Housing Wealth, Psychological Well-being, and Cognitive Functioning of Older Americans

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Objectives. Economic security around retirement age may be an important determinant of psychological and cognitive well-being of older adults. This study examines the impact of the dramatic increase in housing prices from the mid-1990s to the mid-2000s on psychological and cognitive outcomes among Americans born between 1924 and 1960.

Method. Our quasi-experimental empirical strategy exploits geographic differences in housing market price trends during the housing boom (from the mid-1990s until 2006). We use individual-level data from the Health and Retirement Study (HRS) and estimates of housing values from DataQuick, a California-based real estate consultancy firm, to estimate the association of housing price increases with psychological and cognitive outcomes at follow-up.

Results. Greater housing appreciation over the follow-up period was associated with a significantly lower risk of anxiety (for women) and an improved performance on some but not all cognitive tasks. Effects for depressive symptoms, positive and negative affect, and life satisfaction were all in the beneficial direction but not statistically significant. The effects of price run-ups were concentrated on homeowners, as opposed to renters, suggestive of wealth-driven effects.

Discussion. Housing market volatility may influence the psychological and cognitive health of older adults, highlighting potential health consequences of pro-home ownership policies, which may be especially important in light of recent dramatic housing price declines.

Key Words: Cognition—Housing—Mental health—Psychological health—Socioeconomic status—Wealth.

SOCIOECONOMIC factors are strongly associated with health and functioning among older adults (Feinglass et al., 2007; Robert et al., 2009) but less is known about their role in psychological health and cognition. Understanding the social determinants of psychological health and cognitive function in older adults is increasingly important as many countries around the world face aging populations. Depressive symptoms among the elderly are estimated to range in prevalence from 8% to 16% (Blazer, 2003), affecting quality of life directly, and also potentially affecting other outcomes related to health and functioning (Hao & Johnson, 2000; Shippee, Wilkinson, & Ferraro, 2012). Persistent depression, for example, has been associated with a state of “accelerated aging,” indicated by a higher prevalence of a variety of chronic diseases (Wolkowitz, Epel, Reus, & Mellon, 2010). Likewise, cognitive decline at older ages is important as an outcome itself and due to its association with other adverse health outcomes including disability (Millan-Calenti et al., 2012).

Economic security around retirement age may be particularly important for overall psychological and cognitive well-being, but most existing research of economic status and health in older adults has focused on physical health outcomes (Meer, Miller, & Rosen, 2003; Shippee et al., 2012; Smith, 2007). In historical context, the middle of the twentieth century was marked by aggressive pro-homeownership policies in the United States; the majority of Americans who came of age during this time held more wealth in housing equity than in any other form. This housing equity may be particularly important as a last resort store of precautionary savings (Case, Quigley, & Shiller, 2005), and therefore booms and busts in house prices may have important psychological health implications for older Americans.

This study examines the impact of the dramatic increase in housing prices from the mid-1990s to the mid-2000s on psychological and cognitive outcomes of Americans born between 1924 and 1960. Drawing on data from the Health and Retirement Study (HRS), our empirical strategy exploits geographic differences in price trends during that period. For most of our sample, the real value of houses increased during the boom, contributing directly to increased wealth for homeowners in the years around their retirement. Housing prices nationwide began falling roughly a year after the end of our follow-up period (Maitland & Blitzer, 2009).

Our approach seeks to overcome a challenge generic to identifying wealth impacts on well-being, namely that the propensity to gain or lose almost any form of wealth may be correlated with individual characteristics that are in turn correlated with psychological and health outcomes. Because expectations about the future and outcomes in the past play a role in determining wealth, longitudinal data by
themselves are unlikely to solve this problem of confounding. Quasi-experimental designs aim to overcome this problem by taking advantage of arguably exogenous variation in the exposure of interest.

We use variation in prices across time and space as our exposure, based on the key identifying assumption that over the long run, house prices reflect not only current home and neighborhood quality, but also the beliefs of buyers and sellers regarding future prospects. This assumption implies that a group of houses in the same metropolitan area, priced similarly at baseline, should have similar expected appreciation over a long period of time. Buyers and sellers would believe ex ante that any appreciation is just as likely for any one house in such a group as any other house. Ex post, those houses that are actually observed to appreciate more steeply were the ones that were “lucky” compared with the others. The key implication of this assumption is that differences in wealth accumulation within such a group are “as if” randomly assigned and thus uncorrelated with observed and unobserved individual characteristics.

The period from the mid-1990s to the mid-2000s constituted a boom in housing prices that was unusual in its scope, translating directly into wealth accumulation for the vast majority of American homeowners. For those who were near or beyond retirement age around this period, this rise in wealth coincided with the stage in their life cycle when they would be reliant on their wealth to support their consumption. For those who did not capitalize the value of their houses before the “busts” that began around the spring of 2007, much of the rise in wealth proved illusory. However, the follow-up period for our analysis ends in 2006, just as housing values in most of the country were reaching their peak. Some homeowners may have believed all along that prices would eventually fall, but the precise timing, scope, and extent of the subsequent collapse are only known in hindsight.

