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Subjective Socioeconomic Status in Daily Cognitive Functioning and Cognitive Aging

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Subjective Socioeconomic Status in Daily Cognitive Functioning and Cognitive Aging

A Dissertation submitted in partial satisfaction
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in

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by

Catalina Zavala

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At the University of California, Riverside (UCR)

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ABSTRACT OF THE DISSERTATION

Subjective Socioeconomic Status in Daily Cognitive Functioning and Cognitive Aging

by

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Doctor of Philosophy, Graduate Program in Psychology
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Dr. Chandra A. Reynolds, Chairperson

The primary purpose of this dissertation is to investigate to what extent objective and subjective socioeconomic status (SES) provide unique information regarding the impact of SES on cognitive aging trajectories, as well as daily individual variability and plasticity in cognitive functioning. For Study 1, two large samples were drawn from publically available data in the Health and Retirement Study (HRS) to examine cross-sectional performance on episodic memory and fluid reasoning tasks, and longitudinal change in general cognitive functioning across 6 years. Analyses of the cross-sectional sample indicated that subjective SES positively predicted performance on episodic memory and fluid reasoning tasks above and beyond the effect of objective SES. For both cognitive tasks, objective SES remained a significant predictor of cognitive performance after controlling for physical and mental health, but subjective SES was no longer a significant predictor. In the longitudinal sample, growth curve analyses suggested a small positive effect of increasing subjective SES to level of overall cognitive functioning beginning at around age 68, though this boost waned by age 90. This effect was

maintained even while controlling for objective SES, BMI, self-rated health, and depressive symptoms.

For Study 2, cognitive functioning across episodic memory and fluid reasoning domains were examined in a sample of 45 older adults who completed an initial baseline questionnaire including assessment of objective and subjective SES, and a 7-day 'burst' repeated-measures design including cognitive tasks self-administered once a day. Overall, findings suggested that intraindividual variance in cognitive functioning across seven days was inversely related to overall mean performance for both episodic memory and fluid reasoning, such that individuals who showed more variability in performance tended to perform lower on cognitive tasks. Additionally, findings suggested that intraindividual variance in cognitive functioning is likely associated with both objective and subjective SES, though a number of the observed associations did not reach statistical significance. Collectively, these results suggest that an individual's perceptions of their SES may have fundamental impacts on later cognitive outcomes or, alternatively, that individuals may be able to provide a unique insight regarding their SES as not fully assessed by commonly used SES indicators.

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GENERAL INTRODUCTION

By 2030, about 20% of the general population in the United States is expected to be 65 years of age or older (Centers for Disease Control and Prevention, 2013). For older adults in the United States, maintaining independence often requires physically and mentally demanding tasks such as remaining employed and managing instrumental activities of daily living (e.g. household finances). Such day to day activities can be affected or compromised by age-related declines in cognitive functioning, which is comprised of basic cognitive abilities including memory, learning, reasoning, and knowledge (Hertzog & Wallace, 1997; Salthouse, 2012). Indeed, for this reason, high cognitive functioning, along with good health and social engagement, has been included in the definition of successful aging (Rowe & Kahn, 1997). As a large proportion of the population enters late life, there is the potential for a greater strain on public services such as health care systems that may be alleviated by promoting environments and health behaviors that bolster independence in older adults. For this reason, understanding the factors that contribute to the maintenance of normative cognitive functioning as individuals age should be of great concern to researchers and policy makers alike.

Though the underlying neurological brain structures that contribute to cognitive functioning develop mainly in childhood and early adulthood, the maintenance of cognitive functioning and the development of certain cognitive abilities such as language and semantic knowledge show evidence of continuing gains across the adult lifecourse (Hedden & Gabrieli, 2004). The formation of new synapses, neurogenesis, and brain repair response mechanisms appear to be lifelong processes as well, as supported by

animal and human research showing the positive impacts of enriched environments on brain plasticity (Kramer, Bherer, Colcombe, Dong, & Greenough, 2004). For this reason, a theoretical approach influenced by the lifespan perspective (cf. Baltes, Lindenberger, & Staudinger, 2006; Bronfenbrenner & Morris, 2006), wherein development occurs throughout an individual's entire life, is essential when forming hypotheses regarding the mechanisms involved in cognitive functioning and cognitive aging. Evidence suggests that biological, genetic, and environmental influences involved in these processes are necessarily complex, and likely change in relative importance and influence across the lifespan, in part, due to increasing autonomy of individuals via their own maturation and, consequently, the experience of new and changing environments (Reynolds, Finkel, & Zavala, 2014). To consider one piece of the puzzle, further elucidating the impact of environmental contexts on individual differences in cognitive functioning and cognitive aging will likely provide insight regarding the developmentally salient aspects of those environments, and more importantly, lead to understanding the fairly universal but diverse experience of cognitive aging.

Psychologists and other health researchers have long documented the impact of economic adversity on various aspects of human development across the lifespan. Boyce (2007) characterized this phenomenon as "a biology of misfortune", illustrating the pervasive impact of low social status and poverty on individuals' susceptibility to decreased quality of life, including cognitive functioning. The social and economic resources afforded to an individual have important implications for cognitive functioning and cognitive aging in late-life. Individuals with low socioeconomic status (SES) are

often at greater risk for negative health outcomes, as well as greater susceptibility to neurocognitive disorders associated with aging such as Alzheimer's disease and dementia (Case, Lubotsky, & Paxson, 2002; Mirowsky & Ross, 2003; Moceri et al., 2001; Sapolsky, 2005). The influence of socioeconomic status on individual cognitive trajectories is most likely a lifespan process, with cumulative effects for those individuals experiencing poverty throughout their lives (Fors, Lennartsson, & Lundberg, 2009; Richards & Wadsworth, 2004; Turrell et al., 2002). Notably, individuals who experience high childhood SES but later experience low adult SES (e.g. low education, low income) experience greater cognitive deficits compared to those individuals who remain in high SES throughout their lives (Turrell et al., 2002) suggesting important influences of later environments to cognitive aging. For this reason, the environments of older adults are important to examine with regards to the proximal impacts of social and economic resources on cognitive functioning in late life.

Though health researchers and sociologists have delved into methods by which to improve the assessment of SES, psychologists have traditionally used education, occupation, and income indicators to measure socioeconomic status in diverse populations, despite the qualitative differences inherent across the various environments each of these measures are attempting to quantify (Cirino et al., 2002; Muller & Parcel, 1981; Oakes & Rossi, 2003). The result has been limited insight regarding the mechanisms at play across contexts of SES and the associated differential psychological outcomes of individuals within those contexts. This limitation in psychological research has been recognized in the last decade, marked most notably by the American

Psychological Association forming a task force on socioeconomic status in 2005, calling for the examination of how social factors influence individual outcomes (American Psychological Association, Task Force on Socioeconomic Status, 2007). Along with the acknowledgement of the importance of socioeconomic factors to physical and psychological well-being, the task force placed an emphasis on the importance of understanding the psychological experience of social factors as well as effectively measuring objective environments relevant to individual outcomes. Although work has been done on the assessment of individual experience of SES (Adler, Epel, Castellazzo, & Ickovis, 2000; Cundiff, Smith, Uchino, Berg, 2013; Operario, Alder, & Williams, 2004), few areas of research have incorporated such subjective assessments into investigating the contributory mechanisms in the observed relationships between socioeconomic factors and individual outcomes, particular with regards to cognitive functioning in older adults.

Developmental Context and Socioeconomic Status

Socioeconomic status is composed of complex environments contributing to individual cognitive changes across the lifespan, and the contexts created by SES within which cognitive changes (and development) occur must be described and defined. Such descriptions and definitions should be sensitive to contextual experiences that may be primarily psychosocial and subjective in nature, not simply relying on objective, external measures when attempting to meaningfully capture individual experiences of socioeconomic status (Bronfenbrenner & Morris, 2006). Perhaps the most applicable broad theoretical framework for considering both objective and subjective facets of SES

with regards to individual outcomes is Bronfenbrenner's bioecological model of human development. Though the main research focus of Bronfenbrenner's Process-Person-Context-Time (PPCT) model has been childhood and adolescent development, the theory defines development as constant and changing biopsychological characteristics of individuals both within an individual lifespan and across generations (Bronfenbrenner & Morris, 2006). Additionally, the bioecological model describes human development as driven by environments with both objective and subjective properties, encompassing the objective contexts and events experienced by an individual and the subjective interpretations of those experiences.

Within the framework of the bioecological model, we can more broadly understand how environments that make up SES may be a source of influence in individual late-life cognitive functioning. Context can be defined as the physical, socioemotional, and mental settings in which behavior occurs (Williams & Ceci, 1997). Each of these contexts is relevant to the role of SES in cognitive change across the lifespan, though the main research focus in psychology has been on the physical (income, neighborhood, etc.) and socioemotional environments. For socioemotional environments, aspects of stress and allostatic load have been addressed as having a negative impact on cognitive function (McEwen & Gianaros, 2010). Yet, the subjective experiences (and psychosocial contexts) of SES are becoming of greater interest in health and psychological research, with findings indicating that such self-assessments predict mental health and disease susceptibility beyond objective measures of SES such as income and education (Adler, et al., 2000; Cohen et al., 2008; Singh-Manoux, Marmot, & Adler,

2005; Cundiff, Smith, Uchino, & Berg, 2013). As noted by Boyce (2007), it is likely that there are various pathways via which SES impacts development, including (but not limited to) both the flow and access to material resources and an individual's own psychological and biological reactivity to the environment partly based on their own position in salient hierarchical social structures. In light of the limitations researchers have encountered in relying primarily on objective SES measures, we may gain a greater insight to the role of SES in the etiology of cognitive functioning by considering measures that take into account a person's own experience and perceptions of their economic and social situation.

According to Bronfenbrenner, proximal processes must be engaged and sustained over time to impact development long term (Bronfenbrenner & Morris, 2006). Educational and occupational settings could be considered as providing the opportunity for proximal processes relevant to cognitive development and the maintenance of cognitive functioning. Indeed, the PPCT theory specifies that ongoing proximal processes become more complex for development to continue, and relevant examples include problem solving, learning new skills, and doing complex tasks (Bronfenbrenner & Morris, 2006). When considering the association between cognitive functioning and SES (and the components of SES) it is often difficult to separate the aspects endogenous to the individual versus the environmental effects driving changes in both SES and cognition, and in this case, both facets are highlighted as relevant and self-informing in the PPCT theory of development, particularly with the recognition of the individual as having a role in directing their own development (e.g., selecting educational and occupational

contexts). Only partially presented here, the bioecological model is large in scope but relevant to considering the series of complex environments embedded in the larger social structure (as well as historical time via the chronosphere) that contribute to an individual's SES.

To provide some insight and guidance to the bioecological framework from the cognitive literature with regards to a specific mechanism by which proximal processes occurring within environmental contexts may impact the cognitive functioning of an individual, the concept of cognitive reserve is a complementary explanatory theory. Cognitive reserve is considered the capacity of an individual to maintain normative cognitive functioning despite increasing neurological aging deficits (Stern, 2002), and is associated with higher cognitive performance (Staff, Murray, Deary, & Whalley, 2004). More specifically, cognitive reserve has been useful in aging literature as there is some evidence of a threshold aspect to cognitive aging (both normal and abnormal) such that each individual must surpass changes within the cognitive nervous system (CNS) before behavioral deficits become apparent (Stern, 2002). Of note, this capacity to cope with aging in the CNS prior to deficits seems to differ by individual, which is most evident in individuals who present with nuerofibrillary plaques and tangles characteristic of neurocognitive disorders characteristic such as Alzheimer's Disease at autopsy, yet who tested within what is considered normative cognitive functioning prior to death (Ince, 2001; Stern, 2009). Cognitive reserve is likely built across the lifespan, and measures of SES such as education and occupation have been found to be associated with increased cognitive reserve, and indeed are often used as indicators of cognitive reserve, as more

education and higher SES seems to provide this environmentally augmented source of cognitive reserve.

Measurement of Socioeconomic Status in Developmental Psychology

Psychologists have recognized the importance of thoughtfully measuring poverty versus affluence, though more recently the nuances through which environments may impact individual outcomes across the hierarchical structure of SES have become more relevant (e.g., Adler, et al., 2000; Cohen et al., 2008; Singh-Manoux, Marmot, & Adler, 2005; Cundiff et al., 2013). Ultimately, a person's socioeconomic status should be treated as individualized and subjective as any other psychological experience. The implication is not that socioeconomic status resides entirely within the individual but that the experiences of the individual within an environmental context are unique. Capturing both objective and subjective environmental contexts are essential to understanding the relationship of socioeconomic status to cognitive aging.

