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ABSTRACT

Cognition and Economic Outcomes in the Health and Retirement Survey*

Dimensions of cognitive skills are potentially important but often neglected determinants of the central economic outcomes that shape overall well-being over the life course. There exists enormous variation among households in their rates of wealth accumulation, their holdings of financial assets, and the relative risk in their chosen asset portfolios that have proven difficult to explain by conventional demographic factors, the amount of bequests they receive or anticipating giving, and the level of economic resources of the household. These may be cognitively demanding decisions at any age but especially so at older ages. This research examines the association of cognitive skills with wealth, wealth growth, and wealth composition for people in their pre and post-retirement years.

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Dimensions of cognitive skills are potentially important and often neglected determinants of the central economic outcomes that shape overall well-being over the life course. There exists enormous variation among households in their rates of wealth accumulation, their holdings of financial assets, and the relative risk indicated in their asset portfolios that have proven difficult to explain by conventional demographic factors and the level of economic resources of the household. (Smith, 1995). The premium on cognitive skills may be increasing as individuals are asked to take greater control of their wealth, pension, and health care decisions which may in many instances be cognitively demanding.

The mechanisms responsible for cognitive development over the life course that are related to economic outcomes may be the long term result of many factors. It is well-known that children exposed to serious environmental deprivation show markedly reduced cognitive abilities (Rutter 1985), but the detectable effects of normal-range environments on cognitive ability are typically small. This is not surprising, given the large number of environmental risk factors and the small effect expected for any particular factor, and that the genetic contributions may vary as well (Harden et al, 2007). Specific factors associated with lower cognitive performance include low socioeconomic status, birth complications, poor early nutrition, family conflict, and many others (Conger et al., 1994; Ramey et al. 2000; Sternberg & Grigorenko, 1997; Vandell 2000).

In a classic analysis of data from the Berkeley Studies, Elder (1974) found the effects of economic deprivation on adult functioning varied with gender and birth cohort. For males in the older cohort (OGS, born 1920-22), being reared in a family with low SES during the Great Depression was associated with higher resilience in adulthood compared to males reared in more favorable circumstances. In contrast, for boys in the younger cohorts (BGS and GS, born 1928-30)

being reared in economic adversity was associated with lower psychological functioning in adulthood. Grimm and McArdle (2007) recently updated this classical result with newer multilevel modeling. Conger et al (1994) studies families characterized by economic decline and uncertainty where the economic pressure experienced by parents increased parental dysphoria, coercive exchanges, greater hostility, and marital conflict as well as conflicts between parents and children over money. These processes applied equally well to the behavior of mothers and fathers, as well as sons and daughters. Lee et al. (2003) investigated the relation of educational attainment, husband's education, household income, and childhood socioeconomic status to cognitive function and decline among community-dwelling women aged 70-79 years. Among well-educated women, educational attainment predicted cognitive function and decline, although other measures of socioeconomic status had little relation.

Financial matters are often not straightforward for most individuals and may depend in part on their ability to invoke several dimensions of cognitive skills. One needs to feel comfortable in understanding the choices that are available amidst a wide array of options and feel confident about the computations involved in contrasting alterative rates of return of different assets over calculated over different time dimensions (Banks and Oldfield, 2007). This may involve aspects of (a) retrieving relevant prior financial information from *memory*, (b) using one's accumulated knowledge and skills (*Crystallized* intelligence (Gc)), and (c) the ability to draw inferences about what the best thing to do might be (*Fluid* intelligence (Gf)); for details, see Cattell, 1987; Horn & McArdle, 2007; McArdle & Woodcock, 1998).

Recently, parallels have been drawn between the psychological theory of fluid and crystallized intelligence and economic theories of investment in human capital (Willis 2007). In particular, Delevande et al. (2008) consider an individual's knowledge of finance to be a

component of human capital—or crystallized intelligence—that allows people to achieve a higher expected return on their assets, holding risk constant. They assume that an individual produces additional financial knowledge by combining his or her fluid intelligence or ability, crystallized intelligence and effort according to a human capital production function (Ben Porath, 1967; Cunha and Heckman, 2007). The motivation to acquire financial knowledge depends on an important scale economy in this investment process. While increased knowledge raises the feasible expected return per dollar, the total value of the investment depends on the number of dollars to which the improved return is applied. Thus, other things equal, the value of acquiring financial knowledge is higher for persons who desire higher levels of retirement wealth because, of higher lifetime income, a lower rate of time preference or lower defined benefit pension wealth. Similarly, investment will be greater among persons who have lower costs or greater efficiency in acquiring additional knowledge because of greater fluid intelligence or because they have more financial knowledge obtained in their formal education or on-the-job. In the useful formulation of Willis (2007) based on the Ben-Porath human capital production function, fluid intelligence can be thought of as the ability parameter and crystallized intelligence as the accumulated stock of human capital. Of course, most cognitive measures have elements of both fluid and crystallized intelligence so that there is not yet an established tight connection between the cognitive measures and the underlying parameters of the production process.

Moreover, these issues may become increasingly salient as the population ages because many aspects of these basic cognitive skills are known to begin to deteriorate from different levels and at varying rates for individuals starting in middle age and often at even earlier ages. These problems may be compounded if older individuals are asked to take more personal control of their accounts and the financial decisions about their wealth holdings and its future trajectory (e.g.,

Hershey et al., 2007). The recent financial collapse may well placed even greater demands on the ability of individuals to make good financial decisions about their wealth holdings to obtain and maintain income security during their retirement years.

