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THE IMPACT OF SOCIAL SECURITY INCOME ON COGNITIVE FUNCTION AT OLDER AGES

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ABSTRACT

Prior literature has documented a positive association between income and cognitive function at older ages, however, the extent to which this association represents causal effects is unknown. In this study, we use an exogenous change in Social Security income due to amendments to the Social Security Act in the 1970s to identify the causal impact of Social Security income on cognitive function of elderly individuals. We find that higher benefits led to significant improvements in cognitive function and that these improvements in cognition were clinically meaningful. Our results suggest that interventions even at advanced ages can slow the rate of decline in cognitive function.

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I. INTRODUCTION

Given population aging, there is considerable interest in understanding the determinants of cognitive function at older ages and in identifying policies that could potentially prevent or delay cognitive impairment. While some cognitive decline is normal with aging, more severe declines often lead to the onset of Alzheimer's disease (AD) or dementia. Alzheimer's disease (AD) is a progressive brain condition that affects memory, language and reasoning, and can seriously impair an individual's ability to carry out daily activities. In addition, AD and related dementias (ADRD) impose a significant financial burden on patients, caregivers and public programs such as Medicare and Medicaid (Ayyagari, Salm, and Sloan 2007; Langa et al. 2001; Taylor et al. 2001; Hurd et al. 2013). Aggregate health care payments for persons with AD, estimated to be $226 billion in 2015, are expected to grow over the next few years due to the aging of the baby boom generation (Alzheimer's Association Report 2015).

Although the causes of ADRD are not well understood, there is growing evidence that modifiable factors, such as education (Maurer 2010; Banks and Mazzonna 2012), retirement age (Rohwedder and Willis 2010; Bonsang, Adam, and Perelman 2012) and childhood environment (Case and Paxson 2009), influence the risk of cognitive impairment and ADRD. Building upon this literature, in this study, we evaluate the impact of income on cognitive function at older ages. In particular, we focus on Social Security income, which can be modified by amendments to the Social Security Act. Indeed, given concerns about the financial sustainability of the Social Security program, several changes are being considered by policymakers, including increasing minimum benefits for low-wage workers and using the chained CPI to index benefits, which would lower annual increases for recipients. Furthermore, the focus on Social Security income provides important information on the extent to which interventions at advanced ages can prevent cognitive impairment.

Although a large literature has evaluated the impact of income on a wide range of health outcomes (Lindahl 2005; Frijters, Haisken-DeNew, and Shields 2005; Evans and Moore 2011), in general there is not a consensus on the causal impact of income on health (Smith 1999). Further, to the best of our knowledge, no prior study has evaluated the causal impact of income on cognition at older ages in the U.S. The only evidence on causal effects comes from a study based in Mexico that showed that an income supplement program targeted towards the poor elderly led to improvements in measures of episodic memory (Aguila et al., 2015). However, given the considerable differences between the two countries, it is not clear that these effects would generalize to the U.S. Income may affect cognition via several pathways, including lower financial strain or better access to health care, which have been shown to be positively related to cognition. Higher income reduces financial strain, resulting in lower stress and fewer depressive symptoms (e.g. Mendes de Leon, Rapp, and Kasl (1994)). Several studies have documented the detrimental effects of stress on cognitive functioning at older ages (Andel et al. 2012; Johansson et al. 2010) and depressive symptoms are strongly correlated with cognitive decline (van den Kommer et al. 2013). Both chronic stress and depression are associated with elevated levels of corticosteroids, which may lead to hippocampal changes that affect memory and neurodegenerative processes (Korczyn and Halperin 2009).

Individuals with greater income typically have more access to health care. Even among Medicare beneficiaries, income is correlated with more coverage through the purchase of supplemental Medigap coverage (Ettner 1997; Fang, Keane, and Silverman 2008). Greater access to health care services can affect neurocognitive health directly by resulting in earlier detection of mild cognitive impairment (Valcour et al. 2000), thereby enabling treatment that may delay progression to AD (Petersen et al. 2005). Greater access may also affect cognition indirectly via better management of cardiovascular disease, high blood pressure and diabetes, which are associated with an increased risk of cognitive decline (Daviglus et al. 2010).

On the other hand, higher income may lead to earlier retirement, which is negatively related to cognition. French (2005) and van der Klaauw and Wolpin (2008) find that higher Social Security income reduces labor supply and leads to early retirement. Snyder and Evans (2006) document that reductions in Social Security benefit levels led to increases in labor force participation for persons older than 65 years. There is strong evidence that being engaged in work is protective of cognitive impairment and that early retirement leads to faster declines in cognition (Rohwedder and Willis 2010; Bonsang, Adam, and Perelman 2012; Mazzonna and Peracchi 2012). Therefore, early retirement or reduced work may offset the other beneficial pathways through which higher income affects cognition. Thus, the net effect of income on cognition is theoretically ambiguous.

Prior research on the relationship between income and cognitive function finds that higher income is associated with better cognitive function (Cagney and Lauderdale 2002; Lee et al. 2010; Lee et al. 2006); however, any observed association may represent spurious correlation due to unmeasured confounders that are correlated with both income and cognition. For example, persons employed in complex jobs typically earn higher wages and at the same time job complexity is associated with better cognition (Finkel et al. 2009). In addition, childhood environment has been shown to impact both labor market earnings (Almond and Currie 2011) and old-age cognition (Case and Paxson 2009).

This project examines the relationship between income and cognition by determining whether changes in income causally impact cognitive functioning and by uncovering any heterogeneity in this relationship. Specifically, we assess the impact of exogenous changes to Social Security income due to amendments to the Social Security Act in 1972 and 1977, commonly referred to as the "Social Security Notch". Prior to 1972, Social Security payments were not indexed for inflation and instead benefits had been periodically increased by Congress. In 1972, the Social Security Act was amended to provide an annual automatic cost-of-living adjustment for benefits. However, the formula used to index benefits was flawed leading to a faster increase in benefits relative to inflation (referred to as "double indexation"), so that workers born after 1910 received an unintended windfall gain. This error was corrected by Congress in 1977 leading to a reduction in benefits for those born in 1917 or later. To avoid abrupt changes for those close to retirement, a five-year transition period was implemented during which benefits were gradually reduced based on a special transition formula. For persons born in 1922 or later, benefits are calculated using the new formula implemented in 1977. These changes resulted in different cohorts receiving different benefits for the same work history. Moreover, due to grandfathering provisions, these policy changes resulted in permanent changes in the Social Security benefits received by these cohorts.[3] Previous research has examined the benefits notch to determine the impact of Social Security income on prescription drug use (Moran and Simon 2006), weight (Cawley, Moran, and Simon 2010), mental health (Golberstein 2015), mortality (Snyder and Evans 2006), labor supply (Krueger and Pischke 1992), living arrangements (Engelhardt, Gruber, and Perry 2005) and utilization of long term care services (Goda, Golberstein, and Grabowski 2011).

[3] For more details on the notch, see: http://www.ssa.gov/history/notchfile1.html, http://www.ssa.gov/history/notchfile2.html and http://www.ssa.gov/history/notchfile3.html.