Rising home values may affect psychological well-being and cognition through several mechanisms. One important potential pathway involves the biological effects of stress on the brain. Any increase in the value of property provides a deeper reserve for the homeowner to draw on in the event of a negative shock like a job loss or unexpected illness. This type of financial security should translate into lower stress through greater predictability and control in one’s life, and in turn better mental health (Muntaner, Eaton, Diala, Kessler, & Sorlie, 1998). Evidence in the biological literature indicates that chronic exposure to stress hormones harms the capacity of neurons in the brain to interact—especially in the hippocampus (the brain structure that is involved in long-term memory) and prefrontal cortex (which is involved in inhibition, working memory, and other executive functions; Hunter & McEwen, 2013). This stress-induced structural damage, in turn, is implicated in reduced capability for nuanced cognitive function, long-term memory, working memory, and self-regulation.

In contrast, chronic exposure to stress hormones enhances activity in other brain structures—most notably, the amygdala, which is involved in deep emotional processing. Hyperstimulation of the amygdala has been associated with risk of major depression as well as anxiety disorders (McEwen, 2012). Evidence indicates that the aging brain recovers more slowly from exposure to stressors; depression and anxiety may represent important examples of this loss of resilience in brain function (Lupien, McEwen, Gunnar, & Heim, 2009). Financial buffers against the anticipation of stressors may thus benefit cognitive and psychological functioning in older adults.

Improvements in psychological well-being and cognitive function could also arise from the direct effect of wealth on consumption of salubrious goods and services including leisure activities or healthy foods. Even homeowners who were not intending to sell their houses may have felt this effect, since their last resort buffer was becoming more valuable. A final mechanism through which rising home values could affect psychological well-being is through changes in local conditions (improvements in local labor opportunities, neighborhood quality, and so on) that may have driven or been driven by the price increases themselves.

DATA AND MEASURES

Data

We draw on two complementary sources of data: Individual-level information comes from the HRS and estimates of housing values come from DataQuick, a California-based real estate consultancy firm.

The HRS began in 1992 as a biennial longitudinal study of U.S. adults born between 1930 and 1941 and their spouses. In 1998, the study expanded to cover those born between 1924 and 1947 and their spouses. The primary objective of the HRS is to examine economic and health causes and consequences of retirement; it includes detailed modules on debt, income, wealth, and housing as well as demographic characteristics (age, sex, race/ethnicity, and educational attainment) and self-reported physical health and functioning. In 2006, the questionnaire was expanded. One of the special supplements that year was a “leave-behind questionnaire,” which included detailed questions on psychological well-being given to a randomly selected half of respondents. Geocoded information on respondents’ residential location at the ZIP code level is available under restriction.

DataQuick is a private sector real estate consulting firm that applies a proprietary analytical approach to public data on house sales to estimate the market value of residential properties; they sell their estimates to private sector, for-profit clients including lenders and real estate investors. We purchased a data set of estimates of the value of median single-family detached houses over the period 1988–2007,
in each of 2,400 ZIP codes in which HRS respondents were residing at the time of their baseline interview. We cross-checked DataQuick’s estimates against the Standard & Poor/Case-Shiller Housing Price Index, which is a highly respected source of similar information. Where they overlap, the two sources are very highly correlated (results available upon request).

Sample
Our main analytical sample consists of 4,207 homeowners, born between 1924 and 1960, spread across 70 Census-Based Statistical Areas (our operationalization of a “metropolitan area”). Baseline interviews were completed in 1992 for 2,964 of these respondents, who were in the original “core” HRS sample at the inception of the study. For the remaining 1,243 respondents, baseline interviews were completed in 1998, when the study expanded its sample. Our follow-up period for all respondents ends in 2006. Self-reported outcomes were available for all 4,207 respondents. We also analyzed several measured outcomes from the 2006 leave-behind questionnaire; these are available for a total of 1,736 homeowners. In follow-up analyses, we also expanded the sample to include the 713 HRS respondent renters in the same birth cohorts who lived in the same type of housing and in the same ZIP codes as our main sample. The leave-behind questionnaire was administered on 260 of these renters.

The “core” HRS cohort (interviewed in 1992) and the two expansion cohorts (interviewed in 1998) comprised a total of 12,452 homeowners or their spouses born between 1924 and 1960. Of these, 1,812 (14.5%) died before the end of the follow-up period. We restrict attention only to those among the remaining 10,640 respondents who lived in communities where housing price estimates were available. This mostly involved the exclusion of those (mostly rural) areas with very low rates of housing turnover and also the seven “nondisclosure” states—Alaska, Idaho, Louisiana, Mississippi, Missouri, Texas, and Utah—that do not have laws placing housing transactions in the public record. This restriction reduces the sample size to 6,213 homeowners. We further restricted to only those respondents who were successfully contacted for direct, nonproxy reinterview in 2006, generating the final analytical sample of 4,207. Compared with the full set of homeowners at baseline, those in our analytical sample were about a year younger (median year of birth 1938, compared with 1937), more likely to be female (56.3%, compared with 53.6%), and more educated (51.2% going beyond high school, compared with 41.3%), but about equally likely to be white. Our results are thus likely to be most generalizable to this relatively more educated, more female subpopulation who has survived the follow-up period and who lives in more urban areas and in states where details of housing transactions are publicly disclosed.