This research will examine the impact of levels and trajectories of cognitive skills on aspects of wealth, wealth growth, and wealth composition for people in the pre-retirement years. Our analysis will rely on selective waves of the Health and Retirement Survey (HRS), a nationally representative panel survey of Americans who are at least fifty years. HRS is well-known for its high quality measurement of many key SES measures, including income and wealth (see Juster and Smith, 1997 and Juster, Smith, and Stafford, 1999). In addition, HRS measures in some waves a number of salient dimensions of cognitive skills. The measures we will use will start with immediate and delayed memory recall and the TICS battery as these have been established psychometrically to capture cognitive constructs of episodic memory and mental status (see McArdle, Fisher & Kadlec, 2007). We will also present data on two additional measures of numerical reasoning and retrieval fluency, both recently introduced into the HRS as modules, to examine if these additional measures will lead to significant improvements in the predictive validity of the economic outcomes.

The paper is organized into four sections. The following section describes the data that we will use and the main cognition variables available in the Health and Retirement Survey. The second section describes results that are obtained relating individual attributes including their cognitive ability to the total wealth, total financial wealth, and the fraction of wealth held in stock. Section three summarizes the results obtained for joint spousal cognitive variables on the financial outcomes of the household. The final section summarizes our main conclusions.

1. **Data**

This research will rely on a sub-set of surveys from the Health and Retirement Study (HRS), a nationally representative longitudinal survey of the population of the United States who are over fifty years old. The overall objective of the HRS is to monitor economic transitions in work, income, and wealth, as well as changes in many dimensions of health status among those over 50 years old. The current version of HRS is representative of all birth cohorts born in 1947 or earlier. Follow-ups of all surveys have taken place at approximately two-year intervals.

In HRS, questions were included in each core interview on demographics, income and wealth, family structure, health, and employment. An important advantage of these surveys is that they all contain high-quality wealth modules (Smith 1995, 1997). In HRS, a very comprehensive and detailed set of questions was asked to measure household wealth. In addition to housing equity, assets were separated into the following eleven categories; other real estate; vehicles; business equity; IRA or Keogh; stocks or mutual funds; checking savings or money market funds; CD's, government savings bonds or treasury bills; other bonds; other assets; and other debt.

The subsets of the HRS that we used are dictated by the types and availability of cognition measures in the HRS (see Ofstedal et al. 2005; McArdle et al., 2007). HRS cognition variables were intended to measure episodic memory, intactness of mental status, numerical reasoning, broad numeracy, and vocabulary.

We will rely on two measures of memory- immediate and delayed *word recall* that have basically been available in HRS in every round in the same form since 1995. Respondents are read a list of ten simple nouns and are then asked to repeat as many of these words as they can in any order. After a five minute measurement of self-rated depression, they are then asked to recall as many of the original words as possible.[1] Following the analysis of McArdle et al. (2007), we form

[1] In HRS 92 and 94, the original set consisted of twenty words. The same word list is not repeated in the next three subsequent rounds and husbands and wives were given a different list (see Ofstedal et al. 2005).

an episodic memory measure as the average of the immediate and delayed recalled results. Episodic memory may be an important component of *fluid intelligence*.

Our second cognitive measure is the mental status questions of the so-called Telephone Interview of Cognitive Status (*TICS)* battery. These were established to capture the intactness or mental status of the individual. *TICS* questions consist of the following items-serial 7 subtraction from 100 (up to five times), backwards counting (from 20 to 1), naming today's date (month, day and year), and naming the President and Vice-President of the United States. Answers to these sets of questions are aggregated into a single *mental status* score that ranges from 0 to 10. The same form of mental status scores have basically been available since AHEAD 95 and HRS 96 (see McArdle et al., 2007)

The third cognition measure available is a number series test adapted from the Woodcock-Johnson (WJ-R) battery of tests for *fluid reasoning* (McArdle et al, 2008). This test was administered in a 2004 experimental module to a random sample of over 1200 respondents. This represented an attempt to achieve test scores from a subset of items from the Number Series test of WJ III using an adaptive testing methodology. Each respondent was asked no more than six items where the subsequent sequence of items at each point was determined by the correctness of each answer. This test was administered again in a 2006 experimental module where roughly half of the respondents who were tested in 2004 were tested again. Fifty percent of those given the test in the 2006 experimental module had not been tested previously. For each respondent, a score was created on the W-scale (logit metric) where higher scores indicate better performance on the test. Because this numerical reasoning test has not yet been placed in the HRS core, sample size and power are definitely an issue with this dimension of cognition. To mitigate this problem, we

maximized the number of observations by taking an available score from either the 2004 or 2006 experimental module if available. If respondents were tested twice, the scores were averaged.

The forth measure deals with a WJ form of *retrieval fluency,* and this was administered in an experimental module in HRS 2006. Respondents were given a category and asked to mention as many items as they could within a forty-five second time frame (shorter than the typical WJ format). The number of correct and incorrect answers was counted by the interviewer.

Starting with HRS 2002, three questions were added to the core to interview to measure *numeracy* (respondents' numerical ability). These questions involve the computation of three mathematical computations and one is scored as either correct or incorrect on each of them.[2]

Thus there are five different measures of cognition available in the HRS that we use in this analysis. While the *episodic memory, mental status, and numeracy* are available in multiple core waves in the same form, the other measures are in an experimental module in a specific wave (*number series* and *retrieval fluency*). This form of availability basically limits the types of analysis that are possible with the cognition measures.