Using data from the Study of Assets and Health Dynamics among the Oldest Old (AHEAD), we compare the cognitive outcomes of persons in nearby cohorts with differing Social Security income due to the 1977 amendments. Our estimates suggest that increases in income affect multiple dimensions of cognition. Specifically, a thousand dollar permanent increase in annual Social Security income leads to a 2.2% improvement in working memory, measured by the serial 7 score, and a 1.1% improvement in knowledge, language and orientation, measured by the mental status score. There is also a 1.4% improvement in overall cognition, measured by the total cognition score; however this estimate is only significant at the 10% level. Overall, this paper provides the first evidence from the U.S. on the causal impact of income, particularly Social Security income, on cognition among the elderly.

II. METHODS

We first estimate the association between Social Security income and cognition using ordinary least squares (OLS):

$$Cognition_{ih} = \alpha_1 + \alpha_2 SSIncome_h + \alpha_3 X_{ih} + \varepsilon_{ih} \qquad \text{(Equation 1)}$$

where $Cognition_i$ represents a measure of cognition, as described below, for individual i in household h. The key explanatory variable in equation (1) is Social Security income at the household level (‘$SSIncome$’). X represents a vector of individual and household characteristics, ε is a stochastic error term, and α represents the parameters to be estimated.

As mentioned above, a key concern with evaluating the relationship between income and cognition is that unobserved factors may be correlated with both Social Security income and cognitive function leading to a spurious correlation between the two variables. Further, causality may run in the reverse direction with health influencing income, although this is less likely in the case of Social Security income. Thus, the estimate α_2 from equation (1) may not identify the causal impact of Social Security income. To address the endogeneity of income, we estimate an instrumental variable (IV) model using the following specification:

$$SSIncome_h = \beta_1 + \beta_2 Notch_h + \beta_3 X_{ih} + \nu_{ih} \qquad \text{(Equation 2)}$$

$$Cognition_{ih} = \gamma_1 + \gamma_2 SS\widehat{Income}_h + \gamma_3 X_{ih} + \epsilon_{ih} \qquad \text{(Equation 3)}$$

The instrumental variable ($Notch_h$) is a binary indicator that takes the value one for households whose primary beneficiary was born during 1915-1917 and zero for households whose primary beneficiary was born in any other year between 1901 and 1930. $SS\widehat{Income}$ represents predicted Social Security income obtained from the first stage (equation 2).

The IV model represented by equations (2) and (3) identifies the causal impact of Social Security income on health under two key assumptions. The first assumption is that the instrument is a strong predictor of Social Security income. Prior studies have documented that the birth years 1915-17 represent the peak of the benefits notch and the largest deviation of Social Security income from the trend throughout the period between 1901 and 1930. Therefore, a binary variable defining the 1915-17 cohorts provides the strongest instrument and enables the interpretation of the impact of an increase in Social Security income (Goda, Golberstein, and Grabowski 2011; Cawley, Moran, and Simon 2010; Moran and Simon 2006). We also assess the strength of the instrument in our sample based on the first stage Kleibergen-Paap rk Wald F-statistic (Staiger and Stock 1997; Stock and Yogo 2005).

The second key assumption is that the instrument should not be correlated with cognitive health except via its effect on income (exclusion restriction). In the case of our application, it is plausible that, conditional on age, being born during 1915 to 1917 should not be correlated with cognition relative to other adjacent cohorts except due to the notch related differences in Social Security benefits. Although this assumption is not testable, we provide evidence consistent with this assumption by showing that Social Security income, as affected by being born during 1915 to 1917, is conditionally uncorrelated with other individual characteristics that are associated with income but determined prior to the receipt of Social Security payments, specifically, height and education. All regressions cluster the standard errors at the year of birth level to account for correlations within birth cohorts.

The IV model described above identifies the impact of the Social Security income at the conditional mean. However, it is plausible that income has heterogeneous effects at different parts of the distribution of cognition. For example, the largest impact of additional Social Security income may accrue to individuals in the upper tail of the conditional distribution of cognition since these individuals are more efficiently able to translate additional resources into improvements in health. Alternatively, the largest impact of additional Social Security income may accrue to individuals in the lower tail of the conditional distribution of cognition. Therefore, to examine the heterogeneity of the impact of Social Security income, we estimate instrumental variable quantile regression (IVQR) (Chernozhukov and Hansen 2006, Kwak 2010). We estimate this regression for a continuous measure of cognition, specifically, the total cognition score described below. To examine heterogeneity throughout the conditional distribution, we focus on the 0.10, 0.25, 0.5, 0.75, and 0.90 quantiles.

III. DATA

To determine the influence of Social Security income on cognition using the estimation strategy described above, it is necessary to combine measures of cognition with Social Security income for the cohorts of individuals affected by the Social Security benefits notch and of surrounding cohorts. Thus, we use data from the Study of Assets and Health Dynamics among the Oldest Old (AHEAD), which is a longitudinal survey of persons born before 1924 and their spouses, regardless of age. Respondents were first interviewed in 1993 and then re-interviewed in 1995. Initially conducted as a separate study, the AHEAD was merged with the Health and Retirement Study (HRS) in 1998.

The AHEAD includes detailed measures that are designed to capture various dimensions of cognition: knowledge, reasoning, orientation, calculation, and language. Specifically, the measures that we use are (1) serial 7, (2) word recall, (3) mental status, and (4) total cognition score. The AHEAD measures were derived from well-validated scales such as the Mini-Mental State Examination and the Telephone Interview for Cognitive Status and were adapted so that they could be administered in a large population study (Herzog and Wallace 1997). They have been shown to have satisfactory psychometric properties and construct validity (Herzog and Wallace 1997).

Serial 7 measures working memory and is based on a task in which respondents are asked to subtract 7 from 100 and to continue subtracting 7 from each subsequent number for a total of five times. The score, ranging from 0 to 5, is the count of correct subtractions across the five trials, with each subtraction being assessed independently.

Word recall, a measure of episodic memory, is based on a list of 10 nouns read to the respondent who is then asked to recall as many words as possible in any order (immediate word recall). After approximately 5 minutes, during which time respondents are asked other survey questions, they are asked to repeat the task (delayed word recall). The score is the count of the number of words that were correctly recalled from both times and ranges from 0 to 20.

Mental status is based on various tests designed to measure knowledge, language and orientation, and sums the scores for serial 7, backwards counting from 20, object naming, date naming and president/vice-president naming. Respondents are asked to count backwards as quickly as possible beginning with the number 20. Answers are coded 0 for incorrect, 1 for correct on the second try and 2 for correct on the first try. In addition, respondents are asked to report the month, day, year and day of the week during their interview, and to name the object they would "usually use to cut paper" and "the kind of prickly plant that grows in the desert". Each answer is coded 1 for a correct response and 0 for an incorrect one. New-interviewees and re-interviewees aged 65 years or older are also asked to name the current President and Vice President of the United States. Answers are coded 1 for getting each last name right and 0 otherwise. The mental status score ranges from 0 to 15, with a higher value representing better cognition.

