An increasing proportion of the U.S. population is living long enough to experience age-associated cognitive decline. Decline in cognitive functioning increases the risk of developing functional impairments and disability (Fillenbaum et al. 1988; Park 1999; Reed, Jagust, and Seab 1989), in turn increasing risk of mortality (Gallacher et al. 2009; Shipley, Taylor, and Deary 2008; van Gelder et al. 2007). Attempting to benefit the cognitive performance of elderly individuals, a great deal of work has focused on health behaviors such tobacco use, alcohol use and physical activity as potentially modifiable sources of cognitive disparities in old age (Anstey, von Sanden, Salim and O'Kearney 2007; Kramer, Erickson, and Colcombe 2006; Colsher and Wallace 1990). What these studies have often neglected is the impact of socioeconomic position (SEP) on the development of health behaviors and health outcomes (Cockerham 2000; Lynch, Kaplan, and Salonen 1997). Without recognizing disparities in access to socioeconomic resources as a fundamental cause of variation in cognitive performance in the elderly, these studies potentially overestimate the influence of health behaviors on cognitive development in old age.

This project utilized growth curve selection modeling to determine the influence of health behaviors on cognitive functioning in older age. Variation in the relationship between cognitive performance and health behaviors based on SEP and race was examined to assess the presence of cognitive disparities in late adulthood. Individuals were drawn from the Assets and Health Dynamics among the Oldest-Old (AHEAD) study, providing nationally representative longitudinal data on health dynamics in later stages of adulthood. This project contributes to the literature on cognitive aging by testing the impact of multiple health behaviors on cognitive decline in late old age while adjusting for diverse indicators of SEP and recognizing the divergent meanings of SEP for racial minorities. In addition, testing the interactive effects of

health behaviors, SEP, and race on cognitive function in aging Americans will identify specific subgroups that could benefit most from positive lifestyle amendments. Finally, explicitly controlling for the relationship between cognitive decline and mortality selection present in longitudinal studies of aging will provide cautious estimates of the effects of health behaviors on cognitive decline.

Literature Review

The epidemiological transition experienced by developed countries over the past century has shifted the major causes of death from infectious to degenerative disease (Orman 1971), limiting the efficacy for medical interventions to reduce morbidity and mortality. The declined capacity for medicine to benefit population health has shifted responsibility for health outcomes to the individual, emphasizing healthy lifestyles in the prevention of disease (Crawford 1998). To remedy the commonly accepted relation between poor choices and poor health, public health officials tend to focus on the re-education of those exhibiting detrimental health behaviors (Cockerham 2000). Holding the individual solely accountable for their health behaviors negates the socioeconomic context where these beliefs and actions are developed and reinforced (Lynch, Kaplan, and Salonen 1997). Individuals coming from disadvantaged lifecourse pathways are exposed to different constraints on the development of healthy lifestyle practices (Cockerham 2000; Lynch, Kaplan, and Salonen 1997). In addition, research has shown that when controlling for health risk behaviors associated with mortality, individuals with lower income are still at a significantly heightened risk of death (Lantz et al. 1998). When examining the impact of behavior on health, the interlocking roots of SEP and health behaviors must be approached carefully.

A great deal of research on cognitive decline in old age has focused on the impact of health behaviors on cognitive outcomes. Many of these studies neglect robust controls for socioeconomic position measured across the lifecourse. After discussion of the current literature on health behaviors and cognitive decline in the elderly, the relation between cognitive decline, SEP, and race is explored. By linking these often divergent research fields, a better understand of the impact of health behaviors on cognitive decline can be developed for diverse socioeconomic and racial subgroups.

Health behaviors and cognitive decline

Current medical and epidemiological research is burgeoning with studies investigating the relationship between health behaviors, cognitive decline, and mortality. Decline in cognitive functioning has been repeatedly associated with increased risk for developing functional impairments and disability (Fillenbaum et al. 1988; Park 1999; Reed, Jagust, and Seab 1989), in turn heightening risk of mortality (Gallacher et al. 2009; Shipley, Taylor, and Deary 2008; van Gelder et al. 2007). The specific mechanisms linking cognition to mortality are uncertain (Shipley, Taylor, and Deary 2008), but both cognitive functioning and mortality are commonly associated with health related behaviors.

In older individuals, increased risk of morbidity and mortality arise from alcohol abuse (Colsher and Wallace 1990; O'Hare 1995; Saunders et al. 1991). Regarding cognitive performance in older adults, moderate alcohol use has been shown to be protective of cognitive performance in late adulthood (Dufoil et al. 1997). Alcohol use by older adults seems to display a u- shaped relationship with cognitive performance where those that abstain from alcohol use and those with heavy alcohol use have lower cognitive scores and higher risks of cognitive

decline and dementia than those who drink moderately (Letenneur, Larrieu, and Barberger-Gateau 2003).