The cognitive measures listed above are intended to indicate different aspects of the adult cognitive profile (see McArdle et al., 2002). Prior research has suggested strong normative age declines in most of these cognitive functions, but a hierarchy of cognitive strengths and weakness of any individual are indicated in many aspects of adult daily functioning. At a most basic level, the need for an intact neuro-cognitive system is thought to be necessary to deal with everyday issues in communication and learning in the simple judgments needed for survival (e.g., gathering food and water). At another step up in everyday complexity, the ability to remember to complete

[2] Another cognition measure is only available for the original cohort of HRS respondents (those 51-61 years old in 1992) and was also a one occasion measurement. In HRS 92, a modified version of the Similarities subscale of the Wechsler Adult Intelligence Scale revised (*WAIS-R*). This was used to access higher level abstract reasoning by comparing a list of seven pairs of words and then describing how they were alike.

tasks, to be able to react to simple stimuli, and the ability to deal with simple numerical problems, are important skills in the consideration in successfully dealing with everyday challenges (e.g., see Farias et al, 2008) The higher order aspects of cognitive skills, such as having expertise in a specific area (i.e., *Crystallized Intelligence*), or in reasoning in novel situations (i.e., *Fluid Intelligence*), will be necessary fundaments in the ability to deal with more complex economic challenges (Hershey et al, 2007; McArdle et al, 2007).

As pointed out by Banks and Oldfield (2007), there are several credible reasons why numeracy, a score representing knowledge about numerical problems, may be related to financial outcomes. More numerate individuals may be more adept at complex decision-making including those involved in financial decisions (Peters et al. 2006). More numerate individuals also appear to be more patient and thus are more likely to have saved and invested in the past (Parker and Fischhoff, 2005) and perhaps less risk averse (Benjamin et al, 2006).[3] The use of more abstract reasoning with numbers, as in the simple *number series* puzzles, is intended to represent a different form of cognition (i.e., fluid intelligence), and it is not clear how these abilities are useful in the accumulation of wealth). Examining results from a 25-item test of financial knowledge on the Cognitive Economics Survey, Delevande, Willis and Rohwedder (2008) find that the number series score has a strong and significant effect on the test score as does educational attainment and number of economics courses the respondent has had.[4] In addition, they find that women, especially older women, have considerably lower test scores than men, probably reflecting a household division of labor about household financial decisions that was especially sharp in earlier

[3] Reverse causality or a feedback loop may also be operating where greater involvement in complex financial decisions may improve numerical ability.

[4] The Cognitive Economics Survey, designed by a team of economists led by Willis, was administered during 2008 to a national sample of 1,222 persons, age 51 and older and their spouses regardless of age who are participants in the National Change and Growth Survey, a cognition survey designed by McArdle and colleagues.

cohorts. These ideas about the independent impact of different forms of cognition are directly examined in this research.

2. Individual level Analysis

In this section, we describe our main empirical results describing the relation of dimensions of cognition to wealth accumulation among middle aged and older adults. Table 1 lists means, medians, and standard deviations of the variables that will be entered into the statistical analysis. Mean household wealth in this sample is about five hundred thousand dollars but wealth has its well-known features of high variability and skewness as the median is just under two hundred thousand. Similarly, total financial wealth is around $313 thousand dollars and is if anything more highly skewed as the median financial household wealth is on $56 thousand. On average, nine percent of all financial wealth is held in stock. Mean household income is about sixty-two thousand dollars but income too is very unequal across these individuals.

Two-thirds of these individuals live as couples, fifty-nine percent are female, and the average age is 68 years old. The typical sample member is a high school graduate. Nine percent of the sample is Latino and 16 percent are African-American.

On average, HRS respondents remembered half of the ten words that were spoken to them both in immediate and delayed recall with two-thirds of the sample being able to recall between 3 and 7 words. HRS respondents were able to correctly compute only a bit more than one answer correctly in the three question numeracy sequence. The experimental HRS measures of *number series* and *retrieval fluency* are calculated as W scores (see McArdle & Woodcock, 1998). Each W score is artificially centered at 500 based on the 10 year olds in the normative sample, but the W scoring metric is used so that the change in the probability of getting an item right increases by twenty-five percent for every ten point change in the W score. In this W score metric, the resulting

average of *number series* and *retrieval fluency* are slightly below 500 and distribution in scores are approximately normal.

We estimate models for three financial outcomes of the household: total household wealth, total financial wealth, and the fraction of financial wealth held in stocks. The estimated coefficients and associated 't' statistics based on robust standard errors are listed in Table 2. The non-cognition variables included in the models are standard: gender of the respondent (1= female), race (1= African-American), Hispanic (1=Latino), a quadratic in age, marital status (married=1), a quadratic in household income, and years of schooling. The only non-standard demographic is whether the respondent was the financial respondent- that is the partner who was the most knowledgeable about financial matters and who answered all the household level financial questions in the survey.

The full set of available cognition variables is included in all models. As described above, some cognition variables such as *number series* and *retrieval fluency* are only present in experimental modules given to about one thousand respondents in each wave. Other cognition variables such as *memory recall*, *mental status (TICS items)*, and *numeracy* were given to all HRS respondents. Missing value indicators are included in all models for people who either did not answer or who were not asked specific questions involved in the construction of the right hand side variables. By design, missing values for the *number series* and *retrieval fluency* measures are missing at random.