Objective Measures of SES

Education is recognized as very relevant to cognition and life style, as educational attainment represents many aspects of both an individual and their environment. This is particularly exemplified when considering that the highest education level an individual has achieved by late adulthood represents both his own cognitive ability as well as environmental access to traditional education (Galobardes, Lynch, & Smith, 2007). Of course, there are also important contributions of the knowledge gained, and the cognitive stimulation sustained over years of education. Education should provide training for entrance into the work force, as well as socialization to bureaucratic and hierarchical

structures of professional settings. The unique possibility of upward mobility via increased levels of education from one generation to the next also provides interesting variability to between and within generational SES (Turrell et al., 2002), namely that low SES in childhood can be followed up by higher adult SES if an individual pursues higher education and access to higher paying occupations. Yet, education as a measure of SES is largely impacted by cohort differences in availability and provided levels of compulsory education (if any), particularly for older and underrepresented individuals (Galobardes, Shaw, Lawlor, Lynch, & Smith 2006; Schaie, Willis, & Pennak 2005). Additionally, variability in educational experiences arises in part, due to quality of education being a function of regional differences. Consequently, quality of education may vary by greatly by location, even at the neighborhood level within a school district, and even more drastically so across international borders (Sirin, 2005). For these reasons, education is an important but complex measurement of socioeconomic status.

Measurement of occupational history in adult and aging developmental research often provides current or recent environmental context in a broad sense. Within the work force, occupations provide a variety of physical, social, and cognitive experiences. For many blue-collar jobs, individuals are often exposed to increased physical and chemical dangers. Whether an individual may sustain head trauma while working construction, or be exposed to environmental toxins as a welder, these conditions can lead to negative impacts on cognitive aging (Park et al., 2006; Tanner et al., 2009). Individuals in white-collar jobs are at risk for being overweight as the work place is often a sedentary environment (Mummery, Schofield, Steele, Eakin, & Brown, 2005), which may

ultimately may lead to health complications impacting cognitive aging (Cournot et al., 2006; Kanaya et al., 2009). Yet, individuals with similar occupational titles may have vastly different occupational environment experiences. Additionally, occupational measures often do not directly take into account differences in stratification for employed women, unemployed individuals, home-makers or other unpaid labor, retirees, and illegal employment (Galobardes et al., 2007). The result in using occupation (or even spouse occupation for the home-maker) is that it will not capture the labor or unemployment experiences of all individuals relevant to cognitive outcomes.

Income is a common indicator of SES that provides a more direct measure of material resources and assets for which an individual owns or has access. Historically, in the United States, income has provided individuals differential access to quality housing and neighborhoods, which represent both the level of safety in the living environment as well as the quality of available community resources and infrastructures (Moreland, Wing, Roux, & Poole, 2002; Saelens, Sallis, Black, & Chen, 2003; Wen, Hawkley, & Cacioppo, 2006). Income can also provide greater access to higher educational opportunities and access to health care (Oakes & Rossi, 2003). Additionally, an individual's income represents the resources available for managing daily life and unexpected circumstances such as medical emergencies or negative life events. Interestingly, one study found that income was more associated with mortality than educational or occupational measures in older adults, which has important implications for quality of life (Duncan, Daly, McDonough, & Williams, 2002). Yet, an indicator such as total household income may be more difficult to assess accurately, as much of an

individual's purchasing power may be from sources of wealth and income besides occupational salary (Galobardes et al., 2007). For this reason, it is often important to include income as an indictor, but not rely solely on this aspect of an individual's SES to assess overall economic standing or wealth.

Beyond Objective: Considering Subjective Measures of SES

Subjective Social Status. Though the ecological environment undoubtedly has an impact on the individual via nutrition, toxins, and neighborhood infrastructure (Evans, 2004), we are at our basis social individuals embedded within a social context (Gauvain, 1998), which provides meaning to our environment via our interactions and relationships with other individuals. These relationships contribute to our social environment through dyadic and group interactions, providing us with social support, conflict, and (ultimately) context. For the current line of inquiry, the question arises: How may subjective SES as a context influence development, and more specifically cognition?

The immediate social context within which an individual is embedded is important to cognitive change across the lifespan due to the biological consequences associated with social relationships, which are partly influenced by SES. In both humans and primates, gathering into social groups results in hierarchical social interactions (Boyce, 2007). Though ultimately these hierarchical relationships help to order and define social interactions, there may be individual biological consequences to certain hierarchical positions, such as is suggested by the impact of social hierarchies in primates (Sapolsky, 2005). Primate research has documented the biological impact of these psychosocial interactions, providing evidence of biological consequences to animal

hierarchies even with experimenter-controlled food resources (Sapolsky, 2004). Compromised immune function, decreased HDL cholesterol, and higher cortisol levels are often characteristic of lower-rank primates (Sapolsky & Mott 1987; Sapolsky 1989). In parallel, subjective social status has shown to predict individual differences in markers of biological reactivity and stress above and beyond objective indicators of SES, suggesting biological sensitivity to external social factors arising from individual perceptions of social standing that are not fully embodied by income or education (Euteneuer, Mills, Rief, Ziegler, & Dimsdale, 2012; Wright & Steptoe, 2005). To focus on cognition via brain function, animal models have demonstrated that stressful social and environmental contexts lead to atrophy of dendrites in neurons (Hackman, Farah, & Meaney, 2010; Sapolsky, 2004). Social hierarchies and interactions may impact cognitive aging in human beings through similar mechanisms. Thus, the psychological experience of socioeconomic status is not simply limited to an individual's perceptions regarding their current financial situation. Instead, an individual's perceptions and resulting physiological reactivity to his or her own social position in the greater society may lead to consequences in health and cognitive outcomes via endogenous stress pathways.

Subjective measures of economic hardship. Subjective measures of socioeconomic status, beyond education, income, and occupation, are most often conceptualized and operationalized by a study to capture financial hardship. Though some researchers may collect these items as proxies for income and objective SES, other researchers collect these items with the understanding that an individual's economic situation is just that; an individual's present situation involves aspects relevant to hardship beyond monetary

income. This may be debt, medical bills, or even a person's own budgeting behaviors. It may also include comparisons with one's peers or against societal-level indices. Concepts and measures of hardship, or living standards, as conceptualized across studies of older adults are briefly described below:

Relative Deprivation (Yitzhaki, 1979) is a theory of social inequality stating that individuals make social evaluations and comparisons with their peers to determine the extent of their own deprivation. The comparisons an individual makes between their own assets and those of their peers influence an individual's relative deprivation and satisfaction with their own financial situation. Relative deprivation is largely measured by income and quantified by the Gini coefficient. The Gini coefficient is predictive of health risks, such as with smoking and body mass index (BMI), as well as mortality (Eibner & Evans, 2005). Though the theory itself does not focus on the comparison of the individual to the overall society, societal level income inequality has been found to relate to individual level outcomes such as math and literacy scores in secondary education students in developed countries (Wilkinson & Pickett, 2007). Besides their own economic situation, perhaps individuals are able to acknowledge the economic situation of others and to the extent that the overall distribution of wealth may mean for an individual's socioeconomic status within a particular social context.

Perceived standard of living (e.g. Lichtenstein, 1992), as used in the Swedish Adoption Study of Aging (SATSA), this measure focuses on a variety of perceived aspects of an individual's socioeconomic status. Included within the short set of questions, individuals are asked to compare their economic situation to their peers, about

their future economic prospects, and questions about expendable income. This measure of perceived standard of living was found to relate to self-rated health (Lichtenstein et al., 1992), and more recently, cognitive aging (Zavala et al., under revision) in a sample of Swedish adults. For cognitive outcomes, individuals with higher perceived standards of living tended to perform higher on cognitive tasks at age 75 when compared to individuals with low perceived standards of living.

Financial disability (Li et al., 2005) – In a study of older patients on discharge from a hospital, financial disability was determined by asking individuals how many of six needs they would be unable to pay for; buy groceries, pay for small emergency, pay bills, buy medications, pay medical/dental bills, and pay for major emergency. Individuals unable to pay for one to two of the needs were considered to have moderate financial disability. Individuals unable to pay for three or more needs were considered to have severe financial disability. Though those with low income, older individuals, women, and African American participants were more likely to report financial disability, about 20% of individuals with less than $10,000 yearly income did not report financial disability and 5% of individuals with greater than $30,000 yearly income did report financial disability. After adjusting for illness severity and sociodemographic characteristics, financial disability remained associated with mortality after discharge from the hospital. The indication of these results is that individuals may at times report financial disability seemingly discordant with their level of income, highlighting the importance of individual income use and experiences.

Cognitive Functioning and SES

Cognitive Aging and Intraindividual Variability

A greater understanding of cognitive aging processes may be gained by evaluating cognitive performance within two time frames, in a micro time frame evaluating day-to-day functioning in every day settings and a macro-time frame evaluating yearly change across the second half of the lifespan (Nesselroade & Jones, 1991; Ram & Gerstorf, 2009). General findings with regards to cognitive aging in the later part of the lifespan indicate that 'crystallized' cognitive abilities, those relatively more dependent on culture and education such as verbal knowledge, as well as implicit memory and semantic memory, are relatively stable, while 'fluid' abilities, those relatively independent of culture and education including spatial reasoning, as well as working memory and speed of processing, are more susceptible to decline (Hofer & Alwin, 2008; Schaie, 1994; cf. Horn & Catell, 1967). Particularly for speed of processing, there is also evidence of an accelerated decline for older individuals after age 65 compared to those in middle age, while crystallized ability continues to remain fairly stable (Finkel, Reynolds, McArdle, Gatz, & Pedersen, 2003; Reynolds, Finkel, Gatz, & Pedersen, 2002). Measuring individuals longitudinally across the later half of the lifespan is vital for understanding causal long-term processes involved in cognitive development (Schaie, 2000).

Yet, microgenetic methods of intense repeated measurements during hypothesized times of change in human development have increasingly been used in early childhood studies to understand the processes that precede and contribute to developmental change

(Siegler & Crowley, 1991). Similarly, measures of intraindividual variability (IIV) have been applied in studies of adults and involve measuring a single individual multiple times on a single task within a short amount of time (MacDonald, Li, & Bäckman, 2009). Using these methods on older adults may provide insight to cognitive aging mechanisms particularly for endogenous sources such as plasticity, relevant to cognitive reserve. Though increased IIV is often associated with increased vulnerability and predicts susceptibility to later cognitive decline (Lövdén, Li, Shing, & Lindenberger, 2007; MacDonald, Li, & Bäckman, 2009), further work has illustrated that such observations may be related to the type of cognitive trait being measured. Fluid tasks requiring strategy may show higher IIV as associated with increased scores on cognitive tasks, representing practice and plasticity (Allaire & Marsiske, 2005). These differences by task in IIV may be best characterized as adaptive versus maladaptive variability, with the distinction being made by whether an individual's performance improves across trials or, in the latter case shows no change in level of performance (Li, Huxhold, & Schmiedek, 2004).

In the area of IIV, the associations of both objective and subjective SES with IIV have yet to be examined. Yet, important contributions regarding individual changes in daily cognitive functioning may be addressed within this framework, complementing the growing longitudinal research on SES and cognitive decline. Indeed, IIV assessments may be particularly relevant in studying aging adults as the observed variability in performance on cognitive tasks from day to day also brings to consideration whether there are more appropriate methods for measuring aging individuals in longitudinal

studies, and in part, both these methods may be complimentary with IIV included in longitudinal studies (Ram, Gerstorf, Lindenberger, & Smith, 2011; Salthouse, 2007). In Figure 1.1, we can see the conceptualization of cognitive performance on the two different times scales of development, macrotime and microtime, as might be included in one larger study (Ram & Gerstoff, 2009). By measuring cognition on both the macrotime (annual change) and the microtime (daily IIV) scales, we will likely capture in greater detail the contextual factors at play in cognitive aging. For example, we may posit that the grey line represents an individual with high subjective SES and the black line represents an individual with comparatively low subjective SES. When comparing the cognitive performance of both individuals across age, the individual with higher subjective SES may show higher levels of performance on cognitive outcomes in macrotime. When both individuals are then examined on microtime, or with regards to daily cognitive performance, the individual with a lower level of cognitive performance may show more inconsistent performance across several days of assessment (as represented by the greater irregularity of their IIV pattern on microtime).