In the elderly, tobacco use seems to increase the pace of cognitive decline and place older individuals at greater risk of dementia (Anstey, von Sanden, Salim and O'Kearney 2007; Ott et al. 2004), but the relationship between tobacco use and cognitive impairment is far from consistent (Letenneur, Larrieu, and Barberger-Gateau 2003). In a meta-analysis of studies testing the impact of tobacco use on dementia and cognitive decline in the elderly, Anstey and colleagues (2007) reported that current smokers had a substantially higher risk of cognitive decline than non-smokers and former smokers were not at a higher risk of cognitive decline than lifetime non-smokers. Physiological pathways hypothesized to link tobacco use with cognitive decline include the increased inflammation and oxidative stress related to smoking, but study in this area is not well developed (Anstey, von Sanden, Salim and O'Kearney 2007).

Exercise has been found to be protective of health generally and to protect elderly individuals from the onset of cognitive decline, dementia, and Alzheimer's disease (Churchill et al. 2002; Kramer, Erickson, and Colcombe 2006; Larson et al. 2006). Yaffe and colleagues (2001) found that women with higher levels of physical activity were less likely to experience cognitive decline over a 6-8 year period. Experimental interventions have also found improved cognitive function related to increased cardiovascular fitness attained through aerobic exercise, but these gains were not displayed by those in a comparison group who practiced only strength and flexibility training (Dustman et al. 1984).

Socioeconomic position, race, and cognitive decline in the elderly

A wealth of research provides support for the notion that those with lower levels of socioeconomic resources have worse health outcomes than those with higher levels (Davey-

Smith 1997; Lynch and Kaplan 2000). Differential access to health-enabling resources is considered a fundamental cause of disparities in health outcomes (Link & Phelan 1995, 2000, 2005). The fundamental cause perspective has continually emphasized information and resource inequalities as the primary sources of the relationship between socioeconomic status and health (Freese and Lutfey forthcoming). The resources Link and Phelan refer to are various forms of economic, social, and cultural capital that embed individual health within a larger socio-cultural context. SEP is a widely used proxy for access to health-enabling resources and will be utilized in analyses as an indicator of fundamental social causes.

The concept of SEP refers to a varied set of social and economic factors that influence individual position in the social structure of society. Lynch and Kaplan (2000) weigh the relative contributions of traditional indicators of SEP including education, occupation, and income in relation to health and suggest the use of a more robust set of socioeconomic resources. While education, income, and occupation are all shown to be consistent predictors of health, varying measurements of assets (accounting for both monetary assets and income) and a dynamic appreciation of socioeconomic factors developed across the lifecourse can help to more accurately capture the complex relationship between SEP and health.

Socioeconomic position unfolds across the lifecourse and social chains of risk emanate from the SEP of one's early stages of life (Kuh, Power, Blane and Bartley 1997). Those who enjoyed high SEP in childhood are more likely to have favorable SEP in adulthood (Johnson and Reed 1996) as well as experience better health in adulthood (Haas 2008; Rahkonen, Lahelma, and Huuhka 1997). SEP in childhood represents an important measurement of access to and predictor of socioeconomic development across the lifecourse

Access to socioeconomic resources is strongly determined by discrimination. Discrimination generally refers to the expression and institutionalization of social relationships of power (Krieger 2000) and is experienced among racial minorities. Racial discrimination is a strong determinant of access to health-enabling resources, contributing to health disparities between races. Indicators of SEP can have substantially different meaning for individuals from differing racial backgrounds and crude measurements of SEP can produce biased estimates of racial differences in the outcome of interest (Adler and Rehkopf 2008). Racial discrimination can affect health by determining access to socioeconomic resources as well as exposing racial minorities to physiological stresses on the body that result from the experience of being discriminated against. By adjusting for a varied set of socioeconomic indicators, the effects of racial discrimination not captured by SEP can be measured more accurately.

Research on SEP and cognitive aging. Previous studies of the relationship between SEP and cognitive decline have tended to focus on education as the key indicator of SEP. Education has been consistently related to cognitive health outcomes among the elderly (Alley, Suthers and Crimmins 2007; Cagney and Lauderdale 2002; Lee, Kawachi, Berkman and Grodstein 2003). Other researchers using detailed neuropsychological measurement did not find a significant relationship between education and cognitive decline (Van Dijk et al 2008), but generally education is believed an important indicator of cognitive decline. The relationship between education and cognitive aging is complex as education can be an indicator of both SEP as well as a marker of years spent developing and exercising cognitive abilities (Cagney and Lauderdale 2002). In studies with robust controls for SEP including lifetime wealth and current income, the impact of education on cognitive function remained strong (Cagney and Lauderdale 2002; Lee,

Kawachi, Berkman and Grodstein 2003). This indicates that in studies of cognitive decline among the elderly, education may be a better proxy for cognitive development than SEP.

Studies exploring the impact of education on cognitive aging have also included indicators of SEP such as lifetime wealth, current income, and occupation in addition to indicators of childhood SEP. Cagney and Lauderdale (2002) found lower cognitive function among whites with low income and assets, but these relationships did not hold for blacks or Hispanics. Lee and colleagues (2003) reported increased odds of cognitive decline among women whose fathers were farmers compared to white collar workers, but household income was non-significant. Recent work using the Health and Retirement Study tested associations between childhood SEP and social mobility as predictors of cognitive decline using growth curve modeling (Faul 2008). Results indicated that the respondent's father having 8 or more years of education, high childhood SES, and having a father in a white collar as compared to blue-collar or other low-status occupation was protective against cognitive decline. While controlling for childhood SEP, only lifetime wealth remained a significant predictor of cognitive change over time.