Results obtained for the non-cognitive variables, presented in Table 2, are consistent with those widely reported in the literature (Smith, 1995, 1997). Wealth, both total and financial, is higher for couples than single person households, is lower for minorities, increases at a decreasing rate with age, rises with education and with family income at a decreasing rate. Individuals with

higher education, income, and wealth hold more of their financial wealth in stock while minorities hold less in this more risky asset even at the same age, income, and wealth.

Our main interest in this paper centers on the estimated impact of the cognitive variables. The strongest and most consistent results obtained were for the *numeracy* and *memory recall* cognition measures. Answering each question correctly in the three question numeracy sequence is associated with a $20,000 increase in total household wealth and about a seven thousand dollar increase in total financial wealth. Enhanced *numeracy* is also associated with a larger fraction on the financial portfolio held in stocks. All these results are strongly statistically significant.

Similarly, improved *memory recall* is also associated with higher levels of household wealth and financial wealth but not with how risky or stock intensive the financial asset portfolio is. While it is difficult to compare the units in these measures, these results imply that remembering three additional words in the *word recall* has an associated with total household wealth equivalent to answering one additional question correctly in the *numeracy* sequence. Our three other cognitive measures- *number series*, *TICS mental status*, and *retrieval fluency* do not appear to be consistently related to these financial outcomes. Part of the lack of statistical significance for the number series and retrieval fluency variables may be due to the lower effective N for those measures.

The extreme degree of heterogeneity and especially the right skewness of the distribution in the financial outcomes studied implies that estimated mean effects may not characterized many of the individuals in the sample. With that caution in mind, Table 3 (for total household wealth) and Table 4 (for total financial wealth) lists estimates from quantile regressions, estimated for the first and third quartile, the median and the 90th percentile. As expected, estimated effects of most of the

non-cognitive variables increase as we move up towards higher quantiles in the total wealth and non-financial wealth distribution.

Numeracy, the key cognitive variable that we identified in Table 2, behaves in precisely the same way- the estimated impacts of numeracy increase as we move up the total wealth quantiles- from an estimated impact of $2.6 K at the first quartile, to almost $12K for the median household, and $52K at the 90th percentile. A similar pattern is estimated in Table 4 when the outcome is total financial wealth. The other key variable, *memory recall*, does the same but at a far less dramatic rate. Especially for total financial wealth, the estimated impacts of *memory recall* are fairly uniform across these percentiles. Compared to *Numeracy, memory recall* may be relatively more important at lower values in the wealth distribution.

3. Spousal level Analysis

One analytical advantage of HRS for this topic is that interviews are conducted with both spouses and/or partners in the household. Thus information is provided separately by both parties on dimensions of their own cognition (the same dimensions measured in the core interview) alongside the common household data on their wealth holdings and income and their own personal attributes. This allows an examination of the extent to which cogitative attributes of both spouses predict wealth holdings of the household and whether or not the cognition of one spouse is more important than the other at least for these financial outcomes. To do so,a sample of married couples is the basis of our analysis.

Table 5 examines the relationship of *numeracy* scores of both spouses with total household wealth, total financial wealth, and the fraction of financial wealth held in stock. In this table, for reasons that will become obvious below, we array the data by financial and non-financial respondents. Total wealth, total financial wealth, and the fraction of financial wealth held in equity

all increase sharply with the numerical score of both the financial and non-financial respondent. If both scores are zero (about ten percent of the cases), total wealth is about two hundred thousand dollars. In contrast, if both spouses get all the *numeracy* questions correct, total household wealth is more than eight times higher- more than 1.6 million dollars. Wealth is higher when the *numeracy* score of both the financial and non-financial respondent is higher.

A very similar but even more dramatic pattern exists for total financial wealth. If both spouses score a three on the *numeracy* question financial wealth is ten times larger than if both got all the *numeracy* questions incorrect. There is some tendency for the *numeracy* of the financial respondent to matter more since in four of the six off-diagonal pairs, financial wealth is higher if the higher *numeracy* score is that of the financial respondent. We will return to this issue below when discussing the model estimates.

Our final measure is the fraction of financial assets held in stocks where one may think a priori that financial *numeracy* may matter more. Once again there is evidence of sharp increases in the percent of the financial portfolio held in stocks as the *numeracy* score of each spouse rises.

One important issue is whether cognition matters symmetrically with the cognitive ability of each spouse. In many households, there is specialization in the financial decision making with one spouse making most of the calls. In such a situation, one would think that the cognitive ability of the financial decision maker may matter more for household wealth outcomes. To get at this possibility, we arrayed the data for our all cognitive measures in two different ways in Table 6- by gender and by the financially knowledgeable person in the household.

Consider first the stratification by male and female or equivalently by husband and wife. With the exception of memory recall (higher for women), *numeracy* (higher for men) and to a lesser extent *number series* (higher for men), the differences between the other cognitive measures

are all very small. When we shift instead to the comparison between financial and non-financial respondents, there is a much more pronounced shift in favor of the financial respondent with the sole exception of *retrieval fluency* which is the same for both the financial and non-financial respondent.

The bottom panel of Table 6 stratifies by both gender and whether a financial respondent. For women, there is very little difference in the cognitive scores between those who are and are not financial respondents. In contrast, for men and again with the exception of retrieval fluency, financial respondents appear to have higher cognitive ability than non-financial respondents. One interpretation is that men are the default option for financial decision-making in the family unless poor cognitive abilities get in the way.