Total Cognition Score, an overall measure of cognition, sums the mental status and word recall scores, and imputes values for missing observations (Fisher et al. 2012; Ofstedal, Fisher, and Herzog 2005). This measure ranges from 0 to 35, with a higher value representing better cognition.

While the continuous measures of cognition are informative, changes in the rate of dementia and related clinical outcomes are of particular interest. Therefore, we follow Crimmins et al. (2011) and Hsu and Willis (2013) in classifying individuals as normal, cognitively impaired but not demented (CIND), or demented. This classification is based on a 27 point score composed of the word recall, serial 7, and backwards counting tests. The 27-point score was developed by Langa, Kabeto, and Weir (2010) to identify dementia and CIND using data from the Health and Retirement Study (HRS).[4] Scores between 12 and 27 are classified as normal, between 7 and 11 as CIND, and between 0 and 6 as demented. In addition, we follow Herzog and Wallace (1997) in classifying individuals as cognitively impaired if they score 8 or less on the total cognition score.

An advantage of using the Herzog-Wallace classification is that it allows us to account for proxy respondents. The cognitive tests in the AHEAD are only administered to self-respondents. Proxy respondents are interviewed when the primary respondent is not available for any reason. Poor health, in particular poor cognitive health, may be a reason for the unavailability of the main respondent. This implies that persons with severe cognitive impairment will likely be underrepresented in our sample, potentially leading to biased estimates if we exclude proxies. However, proxies report on seven symptoms of the main respondent that can be used to assess cognitive impairment (Jorm 1994; Jorm, Scott, and Jacomb 1989). These seven symptoms, referred to as the Jorm scale, include ratings (excellent to poor) of the sample person's memory, judgment, and organization ability, and reports of whether the sample person gets lost in familiar environments, wanders off and does not return, can be left alone for an hour or so, or hallucinates. A rating of poor memory, judgment or organization is categorized as a Jorm symptom as is an indication that the respondent gets lost, wanders off, hallucinates or cannot be left alone. Persons with two or more Jorm symptoms are classified as cognitively

[4] HRS, the sister survey of the AHEAD, began in 1992 and was merged with the AHEAD in 1998. The HRS contains similar measures of cognitive function as the ones we use in this study. Crimmins et al. (2011) compare the normal, CIND, and demented classifications in the HRS data to diagnostic information from the Aging, Demographics and Memory Study (ADAMS). ADAMS surveyed a random subsample of the HRS sample and performed detailed neuropsychological and clinical assessment of cognitive function. The authors find that this measure correctly predicts 74% of the diagnoses from the ADAMS exams. About 52.18% of persons classified as demented in ADAMS are correctly classified as demented in HRS. However, 12.81% of CIND in ADAMS are classified as demented in HRS and 1.44% of Normal are classified as demented in HRS.

impaired.[5] We use a binary indicator for cognitive impairment that is one if a person scores less than or equal to 8 on the total cognition score or if a proxy reports two or more Jorm symptoms for that person. The indicator is zero if the individual scores more than 8 on the total cognition score or if the proxy reports fewer than 2 symptoms.

The key explanatory variable is self-reported household income from Social Security retirement, spouse or widow benefits. This variable is measured in 1993 dollars. In addition, all regressions include a basic set of covariates – own age and gender, the primary beneficiary's age, race and ethnicity, census region of residence, a binary indicator for residing in an MSA and indicators for the type of household – male head- married or male head – single (female head – never married forms the reference category).

The instrument is a binary variable indicating whether an individual received greater Social Security benefits due to the 1972 and 1977 amendments to the Social Security Act. As described above, this variable is defined as one for households whose primary beneficiary was born during 1915-1917 and zero for households whose primary beneficiary was born in any other year. To construct this instrument, we first determine the primary Social Security beneficiary for each household, following the methodology used by prior studies on the Social Security notch (Goda, Golberstein, and Grabowski 2011; Moran and Simon 2006; Cawley, Moran, and Simon 2010). The instrumental variable is then created based on the primary beneficiary's year of birth. Since the majority of married women in this population were affected by the 1977 amendments via their husband's earnings (Snyder and Evans 2006), the year of birth of the male member is used to create the instrument in the case of two member households. For households with no male members in which the respondent is a never-married female, we use her year of birth.

[5] A similar approach has also been used for the classification developed by Langa, Kabeto and Weir (2010). However, that approach is based on interviewer assessment of cognitive limitations, which is not available in the AHEAD survey.

Prior research using the Social Security notch assumes that the former or deceased spouse is the primary Social Security beneficiary in households with no male members in which the female respondent is widowed or divorced and imputes the female member's year of birth. Engelhardt, Gruber, and Perry (2005) estimate that the median difference in spousal ages for this population is three years. Thus, the primary beneficiary's birth year for widowed or divorced females is commonly calculated by subtracting three years from the female member's year of birth (e.g., Moran and Simon 2006). However, recent work by Stephens and Unayama (2015) shows that IV estimates of the impact of Social Security income using the notch are biased upwards by 20 to 30 percent using Current Population Survey data because age is imputed. As a result, in contrast to the previous literature, we exclude widowed and divorced females from our main analysis sample to minimize bias from imputed data.[6]

Following previous studies on the Social Security benefits notch (Krueger and Pischke 1992; Moran and Simon 2006; Cawley, Moran, and Simon 2010; Goda, Golberstein, and Grabowski 2011), we restrict our analysis to households whose primary Social Security beneficiary was born between 1901 and 1930. In addition to the birth year restrictions and the exclusion of widowed and divorced females, we exclude households that report a Social Security income of less than $100 per month and observations with missing or incomplete data on any analysis variable. Using the 1993 wave, these restrictions yield an analysis sample of 4139

[6] Consistent with the conclusions of Stephens and Unayama (2015), we find that the IV estimates are larger when we include widowed and divorced females and impute the primary beneficiary's birth year. For example, the IV estimate for total cognition score is 0.783 with a standard error of 0.232 and a sample size of 6099 when we construct the instrument for widowed and divorced females as her year of birth minus three. Alternatively, we predict the age difference of spouses based on birth year, race/ethnicity, education, and nationality for this sample as 1.27 years. When we construct the instrument for widowed and divorced females as her year of birth minus 1.27, the IV estimate for total cognition score is 0.739 with a standard error of 0.391 and a sample size of 6099. Overall, we conclude that excluding widowed and divorced females with imputed values of the primary beneficiary's birth year minimizes bias in the IV estimates.

individuals including 673 individuals in households where the primary beneficiary was born between 1915 and 1917.

Figure 1 presents the histograms for each outcome variable. There is considerable variation in each measure of cognition. In the case of serial 7, about 38% of the sample obtains a perfect score while about 7% gets every answer wrong. On the word recall test, the majority of individuals (75%) get at least 50% of the answers wrong. About 26% of the sample obtains a perfect score on the mental status measure. The distribution of the total cognition score is slightly left skewed, with about 27% of the sample obtaining a score of 17 or lower. Figure 2 presents the histogram for the 27-point score used to classify individuals as normal, CIND or demented. The majority (66%) of the sample are in the normal range of cognitive function. About 25% are cognitively impaired but not demented and about 9% are demented.