Research on race and cognitive aging. Compared to work relating SEP to cognitive decline, relatively little research exists on racial disparities and cognitive aging. Racial disparities in cognitive decline in old age are typically attributed to inequalities in education and diseases that predict cognitive decline (Black and Rush 2002). With that said, cognitive disparities in late adulthood have been found when comparing blacks to other races in the face of controls for SEP (Lyketsos, Chen and Anthony 1999; Mehta et al. 2004; Schwartz et al. 2004). A central aim of this work is to examine variation in the relationship between health behaviors, SEP, and cognitive decline among racial subgroups common in the US.

Cognitive decline, health behaviors, socioeconomic position, and race

The inconsistent direct and interactive effects of exercise, alcohol, and tobacco use in relation to cognitive decline in the elderly warrants further research. No studies were found that used nationally representative data to test the impact of the multiple health behaviors on cognitive decline in a multivariate analysis of cognitive change over time. Furthermore, these relationships have not been successfully integrated with research on socioeconomic and racial cognitive disparities. The influence of health behaviors on cognitive aging likely varies among sub-groups with divergent levels of socioeconomic resources, producing different opportunities and constraints on developing and maintain beneficial health behaviors. It is also reasonable that the contribution of health behaviors to cognitive aging varies among racial subgroups that experience substantially different relations with power and discrimination across the lifecourse.

Method

This project employed the Assets and Health Dynamics among the Oldest Old Study (AHEAD) study. The initial AHEAD cohort measured in 1992 was born between 1890 and 1923 and consisted of 11,965 individuals. Individuals surveyed in 1992 were re-interviewed every two years with the most recent interview occurring in 2008. Measurements of cognitive performance used in this analysis were taken over a decade ranging from 1998 to 2008. Restricting the analytic sample to individuals who had non-missing word recall scores and had no missing values on baseline covariates measured in 1998 reduced the final sample size to 2,931.

Measures

Word recall. The outcome variable analyzed was a composite score of two word-recall tasks given to AHEAD respondents. The immediate word recall task asked respondents to recall a list of 10 common nouns immediately after hearing them and delayed word recall was

measured after five minutes of test administration had passed. Factor analysis on the HRS cognitive tests has shown that immediate and delayed word recall load on a single factor with an Eigenvalue greater than one (Ofstedal et al. 2005). The summation of these variables was used as the outcome variable in analysis.

Health behaviors. Current alcohol use, participation in vigorous physical activity, as well as previous and current tobacco use were utilized as indicators of health behavior. Alcohol use was operationalized using recommendations on alcohol consumption for elderly individuals provided by the National Institute on Alcohol Abuse and Alcoholism (NIAAA 1998). The NIAAA recommends that individuals age 65 and older consume no more than one drink per day (NIAAA 1998; O'Connell, Chin, Cunningham and Lawlor 2003). AHEAD respondents were asked how many drinks they have each day they drink. Individuals who reported zero drinks were defined as non-drinkers, those reporting having one drink per day on days when they drink were used as the reference group, and those reporting more than one drink on the days they drink were classified as individuals who exceed NIAAA recommendations for alcohol use among the elderly.

Tobacco consumption across the lifecourse was assessed using two questions. Respondents were asked if they had ever smoked cigarettes (1 = yes; 0 = no). Respondents were also asked if they smoked tobacco at the time of interview (1 = yes; 0 = no). The indicator of vigorous physical activity utilized in analysis asked the respondent if they participated in vigorous physical activities such as sports, heavy housework, or a job that requires intense physical labor 3 or more time per week (1= yes; 0 = no).

Socioeconomic resources. Numerous variables were employed to capture the amount and variety of socioeconomic resources available to respondents across the lifecourse. The amount of

education reported by the respondent was measured as a set of three dummy codes representing less than high school (0-11 years), high school graduates (reference group), and those with more than 12 years of education.

Occupation was measured as the job with longest reported tenure. Individuals who reported their longest employment tenure as professional/ technical workers, managers, officials or proprietors, clerical and kindred workers, and those in sales were defined as white collar workers. Individuals reporting longest employment tenure as craftsmen, foremen, operators, laborers, service workers or farmers were labeled as blue collar workers (1= white collar; 0 = blue collar). This measurement of occupation is believed to be superior to occupation at time of interview because the loss of information in occupation at time of interview due to unemployment and retirement, especially for AHEAD respondents. In addition, longest occupation should be a strong indicator of the cumulative effects of occupation due to the importance of accumulated habits and experiences associated with one's most familiar work environment.

Indicators of economic resources included household annual income earnings as well as the respondent's household net assets. Household income was measured as a summary of the household's wage/salary income, capital income, pension and annuity income, income from social security retirement, social security disability and supplemental security income, spouse or widow benefits, income from unemployment and worker's compensation, income from veteran's benefits, welfare, and food stamps, and other sources of income including alimony and lump sum payments from insurance, pension and inheritance. Household assets were measured as a summary of the net value of housing, all real estate holdings, vehicles, businesses, IRA and Keogh accounts, stocks, mutual funds, investment trusts, checking accounts, saving accounts,

money market accounts, CD's, government savings bonds, T-bills, bonds, bond funds, and other savings less the debt owed to mortgages, home loans, and other sources of debt such as credit card balances, medical debts and loans from relatives. Both household income and household assets were transformed into quartiles with the top 25% being used as the reference group.