Table 7 presents the correlation matrix of full set of cognitive variables for husbands and wives. This table illustrates one current problem with the cognitive variables currently available in the HRS for spousal level analysis. Those cognitive variables which are in the experimental modules only- *number series* and *retrieval fluency*- are randomly assigned to only 1200 respondents in a wave. The probability that both partners are assigned these cognitive measures is very low and thus relatively few HRS couples have these cognitive measures for both partners. Therefore our analysis focuses on the other three cognitive measures.

There are two salient patterns. First, when available the correlation in the scores within gender across cognitive measures is low and the correlation across husbands and wives within a cognitive measure is also low. The only noticeable exception to that across spouses are *mental status* (0.50) and to a lesser extent *numeracy* (0.23). Within person, *memory recall* and *numeracy* are correlated are 0.57 for husbands and 0.43 for wives.

Table 8 presents results for estimates of the relationship between cognitive attributes of both spouses and the three financial outcomes for the household-total wealth, total financial

wealth, and the fraction of financial assets held in stock. These models are estimated over a sample of married couples. The other covariates include the same attributes included in the individual model discussed above with the addition of an age quadratic for the spouse and spousal education. Coefficients on the non-cognitive variables are very similar to those discussed above in the individual model and no new issues are raised in this couples sample. For reasons mentioned above, the cognitive variables are limited to those in the core component of the HRS survey.

Once again, there is scant evidence of any systematic relation for the *TICS* mental status measure for either spouse. With the exception of the total wealth measure (where estimate effects are higher for the non-financial respondents, word recall has similarly estimated impacts for both financial and non-financial respondents. The critical distinction relates to our numeracy measure where estimated effects for financial respondents are three times larger than on better numeracy of the non-financial respondent. Consistent with the relative magnitude of these estimated impacts, the evidence above indicated that families selected the spouse with the higher cognitive measure of numeracy as the financial respondent.

Similar to the corresponding individual level models, Tables 9 and 10 presents quantile models for total household wealth and total financial wealth for the couples sample. As before, we find increasing impacts of *numeracy* as we move to higher percentiles in the wealth distribution. This increase is even steeper for the *numeracy* of the financial respondent implying that the much lower estimated impact of *numeracy* for the non-financial respondent is particularly the case at higher levels of wealth. This is even more the case when we examine total household financial wealth as the economic outcome.

Conclusion

The inclusion of individual cognitive measurements in the prediction of individual economic outcomes has turned out to be useful. While the importance and the pattern of effects needs to consider the specific sources of information (i.e., the entire HRS, or just the modules), these cognitive measures appear to be descriptively informative.

Numeracy, as measured by answers to three simple mathematical questions, is by far the most predictive of wealth among all cognitive variables. This is thought by cognitive psychologists to be a direct measure of practical numerical knowledge (i.e., a form of *Crystallized Intelligence*). We found independent impacts which were statistically significant for all three financial outcomes and for financial and non-financial respondent alike. In addition, and perhaps most importantly, the estimated impact of answering a question correctly is much higher for the financial respondent compared to the non-financial respondent in all three outcomes. To illustrate, the estimated effect of answering a question correctly is thirty thousand dollars greater household wealth for the financial respondent and only ten thousand dollars if one is the non-financial respondent.

The independent impact of *number series* has similar characteristics in its relationship to the financial outcomes, but these relationships are not as important with the strong qualification that there currently exists more limited data on this measure in the HRS. The number series is not simply a measure of numerical knowledge, but is a measure of numerical reasoning (i.e., an indicator of *Fluid Intelligence*), and this is not a pure measure of the acquisition of wealth.

Memory recall also appears to be related to the total and financial wealth holdings of the family and in this case it applies to both the financial and non-financial respondent. The remaining two cognitive measures- *mental status* and *retrieval fluency*- have very weak and erratic

relationships with these financial outcomes. *Mental status* is statistically significant in only two of six cases and *retrieval fluency* in only one of six cases.[5]

Although these specific cognitive measures were useful in this prediction of measures of accumulated wealth, it is certainly possible that other financial outcomes will be better predicted by different indicators of cognitive functions. Additional analyses of HRS data and other data can be conducted using this basic approach, but all available cognitive measures should be considered for different outcomes. The type of unabashedly descriptive analysis in this paper cannot establish causal pathways for these associations. It cannot be dismissed that a history of lifetime investments in the stock market for example could have lead to improved numerical ability. However, the presence of these estimated effects of numeracy on total and financial wealth at lower wealth quartiles where the levels of commitment of investors is relatively modest should caution at least against a purely reverse pathway from investments to cognitive ability.

[5] Remember that retrieval fluency is only available in an experimental module in the 2006 wave so that statistical significance is a more difficult hurdle for this variable.

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Table 1
Means and Standard Deviations

Variable	Mean	Median	Standard Dev
Total household wealth[a]	498.9	198.0	1,228.83
Total financial wealth[a]	312.7	55.9	1,039.9
% of financial wealth in stocks	8.96	0.0	20.86
Couple	0.65	NA	0.487
Total income[a]	62.18	37.00	173.22
Female	0.589	NA	0.492
Hispanic	0.093	NA	0.290
Non-white	0.163	NA	0.369
Education	12.31	12.00	3.40
Age	68.0	68.0	11.1
Cognition Variables[b]			
Number Series (W-scale)	498.8	507.5	40.2
TICS Mental Status (0-10)	8.85	10.00	2.16
Word Recall (0-10)	4.85	5.00	1.73
Numeracy	1.19	1.00	0.90
Retrieval Fluency (W-scale)	496.0	499.6	12.05