Table 1 presents summary statistics for the analysis sample of the cognition measures, Social Security income, and covariates that are used in the methodology described above. The average annual Social Security income for the sample is over $12 thousand, which is about 42% of total household income, and the average age of respondents is 75 years old. Table 1 also presents summary statistics separately for households whose primary Social Security beneficiary was born during 1915-1917 and the other comparison cohorts. Social Security income is, on average, about $1,200 higher in 1993 dollars for the 1915-1917 cohort compared to the other birth cohorts. Additionally, individuals affected by the Social Security notch have better cognitive function across all measures, even though these respondents are older.

IV. RESULTS

Table 2 displays the estimates of the correlation between Social Security income and cognitive function using OLS models. Across all four measures of cognition there is a strong positive relationship between income and cognition. A $1000 increase in annual income is associated with a 0.04 higher serial 7 score (a 1.04% increase relative to the sample mean), 0.06 higher word recall (0.8%), a 0.07 higher mental status score (0.5%), and a 0.13 higher total cognition score (0.6%). As discussed above, these estimates do not represent causal effects due to unobserved factors and reverse causality.

In Table 3, we present results from the IV models that account for the endogeneity of Social Security income. Column (1) presents the first stage equation results, while columns (2) through (5) present the second stage results for each of the cognition measures. The first stage results show that the IV is strongly correlated with Social Security income and the first stage F-statistic is 16.19. Annual Social Security income (in 1993 dollars) is $1,160 higher for individuals born between 1915 and 1917 compared to other cohorts, which is similar to the unconditional difference in mean values for these groups of cohorts shown in Table 1. After accounting for the endogeneity of income, we find a statistically significant, positive impact on the serial 7 and mental status measures. Relative to the sample mean, there is a 2.2% increase in the serial 7 score, and 1.1% increase in the mental status score. We also find a 2% increase in the word recall score and a 1.4% increase in the total cognition score. The estimate for the total cognition score is statistically significant at the 10% level and the coefficient for the word recall score is imprecisely estimated. The IV models identify a larger effect than the OLS models, which may be due to attrition bias in the OLS estimates from measurement error in self-reported Social Security income. It is also plausible that unobserved factors are correlated with Social Security income and cognition in ways that bias OLS estimates downwards. For example, prior studies have shown that Social Security benefits crowd out private savings (Feldstein 1974; Feldstein and Pellechio 1979; Attanasio and Brugiavini 2003), leading to a negative correlation between Social Security income and wealth, which is omitted from the OLS model. To the extent that wealth is positively correlated with cognition this would lead to a downward bias of the OLS estimates.

Next, we assess the extent to which the identified improvements in cognitive function represent clinically meaningful changes. In Table 4, we present results from IV models using normal, CIND and demented cognitive function as the dependent variables. We find a 1.4 percentage point increase in the proportion of individuals exhibiting normal cognitive function and a 0.5 percentage point increase in the proportion of individuals classified as CIND, however, these estimates are not statistically significant. We also find a statistically significant decline in the rates of demented individuals by 1.9 percentage points. Relative to the sample mean, this represents a 21% drop in the rates of demented individuals. In Table 5, we present results from the IV models using the Herzog-Wallace indicator for cognitive impairment as the dependent variable. The first two columns present results for the main sample excluding proxy respondents. The analysis presented in the last two columns includes 202 proxy respondents. In both samples, we find a significant decrease in the number of individuals that are cognitively impaired of approximately 1 percentage point. Thus, higher Social Security benefits due to the notch changes resulted in clinically relevant improvements in cognitive function.

In Table 6, we explore heterogeneous effects by educational attainment. Specifically, we estimate separate regressions for households whose primary beneficiary has less than a high school education and for households whose primary beneficiary has a high school degree or higher education. Heterogeneity by education is important for two reasons. First, the 1977 amendments also increased the covered earnings maximum used to calculate the "average indexed monthly earnings" (AIME) which summarizes up to 35 years of a worker's indexed earnings and is used to determine benefits. As a result of this change, the notch had a larger effect on persons with less than a high school education (Goda, Golberstein, and Grabowski 2011). As shown in Table 6, consistent with prior literature, we find that the instrument is stronger for low education households. Among individuals with less than a high school degree, individuals born between 1915 and 1917 received $1,734 more in Social Security income annually (in 1993 dollars) than individuals born in other cohorts. For individuals with a high school degree and more education, the instrument is less predictive of Social Security income. Secondly, education has been shown to improve cognitive function (Banks and Mazzonna 2012) and it is plausible that Social Security benefits differentially affect low versus high education households. Although the estimates are imprecise when we stratify the sample by education, for individuals with less than a high school degree, except for word recall, the results presented in Table 6 consistently show that Social Security income improves cognition. A $1000 increase in Social Security income increases mental status by 0.16 points and this estimate is statistically significant at the 10% level. Further, although imprecise, the results suggest that the impact of income on cognition does vary by education. For serial 7 and mental status, we find a larger impact of Social Security income for households whose primary beneficiary has less than a high school degree. We also find a larger decline in the rate of demented and the rate of cognitive impairment for low education households. For households whose primary beneficiary is a high school graduate, the effect of Social Security income is larger than the effect for low education households in the case of word recall and total cognition.

Table 7 presents results from the IVQR models for the total cognition score. The point estimate is constant for the bottom half of the conditional cognition distribution, but increases at higher quantiles, which suggests that relative differences in cognition increase sharply with income. At the 10^{th} quantile, a $1000 increase in Social Security income leads to a 0.2 unit increase in the total cognition score, while at the 90^{th} quantile a similar amount of income results in a 1.3 increase in the total cognition score. Only the estimate at the 90^{th} quantile is statistically significant at the 5% level. These results suggest that individuals with better cognition benefit more from increases in Social Security income.

One concern with our identification strategy is that it relies on cohort differences in income and there may be other unobserved factors that correlate with the notch changes and cognition. To assess the potential for such biases in our estimates, we perform several robustness checks (Table 8). First, we estimate the IV models excluding individuals who were born in 1918 or 1919 (Column 1). These individuals were exposed to the 1918 influenza pandemic, which has been shown to affect long-term outcomes for these cohorts (Almond 2006). By excluding these cohorts, we are able to assess the extent to which the better cognitive function of the 1915-1917 cohorts is driven by the changes due to the notch and not due to adverse consequences of the influenza pandemic. Overall, our results are robust to excluding the 1918 and 1919 cohorts and, in fact, are more precisely estimated, which supports our inference that the main results in Table 3 can be attributed to income changes due to the Social Security notch. We further assess the sensitivity of our results to cohort differences by restricting the sample to a progressively smaller range of birth years. Column 2 restricts the sample to households whose primary beneficiary was born between 1902 and 1928, column 3 to households born between 1903 and 1927 and so on.[7] Overall, the results are robust to smaller ranges of birth years.