The IIV area of research may have a particularly unique ability to measure proximal processes a bit more directly. For example, a link between physical functioning and performance on cognitive tasks has been noted, most likely signaling a global impact of aging on individual day to day functioning (Strauss, MacDonald, Hunter, Moll, & Hultsch, 2002). One could conceivably measure other varying aspects of daily life that may contribute and provide insight to the association between SES and cognition functioning, such as sleep habits or daily health behaviors, and provide greater accuracy

of reported behaviors via daily journaling versus retrospective accounts. Namely, the use of IIV methods could provide insight into what aspects of an individual's environment, as related to SES, impact daily cognitive plasticity and vulnerability, and ultimately signal long-term consequences of SES for normative cognitive aging.

Socioeconomic Status and Cognition across the lifespan

In aging research, environments across the lifespan are important to consider due to the unique contributions of both potentially prolonged effects of early SES on cognitive aging via early cognitive development and later SES in adulthood via the maintenance of cognitive functioning. In studies of young children, parental income is a stronger predictor of academic outcomes (such as math and literacy scores) and intelligence in children than neighborhood SES, indicating the importance of immediate, proximal social and environmental contexts to a child's cognitive development (Duncan, Brooks-Gunn, & Klebenov, 1994; Sirin, 2005). The examination of parental occupation on late-life cognition illustrates the long-term effects of early home and family environments. Older adults who grew up with multiple siblings coupled with parents working in manual labor are found to be at an increased risk for cognitive decline in late-life compared to individuals from smaller families with non-manual parental occupations (Fors, Lennartsson, & Lundberg, 2009; Moceri et al., 2001). Though periods of increased socioeconomic status in adulthood may ameliorate some of the impact of early socioeconomic status, childhood SES remains predictive of cognitive decline even when accounting for adult SES (Turrell et al., 2002).

Education and occupation in middle adulthood are important midlife determinants of socioeconomic status and cognitive aging. Privileged adult SES is predictive of better cognitive outcomes in aging individuals, particularly for those individuals who experience upward mobility after low childhood SES (Luo & Waite, 2005; Turrell et al., 2002). Adult income and education remain influential on adult cognitive functioning above and beyond childhood SES (Turrell et al., 2002). Higher educational attainment is predictive of higher levels and better maintenance of cognitive functioning into old age (Anstey and Christensen, 2000; Wilson et al., 2009; Reynolds, Finkel, Gatz & Pedersen, 2002). Indeed, as noted previously, education is considered a proxy measure of cognitive reserve, with one prevalent theory positing that education contributes to neural plasticity and cognitive pathways available to the individual much in the same way that enriched environments have been shown to increase neural plasticity in animals and are associated with less neurological pathologies in human beings (Bennett, Schneider, Wilson, Bienias, & Arnold, 2005). In line with the idea of access to enriched environments, the impact of early education on cognitive aging is associated with and partly mediated by individual's engagement in life-long activities such as learning a foreign language, traveling, and balancing a checkbook (Kliegel, Zimprich, & Rott, 2004; Wilson et al., 2003; see also Gatz, Prescott & Pedersen, 2006 for dementia outcomes). Some activities, particularly traveling, may likely be less available to individuals of low SES due to decreased funds and leisure time.

Occupations involving complexity working with data are associated with higher cognitive functioning after controlling childhood SES and occupation status, indicating

certain occupations may provide cognitive stimulation uniquely contributing to later cognition aside from the financial benefits (Andel, Kåreholt, Parker, Thorslund, & Gatz, 2007). In twins discordant for dementia, greater occupational complexity involving interpersonal tasks was also associated with decreased incidence of dementia, suggesting this type of occupational complexity is beneficial to cognitive aging because of the focus on social interactions within the workplace, as well as the social networks created during one's career (Andel et al., 2005). In particular, individual's occupations involving supervising, persuading, and speaking to others seem particularly relevant to cognitive functioning (Karp et al., 2009). Intellectual and social activity characteristic of higher status occupations and high SES are beneficial environments for long-term impacts on cognitive aging.

Late-life cognitive activities that an individual may choose to engage in, such as reading newspapers, playing games, and reading books, are related to perceptual speed and semantic memory (Jefferson et al., 2011). Even though income, education, and social networks do explain some variation in individual health behaviors (Cutler & Lleras-Muney, 2010; Wister, 1996), the increased likelihood of more negative health behaviors among low SES individuals in not fully explained by an individual's low SES status (Lantz et al., 1998). Cognitive aging is in part affected by health behaviors such as exercise and smoking (Yaffe, et al., 2009) and can be positively influenced by interventions such as increasing physical activity (Geda et al., 2010). One environmental aspect related to SES influencing aging individuals' activity levels is neighborhood infrastructure, with safety, walking paths, and nearby resources such as libraries and

grocery stores promoting higher likelihoods of older individuals venturing out from their homes (Michael, Green, & Farquhar, 2006). Late-life socioeconomic status may impact cognitive aging both via both the objective environments experienced as well as an individual's perceptions of those experiences.

Late-life SES may impact cognitive aging via the immediate social environment that an aging individual experiences. As noted earlier, socially oriented occupations can have positive consequences for cognitive functioning. Yet, the benefits of socially complex occupations noted previously for cognitive performance can often be lost after retirement, putting such professionals at risk for steeper cognitive declines at retirement (Finkel, Andel, Gatz, & Pedersen, 2009). In this case, the main consequence of retirement for many individuals may be their removal from an established social environment. A goal of retirement should be to strengthen established social connections or forge new ones in the greater community. For older individuals aged seventy to seventy-nine years of age, reporting greater emotional support from one's social network is associated with positive cognitive outcomes (Seeman, Lusignolo, Albert, & Berkman, 2001). The impact of SES on late-life cognitive aging may be partially influenced through social pathways and changes in the social environment as an individual enters late adulthood.

Subjective environments are also important to examine. In three longitudinal studies of aging originating from the Swedish Twin Registry, individuals performed better on cognitive tasks if they had higher levels of education *and* rated themselves as higher on subjective SES (Zavala et al., 2014 under revision). Examples of subjective SES questions asked included "How would you compare your economic situation to

others in your age group?" and "How well does your money cover your needs?" Though an individual's objective income is important to measure, the previous results indicate the importance of understanding how the subjective meaning of income may impact aging outcomes. The concurrent conditions of an aging individual's environment as influenced by SES most likely influence cognitive aging outcomes through a variety of pathways that have been largely unexplored to this point.

Aims of the Study

Purpose

The primary purpose of this dissertation is to examine the differential impacts of objective and subjective socioeconomic status on aging individuals' cognitive performance in daily life and across late life. Figure 1.2 represents an organizing model of expected relationships. As shown via the pathway model, objective SES and subjective SES are shown as independently influencing cognition. Cognition is considered in both micro- to macro- time frames, i.e.: (a) daily cognitive functioning across episodic memory, fluid reasoning and processing speed domains; (b) cross-sectional cognitive performance on episodic memory and fluid reasoning tasks; and (c) longitudinal change across six years vis-à-vis general cognitive functioning. Income, education, and occupation will be used as indicators of objective SES, and subjective social status will be used an indicator of subjective SES to compliment the current health and psychology literature measuring subjective SES. Individual health behaviors and emotional well-being may serve as mediators of cognitive change.

The dissertation aims and hypotheses, encapsulated in Figure 1.2, will be evaluated via two separate studies. Study one evaluates daily functioning over seven days in a sample of diverse aging individuals, ages 60 years of age and older, via a local sample of the Riverside and San Bernardino Counties area, as well as an adapted online protocol for older adults in the United States. The second study examines the influence of objective and subjective SES on cross-sectional and longitudinal cognitive aging in the national Health and Retirement Study (Regents of the University of Michigan, 2014). With both components to the dissertation, these studies will provide insight to the contributions of objective and subjective SES to cognitive functioning in day to day settings, which will likely inform the observed associations of SES across cognitive aging.

Research Questions

- Will subjective aspects of SES inform us above and beyond objective measures of SES as to the impact of economic adversity on aging adults' longitudinal, late-life cognitive aging?
- Will subjective aspects of SES inform us above and beyond objective measures of SES as to the impact of economic adversity on aging adults' daily variability (plasticity and vulnerability) in cognitive functioning, socio-emotional wellbeing, and health?

Hypotheses

Hypothesis 1. Objective and subjective SES measures will each provide unique contributions to the assessments of individuals' SES contexts and experience.

Hypothesis 2. Multiple measures of SES will allow for greater distinctions of socioeconomic variation and greater explanatory power than using only objective measure of SES when examining individuals' cognitive plasticity (learning) among diverse community-dwelling older adults.

Hypothesis 3: Both objective SES (as measured by occupation, education, and income) and subjective SES (as measured by subjective social status) will be associated with intraindividual variability in cognitive performance for older adults.

Hypothesis 4. Individual indicators of SES (occupation, education, subjective social status, and economic experience) will predict cognitive performance and greater variability on tasks of cognition, even when socio-emotional wellbeing and health are included as mediators.

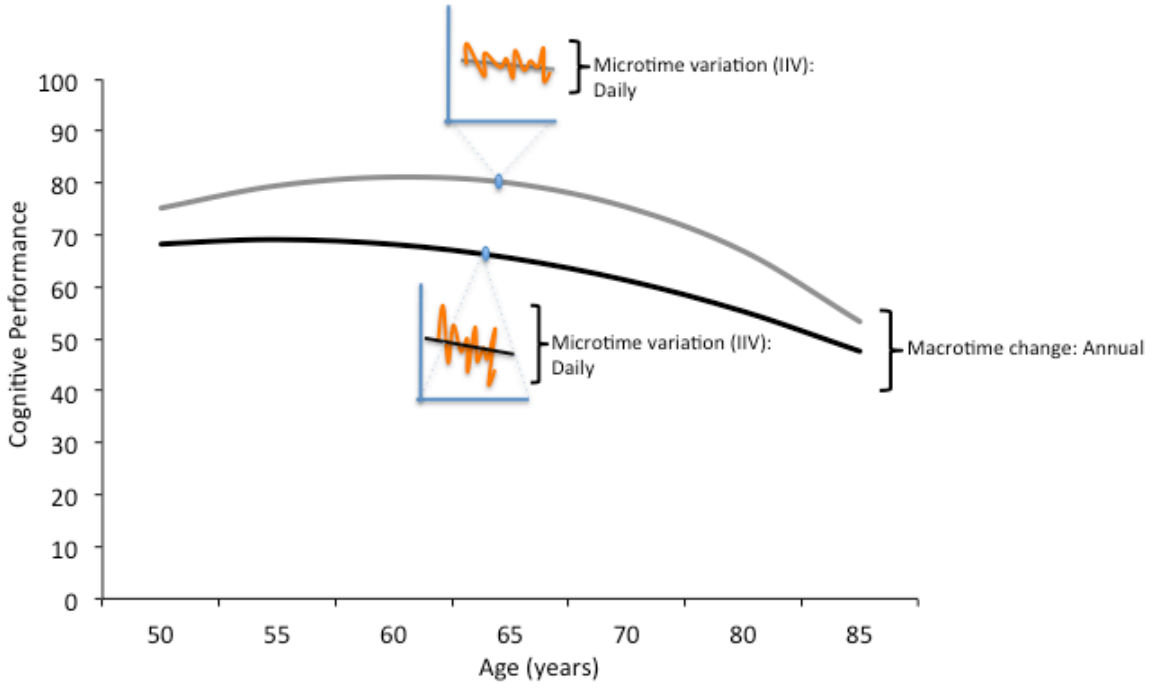

Figure 1.1. Dual time scales of developmental change, with examples of micro versus micro-time change in cognitive performance and variability.