[a] thousands of dollars
[b]- defined over cases asked the cognition questions

Table 2
Relationship of Household Wealth Holdings to Cognition
2006 Individual Sample—Robust Regression
(wealth in thousands of dollars)

	Total Wealth		Total Financial Wealth		Percent in Stock	
	Coef.	t	Coef.	t	Coef.	t
Female	5.04	1.39	-0.69	0.46	0.63	1.72
Hispanic	-7.44	1.21	-16.48	6.46	-1.61	2.43
Non-white	-60.23	12.86	-24.71	12.71	-3.36	6.68
Age	18.13	11.21	6.13	9.13	-0.59	3.47
Age squared	-0.10	9.16	-0.03	7.22	0.01	5.54
Couple	52.01	11.96	14.38	7.97	-0.16	0.36
Education	10.94	18.08	3.86	15.35	1.00	15.71
Fin resp	-20.74	5.02	-7.96	4.64	-1.24	3.01
Total income	2.20	109.0	0.76	90.06	0.01	5.47
Income squared	-0.000	66.63	-0.000	58.55	-1.02e-06	5.83
Cognition Variables						
Number Series W	0.14	1.19	0.03	0.67	0.02	1.26
TICS Mental Status	2.41	2.26	0.34	0.77	-0.02	0.14
Word Recall	7.63	6.67	3.77	7.92	0.17	1.47
Numeracy	20.09	8.92	7.38	7.89	1.65	7.23
Retrieval Fluency W	0.59	1.18	0.42	1.99	-0.07	1.33
Total wealth					0.002	15.39
Cons	-1206.59	4.62	-512.56	4.73	28.83	1.09
N	18,382		18,382		16,220	

Table 3
Relationship of Total Household Wealth Holdings to Cognition
2006 Individual Sample—Quantile Models
(wealth in thousands of dollars)

	25th Quantile		Median		75th Quantile	
	Coef.	t	Coef.	t	Coef.	t
Female	6.130	2.65	6.794	1.79	12.043	1.52
Hispanic	-2.244	0.56	-3.970	0.62	5.199	0.40
Non-white	-23.415	7.62	-50.352	10.25	-92.724	9.37
Age	13.050	13.53	20.016	11.81	30.426	7.88
Age squared	-0.075	11.11	-0.113	9.54	-0.171	6.40
Married	31.281	11.16	44.719	9.81	40.073	4.19
Education	4.530	12.30	9.621	15.15	16.019	11.22
Financial respondent	-10.263	3.87	-22.722	5.24	-41.095	4.57
Income	1.914	127.99	3.542	167.89	7.107	160.26
Income squared	-0.000	87.63	-0.000	127.14	-0.000	140.75
Number Series W	0.093	1.27	0.211	1.70	0.233	0.89
TICS Mental Status	0.497	0.75	0.686	0.61	0.475	0.19
Word Recall	4.758	6.64	5.956	4.96	8.243	3.21
Numeracy	12.078	8.49	27.235	11.52	48.547	9.62
Retrieval fluency W	0.571	1.84	0.572	1.09	2.541	2.23
Cons	-951.354	5.90	-1319.679	4.83	-2720.457	4.55
N	18,382		18,382		18,382	

	90th Quantile	
	Coef.	t
Female	14.393	0.92
Hispanic	-40.208	1.66
Non-white	-182.266	9.81
Age	32.186	4.08
Age squared	-0.173	3.18
Married	59.891	3.17
Education	23.883	8.00
Financial respondent	-58.543	3.30
Income	12.093	148.76
Income squared	-0.001	136.52
Number Series W	0.453	0.82
TICS Mental Status	4.614	0.93
Word Recall	6.892	1.36
Numeracy	76.988	7.72
Retrieval Fluency W	1.935	0.89
Cons	-2613.225	2.28
N	18,382	

Table 4
Relationship of Total Financial Wealth Holdings to Cognition
2006 Individual Sample—Quantile Models
(wealth in thousands of dollars)

	25th Quantile		Median		75th Quantile	
	Coef.	t	Coef.	t	Coef.	t
Female	0.894	1.27	2.208	1.28	4.510	1.02
Hispanic	-3.196	2.58	-6.898	2.35	-18.900	2.67
Non-white	-7.863	8.39	-19.616	8.76	-53.412	9.86
Age	4.422	15.15	8.884	11.48	14.514	6.88
Age squared	-0.026	12.88	-0.051	9.43	-0.081	5.58
Married	-0.213	0.25	0.508	0.24	-0.566	0.11
Education	0.739	6.48	2.762	9.54	5.803	7.45
Financial respondent	-2.649	3.28	-7.915	4.00	-18.973	3.82
Income	0.825	207.93	2.234	232.18	5.432	217.38
Income squared	-0.000	160.79	-0.000	195.68	-0.000	202.25
Number Series W	0.005	0.21	0.102	1.81	0.222	1.50
TICS Mental Status	-0.179	0.89	-0.668	1.31	-0.127	0.09
Word Recall	0.906	4.15	2.069	3.78	1.399	0.99
Numeracy	2.605	6.00	11.847	10.99	27.192	9.78
Retrieval Fluency W	0.179	1.95	0.696	2.91	1.630	2.60
Cons	-285.730	5.95	-798.977	6.41	-1558.952	4.76
N	18,382		18,382		18,382	