Outcome Measures: Psychological Well-being
Psychological well-being was measured using the five variables that represent the full set of standard psychometric and social psychometric instruments contained in the HRS questionnaire. They provide measures of depression risk, risk of anxiety disorders, and general affect. Most measures showed truncated distributions (often with substantial fractions having the minimum score); we dichotomized all outcomes (1 = above median; 0 = median or below). Results were consistent using different cutoffs, using ordered limited-dependent variable approaches, or treating each of these measures as continuous variables.

Depression risk was measured for the full sample on a scale of 0–8 using an 8-item version of the Center for Epidemiologic Studies Depression Scale. A score of 8 indicates highest risk of depression. The remaining psychological well-being measures are available only for the subsample that was chosen for the leave-behind questionnaire. Risk of anxiety disorders was measured using the Beck Anxiety Inventory Scale, which ranges from 0, for minimum risk of anxiety disorders, to 15, for maximum risk (Beck, Epstein, Brown, & Steer, 1988). Positive affect was measured using the Mroczek/Kolarz Positive Affect Inventory, which ranges from 0, for least positive affect, to 24, for most positive affect (Mroczek & Kolarz, 1998). Negative affect was measured using the Mroczek/Kolarz Negative Affect Inventory, which ranges from 0, for least negative affect, to 24, for most negative affect (Mroczek & Kolarz, 1998). Life satisfaction was measured using the Diener Life Satisfaction score, which ranges from 5, for least satisfied with one’s life, to 30, for most satisfied (Diener, 1985).

Each of these five measures represents a distinct psychological and social psychological construct. This theory-based principle is reflected empirically in the fact that they are not highly correlated in our data. The absolute value of all 10 pairwise correlation coefficients among all these measures never exceeds 0.5.

Cognition and Knowledge
Cognition was measured on the full sample by recording respondents’ performance on six of the seven cognitively demanding tasks included in the HRS. We excluded from analysis the task wherein respondents were asked to count backward, 20, 19, 18, . . . , 11, which 96% of respondents completed accurately. We show the results of analyses that dichotomize all measures; results are consistent if we use ordered discrete-dependent variable techniques.

Working memory outcomes.—Working memory represents the capacity to hold things in mind and rapidly access or manipulate them. Successful completion of tasks that require working memory skill is associated with increased cellular activity in the prefrontal cortex of the brain (Wager...
& Smith, 2003). The HRS questionnaire involved two tasks that require this skill. In the serial sevens subtraction test, the interviewer asked the respondent to subtract 7 from 100 and continue subtracting 7 from each subsequent number for a total of five trials. About half the sample successfully completed all five subtractions; therefore, we dichotomized this outcome as follows: 1 = successfully completed all five subtractions; 0 = failed to complete at least one of the five. The second working memory task involved short delay word recall. The interviewer read the respondent a list of 10 nouns, and then immediately upon completion of the list, asked him or her to repeat back as many of them as he or she could remember. About half of the sample was able to recall six or more words from the list of 10. Therefore, we dichotomized as follows: 1 = recalled six or more words; 0 = recalled five or fewer words.

Long-term (hippocampal) memory requires the reconstruction of previously encoded information; successful completion of long-term memory tasks is associated with increased cellular activity in the hippocampus (Cohen et al., 1999). Long-term memory was assessed using a long delay word recall task. Respondents were asked to recall as many as possible of the same 10 nouns that had been used in the short delay word recall, but this time about 5 min later. During the 5-min delay, respondents were answering other survey questions. Successful completion of this task requires the respondent to have encoded the list of nouns, and then to be able to successfully reconstruct/retrieve it after it is no longer held in working memory.

Knowledge outcomes.—The HRS questionnaire included two other tasks that involve the coordinated use of many distinct cognitive systems distributed across the brain and that also require the respondent to draw on information previously acquired in the course of their schooling or education. As such, these tasks assess knowledge rather than what a cognitive psychologist would understand as “cognition.” Respondents aged 65 or older at the time of interview were given a vocabulary test adapted from the Wechsler Adult Intelligence Scale-Revised. Respondents were asked to define five words from one of two randomly assigned sets (examples of words included “repair,” “conceal,” “audacious,” and “plagiarize”). The HRS team classified each response as either “incorrect,” “partially correct,” or “correct.” About a third of respondents had three or more of their five answers assessed “correct,” and another third had exactly two of the answers assessed “correct.” We dichotomized as follows: 1 = three to five answers “correct”; 0 = fewer than three “correct.” Numeracy was measured with three questions: (a) “If the chance of getting a disease is 10%, how many people out of 1,000 would be expected to get the disease?”; (2) “If five people all have the winning numbers in the lottery and the prize is two million dollars, how much will each of them get?”; and (3) “Let’s say you have $200 in a savings account. The account earns 10% interest per year. How much would you have in the account at the end of two years?” About a third answered two of these questions correctly, and another third answered all three correctly. We dichotomized as follows: 1 = all three answers correct; 0 = at least one incorrect answer.