Finally, we assess the impact of the notch related changes on height and educational attainment (Table 9). These regressions serve as placebo or falsification tests and allow us to evaluate whether the IV estimates could be attributable to unobserved cohort differences that are correlated with the notch changes. Both height and education are well known to differ by cohort and they are also strongly correlated with income and cognition (Case and Paxson 2008; Banks and Mazzonna 2012). However, they should not be affected by the 1977 amendments since those changes only impacted retirement income. Consistent with this notion, we do not find any significant effect of the Social Security notch on height or education. Overall, these results suggest that the identified impact of income on cognition cannot be attributed to cohort differences.

V. CONCLUSION

In this paper, we examine the relationship between income and cognition. We focus on Social Security income, which is an important source of income for the elderly and is modifiable through public policy. Our study contributes to the literature by providing the first evidence on the causal impact of Social Security income in the U.S. on cognition using exogenous variation in Social Security benefits due to the Social Security notch. We find robust evidence that higher Social Security income improves multiple dimensions of cognitive function among the elderly. Specifically, a thousand dollar permanent increase in annual Social Security income leads to a 2.2% improvement in working memory, a 1.1% improvement in knowledge, language and orientation, and a 1.4% improvement in overall cognition. Further, these changes represent

[7] Using a narrower range of birth years than 1905-1925 resulted in a singular X matrix.

clinically meaningful improvements in cognitive function. A thousand dollar permanent increase in annual Social Security leads to a 1.9 percentage point reduction in the likelihood of being classified as demented and a 1 percentage point decline in the likelihood of being classified as cognitively impaired.

Our findings have important implications for aging populations. Much of the evidence on the determinants of cognitive function has focused on factors that cannot be easily modified (e.g. genes) or on early life interventions (e.g. education). In contrast, our focus on Social Security income suggests that interventions even late in life can significantly improve cognition. An important piece of evidence in support of late-life interventions comes from the literature on the link between retirement and cognition. Studies by Rohwedder and Willis (2010) and Bonsang, Adam and Perelman (2012) have shown that retirement leads to declines in cognitive function. Thus, our results suggest that permanent increases in income during retirement can partially offset the decline in cognition due to retirement.

The findings of our study also have important implications for public policy. As discussed above, several proposals aiming to improve the financial sustainability of the Social Security program are under consideration by U.S. policymakers. These proposals range from reducing benefits to future recipients (e.g. using the chained CPI to index benefits) to increasing benefits for certain targeted groups (e.g. raising minimum Social Security benefits). Our findings suggest that increases in benefits could lead to significant improvements in neurocognitive health. In addition to the direct impact on population health, increases in Social Security benefits could potentially be offset by reduced health care expenditures by the Medicaid or Medicare program, since cognitive impairments are often associated with significant health care spending. During a period of renewed policy discussion around changes to entitlement programs for the elderly, it is important to understand whether changes to Social Security might influence the health and well-being of the elderly.

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Figure 1: Histograms of Cognition Measures