	90th Quantile	
	Coef.	t
Female	5.737	0.57
Hispanic	-47.886	3.14
Non-white	-114.563	9.65
Age	19.143	3.85
Age squared	-0.099	2.87
Married	6.725	0.55
Education	13.375	7.05
Financial respondent	-39.262	3.44
Income	9.898	173.15
Income squared	-0.001	165.84
Number Series W	0.173	0.50
TICS Mental Status	0.015	0.00
Word Recall	2.350	0.73
Numeracy	52.309	8.13
Retrieval Fluency W	2.356	1.63
Cons	-2105.232	2.77
N	18,382	

Table 5
Total Wealth by Numeracy of Spouse
(wealth in thousands of dollars)

Total Wealth

Numeracy Score of Financial Respondent	Numeracy Score of Non-Financial Respondent 0	1	2	3
0	202.3	339.8	548.5	1,762.1
1	431.5	505.1	682.9	564.9
2	684.5	685.8	852.6	1,357.5
3	971.5	818.3	949.6	1,679.4

Total Financial Wealth

Numeracy Score of Financial Respondent	Numeracy Score of Spouse of Non-Financial Respondent 0	1	2	3
0	94.7	184.1	283.0	1450.9
1	272.6	331.8	461.0	317.6
2	466.7	445.7	545.3	888.5
3	620.0	536.8	648.6	1,066.0

Fraction of Financial Wealth in Stocks

Numeracy Score of Financial Respondent	Numeracy Score of Spouse of Non-Financial Respondent 0	1	2	3
0	3.0	6.3	9.4	16.8
1	6.1	9.0	11.0	11.6
2	9.8	11.7	13.5	15.9
3	11.4	18.1	17.0	17.5

Table 6

Means of Cognition Variables by gender and Whether Financial Respondent
(sample of married families)

	Male	Female	Financial Respondent	Non-Financial Respondent
Number Series (W-scale)	505.4	500.3	504.7	500.6
TICS Mental Status (0-10)	8.958	8.924	9.125	8.735
Word Recall (0-10)	4.704	5.377	5.086	5.016
Retrieval Fluency (W scale)	495.7	498.4	497.4	496.8
Numeracy (0-3)	1.464	1.169	1.450	1.165

	Male Financial Respondent	Male Non-Financial Respondent	Female Financial Respondent	Female Non-Financial Respondent
Number Series (W-scale)	508.2	500.8	500.1	500.5
TICS Mental Status (0-10)	9.203	8.505	8.974	8.893
Word Recall (0-10)	4.883	4.378	5.399	5.362
Retrieval Fluency (W scale)	496.4	494.4	498.8	498.1
Numeracy (0-3)	1.606	1.205	1.209	1.143

Note. HRS 2006- 62% of financial respondents are men.

Table 7
Correlations of Cognition Scores of Husbands and Wives

	Husband Number Series	Husband Mental Status	Husband Word Recall	Husband Numeracy	Husband Retrieval Fluency	Wife Number Series	Wife Mental Status	Wife Word Recall	Wife Numeracy	Wife Retrieval Fluency
Husband Number Series W	1.000									
Husband *TICS* Mental Status	0.058	1.000								
Husband Word Recall	0.085	0.101	1.000							
Husband Numeracy	0.078	0.111	0.570	1.000						
Husband Retrieval Fluency W	0.143	0.063	0.070	0.064	1.000					
Wife Number Series W	NA	NA	NA	NA	NA	1.000				
Wife *TICS* Mental Status	-0.000	0.504	-0.178	-0.090	0.028	0.021	1.000			
Wife Word Recall	0.010	-0.137	0.177	0.167	0.014	0.059	-0.078	1.000		
Wife Numeracy	0.010	-0.079	0.153	0.229	0.038	0.057	-0.049	0.430	1.000	
Wife Retrieval Fluency W	NA	NA	NA	NA	NA	0.121	0.045	0.031	0.004	1.000

Table 8
Relationship of Household Wealth Holdings to Cognition of both Financial and Non-Financial Respondents
2006 sample of married couples
Robust Regression
(wealth in thousands of dollars)

	Total Wealth		Total Financial Wealth		Percent in Stock[a]	
	Coef.	t	Coef.	t	Coef.	t
Female	-0.273	0.04	-0.483	0.15	0.004	0.01
Hispanic	27.357	2.70	-13.558	2.61	0.279	0.36
Non-white	-65.522	7.77	-33.583	7.76	-1.940	3.03
Age	13.453	4.50	6.225	4.06	-0.312	1.38
Age squared	-0.077	3.38	-0.032	2.99	0.004	2.08
Education	10.069	9.24	3.516	6.29	0.617	7.55
Financial respondent	-0.147	0.03	-0.151	0.05	-0.002	0.00
Total income	2.192	69.26	1.030	63.46	0.010	4.11
Income squared	-0.000	45.17	-0.000	47.59	-8.87e-07	4.61
Spouse age	13.622	4.56	6.293	4.11	-0.306	1.35
Spouse age squared	-0.079	3.44	-0.035	3.00	0.004	2.06
Spouse education	10.157	9.37	3.611	6.49	0.619	7.60
Financial Respondent						
TICS Mental Status	0.277	0.14	-1.093	1.10	-0.310	2.11
Word Recall	4.704	2.57	4.426	4.71	-0.122	0.90
Numeracy	31.107	8.93	14.163	7.92	1.675	6.52
Non-Financial Respondent						
TICS Mental Status	4.078	2.47	0.611	0.72	0.091	0.73
Word Recall	10.403	5.67	4.521	4.80	0.189	1.40
Numeracy	9.802	2.72	4.269	2.31	1.010	3.82
Total wealth					0.002	12.88
Cons	-1298.292	11.02	-590.162	9.76	-0.199	0.02
N	11,688		11,688		10,876	

a Percent in stocks estimated with OLS

Table 9
Relationship of Household Wealth Holdings to Cognition of both Financial and Non-Financial Respondents
2006 sample of married couples
Quantile Models
(wealth in thousands of dollars)