Multiple measures of childhood SEP were included in analysis. Mother's and father's education were measured separately using a dummy indicator representing whether each parent had obtained less than 8 years of education or 8 or more years of education. A retrospective assessment of whether the respondent's family was poor during their childhood was created (1= yes; 0 = no). Finally, respondents were asked what their father's occupation was when the respondent was age 16. The responses to this variable were coded using the same scheme used to code the respondent's longest occupation.

Confounding variables. Controls were included to provide a more accurate analysis of the relation between health behaviors, socioeconomic position, and cognitive performance. Performance effects caused by repeated administration of the word recall test were controlled for using a dummy variable coded as zero at first test completion and 1 for completion of subsequent tests. The relationship between age and cognitive function was controlled for using a continuous variable representing age at the beginning of initial interview. Those who are married have been shown to have lower prevalence of dementia than those who are single or previously married (Kristjansson, Helliwell, Forbes, and Hill 2000). Marriage was coded as a dichotomous variable where those married, married without partner present, or partnered were combined (1 = married) and those separated, divorced, or never married were combined (0 = not married).The respondent's self reported health (1 = poor, 5 = excellent) was included as an indicator of health status at baseline measurement.

Statistical analysis. M-Plus version 5 was employed to estimate latent growth curve selection models. Latent growth curve models allow the modeling of change over time in an outcome variable where the trajectory of this change over time is adjusted for influence of covariates. Word recall was analyzed as a time-varying dependent variable where each independent variable provides direction to both the baseline intercept of the model as well as the slope which corresponds to the change in word recall score over the five measurement waves.

Conceptualization of the selection model process requires initial definition of the latent growth model. At each wave of measurement (t), measurements at the individual level (i, y_{it}) are created as a composite of each person's growth and normally distributed random error. When assuming the latent growth process is linear, two latent parameters define the growth process ($y_{it} \sim N(\alpha_i + \beta_i t, \sigma^2)$). The expected value for the model is defined by the individual-specific random intercept (α_i), slope (β_i), and time (t) and random error is normally distributed with a time constant variance (σ^2). This level of the equation places the time-specific measures into the trajectory and random variation around the trajectory. The next level of the equation allows introduction of covariates that influence individual trajectories ($\alpha_i \sim N(X_i\gamma,\tau_\alpha)$, $\beta_i \sim N(Z_i\delta,\tau_\beta)$). Covariates explain both intercept and slope factors (X and Z) and their effects vary as well (γ and δ). Unexplained variance between individuals is measured by τ_α and τ_β, allowing differentiation between individual level error and heterogeneity between individuals.

In selection modeling, the latent growth model is adjusted by modeling the drop-out mechanism. The first measurement y_{i1} is observed for all individuals included in analysis and incomplete measurements are due to drop-out only. Logistic regression estimates are produced for each observation of vital status at each wave of measurement t by regressing the indicator of drop-out on the observed values of word recall score at both t and t - 1. The logistic regression

coefficient for current vital status on current word recall score at the given wave (β_t) and the coefficient for current vital status on word recall score at t - 1 (β_{t-1}) are estimated separately for each measurement of vital status. β_t and β_{t-1} are averaged across models to create global estimates for the coefficients β_1 and β_2. For ease of interpretation, the coefficients for β_1 and β_2 are reparametarized to represent dependence on level and increment in the response variable ($\theta_1 = (\beta_1 + \beta_2)/2$ and $\theta_2 = (\beta_1 - \beta_2)/2$) (Diggle and Kenward 1994).

Results

Following discussion of the necessity of selection modeling to control for mortality selection in research on cognitive performance in the elderly, descriptive statistics and results from the growth curve selection models testing the direct and interactive effects of health behaviors, SEP, and race on word recall score are presented. Subgroup differences in word recall score identified through significant interactions are further examined.

Selection model

To assess the necessity of controlling for mortality selection, the assumption that missing data is not a result of random drop-out must be tested. Data not missing at random (NMAR) results when unobserved variables, in our case missing values of word recall score caused by mortality, predict missingness. When missing values on the current outcome predict dropout, the assumption that data is NMAR is supported. Before formally testing the assumption of NMAR, discussion of mortality rates based upon initial word-recall score can help visualize the impact of mortality selection in the AHEAD sample in relation to cognitive function.

Figure 1 displays the survival distribution function for AHEAD respondents included in analysis with valid measurements of word recall in 1998. Groups were classified by quartiles of word recall scores in 1998. The figure displays that individuals in the 1st word recall quartile in

1998 had a significantly higher mortality rate over the decade of measurement than those in the 2nd, 3rd and 4th quartiles. There was a graded relationship between initial word recall score and probability of mortality over the measurement interval, indicating that individuals with relatively high word recall scores at baseline were more likely to survive over the ten year period of measurement than those with relatively lower word recall scores. Over time, those with lower initial word recall scores would be under-represented in the data, biasing the estimates of change over time to reflect the experiences of those with higher initial scores.