Finally, respondents aged 65 or older were assessed for dementia risk using an instrument based on the Telephone Interview for Cognitive Status (TICS). About 88% of respondents had TICS scores of 9 or 10 out of 10; two thirds had a perfect score. We dichotomized as follows: 1 = perfect score; 0 = less than perfect score.

These six outcomes represent distinct cognitive and knowledge domains; among the 15 pairwise correlation coefficients between them, only one exceeds 0.25 in absolute value.

Stress is consistently linked to declines in memory (Kuhlmann, Piel, & Wolf, 2005) and processing speed (Richardson & VanderKaay Tomasulo, 2011) but less so with general knowledge. Therefore, we expect that the stress buffering effects of housing appreciation may be more important for working and long-term memory tasks compared with tasks that rely more on substantive knowledge.

Empirical Approach

Identifying Assumption

Our key identifying assumption is that housing markets are “efficient” in a specific sense, which is that they build the expectations of the most informed parties about the long-run value of a house into that house’s current price. For example, suppose two houses are equally priced today, but informed real estate investors are very confident that one will be worth more than the other in the long run. In that case, we assume that they will compete for the property with the brighter prospects, bidding up its current price. Research in the housing economics literature indicates that housing markets are not as “efficient” in this sense as other asset markets, in part because a house is bought and sold much less frequently than, say, a stock in a publicly traded company (Case & Shiller, 1989). However, the evidence indicates that the long-run prospects of a house are generally built into its current price (Capozza & Seguin, 1996; Holly, Pesaran, & Yamagata, 2010; Mayer, 2011). Our key identifying assumption is, ultimately, an assumption. To bolster our confidence in this assumption, we have investigated its validity empirically and will discuss evidence that it holds.

If housing markets are “efficient” in the sense of our key identifying assumption, why would prices ever diverge within a metropolitan area? Although current prices build in the long-run expectations of informed parties about the future value of a house, how those expectations match realized long-run outcomes depends on many factors that cannot be perfectly forecast. For example, a particularly attractive...
employer may set up business in one ZIP code rather than another, even though ex ante both ZIP codes were similarly likely to attract that employer’s business. Alternatively, a housing bubble may arbitrarily develop in one ZIP code rather than another, generating windfall wealth for homeowners in that ZIP code. Thus, even under our assumption that efficiency in markets allows us to treat long-run house price growth as quasi-randomly assigned, our estimated effects will reflect the combined effects of different exposures. First, increases in house prices themselves represent wealth accumulation to homeowners; second, they function as a summary measure of the desirability of a neighborhood that has been reflected in the price. We cannot distinguish between these exposures with our data; our results estimate their combined effects.

Analyses

We ran separate regressions for each 2006 health outcome. Moving during the follow-up period would likely be associated with the unobserved characteristics we are trying to control with our design, so our analyses take an “intent-to-treat” approach that averages together those who stay in the same homes and those who sell their homes and move. There is no clear a priori prediction about whether effects should be expected to be similar on movers as on stayers. For example, those who sell their houses convert potential wealth into liquid wealth, and these two types of wealth may have different effects on health. Furthermore, those who sell their houses and those who remain almost certainly differ in any number of unobserved ways—including in terms of characteristics that may be effect modifiers (e.g., the role they might play in local social networks). Nonetheless, we observe that the results we report here are unchanged in terms of sign or significance when the sample is restricted to stayers only. Our exposure variable was the (log of) home values in 2006, as estimated by DataQuick. All models included controls for the following characteristics:

- Home value at baseline, as estimated by DataQuick (logged and splined, with notches at the 10th, 25th, 50th, 75th, and 90th percentiles). Including these controls (in log form) ensures that the coefficient on house valuation in 2006 indicates the effect of the appreciation in home values over the follow-up period. Given the log specification, our regression equation reduces algebraically to a more flexible version of one that has average annual growth as the exposure.
- Dollar value of total nonhousing wealth at baseline (logged and splined, with notches at the quartiles).
- Share of housing equity at baseline. This is a measure of housing debt (indicators for equity stake amounting to less than two thirds of the purchase value of the house and less than the full purchase value of the house). Nonhousing debt at baseline (indicators for none, more than a fifth, or more than three quarters of total nonhousing wealth). Including these wealth and debt controls ensures that comparisons are between respondents with similar levels of baseline net worth, which allows us to more precisely identify the wealth accumulation effect of housing price appreciation.
- Birth year (splined, with notches at 1931, 1938, 1945, and 1952), sex, and birth year-by-sex interactions (splined identically to birth year). Since effects may vary by age and sex, inclusion of these controls allow us to more precisely identify the price growth effect by improving the focus of comparisons onto groups of individuals for whom expected effects are similar.
- Study cohort. The “core” HRS study cohort had its baseline interview in 1992; the other two cohorts had their baseline interviews in 1998. Inclusion of the study cohort fixed effect ensures that all effects are based exclusively on comparisons between individuals who had the same year of baseline interview.
- Metropolitan area of residence at baseline. The inclusion of the metropolitan area fixed effect ensures that all effects are identified entirely from comparisons between ZIP codes within a metropolitan area.
- Self-rated health and indicators for ever smoked and exercised regularly at baseline, as further assurance that our results are not driven by any association of housing appreciation with health or health-related behaviors at baseline.

As a step toward disentangling the effects of wealth accumulation from increases in neighborhood desirability, we stratify our analyses along two dimensions.

First, we compare effects among owners to those among renters. Effects primarily mediated by wealth might arguably be isolated on homeowners, whereas those primarily mediated by local improvements would be felt more uniformly by both groups. Therefore, differences in treatment effects between the two strata can arguably shed light on the importance of wealth effects specifically. However, these results are only suggestive; homeowners likely differ on average from renters on many characteristics, so unobserved differences between these strata might drive differences in observed effects.

We also stratify our main analyses by sex. Women tend to live longer, and therefore may anticipate relying on their wealth to support them longer, thus feeling wealth effects more acutely. Alternatively, men may feel more pressure from social norms regarding responsibility for their families’ financial security. Sex differences in the biology of the stress response may affect the outcomes we analyze. Finally, men and women may vary in how closely they track changes in the value of their houses and the quality of their neighborhoods. For the cognition outcomes, we found no evidence of sex differences and report only the results of the combined analyses.
Multiple Hypothesis Considerations

Finally, we note that our analyses have involved the testing of many hypotheses (five psychometric or social psychometric outcomes and six cognitive or knowledge outcomes, each stratified by sex). This naturally raises the concern that our analysis is at increased risk of Type I error in the aggregate. We deal with this concern by taking three different (increasingly conservative, but decreasingly powerful) approaches to computing \( p \) values for the null hypothesis of zero effects; for each result, we report all three \( p \) values in the Supplementary appendix tables. All three approaches are inspired by Anderson (2008); details of each are discussed in Supplementary Appendix A.

RESULTS

Sample Characteristics

Sample characteristics are presented in Table 1. The left pair of columns summarizes characteristics of the full sample; the right pair summarizes characteristics of those who completed the supplementary leave-behind questionnaire. The similarity suggests that the HRS was reasonably successful at achieving a randomly selected subsample for the supplement, with some evidence that the supplement slightly underrepresents women, overrepresents whites, and underrepresents the very wealthiest and most asset-poor respondents.

The median owner-occupied house doubled in nominal value over the follow-up period, whereas prices of consumer goods increased by only 43\% over the same period (www.bls.gov/cpi; average annual inflation was about 2.5\% per year, both for the period 1992–2006 and for the period 1998–2006).

Housing was an important store of wealth for this sample—the median homeowner had about $250,000 in net assets at the baseline interview, of which about 77\% was in their house.

Psychological Well-being

Table 2 reports the results for housing appreciation and psychological outcomes. Sample sizes, the three resampling-based \( p \) values (using alternative multiple hypothesis adjustments) and fit statistics are reported in Supplementary Appendix Table 1. Among homeowners, all point estimates are in the expected direction—steeper growth is associated with better psychological health. At a 2\%–6\% level of statistical significance (depending on how conservative one wants to be with multiple hypothesis adjustment), steeper growth in housing values reduces anxiety risk in women.

Rising prices were generally less psychologically salubrious for renters than for owners, suggesting that observed effects may be driven more by wealth augmentation than by local improvements.

Cognitive Outcomes

Table 3 reports the results for the task-based cognitive measures. In results not reported here, we observed no difference in effects by sex, so we pool men and women to improve power. Sample sizes, \( p \) values, and fit statistics are reported in Supplementary Appendix Table 2. Among homeowners, all point estimates are in the expected direction, with steeper rises in prices associated with improved performance on every type of task. Effects on homeowners’ long-term (hippocampal) memory are statistically significant at the 3\% level, and since there are no other hippocampal memory measures available in the HRS questionnaire, significance is unaffected by multiple hypothesis adjustment. This beneficial effect of price rises is not observed among renters. For both owners and renters, effects on the tasks specifically related to the prefrontal cortex are small and imprecisely estimated. Effects on the knowledge-intensive tasks were mixed—for owners (but not renters), steeper growth in housing prices improved performance in the numeracy quiz, but effects on the vocabulary quiz were small and imprecisely estimated for both strata.