	25th Quantile		Median		75th Quantile	
	Coef.	t	Coef.	t	Coef.	t
Female	-0.397	0.09	-0.450	0.08	-1.129	0.09
Hispanic	12.922	1.72	50.321	5.68	87.513	4.40
Non-white	-27.584	4.52	-51.208	6.95	-92.610	5.50
Age	8.732	4.26	10.886	4.18	22.667	3.48
Age squared	-0.049	3.06	-0.056	2.80	-0.126	2.57
Education	5.017	6.69	9.593	10.07	14.400	6.14
Fin respondent	0.194	0.05	0.553	0.11	-0.753	0.07
Total income	1.917	83.24	3.368	121.65	6.539	94.54
Income squared	-0.000	56.82	-0.000	94.75	-0.000	85.24
Spouse age	8.968	4.36	11.353	4.35	21.472	3.32
Spouse age squared	-0.051	3.17	-0.058	2.90	-0.119	2.43
Spouse education	4.932	6.60	9.855	10.40	14.355	6.16
Financial Respondent						
TICS Mental Status	-0.168	0.12	0.098	0.06	-6.286	1.53
Word Recall	4.417	3.36	3.843	2.40	6.532	1.70
Numeracy	16.841	6.81	37.857	12.42	71.464	9.74
Non-Financial Respondent						
TICS Mental Status	1.297	1.11	2.122	1.47	3.595	1.04
Word Recall	7.760	6.00	6.949	4.23	3.383	0.88
Numeracy	6.628	2.28	20.285	5.41	22.547	2.98
Cons	-895.353	11.13	-1193.727	5.99	-2,049.343	7.88
N	11,688		11,688		11,688	

	90th Quantile	
	Coef.	t
Female	0.599	0.02
Hispanic	215.708	5.84
Non-white	-108.479	3.33
Age	23.861	1.73
Age squared	-0.121	1.18
Education	22.218	4.57
Financial respondent	0.422	0.02

Total income	11.315	84.41
Income squared	-0.001	79.92
Spouse age	23.299	1.72
Spouse age squared	-0.118	1.17
Spouse education	23.326	4.89
Financial Respondent		
TICS Mental Status	-2.947	0.37
Word Recall	16.193	2.16
Numeracy	102.421	7.19
Non-Financial Respondent		
TICS Mental Status	-3.716	0.54
Word Recall	9.898	1.29
Numeracy	71.034	4.55
Cons	-2363.323	4.26
N	11,688	

Table 10
Relationship of Total Financial Wealth to Cognition of both Financial and Non-Financial Respondents
2006 sample of married couples
Quantile Models
(wealth in thousands of dollars)

	25th Quantile		Median		75th Quantile	
	Coef.	t	Coef.	t	Coef.	t
Female	-0.023	0.01	0.0308	0.01	-0.611	0.08
Hispanic	-2.296	0.84	5.685	0.99	5.950	0.50
Non-white	-12.359	5.55	-26.533	5.55	-66.479	6.48
Age	4.1000	5.62	5.336	3.15	9.881	2.53
Age squared	-0.025	4.40	-0.028	2.11	-0.052	1.77
Education	1.244	4.49	3.343	5.41	5.671	4.03
Financial respondent	-0.011	0.01	-0.071	0.02	-0.302	0.04
Total income	0.922	121.81	2.226	123.97	5.226	121.42
Income squared	-0.000	98.89	-0.000	108.58	-0.000	116.71
Spouse age	4.107	5.63	5.203	3.07	10.180	2.59
Spouse age squared	-0.025	4.41	-0.027	2.05	-0.0551	1.85
Spouse education	1.235	4.49	3.334	5.42	5.940	4.25
Financial Respondent						
TICS Mental Status	-0.780	1.60	-1.613	1.48	-2.571	1.02
Word Recall	1.214	2.58	2.984	2.88	1.015	0.44
Numeracy	5.439	6.14	17.171	8.69	42.099	9.46
Non-Financial Respondent						
TICS Mental Status	-0.562	1.35	0.044	0.05	0.204	0.10
Word Recall	1.979	4.31	2.497	2.40	2.263	0.99
Numeracy	1.591	1.76	9.961	4.88	9.703	2.11
Cons	-364.185	12.72	-556.740	8.33	-4380.231	5.12
N	11,688		11,688		11,688	

	90th Quantile	
	Coef.	t
Female	-3.880	0.22
Hispanic	100.347	3.78
Non-white	-102.394	4.34
Age	10.633	1.01
Age squared	-0.041	0.53
Education	15.086	4.30

Financial respondent	-2.998	0.18
Total income	8.600	89.74
Income squared	-0.001	87.93
Spouse age	11.626	1.12
Spouse age squared	-0.049	0.63
Spouse education	16.241	4.68
Financial Respondent		
TICS Mental Status	-5.602	0.94
Word Recall	11.405	2.14
Numeracy	68.350	6.58
Non-Financial Respondent		
TICS Mental Status	-3.206	0.63
Word Recall	-0.600	0.10
Numeracy	28.724	2.56
Cons	-1240.893	2.98
N	11,688	