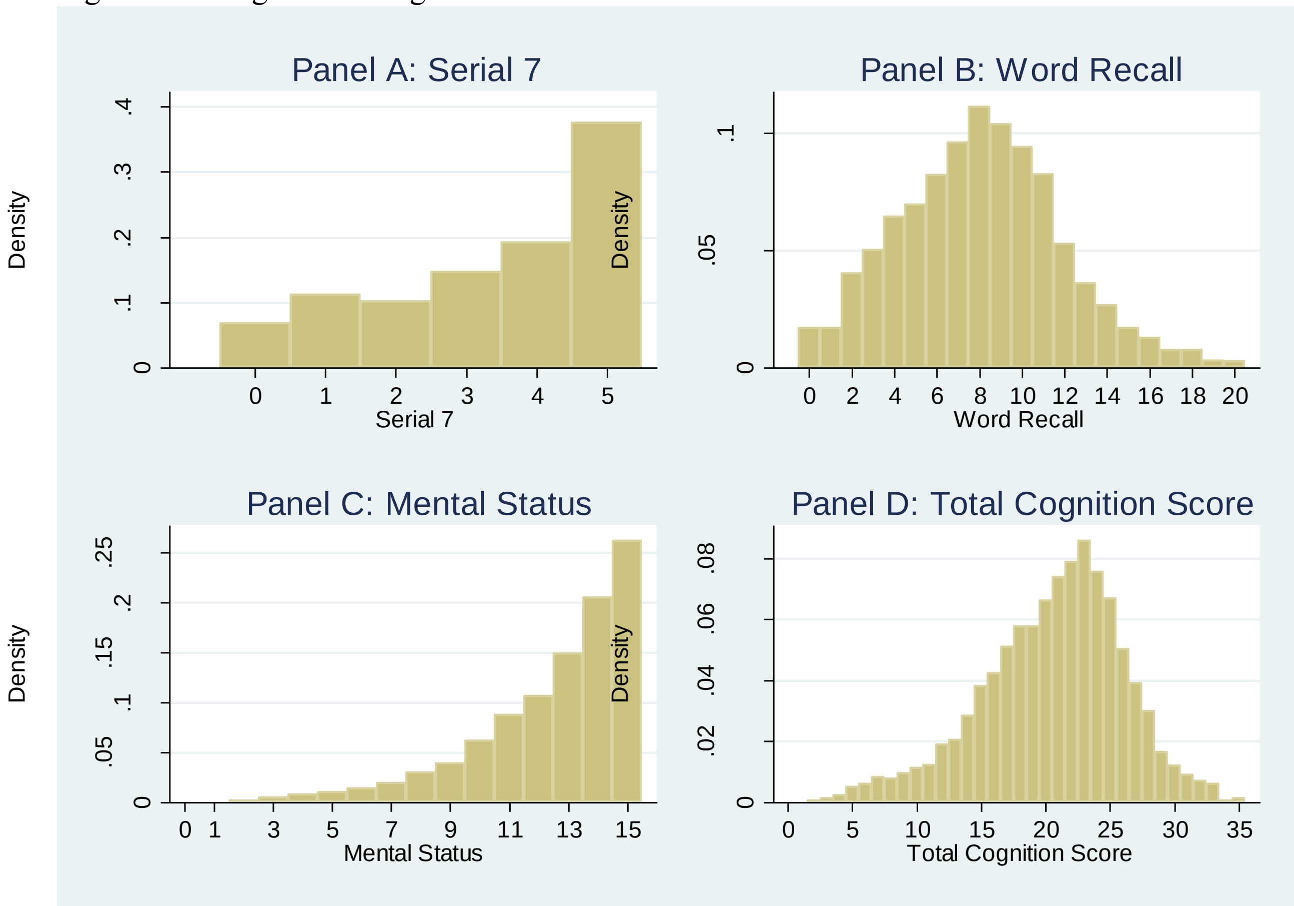

Figure 2: Histogram of 27-Point Cognition Score

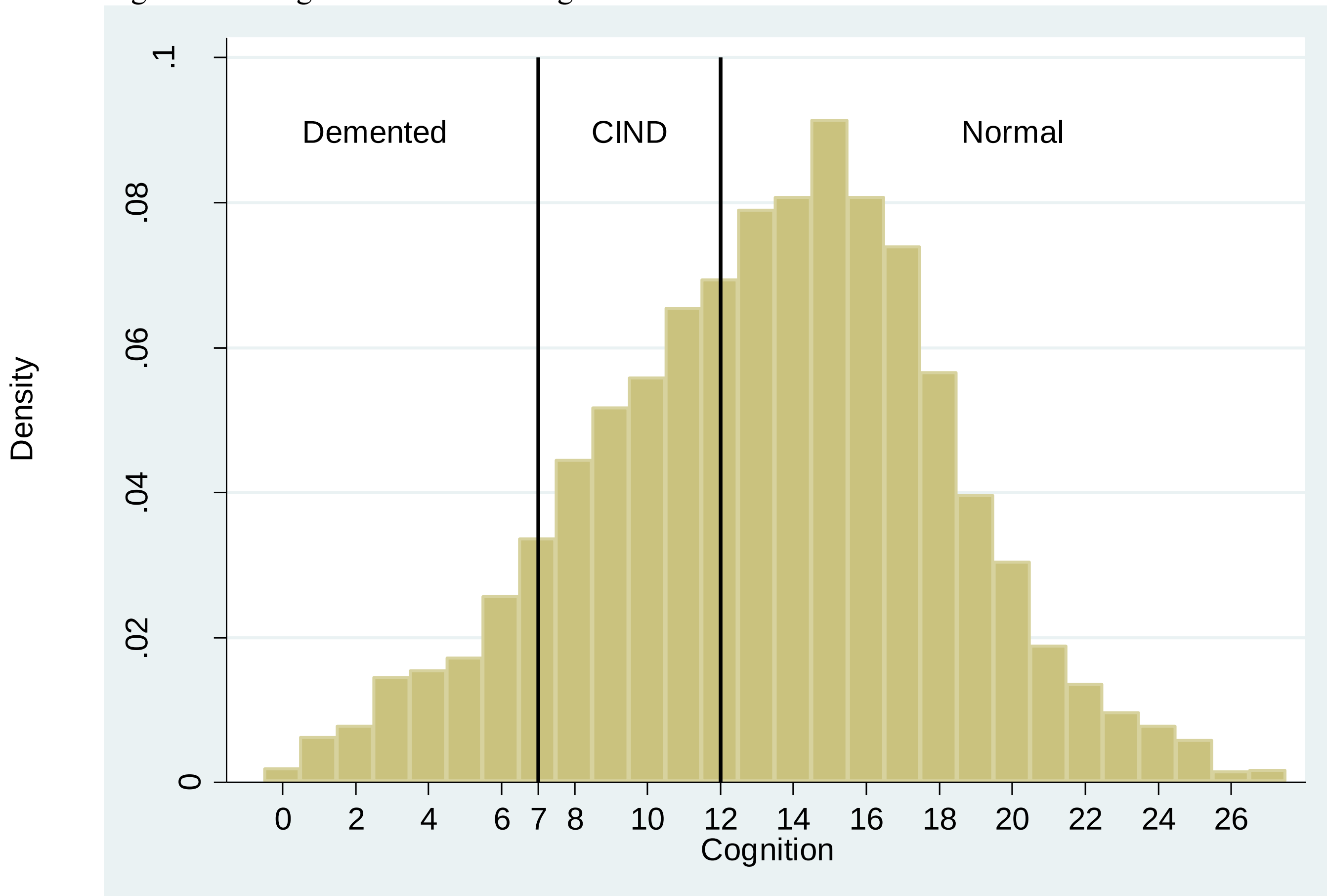

Table 1: Summary Statistics

	Full Sample	1915-1917 Cohort (IV)	Other Birth Years
Serial 7	3.4107	3.5022	3.3930
	(1.6431)	(1.5794)	(1.6548)
Word recall	8.0667	8.1471	8.0511
	(3.8338)	(3.7186)	(3.8561)
Mental status	12.5098	12.6597	12.4807
	(2.6242)	(2.3078)	(2.6807)
Total cognition score	20.5765	20.8068	20.5317
	(5.5384)	(5.0266)	(5.6320)
Normal	0.6603	0.6701	0.6584
	(0.4737)	(0.4705)	(0.4743)
CIND	0.2510	0.2600	0.2493
	(0.4337)	(0.4390)	(0.4327)
Demented	0.0887	0.0698	0.0923
	(0.2843)	(0.2551)	(0.2895)
Annual SS income	12.4201	13.4439	12.2213
	(5.1860)	(5.4311)	(5.1142)
Primary beneficiary's age	76.3151	76.9376	76.1942
	(5.3432)	(0.8031)	(5.8206)
Male head–married	0.8367	0.8247	0.8390
	(0.3697)	(0.3805)	(0.3676)
Male head-single	0.1377	0.1516	0.1350
	(0.3446)	(0.3589)	(0.3418)
MSA/Urban Area	0.7497	0.7162	0.7562
	(0.4332)	(0.4512)	(0.4294)
Primary beneficiary's race - Hispanic	0.0517	0.0401	0.0540
	(0.2215)	(0.1964)	(0.2260)
Primary beneficiary's race - Black	0.0988	0.0773	0.1030
	(0.2985)	(0.2672)	(0.3040)
Primary beneficiary's race - Other	0.0167	0.0178	0.0165
	(0.1281)	(0.1324)	(0.1272)
Own age	74.7799	75.2615	74.6864
	(6.3036)	(3.9955)	(6.6560)
Male	0.5526	0.5557	0.5519
	(0.4973)	(0.4973)	0.4974
N	4,139	673	3,466

Notes: Annual Social Security income is measured in 1000s in 1993 dollars. Other birth years includes individuals born between 1901 and 1914 and between 1918 and 1930.
Source: Study of Assets and Health Dynamics among the Oldest Old, 1993 wave.

