Full Military Sample

	Matched HE Sample			Military Sample				T-Stat
	Mean	s.d	N	Mean	s.d.	N	Diff.	of diff
Variables from Military Sample								
Enlistment Age	19.6	2.4	1380	19.8	2.54	828314	-0.12	-1.86
Education	12.1	0.68	1383	12.0	1.26	829999	0.12	6.71
Black	22.4%	0.42	1393	19.8%	0.40	829999	0.03	2.30
White	71.4%	0.45	1393	69.8%	0.46	829999	0.02	1.29
Other	6.2%	0.24	1393	10.4%	0.31	829999	-0.04	-6.38
Male	86.6%	0.34	1393	87.6%	0.33	829999	-0.01	-1.08
Female	13.4%	0.34	1393	12.4%	0.33	829999	0.01	1.08
Married	35.2%	0.48	1393	33.9%	0.47	829999	0.01	1.05
AFQT Score	63.3	16.57	1391	61.0	18.92	828819	2.27	5.09
Word Knowl.	28.9	3.91	1393	28.4	4.46	829999	0.46	4.37
Arithmetic Reas.	21.5	4.71	1393	21.1	5.19	829999	0.45	3.58
Math Knowledge	17.0	4.52	1393	16.5	4.86	829999	0.48	3.95
Paragraph Comp.	12.8	1.82	1393	12.6	2.00	829999	0.20	4.07
Numerical Oper.	41.4	7.16	1393	41.4	7.28	829969	0.03	0.13
Electronic Info.	12.9	3.45	1393	12.6	3.46	829797	0.29	3.12
Mechanical Comp.	16.9	4.01	1393	16.9	4.10	829963	0.06	0.54
General Science	18.2	3.77	1393	17.8	3.94	829994	0.40	3.93
Coding Speed	54.4	11.56	1393	54.1	11.74	829983	0.33	1.05
Automotive/Shop	15.7	5.07	1393	15.5	5.06	829935	0.19	1.36

Panel B: Comparison of Matched Home Equity Sample to Full Home Equity Sample

	Matched HE Sample			Full HE Sample				T-Stat
	Mean	s.d	N	Mean	s.d	N	Diff.	of diff
Variables from Home Equity Sample								
Years on the Job	9.1	7.2	1393	6.66	8.38	75927	2.42	12.40
Appraised Value	249350	134852	1393	228310	148717	75927	21040	5.76
Self Employed	7.2%	25.8%	1393	7.9%	27.0%	75927	-0.01	-0.99
Improvement	22.0%	41.5%	1393	20.0%	40.4%	75927	0.02	1.85
Refinancing	40.4%	49.1%	1393	58.4%	47.6%	75927	-0.18	-13.59
Equity Loan	18.2%	38.6%	1393	24.8%	42.8%	75927	-0.07	-6.30
Income	108768	114758	1393	82012	132044	75927	26756	8.60
First Mortgage Bal.	116489	83738	1393	100481	91801	75927	16008	7.06
FICO Score	728	48.80	1393	719	53.32	75927	9.42	7.12
APR	5.1	1.53	1393	7.0	1.0816	75927	-1.96	-47.63
DTI ratio	33.69	17.26	1393	40.28	18.28	75927	-6.59	-14.10

Table A3: Summary Statistics by "Eureka" Moments among credit card borrowers

Panel A: Comparison of Demographic Characteristics and Test Scores

	Eureka Sample			Non-Eureka Sample				T-Stat
	Mean	s.d.	N	Mean	s.d	N	Diff.	of diff
Enlistment Age	19.67	2.33	399	19.80	2.25	142	-0.12	-0.559
Education	12.14	0.71	399	12.01	0.17	142	0.12	3.225
Black	21.8%	0.41	399	35.2%	0.48	142	-0.13	-2.964
White	71.4%	0.45	399	55.6%	0.50	142	0.16	3.320
Other	6.8%	0.25	399	9.2%	0.29	142	-0.02	-0.873
Male	89.5%	0.31	399	87.3%	0.33	142	0.02	0.673
Female	10.5%	0.31	399	12.7%	0.33	142	-0.02	-0.673
Married	33.3%	0.47	399	36.6%	0.48	142	-0.03	-0.700
AFQT Score	66.15	18.23	399	43.33	9.74	142	22.81	18.624
Word Knowl.	29.11	4.29	399	26.24	4.10	142	2.87	7.060
Arithmetic Reas.	22.50	4.96	399	16.57	3.04	142	5.93	16.658
Math Knowledge	17.66	4.56	399	12.23	3.59	142	5.43	14.371
Paragraph Comp.	12.77	1.95	399	11.68	1.92	142	1.08	5.757
Numerical Oper.	41.74	7.10	399	38.83	7.46	142	2.91	4.047
Electronic Info.	13.04	3.39	399	11.27	3.25	142	1.76	5.484
Mechanical Comp.	17.45	4.06	399	14.46	4.11	142	2.99	7.475
General Science	18.60	3.96	399	15.69	3.40	142	2.91	8.362
Coding Speed	54.98	10.95	399	49.20	11.55	142	5.78	5.192
Automotive/Shop	15.78	5.09	399	14.22	5.15	142	1.559	3.108