The visual results displayed in Figure 1 are statistically confirmed by the results of formal hypothesis testing. Table 2 shows the estimates and significance values of the global logistic regression coefficients ($\beta_1$and β_2) and theta reparameterizations (θ_1 and θ_2). The fact that the regression slope for the missing value on the current outcome is significant (β_1 (t)) suggests the assumption that data is missing at random does not hold and controls for mortality selection are necessary. The theta value for the prevailing word recall score (θ_1) suggests that the probability of dropout increases when initial word recall scores are low or when the increment between the previous and current word recall score is low (θ_2). The estimates represented by θ_1 confirm the results of the survival distribution function of figure 1. The estimate for θ_2 suggests that individuals with smaller changes in word recall score between t-1 and t are also more likely to drop out of the sample. This finding indicates a floor effect where individuals with low initial word recall scores have less change in word recall score over time since their baseline scores were low to begin with. These results support the use of selection modeling in this research.

Descriptive statistics

Table 1 presents the descriptive statistics for the analytic sample. The mean age of respondents was around 79 years old, the average self reported health was fair and 81% of the

sample completed the second word recall test in the year 2000. Fifty-five percent of the sample was female, 91% were white, 6% black and 3% Hispanic. Fifty-two percent of individuals were married or partnered at time of initial interview.

Concerning levels of formal education in the sample, 29% of respondents had less than a high school degree, 36% had earned a high school degree, and 35% had education greater than a high school degree. Around 58% of the sample reported longest tenure in white collar occupation. The mean household income in the 1st, 2nd, 3rd and 4th income quartile was $9,787, $18,080, $29, 536, and $76,457, respectively. The mean value of household assets in the 1st, 2nd, 3rd and 4th asset quartiles was $15,064, $86,380, $214,316, and $901,822, respectively. Regarding childhood SEP, 53% of respondents reported their father having 8 or more years of education and 57% reported their mother had 8 or more years of education. Thirty-one percent of the sample reported living in poor childhood circumstances and 25% reported their father having a white collar occupation.

For health behaviors, 57% of all individuals sampled reported having smoked at some point in their life but only 7% reported smoking in 1998. Seventy-one percent reported they did not drink alcohol, 19% reported having one drink on days that they drank, and 10% reported having 2 or more drinks on days that they consumed alcohol. Around 37% of respondents participated in vigorous physical activity 3 or more times each week.

Growth curve models

Table 3 contains estimates of the impact of covariates, health behaviors, life course SEP and race on cognitive trajectories in the AHEAD sample. Models 1 through 5 contain estimates of main effects and Models 6 and 7 contain estimates of the differential effects of SEP on

cognitive performance based upon race and gender. The estimated mean intercept and slope are included for each model as is R^2 as an indicator of model fit.

Model 1 controlled for testing effects, gender, age, marital status and self-reported health. Females had higher initial word recall scores than men, older individuals had lower initial word recall scores and steeper decline in word recall than those who were younger, and healthier individuals had higher baseline scores and lower rates of decline in word recall than the less healthy. Marital status was not significantly related to preliminary word recall or change in word recall over time. The estimate of the test effect on the intercept indicates that individuals who completed at least the word recall test in 1998 and the follow-up test in 2000 had a predicted baseline word recall score more than 2 points higher than those who did not complete the test in 2000. These individuals also had significantly less rapid decline in word recall. The significance of the test effect on the intercept is another indicator of the impact of word recall score on mortality selection occurring in the AHEAD sample over time. The relationship between the indicator of test effects and word recall trajectory captured both possible test effects and lower rates of cognitive decline in those who survived the measurement interval between 1998 and 2000. The covariates included in Model 1 predicted 38% of the variance in initial word recall and 20% of the variation in word recall slope. The estimated mean for initial word recall was 8.39 words and the estimated mean change in word recall over the 10 years of measurement was 5.03 words.

Model 2 included all covariates as well as indicators of tobacco use, alcohol use and participation in vigorous physical activity. Those reporting previous tobacco use had lower baseline word recall scores than those reporting never using tobacco, but the estimate was rather small. Individuals reporting that they did not drink alcohol had lower baseline word recall than

those reporting having one alcoholic beverage each day. Those reporting drinking more than one alcoholic drink per day did not have significantly different initial recall scores than those who reported having one drink per day. Participation in vigorous physical activity contributed to higher preliminary word recall scores. None of the health behavior indicators predicted significant variation in word recall score over time. Introduction of health behaviors to the previous model predicted another 2% of variation in word recall intercept but these variables did not contribute to prediction of variance in word recall over time.

Race was introduced to controls for confounding variables and indicators of health behaviors in Model 3. Both blacks and Hispanics had significantly lower predicted values of initial word recall scores than whites. On average, blacks recalled 1.31 words less than whites and Hispanics 1.5 words less. Concerning change in word recall over time, the estimated change in word recall for blacks was 1.17 words less than that predicted for whites. This result is likely attributable to the lower initial word recall scores displayed by black individuals. The addition of race to variables included in Model 2 accounted for an additional 2% of the variation in both the intercept and slope of word recall.