DISCUSSION

Potential health effects of the pronounced volatility in housing markets over the past two decades have drawn increasing attention. These effects may be most concentrated on those who came of age in the United States around mid-century, when policymakers were pushing homeownership aggressively as a strategy for storing and accumulating wealth. In our sample of Americans in this category, the median homeowner had stored about three quarters of their wealth in their house. By the mid-2000s, the housing-centric savings/investment strategy appeared to have served these Americans well. They had accumulated substantial wealth in their most valuable asset just as they were approaching the point in their life cycle when they would be relying on their wealth to support their consumption and protect them against the increasing risk of costly health events. Using third-party valuation estimates, we compared outcomes among homeowners in more steeply appreciating ZIP codes to those among homeowners in less steeply appreciating ZIP codes in the same metropolitan area. We found evidence that the housing price run-ups of the 1990s and early 2000s reduced female homeowners’ risk of anxiety and both male and female homeowners’ performance on some cognitively demanding tasks. These beneficial effects were not observed among renters, indicating that the “direct” effect of wealth accumulation may be more important than the “indirect” effects of improvements in neighborhood desirability associated with price increases. However, we cannot rule either the “direct” or “indirect” types of effects in the current analysis.
Table 1. Summary Statistics, Analytical Sample, Health and Retirement Study 2006

<table>
<thead>
<tr>
<th>Variable</th>
<th>Statistic</th>
<th>Main analytical sample</th>
<th>“Leave-behind” questionnaire sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Homeowners</td>
<td>Renters</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Right-hand side covariates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Fraction</td>
<td>43.7%</td>
<td>39.1%</td>
</tr>
<tr>
<td>1998 Baseline (otherwise, 1992)</td>
<td>Fraction</td>
<td>29.5%</td>
<td>10.2%</td>
</tr>
<tr>
<td>Nonhousing assets (baseline), thousands of $</td>
<td>Median [IQR]</td>
<td>61.4 [12.0, 180]</td>
<td>2.3 [0.21, 0]</td>
</tr>
<tr>
<td>Nonhousing debt (baseline), thousands of $</td>
<td>Median [IQR]</td>
<td>0 [0, 2.5]</td>
<td>0 [0, 2.5]</td>
</tr>
<tr>
<td>Housing equity (baseline)</td>
<td>Average (SD)</td>
<td>73.9% (29.7%)</td>
<td>Does not apply</td>
</tr>
<tr>
<td>Went beyond high school</td>
<td>Fraction</td>
<td>51.2%</td>
<td>34.8%</td>
</tr>
<tr>
<td>Did not finish high school</td>
<td>Fraction</td>
<td>14.6%</td>
<td>31.6%</td>
</tr>
<tr>
<td>Exercised regularly (baseline)</td>
<td>Fraction</td>
<td>60.4%</td>
<td>46.4%</td>
</tr>
<tr>
<td>Ever smoked regularly</td>
<td>Fraction</td>
<td>59.9%</td>
<td>64.1%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Fraction</td>
<td>5.6%</td>
<td>16.1%</td>
</tr>
<tr>
<td>White</td>
<td>Fraction</td>
<td>85.2%</td>
<td>64.8%</td>
</tr>
<tr>
<td>DataQuick estimate of housing price in ZIP</td>
<td>Median [IQR]</td>
<td>112 [76.9, 152]</td>
<td>108 [75.5, 150]</td>
</tr>
<tr>
<td>Code (baseline), thousands of $</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Code (2006), thousands of $</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beck Anxiety Inventory score</td>
<td>Median [IQR]</td>
<td>Measured in leave-behind sample only</td>
<td>2 [0, 4]</td>
</tr>
<tr>
<td>CES-D-8 score</td>
<td>Mean (SD)</td>
<td>1.5 (1.8)</td>
<td>2.1 (2.2)</td>
</tr>
<tr>
<td>Mroczek/Kolarz Negative Affect Inventory score</td>
<td>Median [IQR]</td>
<td>Measured in leave-behind sample only</td>
<td>2 [0, 4]</td>
</tr>
<tr>
<td>Mroczek/Kolarz Positive Affect Inventory score</td>
<td>Median [IQR]</td>
<td>Measured in leave-behind sample only</td>
<td>17 [14, 18]</td>
</tr>
<tr>
<td>Accurately subtracted 7’s, 5 times</td>
<td>Mean (SD)</td>
<td>49.7% (50.1%)</td>
<td>37.3% (48.4%)</td>
</tr>
<tr>
<td>Number of vocabulary words defined correctly (out of 5)</td>
<td>Median [IQR]</td>
<td>2 [1.3]</td>
<td>2 [1.3]</td>
</tr>
<tr>
<td>Number of numeracy questions answered correctly (out of 3)</td>
<td>Mean (SD)</td>
<td>1.9 (1.1)</td>
<td>1.5 (1.2)</td>
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<tr>
<td>Telephone Inventory of Cognitive Status score</td>
<td>Mean (SD)</td>
<td>9.5 (0.9)</td>
<td>9.2 (1.1)</td>
</tr>
<tr>
<td>Number of respondents</td>
<td></td>
<td>4,207</td>
<td>713</td>
</tr>
</tbody>
</table>

Notes. CES-D-8 = Center for Epidemiologic Studies; IQR = interquartile range.