Panel B: Comparison of Financial Variables

	Eureka Sample			Non-Eureka Sample				T-Stat
	Mean	s.d.	N	Mean	s.d	N	Diff.	of diff
Bal. Transfer APR	7.22	2.80	399	6.97	2.92	142	0.25	0.883
Purchase APR	7.43	5.12	399	9.26	4.86	142	-1.83	-3.805
Account Age	14.65	9.73	399	16.71	9.88	142	-2.06	-2.142
Behavior Score	685.39	123.35	399	600.45	216.20	142	84.94	4.432
Fico Score	708.39	68.91	375	703.71	48.03	133	4.68	0.855
Income	72613	72836	376	67883	64911	135	4730	0.703

Table A4: Summary Statistics by "Rate Changing Mistakes" among home equity borrowers

Panel A: Comparison of Demographic Characteristics and Test Scores

	No RCM			Rate Changing Mistake				T-Stat
	Mean	s.d	N	Mean	s.d.	N	Diff.	of diff
Enlistment Age	19.65	2.44	1211	19.57	2.31	169	0.08	0.410
Education	12.13	0.66	1214	12.15	0.79	169	-0.02	-0.391
Black	22.1%	0.41	1214	25.4%	0.44	169	-0.03	-0.945
White	71.1%	0.45	1214	72.8%	0.45	169	-0.02	-0.461
Other	6.8%	0.25	1214	1.8%	0.13	169	0.05	4.049
Male	87.3%	0.33	1214	81.1%	0.39	169	0.06	1.971
Female	12.7%	0.33	1214	18.9%	0.39	169	-0.06	-1.971
Married	34.9%	0.48	1214	37.9%	0.49	169	-0.03	-0.739
AFQT Score	64.80	16.71	1214	52.16	10.31	167	12.64	13.585
Word Knowl.	29.09	3.85	1214	27.32	4.01	169	1.77	5.416
Arithmetic Reas.	21.90	4.73	1214	18.74	3.55	169	3.16	10.365
Math Knowledge	17.39	4.52	1214	14.05	3.28	169	3.34	11.792
Paragraph Comp.	12.84	1.80	1214	12.40	1.92	167	0.44	2.798
Numerical Oper.	41.65	7.13	1214	39.84	7.26	169	1.81	3.051
Electronic Info.	13.03	3.44	1213	11.81	3.32	169	1.22	4.468
Mechanical Comp.	17.11	3.98	1213	15.40	3.87	169	1.71	5.363
General Science	18.39	3.78	1214	16.96	3.48	169	1.43	4.942
Coding Speed	54.55	11.53	1214	53.48	11.94	167	1.07	1.094
Automotive/Shop	15.88	5.07	1214	14.62	5.01	167	1.267	3.060

Panel B: Comparison of Financial Variables

	No RCM			Rate Changing Mistake				T-Stat
	Mean	s.d	N	Mean	s.d.	N	Diff.	of diff
Years on the Job	9.3	7.3	1214	7.22	6.27	169	2.12	4.03
Appraised Value	257974	137881	1214	183962	86684	169	74013	9.55
Self Employed	7.4%	26.2%	1214	4.7%	21.3%	169	0.03	1.49
Improvement	21.6%	41.2%	1214	24.9%	43.3%	169	-0.03	-0.92
Refinancing	38.3%	48.6%	1214	56.8%	49.7%	169	-0.19	-4.55
Equity Loan	11.0%	31.2%	1214	70.4%	45.8%	169	-0.59	-16.36
Income	111105	115325	1214	90748	107109	169	20357	2.29
First Mortgage Bal.	118351	86024	1214	102545	63556	169	15807	2.89
FICO Score	731.01	48.23	1214	706.35	47.14	169	24.66	6.35
APR	4.73	1.28	1214	7.42	1.00	169	-2.69	-31.60
DTI ratio	33.02	17.21	1214	38.69	16.99	169	-5.67	-4.06