Model 4 added indicators of adult SEP to all variables included in Model 3. With the introduction of SEP, marital status emerged as a significant predictor of initial word recall, displaying a negative relationship with baseline word recall. The relationship between ever having smoked and initial word recall score decreased to a non-significant level. The inclusion of adult SEP contributed another 6% of explained variation in initial word recall and 1% of explained variation in word recall change over time.

Numerous indicators of adult SEP were significantly related to variation in word recall. Those with less than a high school degree had preliminary word recall scores .39 units lower

than individuals with a high school degree ($p < .01$). Though income was not significantly related to baseline word recall, results indicated that household assets were positively related to baseline word recall. Individuals in the 1st, 2nd and 3rd income quartile had preliminary word recall scores .89 ($p < .001$), .59 ($p < .001$), and .42 ($p < .001$) units lower then individuals in the highest household asset quartile, respectively. Respondents reporting longest tenure in white collar occupations had opening word recall scores higher than those reporting longest tenure in blue collar or other occupations. Longest tenure in white collar occupation was the only indicator of adult SEP significantly related to change in word recall over time. Those reporting longest tenure in white collar positions had word recall scores that declined more steeply than respondents reporting longest tenure in blue collar or other occupations.

Model 5 included all variables in Model 4 as well as indicators of childhood SEP. In the face of controls for adult SEP, none of the indicators of childhood SEP were significant predictors of baseline word recall or change in word recall scores over time. Inclusion of controls for childhood SEP reduced the relationship between reporting smoking in 1998 and change in word recall to non-significance, but estimates were otherwise unchanged. Addition of childhood SEP did not contribute to better prediction of variance in the intercept and the R^2 for the slope increased by only 1%.

In the final main effect model, reporting no alcohol use was significantly associated with lower baseline word recall scores. Participating in vigorous physical activity was associated with higher cognitive scores in 1998.Both blacks and Hispanics had lower estimated baseline word recall scores than whites, and black word recall declined at a significantly slower rate than white word recall. Individuals with less than a high school education had opening word recall scores .38 units lower than individuals with a high school degree ($p < .01$) and having greater than a

high school degree was not associated with word recall scores. In light of other controls for SEP, household assets maintained a strong positive relationship with baseline word recall. Those reporting longest tenure in white collar occupations had higher word recall scores and steeper rates of decline in word recall than individuals reporting longest tenure in blue collar or other occupations.

Significant interaction results are presented in Models 6 and 7 of Table 3. Differential effects of health behaviors on word recall scores were tested for each racial and socioeconomic subgroup represented in analysis. The small proportion of Hispanics in the analytic sample did not allow for testing the differential effects of SEP on word recall for Hispanics. No significant differences in the relation between health behaviors and cognitive performance existed among black and white respondents. Significant differences were found in the relationship between select indicators of adult SEP and cognitive performance among subgroups of white and black females. Namely, Model 6 illustrates that black individuals with less than a high school degree had lower starting values and smaller declines over time then the reference category (white individuals with a high school degree). In addition, blacks in the lowest household income quartile had significantly steeper slopes than the reference group (whites in the highest income quartile). Model 7 displays a significant three-way interaction effect for black females with less than a high school degree. The significant interaction found in Model 7 was probed so that significance tests could be produced when comparing subgroups of interest.

To probe the significant three-way interaction between indicators of black, female and less than a high school education found in Model 7, the sample was restricted to black and white females with less than a high school degree. All variables included in Model 5 excluding indicators of Hispanic race, education, and gender were included in the probing model. Black

females with less than a high school degree had an estimated initial word recall score 1.26 units lower than white females with less than a high school degree ($p < .001$). The estimated mean word recall at baseline for white women without a high school degree was 7.78 and for black women without a high school degree the estimated opening word recall score was 6.52. A comparable model for males without high school degree was tested and produced non-significant estimates comparing white males and black males.

Discussion

This article set out to test the association between cognitive performance and health behaviors among the elderly while controlling for diverse indicators of SEP. Significant associations between select health behaviors and cognitive performance at baseline were attenuated by the inclusion of adult SEP but not by indicators of childhood SEP. When adjusted for SEP across the lifecourse, individuals who reported never drinking alcohol had significantly lower initial word recall scores than those reporting having one drink on the days that they drank. Those reporting participation in vigorous physical activities such as sports, heavy housework, or having a physically demanding job had higher initial word recall scores than those not reporting involvement in these kinds of activities. No health behavior was associated with significant variation in cognitive trajectory nor were health behaviors associated with significant variation in cognitive performance among socioeconomic and racial subgroups.

Select proxies of SEP in adulthood were significant predictors of both baseline word recall score and change in word recall score over time. In the final main effects model with controls for confounding variables, race, and childhood SEP (Model 5), those with less than a high school degree had significantly lower word recall scores than those with a high school degree. This result confirms findings of others attributing the association between education and cognitive function not solely to a socioeconomic gradient but also to cognitive training and

mental development produced through the education process (Cagney and Lauderdale 2002; Lee, Kawachi, Berkman and Grodstein 2003). The effect of education on baseline cognitive performance showed significant variation among subgroups.