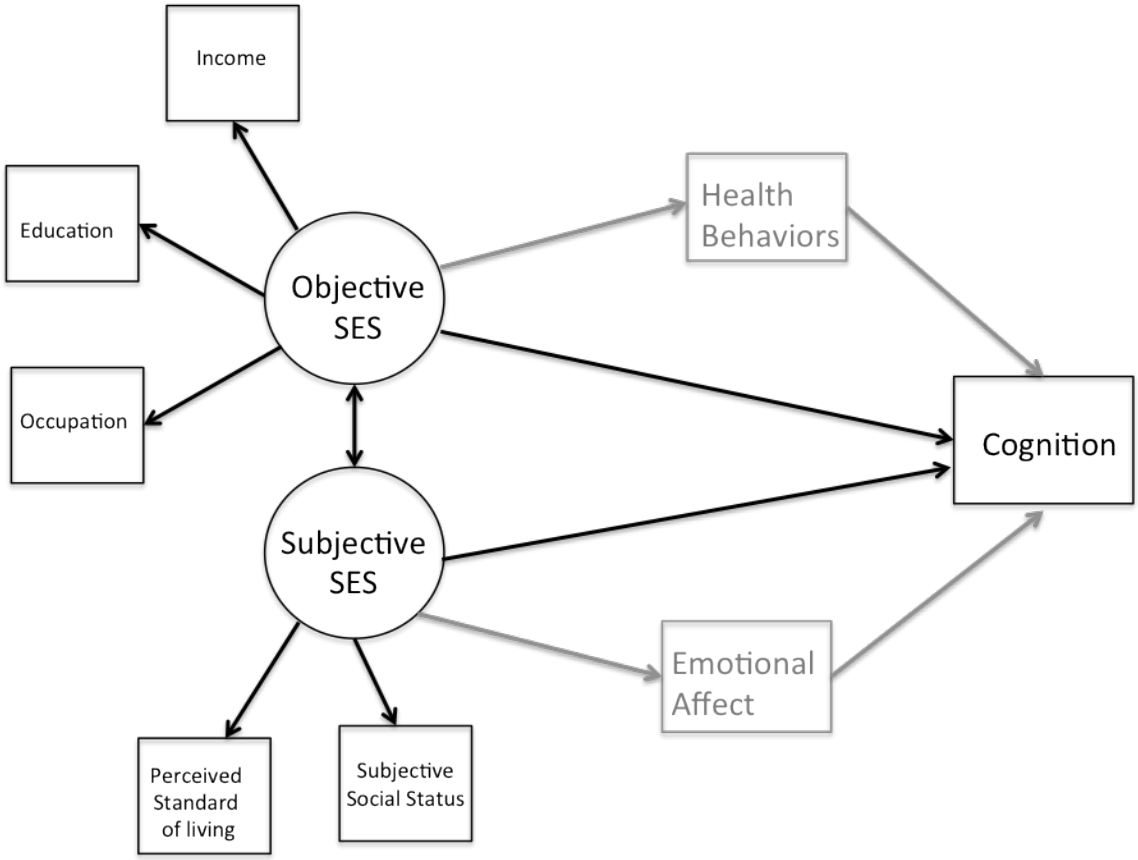

Figure 1.2. Theoretical model: Unique and mediated impacts of objective and subjective SES on cognition in late life.

Study 1

Cognitive Performance as Predicted by Objective and Subjective Measures of Socioeconomic Status in the Health and Retirement Study (HRS)

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INTRODUCTION

Developmental and cognitive research have provided a general description of cognitive aging, used here to refer to normative, age-related changes in cognitive abilities often observed in late-life (Drag & Bieliauskas, 2010; Salthouse, 2010). Both cross-sectional and longitudinal studies tend to show similar trends regarding the relative timing of late-life developmental changes in cognitive abilities that can be summarized by broadly distinguishing between 'fluid' versus 'crystalized' intelligence (Cattell, 1963; Horn & Cattell, 1966; Deary et al., 2009; Wilson et al., 2002). Fluid abilities such as executive functions, working memory, processing speed, and spatial reasoning are more sensitive to age-related cognitive declines, showing declines as early as midlife (Hedden & Gabrieli, 2004; Park et al., 2002) or even earlier (Salthouse, 2009). Yet, crystallized abilities such as verbal ability, semantic memory, and implicit memory, are more robust in the face of cognitive aging, peaking later in life and showing fewer declines across the lifespan (Hedden & Gabrieli, 2004; Horn & Cattell, 1967; Park et al., 2002). Still, within this general pattern of cognitive aging, individual differences are consistently observed.

Though particular patterns of declines in cognitive abilities are expected with aging, great between-person variability has been observed for older adults' late-life cognitive functioning (e.g., Reynolds et al., 2005; Schaie, 2005; Wilson et al., 2002). Individuals' own performances across cognitive tasks are highly inter-related, showing within-person consistency across cognitive traits, and suggesting an underlying pattern of general cognitive aging (Christensen, 2001; Tucker-Drob et al., 2011), although some domain-specific patterns have been suggested on the basis of genetic and environmental

contributions, e.g., memory versus other domains (see Reynolds et al., 2005; Tucker-Drob et al., 2013). The large between-person variation observed for cognitive aging, most likely reflects the myriad of biological, health, and lifestyle factors at play across the lifespan trajectory of each individual (Christensen, 2001; Hendrie, et al., 2006; Schaie, 2005). These observations have led interest in the efforts to further understand the sources of lifespan developmental diversity in cognitive aging, marked by the recognition of the National Institute on Aging as one of the organization's primary research goals; the importance of research in changing psychosocial factors (National Institute on Aging, 2007).

One proposed mechanism for individual differences in late-life cognitive functioning is via differences in cognitive reserve that accumulate over a lifetime (Richards & Deary, 2005). Cognitive reserve is conceptualized as an individual's capacity to maintain normative cognitive functioning in the face of increased cognitive demands or changes to the underlying cognitive pathways that may occur due to (but not limited to) neurological aging in the brain (Richards & Deary, 2005; Stern, 2002). Indeed, cognitive reserve is one theory used to explain how some individuals with no behavioral indicators of cognitive impairment prior to death show evidence of brain pathologies at autopsy (Ince, 2001). Individual differences in cognitive reserve may be accomplished through greater 'neuronal efficiency' or 'neuronal capacity' (Tucker & Stern, 2011). Though it would be preferable to measure cognitive reserve via a physiological assessment of neurological integrity such as synaptic count or dendritic branching, most often, cognitive reserve is most often captured as a proxy variable using

measures such as education and/or occupation (Stern 2002). As prior research has suggested that higher levels of education and occupational attainment are associated with better cognitive performance, these lifestyle factors have been theorized to augment cognitive reserve (Richards & Sacker, 2003; Singh-Manoux et al., 2011; Staff, Murray, Deary, Whalley, 2004; Stern, 2009). Other lifestyle factors such as engagement in socially and cognitively stimulating leisure activities (e.g. reading or playing games) and social engagement have also been used as proxy variables for cognitive reserve (Foubert-Samier et al., 2012; Jefferson & Gibbons, 2011; Krueger et al., 2009; Zunzunegui, Alvarado, Del Ser, & Otero, 2003), highlighting the theoretical and empirical support for environmental sources of variation to cognitive reserve, and by extension, maintenance of normative cognitive functioning.

Several common proxy measures of cognitive reserve are also easily recognizable as components of socioeconomic status (SES). Though clear distinctions aren't often proposed between what might be more innately-driven cognitive reserve (such as could be argued regarding the psychometric intelligence 'g' measures) versus augmentation of cognitive reserve over the lifespan (via more environmental factors such as educational attainment or occupational complexity), there is some indication in the literature that individual differences may in part arise from the latter source. Evidence that environmental factors may play a key role is based on differences across the lifespan in SES environments of origin versus SES environments in adulthood, and the independent contributions of each of these environments to late-life cognitive functioning (Jefferson, et al., 2011; Kaplan et al., 2001; Richards & Sacker, 2003; Turrell et al., 2002). One

study of social mobility found that more than half of their participants differed from their parental social class, or SES of origin (Deary et al., 2005). Herein lies the interest in further understanding cognitive reserve and the varying aspects of an individual's environment that contribute to increased cognitive reserve across the lifespan. Yet, much of the work in the cognitive reserve literature is cross-sectional in nature, and cannot speak directly to how SES may affect cognitive functioning and cognitive aging across time.

Evidence regarding the importance of both early SES and multiple indicators of what is be considered to be 'adult SES' may be revealing the sensitivity of cognitive functioning to environmental factors across the lifespan. Both proximal environments such as occupation and more distal environments such as early educational attainment may be essentially helping researchers construct a story regarding the individual trajectories of environmental exposures, both positive and negative, that have unique consequences for late-life cognitive functioning. Cross-sectional work in the general cognitive aging literature addressing the impact of SES corroborates with the cognitive reserve literature, suggesting that education, income, and occupation independently predict differences in mean level of cognitive performance, with level of educational attainment often being the most significant predictor and seeming to provide the most benefit (Fors, Lennartsson, & Lundberg, 2009; Lee, Buring, Cook, & Grodstein, 2006). These associations between these particular aspects of adult SES and level of cognitive functioning persist when controlling for early life SES via parental occupation and parental education (Turrell et al., 2002). Though there may be a concern that separate

indicators of SES are highly correlated, evidence suggests that correlations between income and education tend to be low to moderate, and each indicator often independently predicts cognitive outcomes (Karlamangla et al., 2009; Mortensen et al., 2014).

Though much of the work examining the impact of SES on cognition has been cross-sectional in nature, longitudinal work has thus far corroborated much of the results. There is evidence that education and income independently contribute to individual mean level of cognition functioning, though there are mixed results regarding the impact of individual indicators of SES on cognitive change (i.e. cognitive aging). Generally, longitudinal studies have found no influence of education on change in cognitive functioning across time, or have found that some individuals with higher education experience accelerated decline (Zahodne et al., 2011; Karlamangla et al., 2009). Yet, at least one study has found that level of education may be associated with less cognitive decline on measures of non-verbal memory and working memory, with evidence that prior work may be underestimating change in high-functioning individuals due to ceiling effects in the psychometric measures being used to assess cognitive functioning across time (Glymour, Tzourio, & Dufouil, 2011).

Providing a more comprehensive picture of individual SES and the corresponding environmental experiences that may contribute to cognitive functioning will most likely provide insight into how SES may augment cognitive reserve across the lifespan. For example, in the Seattle Longitudinal Study, above-average level of cognitive functioning is associated with occupations of higher prestige, higher social classes, and intellectually stimulating environments, and socially active individuals of middle to high SES showed

the least declines in cognitive functioning (Schaie, 2005). Yet, since separate indicators of SES seem important to accounting for individual variation in cognitive functioning, this may almost seem to circumvent the idea of an overall SES environment or experience.

What exactly has been gained by the conceptualization of such multi-faceted environments into one broad concept of a stratified societal structure such as SES? Separate bodies of work spanning decades seems to indicate individuals themselves conceptualize some form of salient social status. Jackman & Jackman (1973) found that individuals do identify to a significant degree with a social class, broadly consistent with education, income, and occupation, though observed differences between 'objective' social status and 'subjective' or self-identified social status were found to be at least partially mediated by status-based social relationships. Interestingly, work from epidemiological, developmental, and animal research seem to indicate that individuals (and primates) show biologically sensitivity to social hierarchical structures, most evident in stratified health and well-being outcomes, with lower ranking individuals experiencing an increasing burden of negative outcomes (Boyce, 2007; Sapolsky, 2005). For this reason, there has been a growing interest in capturing an individual's perceptions or self-evaluation regarding their social status as relevant to measures of SES and psychosocial outcomes.

Much of the recent work regarding the measuring of individual perceptions of socioeconomic status positions has relied on the MacArthur measure of Subjective Social Status (SubjSS), a simple pictorial representation of a ladder on which participants are

asked to rank themselves compared to others in the United States based on income, education, and occupations (Adler, Epel, Castellazzo, & Ickovics, 2000). The SubjSS measure has been shown to correlate low to moderately with objective SES indicators including education and income, and has a slightly higher bivariate association with a composite measure of adult SES (Adler et al., 2000; Cohen et al., 2008; Domenico & Fournier, 2014). A lower, but positive association was found between SubjSS and a composite measure of childhood SES (Singh-Manoux, Marmot, & Adler, 2005). These low to moderate associations between objective and subjective measures of SES may indicate that individuals are perhaps assessing their own SES using much broader but relevant information regarding their financial and social circumstances.