1Scores can range from 0 (minimum anxiety risk) up to 15 (maximum anxiety risk).
2Scores can range from 0 (minimum depression risk) up to 8 (maximum depression risk).
3Scores can range from 0 (least positive/negative affect) to 24 (most positive/negative affect).
4Scores can range from 5 (least satisfied with life) to 30 (most satisfied with life).
5Respondents began at 100. Shown is the fraction who accurately gave this sequence: 93, 86, 79, 72, and 65.
6Scores can range from 0 (highest dementia/cognitive impairment risk) to 10 (lowest dementia/cognitive impairment risk).
Table 2. House Price Appreciation and Psychological Health

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Sex</th>
<th>Owners</th>
<th>Renters</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Family” 1: Clinical outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beck Anxiety Inventory above median: higher anxiety risk (percentage points)</td>
<td>F</td>
<td>-19.6 [8.1]</td>
<td>2.9 [26.7]</td>
</tr>
<tr>
<td>CES-D-8 score above median: higher depression risk (percentage points)</td>
<td>M</td>
<td>1.7 [9.2]</td>
<td>68.2 [58.7]</td>
</tr>
<tr>
<td>“Family” 2: General affect outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mroczek/Kolarz Negative Affect score above median (percentage points)</td>
<td>F</td>
<td>-3.5 [9.0]</td>
<td>27.7 [22.5]</td>
</tr>
<tr>
<td>Mroczek/Kolarz Positive Affect score above median (percentage points)</td>
<td>M</td>
<td>-7.7 [9.7]</td>
<td>35.8 [38.2]</td>
</tr>
<tr>
<td>Diener Life Satisfaction score above median (percentage points)</td>
<td>F</td>
<td>5.9 [8.8]</td>
<td>-18.7 [23.1]</td>
</tr>
<tr>
<td>(percentage points)</td>
<td>M</td>
<td>1.9 [9.3]</td>
<td>8.3 [40.1]</td>
</tr>
</tbody>
</table>

Notes. CES-D-8 = Center for Epidemiologic Studies Depression Scale. Each row represents a separate regression. Other covariates in each regression include all those summarized in Table 1. Sample sizes, p values, and R² values are given in Supplementary Appendix Table 1. Standard errors—clustered by ZIP code—are given in square brackets.

- Regression coefficients on log of 2006 house price, multiplied by 100. These can be interpreted as the change in the probability of the outcome (in percentage points) associated with moving from the 10th to the 90th percentile in terms of housing price appreciation.
- Indicates that the effect on renters differs from the effect on owners at p < .10.
- CES-D-8 is an eight-item depression screen.

Table 3. House Price Appreciation and Cognitive Functioning

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Effect of price change* [SE]</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Family” 1: Working memory outcomes</td>
<td></td>
</tr>
<tr>
<td>Recalled more than 6 of 10 words after short delay (percentage points)</td>
<td>2.7 [2.8]</td>
</tr>
<tr>
<td>Accurately subtracted 7’s, 5 times (percentage points)</td>
<td>2.5 [3.6]</td>
</tr>
<tr>
<td>“Family” 2: Hippocampal memory outcome</td>
<td></td>
</tr>
<tr>
<td>Recalled more than 5 of 10 words after long delay (percentage points)</td>
<td>6.6 [2.5]</td>
</tr>
<tr>
<td>“Family” 3: Knowledge outcomes</td>
<td></td>
</tr>
<tr>
<td>Answered 3 of 3 numeracy questions accurately (percentage points)</td>
<td>7.7 [3.3]</td>
</tr>
<tr>
<td>Accurately defined at least 3 of 5 vocabulary words (percentage points); 65 and older only</td>
<td>2.8 [4.0]</td>
</tr>
<tr>
<td>“Family” 4: Dementia risk outcome</td>
<td></td>
</tr>
<tr>
<td>Perfect score on Telephone Interview for Cognitive Status test (percentage points); 65 and older only</td>
<td>4.1 [2.9]</td>
</tr>
</tbody>
</table>

Notes. Each row represents a separate regression. Other covariates in each regression include all those summarized in Table 1. Sample sizes, p values, and R² values are given in Supplementary Appendix Table 2. Standard errors—clustered by ZIP code—are given in square brackets.

- Regression coefficients on log of 2006 house price, multiplied by 100. These can be interpreted as the change in the probability of the outcome (in percentage points) associated with moving from the 10th to the 90th percentile in terms of housing price appreciation.