Table A5: Effects of AFQT on implied discount rates using NLSY

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AFQT Score	-44.066**	-38.781**	-40.574**	-51.871**				
	[3.703]	[6.146]	[7.810]	[20.878]				
Arithmetic Reas.					-28.026**	-26.297**	-32.258**	-44.483**
					[5.428]	[5.694]	[7.360]	[20.923]
Math Knowledge					-7.664	-6.201	-1.134	4.86
					[5.178]	[5.318]	[6.843]	[17.580]
Paragraph Comp.					-6.351	-1.596	1.953	-28.62
					[5.290]	[6.155]	[7.971]	[21.684]
Word Knowl.					-5.102	-4.437	-7.248	-0.104
					[5.038]	[5.142]	[6.523]	[15.242]
Female	18.551***	16.411**	9.556	60.619**	15.739***	12.498*	4.378	61.006**
	[5.315]	[6.917]	[8.995]	[24.199]	[5.504]	[7.123]	[9.246]	[24.784]
Black	65.282***	62.458***	55.858***		65.506***	62.755***	54.898***	
	[7.329]	[7.683]	[10.352]		[7.429]	[7.696]	[10.374]	
Hispanic	18.056**	16.877**	11.153		18.543**	16.976**	10.234	
	[7.677]	[7.807]	[9.990]		[7.677]	[7.794]	[9.990]	
Education	-2.046*	-1.997*	-1.435	-2.425	-2.354**	-2.296*	-1.858	-2.465
	[1.142]	[1.164]	[1.386]	[2.569]	[1.159]	[1.176]	[1.391]	[2.562]
Log Earnings			-9.033**	10.063			-9.083**	9.077
			[3.933]	[9.487]			[3.934]	[9.491]
Other 6 ASVAB Tests	N	Y	Y	Y	N	Y	Y	Y
Childhood Family Inc.	N	N	Y	N	N	N	Y	N
Family Fixed Effects	N	N	N	Y	N	N	N	Y
Observations	4158	4158	2476	2476	4167	4167	2480	2480
R-squared								

*** p<0.01, ** p<0.05, * p<0.1

Table A6: Effects of cognitive skills on financial and non-financial outcomes using HRS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				Instrumental Activaties of Daily Living (IADLs)					
	Financial			Non-Financial					Financial
	Total Wealth	Tot. Fin. Wealth	Pct. Stock	Read Map	Buy Groceries	Take Medic.	Make Ph. Call	Prepare a Meal	Manage Money
Female	27.653	21.353	0.458	-9.891***	-4.423***	-1.303***	0.211	-2.815***	-1.544***
	(34.770)	(21.531)	(0.455)	(0.555)	(0.443)	(0.324)	(0.312)	(0.377)	(0.356)
Hispanic	-22.843	-24.958	-3.471***	-2.856***	1.494**	-0.218	1.089**	0.717	0.248
	(58.721)	(36.363)	(0.839)	(0.987)	(0.749)	(0.546)	(0.528)	(0.633)	(0.600)
Nonwhite	-184.179***	-87.346***	-4.812***	-4.671***	-0.869	0.325	0.085	-0.575	0.052
	(44.948)	(27.834)	(0.623)	(0.744)	(0.574)	(0.419)	(0.405)	(0.486)	(0.459)
Couple	201.588***	70.020***	1.219**	3.051***	1.978***	1.010***	0.518	0.791*	2.535***
	(41.676)	(25.808)	(0.548)	(0.667)	(0.525)	(0.388)	(0.374)	(0.448)	(0.421)
Education	48.638***	20.620***	1.359***	1.698***	0.552***	0.092*	0.373***	0.288***	0.273***
	(5.779)	(3.579)	(0.080)	(0.097)	(0.075)	(0.054)	(0.052)	(0.063)	(0.060)
Total Income	3.347***	1.934***	0.020***	0.003	0.006***	0.002*	0.002*	0.004**	0.003**
	(0.143)	(0.089)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
Cognitive Measures									
Number Series	1.927*	1.494**	0.020	0.048***	-0.002	0.010	0.002	0.032***	-0.019*
	(1.102)	(0.682)	(0.016)	(0.018)	(0.014)	(0.010)	(0.010)	(0.012)	(0.011)
Mental Status	-7.668	-3.716	0.057	1.894***	1.625***	1.551***	1.425***	1.319***	2.041***
	(10.301)	(6.379)	(0.143)	(0.173)	(0.134)	(0.096)	(0.093)	(0.113)	(0.108)
Word Recall	6.813	-4.959	0.330**	1.180***	0.852***	0.443***	0.154	0.669***	0.640***
	(11.027)	(6.828)	(0.144)	(0.177)	(0.140)	(0.103)	(0.099)	(0.119)	(0.113)
Numeracy	107.672***	65.666***	2.083***	2.414***	0.177	0.148	-0.136	-0.022	0.482**
	(21.651)	(13.408)	(0.280)	(0.344)	(0.273)	(0.201)	(0.194)	(0.232)	(0.220)
Retrieval Fluency	6.744***	4.038***	0.010	0.012	0.013	0.006	-0.009	-0.002	0.013
	(2.399)	(1.486)	(0.031)	(0.038)	(0.030)	(0.022)	(0.021)	(0.026)	(0.024)
Observations	18338	18338	16086	16152	17119	18030	18059	17111	17203
R-squared	0.158	0.046	0.075	0.157	0.119	0.149	0.179	0.136	0.167

Notes: The following variables have been omitted from the results for convenience: age age squared, whether the respondent was the financial respondent, total income squared and indicators for missing values on each of the five cognitive measures. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

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