Having less than a high school education was a significant predictor of baseline word recall for black women. Black females with less than a high school education had a predicted opening word recall score nearly two units lower than white females with less than a high school education. The effect of low education was particularly detrimental to the initial word recall scores of black females, representing the negative impact of living along intersecting lines of low education and experiencing life as a racial minority. The impact of having less than a high school diploma was not a significant indicator of cognitive function among white and black men, but this may be a result of the small number of black males represented in the analytic sample.

Returning to discussion of significant main effects displayed in Model 5, cognitive function at baseline displayed a graded relationship with household assets. Those in the highest asset quartile had the highest predicted baseline word recall scores and each decrease in household asset quartile was associated with a corresponding decrease in predicted cognitive score in 1998. This finding aligns with work by Faul (2008) suggesting that lifetime wealth remains a significant predictor of cognitive function in light of other controls for SEP.

Reporting longest tenure in a white collar work setting was associated with higher initial word recall scores when compared to those reporting longest tenure in blue collar or other low status work environments. This finding harmonizes with others who have shown the negative impact of low status occupation on cognition in aging adults (Faul 2008; Stern, Albert, Tang and Tsai 1999). The association between work setting and cognitive function could result from the

differing cognitive demands and practices inherent in different kinds of work, but the measure of occupation used here cannot be used to test this assertion.

The results of this project support the tenants of the fundamental cause perspective. Measures of education, monetary assets, and occupational setting were significant predictors of initial word recall score. The impact of low education was especially detrimental to the baseline word recall scores of black females, indicating how minority status can exacerbate the impact of low education on the cognitive performance of elderly adults. The measures of SEP included in this analysis are proxies for resources that develop an individual's capacities and life chances through education, that support wellbeing and provide protection through monetary resources, and that determine work environment and prestige associated with occupation. Individuals with unequal levels of these varied resources continue through life and old age with differential capacities for self determination and empowerment. Decreased cognitive performance is commonly associated with greater morbidity and mortality, in end producing inequalities in quality of life and years of life lived.

Though certain indicators of health habits and behaviors were significantly associated with baseline word recall, the greatest proportion of variation in opening word recall score was attributable to the inclusion of controls for SEP. Health behaviors represent a common focus of public health officials because these actions are deemed modifiable, yet the majority of variation in both behavior and health can be attributed to differential access to socioeconomic resources (Lantz et al. 1998; Lynch, Kaplan, and Salonen 1997). The social conditions that determine inequalities in education, accumulation of assets, and occupational setting are deeply entrenched in American culture. While strategies that focus on the promotion of health behaviors such as encouraging participation in vigorous physical activity and moderate alcohol use can benefit the

cognitive performance of older adults, socioeconomic differentials in cognitive function will continue in light of behavioral modifications. Focusing on the eradication of socioeconomic disparities through innovate education and economic policies can serve great benefit to the health of aging Americans for generations to come.

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Table 1. Weighted descriptive statistics AHEAD (1998-2008)

		Mean	%	SD	Min	Max
Age		78.62		5.39	65	100
Health		3.00		1.11	1	5
Test Effect			81.32	0.41	0	1
Female			55.35	0.50	0	1
White			91.16	0.35	0	1
Black			6.27	0.32	0	1
Hispanic			2.58	0.18	0	1
Married			52.61	0.50	0	1
Less than HS degree			29.14	0.46	0	1
HS degree			36.20	0.48	0	1
Greater than HS degree			34.65	0.47	0	1
Longest occ. white collar			58.25	0.50	0	1
1st HH income quartile	($)	9787		2775	0	13849
2nd HH income quartile	($)	18080		2567	13900	22814
3rd HH income quartile	($)	29536		4307	22900	38178
4th HH income quartile	($)	76457		63030	38200	823904
1st HH asset quartile	($)	15064		19430	-173800	46500
2nd HH asset quartile	($)	86380		25262	47000	136500
3rd HH asset quartile	($)	214316		52336	136750	320000
4th HH asset quartile	($)	901822		1603466	320500	30783000
Father ≥ 8 yrs education			52.78	0.50	0	1
Mother ≥ 8 yrs education			57.11	0.50	0	1
Poor childhood circumstance			31.21	0.46	0	1
Father occupation white collar			24.55	0.43	0	1
Smoke ever			56.63	0.50	0	1
Smoke now			6.63	0.25	0	1
No alcohol			71.07	0.45	0	1
One alcoholic drink per day			18.52	0.38	0	1
≥ 2 alcoholic drinks per day			10.41	0.30	0	1
Vigorous Physical activity			37.09	0.48	0	1

Note: *n =2931*

Table 2. Logistic regression and theta estimates from selection model

	$\beta_1(t)$	$\beta_2(t\text{-}1)$	θ_1 $((\beta_1 + \beta_2)/2)$	θ_2 $(\beta_1 - \beta_2)/2$
estimate	-0.693***	0.186***	-0.254***	-0.439***

Note: *** $p < .001$

Table 3: Results for growth curve selection models of word recall score (AHEAD 1998-2008)