Although we cannot test specific biological mechanisms, we are motivated by hypotheses regarding differences in exposure to stress hormones brought about by the changes in market conditions. Our findings for cognition are consistent with experimental work linking stress to declines in memory (Lupien et al., 2009) and processing speed (Kuhlmann et al., 2005) but less with general knowledge. For the psychological health outcomes, our findings of price effects on anxiety risk but not general affect are consistent with associations reported in the psychological literature between stress and depression and anxiety, with more mixed results for the association of stress hormones with negative and positive affect (Het, Schoofs, Rohleder, & Wolf, 2012; Richardson & VanderKaa y Tomasulo, 2011).

In order for wealth augmentation driven by rising prices to directly improve psychological and cognitive health, homeowners would most likely need to perceive the rise in housing prices and interpret it as an improvement in actual wealth. We note two pieces of evidence that they do. First, each wave of the HRS questionnaire includes a question to all homeowners, asking how much they think they could get for their house if they sold it. Using answers to this question at baseline and at the end of follow-up for every homeowner who did not move, we can compute the implicit trajectory that they believed their house price to have followed. Comparing that against the rate of growth estimated by DataQuick over the same period, we observe a close correspondence. Specifically, regressing owner-assessed value against DataQuick’s assessment generates an R² of 0.88. This implies that owners do perceive rises in the market value of housing in their area. Second, in results not shown here, we have observed that steeper increases in housing values are associated with increased propensity for
a homeowner to report that they intend to provide economic support to friends or family in the future. This indicates that they may have perceived increased value of housing as an augmentation in their actual wealth and were intending to share that new wealth with loved ones.

To the extent that our key identifying assumption of long-run "efficiency" in housing markets holds, homeowners in less steeply appreciating ZIP codes are a valid comparison group for those in more steeply appreciating ZIP codes in the same metropolitan area. This assumption plays two critical roles in our analysis. First and more importantly, subject to that assumption, we can justify the claim that observed "effects" are genuine counterfactual effects. A second and closely related role is that, subject to the assumption, we are able to generate interpretable results despite an important data limitation in the survey—namely, the fact that many of our outcome measures are only available for the end of the follow-up period. When interpreting regression results with nonrandomly assigned covariates, it is often difficult to interpret differences in end-of-period outcome measures without first controlling for baseline differences. However, when covariates are randomly (or quasi-randomly) assigned, baseline differences in the outcome measure are zero in expectation. Thus, to the extent that our assumption holds, we are able to interpret our results as effects on each outcome, even when measures are only available for the end of the follow-up period. Given these two critical roles played by our key identifying assumption, its validity is of central importance to the interpretation of our results.

Supplementary Appendix Table 3 contains evidence that shores up the validity of our identifying assumption. We first regress 19 health-relevant baseline characteristics—including the baseline values for every one of our main outcomes that has a baseline measure available—against log estimated 2006 housing price in the ZIP code, sex, birth year, and sex-by-birth-year interactions (splined as described in the “Analyses” section, above), race, and our metropolitan area fixed effect. In this specification—which, again does not account for baseline prices—14 of these 19 (including all of our baseline psychological and cognitive outcomes) are significantly associated with price in 2006. The housing market, however, builds information about these characteristics into the baseline price, as indicated by the results when flexible controls for log baseline price are added to the regression; switching to this growth specification drives 13 of the 14 previously significant associations—including all of our baseline psychological and cognitive outcomes—to zero.

To our knowledge, no articles have used a similar approach to examine housing price effects on psychological or mental health outcomes, but one article used a similar approach to examine the general health consequences of changes in non-housing wealth. Specifically, Smith used data from the HRS and the Panel Study of Income Dynamics (PSID) to examine the health effects of changes in stock wealth during the 1990s, identifying only very modest health effects (Smith, 2004, 2007). One key difference between this approach and ours is that detailed stock portfolio composition is unobserved in the data. Therefore, it is impossible to distinguish empirically between two very different circumstances: (a) total wealth changed because stock that an investor held initially became more valuable or (b) stock wealth changed because an investor reacted to price changes by changing their investments. This distinction is important, since the former source of change in asset wealth is plausibly quasi-random, whereas the latter is almost certainly not. Housing wealth does not suffer from this problem—knowing the homeowner's address, we could isolate the change in their wealth portfolio specifically driven by a change in the price of their house.

Recent findings from the HRS have linked self-reported mortgage delinquency to incident depression (Alley et al., 2011). The psychological impact of recent sharp declines in housing values may be even larger than the benefits of gains (Kahneman, 2003). Our findings point to the importance of public policies that influence the size and scope of swings in housing markets and the impacts these swings have on Americans' later life economic security. The public health impacts of aggressive pro-homeownership policies should be more directly considered (Glaeser & Shapiro, 2003; Rosnick & Baker, 2009; Slivinski, 2008), and the implications of the recent dramatic housing decline for psychological and cognitive well-being among older Americans should be assessed as the necessary data become available.

Supplementary Material
Supplementary material can be found at: http://psychsocgerontology.oxfordjournals.org/

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References