Much of the research including SubjSS as a measure of SES has examined physiological, health, and psychosocial outcomes. Lower SubjSS is associated with higher cortisol reactivity and higher abdominal fat distribution, as well as higher self-reported chronic stress (Alder et al., 2000). An experimental design showed lower SubjSS increased susceptibility to the cold virus, which was partially mediated by poorer sleep quality (Cohen et al., 2008). SubjSS was also found to predictor overall physical and mental health, and predicted health declines above and beyond objective SES as measured by occupation, income, and household wealth (Singh-Manoux et al., 2005). Researchers have hypothesized that SubjSS may act, in part, as an indicator of psychosocial vulnerability relevant to subjective SES, and recent work confirmed that a composite measure including depressive symptoms, pessimism, and neuroticism partly mediated the relationship between SubjSS and self-rated health (Cundiff, Smith, Uchino,

& Berg, 2013). To date, though no work has examined the association of SubjSS with cognitive functioning, the reviewed literature may provide insights regarding the various pathways via which both objective and subjective SES may impact cognitive reserve relevant to understanding late-life cognitive functioning.

As individuals age, they experience declines in both physical and cognitive functioning (Drag & Bieliauskas, 2009; Salthouse, 2012) with individuals in lower SES showing greater declines in both domains compared to older adults of higher SES (Karlamangla, Singer, McEwen, Rowe, & Seeman, 2002; Lynch, Kaplan, & Shema, 1997). Performances on physical functioning tasks were found to be related to general cognitive functioning as well as fluid cognitive ability, associations that remained after controlling for education, income, level of physical activity, and comorbidities (Rosano et al., 2005). Another study found decline in gait speed was associated with overall cognitive functioning and fluid cognitive ability as well (Atkinson et al., 2007). Additionally, there is a growing body of work suggesting that exercise likely provides both physical and cognitive functioning benefits via the improved functioning of the CNS (Colcombe et al., 2006; Kramer, Erickson, Colcombe, 2006; Berchicci, Lucci, & Di Russo, 2013), offering further support for a connection between cognitive reserve and physical health in aging individuals.

The increased levels of chronic stress and allostatic load observed in older adults at lower levels of SES (Matthews & Gallo, 2011; Seeman et al., 2004), associated with subjective SES as indicated by SubjSS (Adler et al., 2002), may be a direct pathway for the impact of SES on cognitive aging. Increased stress has been linked to decreased

hippocampal volume and loss of brain plasticity, resulting in memory deficits (Miller & Callaghan, 2005). The improved memory functioning of both younger and older adults via pharmacological manipulation of glucocorticoids provides support that this effect of stress on cognition is at least in part due to endogenous stress hormone responses (Lupien et al., 2005). Subjective SES may have downstream impacts on cognitive functioning via the consequences to physical health, or mechanisms relevant to overall functioning (such as stress) that may lead to individual differences in both health and cognitive functioning as we age.

Ultimately, there are likely various pathways that subjective SES is relevant to cognitive aging. As noted above, subjective SES may be an index to the extent that an individual's SES is associated with stress above and beyond objective assessments of SES. Additionally, as psychosocial vulnerabilities mediate the relationship between subjective SES and individual outcomes, subjective SES may be an indicator of increased psychological distress via perceived economic and social hardship (or vice versa). It is also likely that the most commonly assessed indicators of SES do not fully capture an individual's SES experience as relative to cognitive outcomes, and subjective SES may act as a personally-determined composite measure in which an individual is able to globally assess their own SES experience incorporating all salient aspects beyond relatively static indicators such as educational attainment or relatively changing indicators such as household income (Singh-Manoux, Adler, Marmot, 2003). As such, it may be difficult for researchers to approximate this subjective assessment of SES via

traditional (i.e. objective) measures of SES, and should instead include both types of SES measures to increase predictability of cognitive functioning in older adults.

The current study will examine the association of subjective SES (as assessed by SubjSS) with cognitive functioning and cognitive aging in participants 50 years of age and older from the Health and Retirement study (HRS). The HRS is a representative longitudinal panel study of Americans that began in 1992, in large part, to address the changes in lifespan and health as relevant to retirement (Juster & Suzman, 1995). Since then, participants have been interviewed every 2 years regarding income and assets, mental and physical health. In the last decade, measures relevant to psychosocial factors, including subjective SES, have been added. The HRS offers a unique opportunity to examine the association of objective and subjective SES with cognition in a large, diverse sample of older adults while accounting for important potential covariates such as health and psychosocial vulnerabilities. With the available measures of cognition in the HRS study, we will be examining these associations cross-sectionally with memory, processing speed, and longitudinally in overall cognitive functioning.

Consistent with the current literature on SubjSS, we expect that objective measures of SES such as years of education and income will be moderately associated with subjective SES in the HRS. Additionally, we expect to find comparable associations between measures of health and negative emotionality with subjective SES as would be expected with objective SES. For example, both objective and subjective SES are expected to have positive associations with self-rated health but negative associations with depressive symptoms. In accordance with objective and subjective SES predicting

physical and mental health outcomes, we expect that subjective SES will mirror objective SES in predicting level of cognitive functioning, such that individuals with higher objective and subjective SES will perform better on measures of cognitive functioning, verbal episodic memory, and processing speed. Finally, we predict that subjective SES will be associated with longitudinal memory and overall cognitive functioning above and beyond included objective measures of SES.

Methods

Two samples were drawn from the Health and Retirement Study (HRS) to examine the association of subjective and objective indicators of SES with cognitive outcomes. The Health and Retirement Study (HRS) is a longitudinal cohort-sequential study of health, retirement, and aging created in in 1990 and supported by the National Institute of Aging (Karp, 2007). The full sample comprises 30,000 unique individuals interviewed at least once. Currently, about 26,000 Americans aged 50 years and older are followed up at two-year intervals with the HRS questionnaire. New cohorts of individuals are added every 6 years as they turn 50 years of age. HRS has oversampled for African American and Hispanic Americans, ensuring a very diverse pool of participants for study. Each sample for the current study was chosen based on the available predictors and cognitive outcomes at each wave (or 'baseline' wave, in the case of the longitudinal studies) as described below. Objective socioeconomic status indicator variables and cognitive variables for both samples were drawn from RAND HRS Data File Version M (Rand, 2013).

Sample 1: Cross-Sectional

For the cross-sectional sample 5,991 individuals were drawn across all available cohorts in the Health and Retirement Study (HRS) 2010 wave based on those individuals who had completed the subjective social status item in the Health and Retirement Study *Psychosocial and Lifestyle* Questionnaire (Smith et al., 2013), participated cognitive tasks via the phone interview, and were age 50 years or older in 2010. Participants in this sample were 69.8 (*SD*=9.68) years old and 58% female. 84% identified as White/Caucasian, 12% identified as Black/African American, and the remaining identified as 'Other'.

SES measures

The Health and Retirement Study *Psychosocial and Lifestyle* Questionnaire (Smith et al., 2013) was first conducted as a pilot with a subsample of HRS participants in 2004. In 2006, this questionnaire was administered again via computerized module for half the HRS sample, randomly selected, creating the A subgroup. In 2008, the other half of the HRS sample completed the computerized questionnaire, creating the B subgroup. As such, each subgroup is scheduled to complete the Questionnaire every 4 years. As part of this questionnaire, subjective social status (SubjSS) was assessed. Individuals were shown the image of a ladder with check boxes on each rung, and were given instructions to indicate their position on the ladder if those at the top are the best off in society, and those at the bottom are worst off in society. Subsequently, individuals were asked to indicate whether their position on the ladder had changed in the last 2 years, and if so, in which direction. SubjSS was drawn directly from the HRS public release data for both

samples, as the variable is not included in the RAND HRS data file. For the 2010 sample, the median reported SubjSS score was 7 (*SD*=1.73).

Participants are asked regarding years of education at intake, and are asked yearly regarding income information via phone interview. The interview process is conducted using specific guiding questions to encourage reporting. For the cross-sectional analyses in 2010, the median was 12 years of education (*SD*=2.93) and the median household income was about $41,500 (*SD*=$72,541). Due to a negative skew, the years of education variable was reflected and log transformed, then multiplied by -1 to assist in interpretation. Due to a positive skew, a log transformation was used for household income after adding +1 to income values in order to retain individuals reporting zero income. For the regression analyses, SES predictors were centered on the median.

Cognitive measures

As detailed below, memory performance was assessed as part of cognitive battery administered at each assessment via telephone interview. For this measure, each participant was read a list of 10 common nouns (e.g. lake, car, army, etc.) and was asked to immediately recall as many words as possible from the list (Immediate Word Recall). Five minutes later, the participant was once again asked to recall as many words as they could remember (Delayed Word recall). Both scores were summed to create a total score ranging from 0 to 20 (M= 9.78, *SD*=3.26).

Fluid reasoning was measured via the Number Series task. This measure was first piloted with a subsample of HRS participants in 2004 as part of the development of an additional cognitive assessment geared towards including measures of fluid intelligence

in the HRS (Fisher, McArdle, McCammon, Sonnega, & Weir, 2014). The measure was administered more widely to HRS participants starting in 2010. Each participant was given a series of numbers with a number missing. The participant was asked to determine the numerical patterns then provide the missing number in the series. This task was presented using adaptive testing methodology, and each participant was given up to 6 problems to solve. Respondents were assigned scores ranging from 390.20 to 576.90 (*M*=497.40, *SD*=43.48) based on the scoring method used in the Woodcock-Johnson III.

Covariates

To account for possible mediation of any observed associations between SES and cognitive performance, physical and mental health measures from the 2010 assessment were included as predictors in the analyses. Body Mass Index (BMI), self-rated health, and an eight-item CESD depression inventory were assessed at each wave in the HRS, and described in further detail below. For the 2010 assessment, participants reported a mean BMI of 29.39 (*SD*=5.97). For analyses, BMI was centered at 25 to reflect the standard cut-off point for normal BMI. For analyses, self-rated health was centered at the mean (*M*=3.22, *SD*=1.06). For CESD, the mean reported score was 1.30 out of a possible 8 points (*SD*=1.86). This measure has a natural zero point for the present analyses as many participants reported no depressive symptoms (or a score of zero).

Analytical Approach

For the cross-sectional analyses, a series of regression analyses were conducted using Proc MIXED in SAS 9.3 (SAS Institute, Inc., Cary, NC) using full maximum likelihood and accounting for nesting within households (i.e., spouses aged 50 and older

were included as HRS participants). The regression analyses were used to determine if both objective and subjective measures of SES significantly predicted cognitive performance on Total Word Recall and Number Series. Cognitive scores for both tasks were converted into percent correct to aid in interpretation of results. Regression analyses included four models fitted to each cognitive task. Model 1 controlled for age effects by regressing participant age in 2010 on cognitive scores, centered at the mean age of 69.8 years. Model 1 also controlled for sex effects by regressing sex on cognitive score with male participants as the reference, and each following model regressing an indicator of SES on cognitive performance. SubjSS was entered in Model 2 to assess the unique contribution of this indicator of subjective SES measure on the cognitive outcomes. Household income and years of education were entered in Model 3 to assess the contribution of objective SES in predicting cognitive outcomes. Finally, in Model 4, BMI, self-rated health, and CESD were entered into the analyses to consider possible mediational effects of physical and mental health on cognitive performance.

Sample 2: Longitudinal

For the cross-sectional sample 6,678 individuals were drawn across all available cohorts in the Health and Retirement Study (HRS) from the 2004 through to the 2010 waves based on those individuals who had completed the SubjSS item in the *Health and Retirement Study Participant Lifestyle Leave Behind* Questionnaire (Regents of the University of Michigan, 2011) in 2006, and participated in the Telephone Interview for Cognitive Status (TICS), and were age 50 years or older in 2004. All key variables for this sample are drawn from the 2006 HRS wave to maximize the availability of key

predictors. In 2006, participants in this sample were 68.4 (*SD*=9.81) years old and 57% female. 86.45% identified as White/Caucasian, 11.32% identified as Black/African American, and the remaining identified as 'Other'.

SES Measures

At the 2006 HRS wave, years of education and income were assessed as previously described. For the current sample, the median was 12 years of education (*SD*=3.05). Due to negative skew, years of education was reflected and log-transformed, then multiplied by -1 to assist in interpretation. The median household income was about $40,200 (*SD*=$204,277.20). Due to considerable positive skew, household income was log transformed after adding +1 in order to retain individuals with zero income values for use in analyses. As previously described, a questionnaire including psychosocial scales and items was first widely administered in the HRS during the 2006 wave, and included the SubjSS measure. Participants reported a median SubjSS of 7 (*SD*=1.76).

Cognitive Measure

In the HRS, cognition was assessed using the Telephone Interview for Cognitive Status (TICS), which consists of eleven items modeled after the Mini-Mental Status exam (Brandt, Spencer, & Folstein 1988). In this task, the interview asks the participant's full name and current address, which is then verified and scored. Then the participant is asked to complete a series of cognitive tasks, including:

- Immediate Word Recall - the participant is asked to listen carefully to a list of ten words, and to remember as many as possible for immediate recall.