	Model 1		Model 2		Model 3		Model 4		Model 5	
	I	S	I	S	I	S	I	S	I	S
Test Effect	2.24***	2.38***	2.15***	2.37***	2.10***	2.43***	1.95***	2.38***	1.94***	2.44***
Female	1.22***	-0.28	1.24***	-0.34	1.21***	-0.32	1.07***	-0.21	1.07***	-0.21
Age	-0.19***	-0.15***	-0.19***	-0.15***	-0.19***	-0.15***	-0.19***	-0.15***	-0.19***	-0.15***
Married	0.08	0.15	0.01	0.12	-0.05	0.17	-0.46***	0.38	-0.45***	0.38
Health	0.49***	0.31***	0.40***	0.32***	0.38***	0.34***	0.29***	0.35***	0.29***	0.37**
Smoke ever			-0.29*	-0.17	-0.29*	-0.17	-0.22	-0.19	-0.23	-0.19
Smoke now			-0.22	-0.94	-0.18	-0.97	-0.07	-0.96	-0.06	-0.93
No alcohol			-0.80***	0.09	-0.71***	0.01	-0.36*	-0.12	-0.37**	-0.10
≥ 2 alcoholic drinks per day			-0.35	-0.23	-0.31	-0.26	-0.24	-0.24	-0.26	-0.25
Vigorous physical activity			0.50***	0.14	0.47***	0.16	0.41***	0.16	0.40***	0.18
Black					-1.31***	1.17***	-0.63***	0.90**	-0.61***	0.84**
Hispanic					-1.50***	1.12	-0.89**	0.85	-0.87**	0.70
Less than HS degree							-0.39**	-0.11	-0.38**	-0.19
Greater than HS degree							0.27	-0.05	0.24	-0.03
1stHH income quartile (0-24.99%)							-0.41	0.56	-0.39	0.55
2nd HH income quartile (25-49.99%)							-0.25	0.25	-0.23	0.24
3rd HH income quartile (50-74.99%)							0.08	-0.07	0.09	-0.03
1st HH asset quartile (0-24.99%)							-0.89***	-0.04	-0.88***	-0.10
2nd HH asset quartile (25-49.99%)							-0.59***	-0.29	-0.57***	-0.34
3rd HH asset quartile (50-74.99%)							-0.42***	0.14	-0.40**	0.10
Longest occupation white collar							0.67***	-0.66	0.67***	-0.68**
Mother ≥ 8 yrs education									0.20	-0.40
Father ≥ 8 yrs education									-0.01	-0.18
Poor childhood circumstance									0.20	0.25
Father occupation white collar									0.12	0.30
R square	0.38	0.20	0.40	0.20	0.42	0.21	0.48	0.22	0.48	0.23
Estimated Mean	8.39	-5.03	8.39	-5.11	8.39	-5.11	8.39	-5.03	8.40	-5.06

Notes: $n = 2931$; *$p < .05$, **$p < .01$, *** $p < .001$

Table 3: Results for growth curve selection models of word recall score (AHEAD 1998-2008; continued)

	Model 6		Model 7	
	I	S	I	S
Test Effect	1.93***	2.44***	1.93***	2.45***
Female	1.07***	-0.19	0.99***	-0.08
Age	-0.19***	-0.15***	-0.19***	-0.15***
Married	-0.46***	0.39	-0.45***	0.39
Health	0.29***	0.36***	0.29***	0.36***
Smoke ever	-0.23	-0.18	-0.23	-0.18
Smoke now	-0.07	-0.91	-0.06	-0.95
No alcohol	-0.36***	-0.10	-0.36**	-0.11
≥ 2 alcoholic drinks per day	-0.25	-0.26	-0.25	-0.25
Vigorous physical activity	0.40***	0.19	0.40***	0.19
Black	-0.31	0.74	-0.83	0.12
Hispanic	-0.89**	0.71	-0.87***	0.69
Less than HS degree	-0.32	-0.30	-0.51***	-0.07
Greater than HS degree	0.24	-0.02	0.23	-0.01
1stHH income quartile (0-24.99%)	-0.42	0.69	-0.43	0.70
2nd HH income quartile (25-49.99%)	-0.23	0.23	-0.22	0.21
3rd HH income quartile (50-74.99%)	0.09	-0.03	0.10	-0.03
1st HH asset quartile (0-24.99%)	-0.87***	-0.13	-0.87***	-0.13
2nd HH asset quartile (25-49.99%)	-0.57***	-0.35	-0.57***	-0.35
3rd HH asset quartile (50-74.99%)	-0.40**	0.09	-0.39*	0.09
Longest occupation white collar	0.68***	-0.69**	0.67***	-0.70**
Mother ≥ 8 yrs education	0.19	-0.39	0.19	-0.40
Father ≥ 8 yrs education	-0.01	-0.18	-0.01	-0.19
Poor childhood circumstance	0.20	0.25	0.21	0.25
Father occupation white collar	0.12	0.30	0.13	0.30
Black*Less then HS degree	-0.91**	1.65***	0.18	2.38**
Black*1st income quartile	0.46	-1.78**	0.55	-1.80**
Black*Female			0.76	0.74
Female*Less then HS degree			0.39	-0.43
Black*Female*Less then HS degree			-1.91**	-0.88
R square	0.48	0.24	0.48	0.24
Estimated Mean	8.39	-5.05	8.40	-5.06

Notes: $n = 2931$; *$p < .05$, **$p < .01$, *** $p < .001$

Figure 1. Survival distribution function for AHEAD respondents classified by word recall quartile (1998-2008)