Table 2: OLS Estimates of the Relationship between Social Security Income and Cognitive Function

	(1)	(2)	(3)	(4)
	Serial 7	Word Recall	Mental Status	Total Cognition Score
Annual SS income	0.0355***	0.0617***	0.0673***	0.1290***
	(0.0060)	(0.0119)	(0.0092)	(0.0179)
Primary beneficiary's age	-0.0195**	-0.0383**	-0.0468***	-0.0851***
	(0.0078)	(0.0183)	(0.0133)	(0.0278)
Male head–married	-0.2306	0.0247	-0.1743	-0.1496
	(0.1610)	(0.3978)	(0.2450)	(0.5582)
Male head-single	-0.1742	-0.0811	-0.1375	-0.2187
	(0.1817)	(0.4250)	(0.2882)	(0.6162)
MSA/Urban Area	0.2332***	0.6271***	0.4255***	1.0526***
	(0.0626)	(0.1349)	(0.1069)	(0.1983)
Primary beneficiary's race - Hispanic	-1.1536***	-1.6097***	-2.1003***	-3.7100***
	(0.1400)	(0.2446)	(0.2605)	(0.4504)
Primary beneficiary's race - Black	-1.4035***	-1.9296***	-2.6478***	-4.5774***
	(0.0938)	(0.1213)	(0.1903)	(0.2626)
Primary beneficiary's race - Other	-0.4305**	-0.9390**	-0.9400**	-1.8790**
	(0.2075)	(0.4410)	(0.4034)	(0.7373)
Own age	-0.0224***	-0.1640***	-0.0540***	-0.2180***
	(0.0067)	(0.0201)	(0.0110)	(0.0282)
Male	0.3711***	-0.9550***	0.3078***	-0.6472***
	(0.0471)	(0.1460)	(0.0791)	(0.1853)
Constant	6.0432***	22.6888***	19.2002***	41.8890***
	(0.4649)	(0.9722)	(0.8801)	(1.7023)
N	4,139	4,139	4,139	4,139

Notes: Robust standard errors clustered at the year-of-birth level are shown in parentheses. Annual Social Security income is measured in 1000s in 1993 dollars. Regressions also include census region of residence dummies. * p<0.10, ** p<0.05, *** p<0.01

Table 3: IV Estimates of the Impact of Social Security Income on Cognitive Function

	(1)	(2)	(3)	(4)	(5)
	IV 1st Stage	IV 2nd Stage			
Dep. Var.	Annual SS income	Serial 7	Word Recall	Mental Status	Total Cognition Score
Annual SS income		0.0755**	0.1608	0.1312**	0.2920*
		(0.0344)	(0.1221)	(0.0525)	(0.1594)
1915-1917 Cohort (IV)	1.1598***				
	(0.4187)				
Primary beneficiary's age	-0.0104	-0.0193***	-0.0378**	-0.0465***	-0.0843***
	(0.0246)	(0.0075)	(0.0172)	(0.0127)	(0.0260)
Male head–married	6.4302***	-0.4879**	-0.6135	-0.5860	-1.1994
	(0.3203)	(0.2373)	(0.8353)	(0.3986)	(1.1299)
Male head-single	1.7524***	-0.2456	-0.2581	-0.2517	-0.5098
	(0.3356)	(0.1816)	(0.4650)	(0.2939)	(0.6654)
MSA/Urban Area	1.1269***	0.1898***	0.5194***	0.3560***	0.8754***
	(0.1992)	(0.0619)	(0.1673)	(0.1063)	(0.2358)
Primary beneficiary's race - Hispanic	-3.0758***	-1.0293***	-1.3016***	-1.9015***	-3.2031***
	(0.3886)	(0.1759)	(0.4557)	(0.2814)	(0.6349)
Primary beneficiary's race - Black	-2.6147***	-1.2971***	-1.6658***	-2.4776***	-4.1434***
	(0.4013)	(0.1392)	(0.3717)	(0.2558)	(0.5330)
Primary beneficiary's race - Other	-1.2343	-0.3820**	-0.8186*	-0.8623**	-1.6809**
	(0.7917)	(0.1912)	(0.4202)	(0.3670)	(0.6539)
Own age	0.0597***	-0.0247***	-0.1697***	-0.0577***	-0.2275***
	(0.0210)	(0.0066)	(0.0198)	(0.0108)	(0.0277)
Male	-0.1534	0.3771***	-0.9400***	0.3174***	-0.6226***
	(0.1083)	(0.0453)	(0.1359)	(0.0780)	(0.1743)
Constant	2.6249	5.9415***	22.4366***	19.0376***	41.4742***
	(1.7243)	(0.4977)	(1.0544)	(0.9022)	(1.7955)
N	4,139	4,139	4,139	4,139	4,139
F-statistic	16.1902				

Notes: Robust standard errors clustered at the year-of-birth level are shown in parentheses. Annual Social Security income is measured in 1000s in 1993 dollars. Regressions also include census region of residence dummies. * p<0.10, ** p<0.05, *** p<0.01

Table 4: IV Estimates of the Impact of Social Security Income on Normal, Cognitively Impaired but Not Demented (CIND), and Demented

	(1)	(2)	(3)	(4)
	IV-1st Stage		IV-2nd Stage	
Dep. Var.	Annual SS income	Normal	CIND	Demented
Annual SS income		0.0139	0.0046	-0.0186***
		(0.0222)	(0.0250)	(0.0066)
1915-1917 Cohort (IV)	1.1598***			
	(0.4187)			
Primary beneficiary's age	-0.0104	-0.0047*	0.0025	0.0022
	(0.0246)	(0.0025)	(0.0025)	(0.0013)
Male head–married	6.4302***	-0.0534	0.0069	0.0465
	(0.3203)	(0.1501)	(0.1660)	(0.0574)
Male head-single	1.7524***	-0.0569	0.0910	-0.0341
	(0.3356)	(0.0653)	(0.0693)	(0.0447)
MSA/Urban Area	1.1269***	0.0617***	-0.0319	-0.0298**
	(0.1992)	(0.0214)	(0.0246)	(0.0119)
Primary beneficiary's race - Hispanic	-3.0758***	-0.2023***	0.1378*	0.0644**
	(0.3886)	(0.0763)	(0.0826)	(0.0325)
Primary beneficiary's race - Black	-2.6147***	-0.3076***	0.1607**	0.1469***
	(0.4013)	(0.0605)	(0.0700)	(0.0258)
Primary beneficiary's race - Other	-1.2343	-0.0814	-0.0173	0.0987**
	(0.7917)	(0.0742)	(0.0629)	(0.0412)
Own age	0.0597***	-0.0173***	0.0103***	0.0070***
	(0.0210)	(0.0026)	(0.0024)	(0.0014)
Male	-0.1534	-0.0152	0.0044	0.0108
	(0.1083)	(0.0157)	(0.0172)	(0.0101)
Constant	2.6249	2.1866***	-0.7605***	-0.4261***
	(1.7243)	(0.1687)	(0.1356)	(0.0869)
N	4,139	4,139	4,139	4,139
F-statistic	16.1902			

Notes: Robust standard errors clustered at the year-of-birth level are shown in parentheses. Annual Social Security income is measured in 1000s in 1993 dollars. Regressions also include census region of residence dummies. * p<0.10, ** p<0.05, *** p<0.01.