- Delayed Word Recall – After about a five-minute delay, the participant is asked to recall the list of ten words previously presented to them.
- Serial 7's - the participant is asked to do serial subtractions in which the interviewer asks "One hundred minus 7 equals what" and then "and 7 from that" for 5 trials.
- Names - the participant is asked to name common items and identify the current president and vice president.
- Backward Counting - the participant is asked to count backwards from twenty to one.

A total cognitive summary score was created by summing scores obtained in the previously described tasks, as well as up to 4 points for providing correct identification of the date, including day of the week, month, day, and year, for a possible total cognitive summary score ranging from 0 to 35 points. For the present analyses, scores were converted to percent correct to aid in interpretation of results.

The current study utilizes cognitive data from 4 HRS waves, starting in 2004, and including 2006, 2008, and 2010. Imputations of missing cognitive data were applied by HRS for interviewed individuals in the case of missing data, refusals, and non-applicable responses. Imputations were done using available raw data in the current wave, and imputed data from the previous wave (Fisher, Hassan, Rodgers, Weir, & Arbor, 2013). Current analyses include a dichotomous variable indicating whether an individual has at least one imputed value used in creating their Total Cognition Score, and controlling for the effect of imputations.

Covariates

To account for possible mediation of any observed associations between SES and cognitive performance, physical and mental health measures from the 2006 assessment were included as predictors of cognitive functioning in the analyses. Emotional affect was assessed using the modified HRS eight-item Center for Epidemiologic Studies Depression Scale (CESD; Steffick, 2000), which measures symptoms of depression and anxiety. Scores ranged from 0 to 8 (*M*=1.39; *SD*=1.9); CESD had a natural zero for the present analyses, as almost half the participants reported no symptoms of depression (or a score of 0). Self-Rated Health (SRH) was assessed via a one-item question "Would you say your health is excellent, very good, good, fair, or poor?" with 5 the possible options scored as follows: 1=Excellent, 2=very good, 3=good, 4=fair, 5=poor. For the present study, participant responses were recoded so that higher scores indicate higher self-rated health (e.g. 5=excellent), resulting in a mean SRH score of 3.21 (*SD*=1.09). For the present analyses, self-rated health was centered at the mean score. For Body Mass Index (BMI), participants are asked their height and weight at intake, and asked their weight at each wave thereafter. Height and weight are then converted to meters and kilograms, respectively. The standard equation was used to calculate BMI such that weight was divided by height squared: BMI= weight (kg)/height(m)^2. At the 2006 assessment, participants reported an overall mean BMI=28.18 (*SD*=5.84). For analyses, BMI was centered at 25 to represent the standard cut-off for normal-weight range BMI.

Analytical Approach

For the longitudinal analyses, growth curve models were fit the data with Proc MIXED in SAS 9.3 (SAS Institute, Inc., Cary, NC) with full maximum likelihood option and accounting for nesting within households (i.e., spouses aged 50 and older were included as HRS participants). The model was centered at average participant age in 2006 (68.4 years), and included a linear age term representing rate of change per year at the centering age and a quadratic age term (age^2) representing either accelerated or decelerated rate of change. In addition, all models accounted for nesting within households. First, an unconditional model was fit to determine if a linear model fit better than a no change model, and if a quadratic model fit the data better than a linear model. Chi-square difference tests were applied to the deviance statistics using change in number of parameters as degrees of freedom for the nested growth curve models to evaluate improvement of fit (Singer & Willet, 2003). As shown in Table 2.4, four models were fit to the data to determine if objective and subjective SES measures would predict change in cognitive functioning across age. All predictors were entered into the models on each term (intercept, linear, and quadratic) as follows: Model 1 controlled for retest effects (only on the intercept term), sex effects, and included a term for cognitive imputations. For Model 2, median-centered SubjSS was entered as a predictor to determine the unique association of subjective SES with change in cognitive functioning across age prior to entering other indicators of SES. Model 3 entered household income and years of education to determine the contribution of objective indicators of SES to predicting change in cognitive functioning. Finally, Model 4 entered BMI, Self-rated health, and

CESD to control for possible effects of physical and mental health on longitudinal changes in cognitive functioning that may mediate observed associations between SES and the cognitive outcome.

Results

Cross-sectional Analyses

As shown in Table 2.1, correlation analyses indicated that years of education, SubjSS, and household income were moderately correlated, ranging from 0.28 to 0.33 (all $p<.001$). Performance on Total Word Recall was positively correlated with years of education (r=0.35), household income (r=0.24), and to a smaller extent with SubjSS (r=0.11). Similarly, performance on Number Series was also positively correlated with years of education (r=0.46), household income (r=0.27), and to a smaller extent with SubjSS (r=0.16). This suggests that individuals with higher education and higher household income tended to receive higher scores on the administered cognitive tasks. Moreover, those with higher SubjSS tended to show higher performance, although the effect sizes were small. Performance on both cognitive tasks was moderately, positively correlated (r=0.35). All correlations were statistically significant at $p<.001$ level.

Table 2.2 shows the regression results for both Total Word Recall and Number Comparison, and Table 2.3 shows the model fit statistics. For both cognitive tasks, each model improved fit compared to the previous for all models fitted (all $p<.001$). For Total Word Recall, Model 1 showed a significant effect of age on memory performance, with older adults performing on average -0.61% lower on the task per year of age above the mean ($p < .001$). Model 1 also showed a significant effect of sex on memory performance

such that, on average, men performed about 5.06% lower than women (p<.001). Model 2 showed that SubjSS significantly predicted cognitive performance, such that each unit increase in SubjSS above the median predicted about 1.35% increase in average score (p<.001). Model 3 entered household income and years of education, and each was a significant predictor of memory performance: higher household income and more years of education, as compared to the median, predicted higher average performance. SubjSS continued to be positively associated with performance above and beyond the effects of objective SES, predicting an increase of 0.42% in performance for each unit above the median. In Model 4, BMI, self-rated health, and CESD were significant predictors of memory performance (all p=.001 or smaller), and the association of SubjSS was reduced to non-significance (p = .456). Figure 2.1 shows the predicted performance for Total Word Recall based on level of SubjSS before controlling for objective indicators of SES (Model 2), upon entering household income and years of education into the model (Model 3), and after entering BMI, self-rated health, and CESD into the model (Model 4).

For Number Series, Model 1 showed a significant effect of age on fluid reasoning, with older adults on average performing -0.20% lower per year above the mean age (p<.001). Additionally, Model 1 showed a significant effect of sex on fluid reasoning such that, on average, men performed about 1.58% higher than women on the task (p=<.001). Model 2 showed that SubjSS significantly predicts fluid reasoning performance, such that each unit increase in SubjSS above the median predicts about 0.67% higher than average Number Series score (p<.001). Model 3 entered household income and years of education as significant predictors of fluid reasoning, such that

higher household income and more years of education (as compared to the median) predict higher than average fluid reasoning performance (both $p<.001$). In Model 3, the association between SubjSS and fluid reasoning performance was reduced to trend significance ($p=.414$) after including objective SES indicators. Model 4 indicated that self-rated health and CESD significantly predicted fluid reasoning performance ($p<.001$), and the association of SubjSS with cognitive performance became non-significant ($p=0.933$). Figure 2.2 shows the predicted performance for Number Series based on level of SubjSS before controlling for objective indicators of SES (Model 2), upon entering household income and years of education into the model (Model 3), and after entering BMI, self-rated health, and CESD into the model (Model 4).

Longitudinal Analyses

Model estimates and expected trajectories for the total cognitive summary score are presented in Table 2.4 and Figure 3, respectively. Model 1 suggested that sex was a significant predictor of performance at age 68.4 (mean age in 2006 assessment, $p<.001$). Model 2 suggested that SubjSS, the SES indicator of interest in these analyses, significantly predicted performance level at age 68.4 years ($p<0.001$) such that each unit increase in SubjSS above the median predicted up to 1.60% increase in performance score. Additionally, Model 2 indicated that SubjSS significantly predicted negative quadratic change ($p=.006$), suggesting the positive SubjSS effects wane across age. Model 3 indicated that household income and years of education both predicted higher scores on level of cognitive performance at age 68.4 for individuals with the median income and education (both $p<.001$). With the inclusion of these objective SES

indicators, SubjSS remained a significant predictor of performance at age 68.4 (p<.001) and of quadratic change (p=.009).

Finally, Model 4 indicated that self-rated health and CESD were significant predictors of cognitive performance level at age 68.4 years (both p<.001). Specifically, individuals performed up to 1.45% higher on cognitive performance for each unit above the average self-rated health score. Additionally, for each unit increase in CESD score above 0, individuals experienced a 0.44% lower score on cognitive performance at age 68.4. BMI was not a significant predictor of cognitive performance or change. After including both the physical and mental health indicators, SubjSS remained a significant predictor of level of performance at the centered age (p=.005) with individuals experiencing a boost of up to 0.32% on performance at age 68.4. SubjSS remained a significant negative predictor of quadratic change (p=.001), suggesting that the positive gains accorded to SubjSS wane across age. As depicted in the expected trajectories in Figure 3, individuals with a higher than median SubjSS experience a slight boost (0.63%) in cognitive performance around age 70 compared to those one point below the median (Cohen's d=0.13) (Feingold, 2009). These gains wane across age, wherein those with higher SubjSS then experience a slightly accelerated decline in performance after about age 90 compared to individuals at the median level SubjSS.

Discussion

The current study drew from publically available data in the Health and Retirement Study (HRS) to investigate both cross-sectional and longitudinal relationships between objective and subjective indicators of socioeconomic status (SES) and cognitive

performance. Objective measures of SES included years of education and household income. Previous studies have found a positive association between objective indicators of SES and level of cognitive performance for both measures of crystallized and fluid intelligence (Lee, Buring, Cook, & Grodstein, 2006; Mortensen et al., 2014), though the association of specific indicators of SES with cognitive change is mixed (Glymour et al., 2011; Karlamangla et al., 2009; Zahodne et al., 2011). While the relationship of subjective social status with cognitive performance has been essentially unexamined, until now, subjective social status has been found to predict mental and physical health outcomes above and beyond objective measures of SES (Dennis et al., 2012; Li et al., 2005; Singh-Manoux et al., 2003). More recently, low levels of subjective SES was found to be a risk factor for functional decline in older adults from the HRS sample, suggesting an important role of subjective SES in predicting aging outcomes (Chen et al., 2012).

Of particular interest in the current study was evaluating the independent contribution of a subjective social status, a subjective measure of SES, on cognitive outcomes in older adults above and beyond objective measures of SES. Cross-sectional analyses examined the associations of both subjective and objective indicators of SES with cognitive performance on measures of memory ability and fluid reasoning in a HRS subsample from the 2010 wave. Longitudinal analyses examined the association of subjective and objective SES as assessed in 2006 with level and change in overall cognitive performance across age in older adults ranging from ages 50 to just over 100 years in four waves of the HRS. For the current study, we hypothesized that higher levels

of both subjective SES and objective SES would predict higher overall performance on cognitive outcomes, and additionally, that subjective SES would predict cognitive performance above and beyond objective measures. We also expected that subjective SES and objective SES would predict cognitive change across age, and that subjective SES would predict change on overall cognitive performance above and beyond years of education and household income.

In the cross-sectional analyses, a series of regression models were used to sequentially evaluate the impact of concordant subjective social status, household income, and years of education for participants' performance on cognitive tasks measuring memory ability and fluid reasoning. Analyses controlled for the effect of sex, with initial models indicating that men tended to perform higher on fluid reasoning and lower on memory ability as compared to women (consistent with prior work, e.g., Finkel et al, 2003). Subjective social status was included as the first indicator of SES in order to explore independent associations with cognitive performance. Consistent with our hypothesis, subjective SES positively predicted scores on both memory ability and fluid reasoning above and beyond objective SES, such that individuals with higher than median subjective social status tended to show better overall performance on cognitive tasks compared to individuals with median level subjective social status. Our results are consistent with other work showing that when multiple indicators of SES are used to predict cognitive performance, education is more strongly associated with cognitive outcomes compared to income or occupation (Mortensen et al., 2014). Additionally, each

indicator of SES was shown to uniquely contribute to predicting cognitive performance, highlighting the importance of assessing both subjective and objective SES.

Further analyses revealed possible mediation of the observed association between subjective social status and cognitive performance by physical and mental health. The effect of subjective SES was no longer significant (though still in the positive direction) after including body mass index, self-rated health, and depressive symptoms as predictors of cognitive performance. Though these results are not consistent with our hypothesis overall, this outcome is consistent based on the subjective social status literature examining physical and mental health domains, showing that subjective social status is associated with both physical and mental health outcomes (Adler, Epel, Castellazzo, & Ickovis, 2000; Cundiff, Smith, Uchino, Berg, 2013; Operario, Alder, & Williams, 2004). Concurrent effects of subjective SES on memory and fluid reasoning performance may be fully accounted for by these health pathways, noting the importance of physical and mental health to cognitive performance in older adults.

To examine longitudinal influences of subjective social status on overall cognitive performance in older adults, a series of growth curve models were used to evaluate this association before and after including objective indicators of SES, and before and after controlling for possible physical and mental health moderators. In the longitudinal analyses, subjective social status, household income, and education were all found to be significant predictors of performance at about 68 years of age (the average age of HRS participants in 2006). Individuals higher than the median on each measure of SES, on average, received a slightly positive boost to level of cognitive functioning. Additionally,

subjective social status uniquely predicted change in linear aging trajectories. After controlling for BMI, self-rated health, and depressive symptoms, only subjective social status remained as a significant predictor for level of cognitive performance, and continued to significantly predict aging trajectories, such that individuals received a small boost in performance evident at about age 70 but then experienced a loss of this gain by age 90 and beyond. The current findings suggest that subjective social has unique effects on both level of cognitive functioning and the shape of cognitive aging trajectories in older adults, above and beyond the effects of income, education, as well as physical and mental health. As previous literature has indicated an association of subjective social status with self rated health, which is partially mediated by depressive symptoms (Cundiff et al., 2013), this suggests unique effects on cognitive aging above and beyond possible associations with health outcomes.

As both the cross-sectional subsample and longitudinal subsample were drawn from the same representative sample of older adults, the current study seems to suggest that subjective social status may have a slightly different relationship to cognitive outcomes than to previously described associations with health and well-being. Namely, concurrent effects of subjective social status may not predict cognitive performance above and beyond effects of physical and mental health, but there may be small but salient effects of subjective SES on cognitive functioning that can only be fully evaluated in a longitudinal framework. In particular (and in accordance with initial cross-sectional results) there does seem to be a small positive effect of higher subjective social status on level of cognitive performance, though this boost does seem to wane at much older ages.

Since we also controlled for physical and mental health effects, one explanation for the observed effect of subjective social status on cognitive aging is that this particular measure of SES captures an individual's own biographical sketch of overall SES across time, including subjective assessments of past and future SES (or SES trajectories) not captured by objective measures of SES. Moreover, the longitudinal analyses may point to a sensitive age period, approximately 65 to 80 years, when a more positive perception of social status appears to a contribute a small buffer to declines—this period is notable since accelerations in decline have been observed at about age 65 to 70 years (Finkel et al., 2003).

One of the limitations of the present study are in part related to the current availability of both the cognitive and subjective social status measures across waves in the HRS sample. The measure of fluid reasoning, Number Series, was evaluated only on a cross-sectional basis in the current study; this measure was first widely administered in 2010, as the task was added to include the evaluation of fluid intelligence, previously not adequately assessed in the cognitive battery administered to individuals in the HRS sample. For this reason, the specific influence of subjective social status across time as observed in the longitudinal analyses could not be evaluated specifically for fluid reasoning, and any possible associations are left unexamined. Additionally, the total cognitive score used to examine the influence of subjective SES on longitudinal cognitive aging is comprised of items measuring various cognitive domains, including basic mental status questions, working and episodic memory tasks. The results do not speak to specific associations of subjective SES with 'fluid' versus 'crystallized' intelligence, which have

been found to show distinct patterns in normative aging. Additionally, subjective SES is not available at every wave of cognitive data, limiting the examination of causal associations between subjective SES and cognitive performance.

The current study suggests that an individual's subjective evaluation of one's own economic and social resources predicts late-life cognitive performance. Though the predictive effect of subjective social status on cognitive aging in the current study is fairly small, this effect was found after controlling for substantive moderators, including objective measures of SES and physical and mental health outcomes. As such, further studies should evaluate the causal mechanisms and unique pathways linking subjective SES to cognitive aging outcomes above and beyond the association of both with objective measures of SES.

Table 2.1

Cross-Sectional Analyses: Predictor and Outcome Variable Correlations in 2010

Variable	n	SubjSS	Household Income	Years of Education	Total Word Recall	Number Series
SubjSS	5991	--				
Household Income	5991	0.28	--			
Years of Education	5991	0.28	0.33	--		
Total Word Recall	5816	0.11	0.24	0.35	--	
Number Series	5443	0.16	0.27	0.46	0.35	--

Note. All correlations presented in the table are statistically significant $p<.001$. Tolerance values for predictors were between 0.76 and 0.98, indicating no significant multicollinearity.

Table 2.2

Cross-Sectional Analyses: Estimated Fixed Effects (se)

Effect	Model 1	Model 2	Model 3	Model 4
Memory (Total Word Recall)				
Intercept	50.88 (0.26) **	51.73 (0.26) **	49.44 (0.28) **	50.11 (0.33) **
Age	-0.61 (0.02) **	-0.63 (0.02) **	-0.56 (0.02) **	-0.53 (0.02) **
Gender (Male)	-5.06 (0.38) **	-5.33 (0.38) **	-6.12 (0.37) **	-6.26 (0.37) **
Subjective Social Status	-	1.35 (0.11) **	0.42 (0.11) **	0.09 (0.12)
Household Income	-	-	2.82 (0.34) **	2.26 (0.34) **
Years of Education	-	-	13.72 (0.66) **	12.89 (0.66) **
Body Mass Index (BMI)	-	-	-	0.11 (0.03) **
Self-Rated Health	-	-	-	1.35 (0.20) **
Depression Inventory (CESD)	-	-	-	-0.81 (0.11) **
Fluid reasoning (Number Series)				
Intercept	85.00 (0.13) **	85.40 (0.13) **	83.82 (0.13) **	84.02 (0.16) **
Age	-0.20 (0.01) **	-0.21 (0.01) **	-0.16 (0.01) **	-0.15 (0.01) **
Gender (Male)	1.58 (0.18) **	1.46 (0.19) **	0.97 (0.18) **	0.95 (0.18) **
Subjective Social Status	-	0.67 (0.06) **	0.14 (0.06) *	0.004 (0.06)
Household Income	-	-	1.27 (0.17) **	1.04 (0.17) **
Years of Education	-	-	8.95 (0.32) **	8.62 (0.32) **
Body Mass Index (BMI)	-	-	-	0.03 (0.02)
Self-Rated Health	-	-	-	0.67 (0.10) **
Depression Inventory (CESD)	-	-	-	-0.26 (0.05) **

Note. $^{**}p < 0.01$; $^{*}p < 0.05$; $^{\dagger}p < 0.10$

Table 2.3

Cross-Sectional Analyses: Fit Statistics for Mixed Linear Regression Models

Model	AIC	-2 log Likelihood	df change	χ change	*p*
Memory (Total Word Recall)					
M1. Age + Gender	47367.6	47357.6	-	-	-
M2. Age + Gender + SubjSS	47232.4	47220.4	1	137.2	<.001
M3. Age + Gender + SubjSS + H.H. Income + Years of Educ.	46653.4	46637.4	2	583.07	<.001
M4. Age + Gender + SubjSS + H.H. Income + Years of Educ. + BMI +SRH + CESD	46505.2	46483.2	3	154.15	<.001
Fluid reasoning (Number Series)					
M1. Age + Gender	36542.8	36532.8	-	-	-
M2. Age + Gender + SubjSS	36414.4	36402.4	1	130.42	<.001
M3. Age + Gender + SubjSS + H.H. Income + Years of Educ.	35527.7	35511.7	2	890.75	<.001
M4. Age + Gender + SubjSS + H.H. Income + Years of Educ. + BMI +SRH + CESD	35428.8	35406.8	3	104.83	<.001

Note. SubjSS =Subjective Social Status, H.H. Income = Household Income, Years of Educ.= Years of Education, BMI=body mass index, SRH=self-rated health, CESD=Depression Inventory.

Table 2.4

Estimated Fixed Effects for Longitudinal Models of Change in Cognitive Functioning

Fixed Effects	Unconditional Model	Model 1	Model 2	Model 3	Model 4
Effects on Intercept					
Performance at 68.4 years	67.06 (0.19) **	69.04 (1.00) **	70.19 (0.99) **	66.77 (0.95) **	66.96 (0.97) **
Retest	-	-2.14 (1.04) *	-2.69(1.03) **	-1.18 (0.99)	-1.18 (0.99)
Cognitive Imputations	-	-5.10 (0.57) **	-5.15 (0.57) **	-4.82 (0.55) **	-4.80 (0.55) **
Sex	-	2.04 (0.32) **	2.41 (0.33) **	3.25 (0.31) **	3.23 (0.31) **
Subjective Social Status	-	-	1.60 (0.10) **	0.57 (0.10) **	0.32 (0.10) **
Household Income	-	-	-	3.71 (0.38) **	2.87 (0.38)
Years of Education	-	-	-	13.26 (0.59) **	12.58 (0.59)
Body Mass Index (BMI)	-	-	-	-	-0.01(0.03)
Self-Rated Health	-	-	-	-	1.45 (0.17) **
Depression Inventory (CESD)	-	-	-	-	-0.44 (0.09) **
Effects on Linear Change					
Linear term	-0.48 (0.02) **	-0.42 (0.03) **	-0.41 (0.03) **	-0.35 (0.03) **	-0.35 (0.03) **
Cognitive Imputations	-	0.13 (0.08) †	0.11 (0.08)	0.04 (0.07)	0.04 (0.07)
Sex	-	0.01 (0.03)	0.02 (0.03)	0.04 (0.03)	0.04 (0.03)
Subjective Social Status	-	-	0.01 (0.01)	0.005 (0.01)	0.01 (0.01)
Household Income	-	-	-	0.03 (0.03)	0.04 (0.03)
Years of Education	-	-	-	0.03 (0.05)	0.01 (0.05)
Body Mass Index (BMI)	-	-	-	-	< 0.001 (.002)
Self-Rated Health	-	-	-	-	-0.002 (0.02)
Depression Inventory (CESD)	-	-	-	-	< 0.001 (0.01)

Fixed Effects	Unconditional Model	Model 1	Model 2	Model 3	Model 4
Effects on Quadratic Change					
Quadratic term	-0.02 (0.001) **	-0.022 (0.002) **	-0.023 (0.002) **	-0.022 (0.002) **	-0.021 (0.002) **
Cognitive Imputations	-	-0.008(0.004) †	-0.006 (0.004)	-0.004 (0.004)	-0.003 (0.002)
Sex	-	0.002 (0.002)	-0.003 (0.002)	-0.003 (0.002)	-0.002 (0.001)
Subjective Social Status	-	-	-0.002 (0.001) **	-0.002(0.001) **	-0.002(0.001) **
Household Income	-	-	-	-0.001 (0.002)	< 0.001 (0.002)
Years of Education	-	-	-	0.002 (0.004)	< 0.001 (0.004)
Body Mass Index (BMI)	-	-	-	-	< 0.001 (< 0.01)
Self-Rated Health	-	-	-	-	< 0.001 (0.001)
Depression Inventory (CESD)	-	-	-	-	< 0.001 (0.001)