Table 5: The Impact of Social Security Income on Cognitive Impairment

	(1)	(2)	(3)	(4)
	Proxies Excluded		Proxies Included	
	IV–1st Stage	IV-2nd Stage	IV–1st Stage	IV-2nd Stage
Annual SS income		-0.0154***		-0.0104***
		(0.0044)		(0.0038)
1915-1917 Cohort (IV)	1.1598***		1.2966***	
	(0.4187)		(0.4703)	
Primary beneficiary's age	-0.0104	0.0017**	-0.0121	0.0019*
	(0.0246)	(0.0008)	(0.0238)	(0.0011)
Male head–married	6.4302***	0.0744**	6.4286***	0.0662**
	(0.3203)	(0.0329)	(0.3208)	(0.0316)
Male head-single	1.7524***	0.0002	1.7910***	0.0012
	(0.3356)	(0.0254)	(0.3247)	(0.0273)
MSA/Urban Area	1.1269***	0.0017	1.1164***	-0.0030
	(0.1992)	(0.0069)	(0.1972)	(0.0081)
Primary beneficiary's race - Hispanic	-3.0758***	0.0117	-3.1232***	0.0429**
	(0.3886)	(0.0185)	(0.3495)	(0.0215)
Primary beneficiary's race - Black	-2.6147***	0.0602***	-2.5242***	0.1079***
	(0.4013)	(0.0229)	(0.4140)	(0.0201)
Primary beneficiary's race - Other	-1.2343	0.0234	-1.0921	0.0099
	(0.7917)	(0.0281)	(0.7282)	(0.0284)
Own age	0.0597***	0.0034***	0.0548**	0.0044***
	(0.0210)	(0.0009)	(0.0200)	(0.0011)
Male	-0.1534	0.0026	-0.2009**	0.0120*
	(0.1083)	(0.0054)	(0.0833)	(0.0063)
Constant	2.6249	-0.2285***	3.1751*	-0.3796***
	(1.7243)	(0.0612)	(1.6440)	(0.0731)
N	4,139	4,139	4,341	4,341
F-statistic	16.1902		20.1915	

Notes: Robust standard errors clustered at the year-of-birth level are shown in parentheses. Annual Social Security income is measured in 1000s in 1993 dollars. Regressions also include census region of residence dummies. * p<0.10, ** p<0.05, *** p<0.01.

Table 6: Heterogeneous Effects by Educational Attainment

	(1) < High School	(2) ≥ High School
Serial 7	0.0829	0.0450
	(0.0622)	(0.1165)
Word Recall	-0.0004	0.3650
	(0.2010)	(0.3823)
Mental Status	0.1583*	-0.0155
	(0.0847)	(0.1186)
Total Cognition	0.1580	0.3496
	(0.2713)	(0.4202)
Demented	-0.0176	-0.0092
	(0.0112)	(0.0173)
Impaired	-0.0193**	0.0121
	(0.0089)	(0.0081)
N	1,703	2,434
1st Stage Coefficient		
1915-1917 Cohort (IV)	1.7343***	0.6853
	(0.4376)	(0.6125)
F-Statistic	19.8995	2.9596

Notes: Robust standard errors clustered at the year-of-birth level are shown in parentheses. Annual Social Security income is measured in 1000s in 1993 dollars. The results on cognitive impairment are presented for the sample including proxies. For this outcome, the sample size for individuals with less than a high school degree is 1,827 and the first-stage F statistic is 22.1441; for individuals with at least a high school degree, the sample size is 2,512 and the first-stage F statistic is 4.2847. * p<0.10, ** p<0.05, *** p<0.01

Table 7: Heterogeneous Effects on Total Cognition (IV Quantile Regressions)

	(1) 10th Quantile	(2) 25th Quantile	(3) 50th Quantile	(4) 75th Quantile	(5) 90th Quantile
Annual SS income	0.2128	0.2028	0.2336	0.3806	1.3037**
	(0.3493)	(0.2765)	(0.2541)	(0.2824)	(0.5283)
Mean Cognition	9.8046	15.7236	19.6115	22.9869	25.8223
N	4,139	4,139	4,139	4,139	4,139

Notes: Robust standard errors clustered at the year-of-birth level are shown in parentheses. Annual Social Security income is measured in 1000s in 1993 dollars. Mean cognition represents the means for observations between 0 and the 10th percentile, above the 10th and up to the 25th percentile, above the 25th and up to the 50th percentile, above the 50th and up to the 75th percentile, and above the 75th and up to the 90th percentile. Since the 50th and 75th quantile regressions did not converge, these regressions are estimated at the 50.5th and 74.5th quantile.
* p<0.10, ** p<0.05, *** p<0.01

Table 8: Robustness Checks

	(1) Exclude 1918 and 1919 Cohorts	(2) Birth Years 1902 to 1928	(3) Birth Years 1903 to 1927	(4) Birth Years 1904 to 1926	(5) Birth Years 1905 to 1925
Serial 7	0.0784***	0.0746**	0.0767**	0.0746**	0.0677**
	(0.0286)	(0.0350)	(0.0358)	(0.0360)	(0.0343)
Word Recall	0.1924**	0.1604	0.1695	0.1629	0.1636
	(0.0971)	(0.1240)	(0.1254)	(0.1256)	(0.1272)
Mental Status	0.1298***	0.1316**	0.1342**	0.1296**	0.1201**
	(0.0500)	(0.0540)	(0.0552)	(0.0555)	(0.0540)
Total Cognition	0.3222**	0.2920*	0.3036*	0.2924*	0.2837*
	(0.1318)	(0.1622)	(0.1646)	(0.1651)	(0.1661)
Demented	-0.0171**	-0.0192***	-0.0194***	-0.0192***	-0.0167***
	(0.0067)	(0.0069)	(0.0071)	(0.0071)	(0.0060)
Impaired	-0.0083**	-0.0105***	-0.0100***	-0.0095***	-0.0087**
	(0.0037)	(0.0039)	(0.0038)	(0.0037)	(0.0035)
N	3,610	4,107	4,091	4,059	3,998
1st Stage Coefficient					
1915-1917 Cohort (IV)	1.2608***	1.1402**	1.1317**	1.1201**	1.1142**
	(0.4564)	(0.4176)	(0.4191)	(0.4207)	(0.4241)
F-Statistic	18.1122	15.5842	15.2990	14.8918	14.5750

Notes: Robust standard errors clustered at the year-of-birth level are shown in parentheses. Annual Social Security income is measured in 1000s in 1993 dollars. The results on cognitive impairment are presented for the sample including proxies. Across the columns, the respective sample sizes for this outcome are 3780, 4306, 4286, 4251, and 4185 and the first-stage F statistic is 22.0153, 19.5626, 19.2348, 18.6186, and 18.2703. * p<0.10, ** p<0.05, *** p<0.01

Table 9: Placebo Tests – Effect of the Social Security Notch on Height and Education

	(1)	(2)	(3)	(4)
Dep. Var.	Height	Primary Beneficiary's Years of Schooling	< High School (Primary Beneficiary)	Own Years of Schooling
Annual SS income	0.0967	0.1388	-0.0132	0.1093
	(0.1033)	(0.1347)	(0.0293)	(0.1568)
N	4,130	4,138	4,137	4,139
1915-1917 Cohort (IV)	1.1565***	1.1597***	1.1591***	1.1598***
	(0.4181)	(0.4188)	(0.4189)	(0.4187)
First Stage F-statistic	16.0412	16.1846	16.1624	16.1902

Notes: Robust standard errors clustered at the year-of-birth level are shown in parentheses. Annual Social Security income is measured in 1000s in 1993 dollars. * p<0.10, ** p<0.05, *** p<0.01