Note. $^{**}p < 0.01$; $^{*}p < 0.05$; $^{\dagger}p < 0.10$

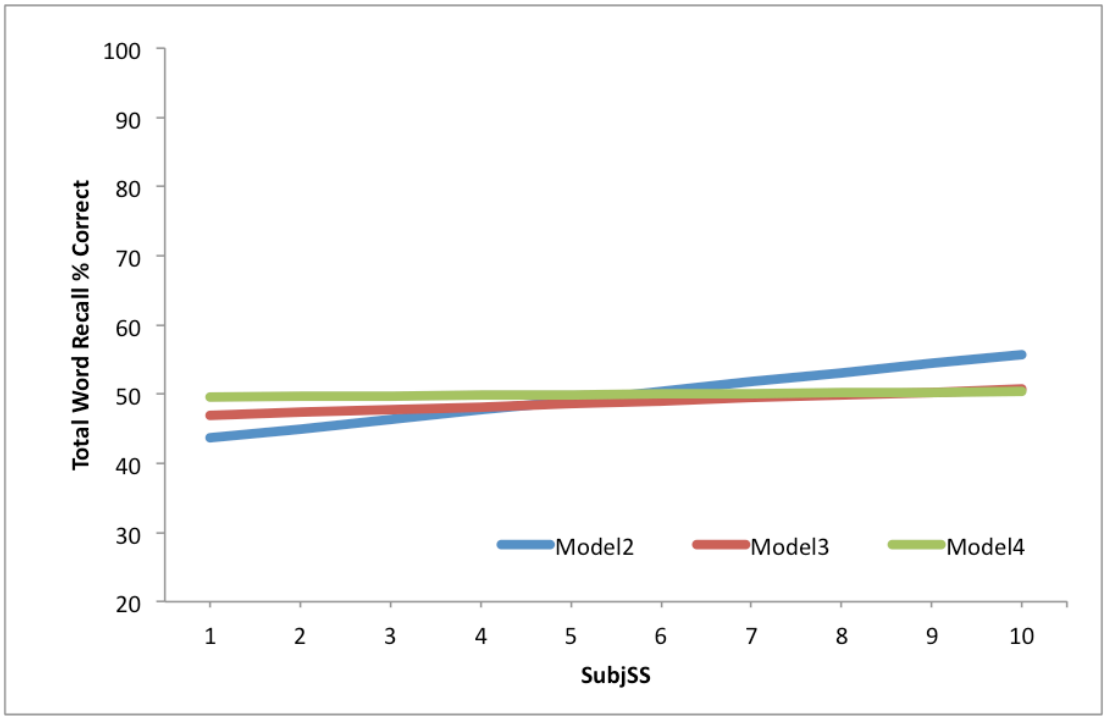

Figure 2.1. Predicted memory performance by level of Subjective Social Status (SubjSS) for Model 2 (in blue), Model 3 (in red), and Model 4 (in green).

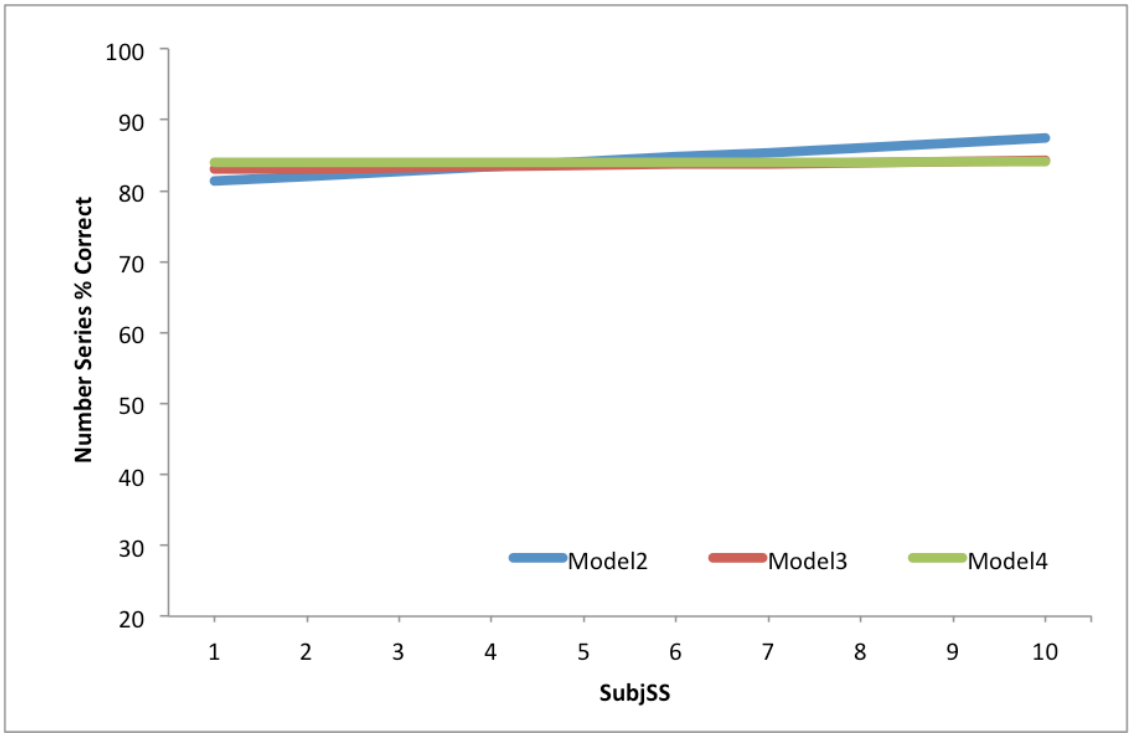

Figure 2.2. Predicted fluid reasoning performance by level of Subjective Social Status (SubjSS) for Model 2 (in blue), Model 3 (in red), and Model 4 (in green).

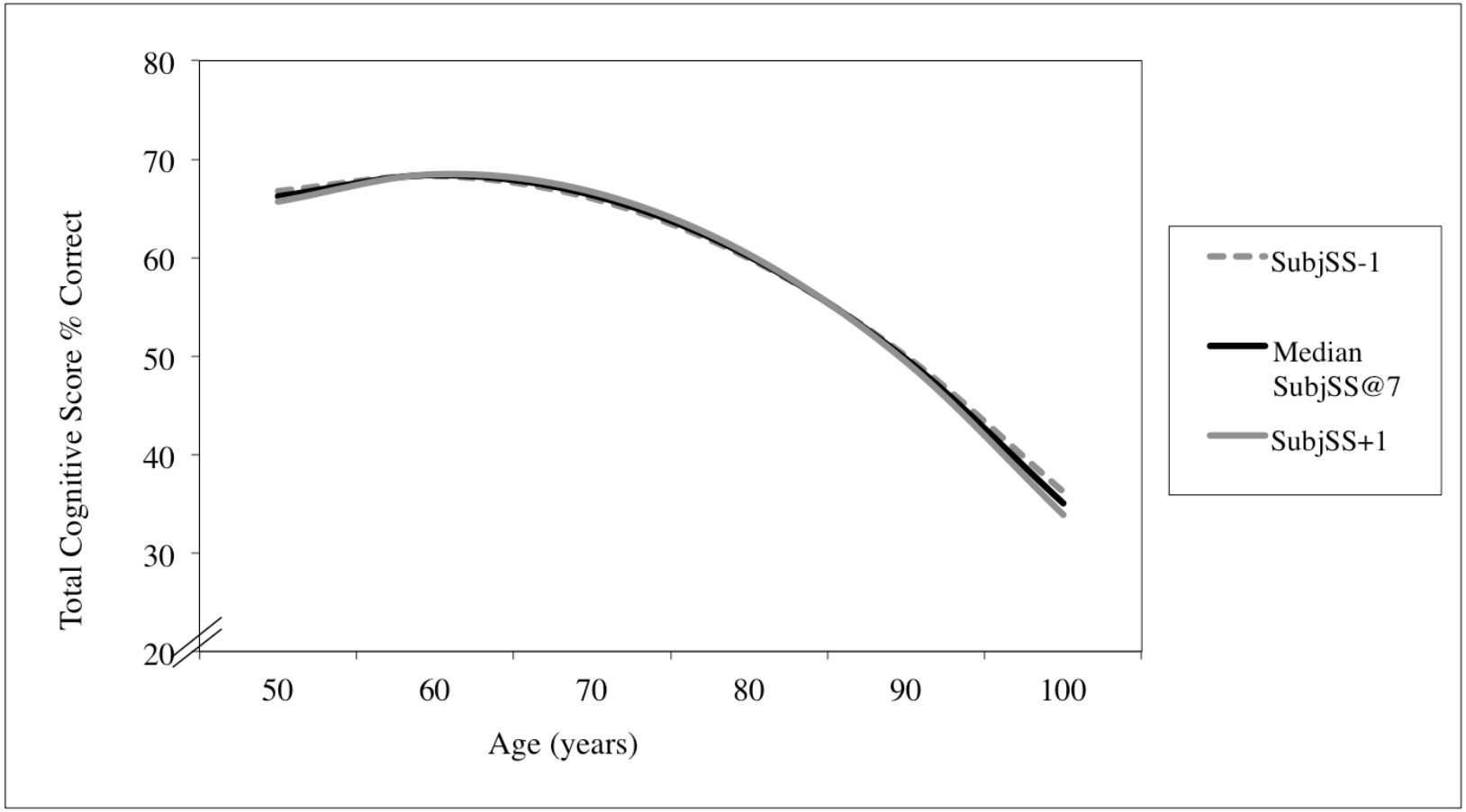

Figure 2.3. Expected trajectories for total cognitive score across age for individuals with Subjective Social Status (SubjSS) at the median score of 7, and individuals one unit below and one unit above the median.

Study 2

Examining Intraindividual Variability and Cognitive Plasticity Across Seven Days as Predicted by Socioeconomic Status in Community-Dwelling Older Adults

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INTRODUCTION

As more and more individuals in the last century have experienced increased longevity, there is an interest in identifying the factors that contribute to 'successful aging.' Successful aging is often denoted, at least in part, as maintaining a high level physical and cognitive functioning (Bowling & Dieppe, 2005; Row & Kahn, 1997). Researchers interested in how our cognitive functioning may change as we age now come from a wide variety of fields and disciplines, including many branches of psychology, neuroscience, and epidemiology just to name a few (Salthouse, 2010). Particularly in the field of developmental psychology, a major theoretical framework guiding research is the life span theory, which has as a defining principle that ontogenetic change continues throughout the lifespan of the individual (Baltes, Lindenberger, Staudinger, 2006). Within this framework, a paradigm shift occurred over the last several decades in which developmental psychologists interested in describing cognitive changes, including in the later half of the lifespan, have increasingly turned to longitudinal methodology over cross-sectional studies as a way to better address the mechanisms contributing to change (see for review Schaie, 2000; Schaie, 2005; and early work promoting such a shift; e.g., Schaie, 1965; Wohlwill, 1973).

Yet, the experience of aging and the importance of maintaining cognitive functioning are still most relevant to the day-to-day life of the individual, as each individual must navigate and adapt to their own daily challenges particularly as they experience changes in physical and cognitive health. This practical consideration is underscored by aging research concerning, for example, the maintenance of instrumental

activities of daily living (IADLs), identified key aspects of daily life that contribute to daily functioning and independence (e.g., maintaining own finances, shopping and food preparation, etc.; Lawton & Brody, 1969). Individuals from lower socioeconomic status (SES) are at a greater risk for functional decline (Beland & Zunzunegui, 1999; Beydoun & Popkin, 2005). This loss seems to arise partly from changes in cognitive functioning, as cognitive decline has been tied to predictable loss in IADLs and other measures relevant to independent functioning in older adults (Dodge et al., 2005; Njegovan, Man-Son-Hing, Mitchell, & Molnar, 2001). Some suggest that a greater understanding regarding these aging processes may be achieved by following individuals more frequently than is done in standard longitudinal frameworks (Njegovan at al., 2001). As such, we get back to the ever more pressing concern, understanding what aspects of day-to-day life may contribute to successful aging, with the current focus being on maintenance of cognitive functioning.

Though we continue to gain insight regarding late life cognitive functioning via ongoing longitudinal studies (e.g. ,Schaie, 2005; Finkel & Pedersen, 2004; McGue & Christensen, 2013), there has been an increasing interest in distinctions between intraindividual change and intraindividual variability (IIV) (cf. Nesselroade & Jones, 1991). Li, Huxhold, and Shmiedak (2004) make the distinction, by noting that intraindividual change is the more permanent within-person developmental shifts measured across longitudinal assessments (typically years), while IIV is short-term, more reversible variation in developmental functioning that can be measured over the course of repeated trials, days, or months (Allaire & Marsiske, 2005; Fuentes, Hunter, Strauss, &

Hultsch, 2001; MacDonald, Hultsch, & Dixon, 2003; Rabbit, Osman, Moore, & Strollery, 2001). Historically, this short-term variability has been considered part of measurement error or a 'methodological consideration' that must be take into account at single measurement occasions, even within longitudinal studies, as such variability may impede measurement of true individual change (Anstey, 2004; Salthouse, 2007). Yet, there is increasing evidence indicating that this type of variability is an individual characteristic, and shows reliability within domain (Nesselroade & Ram, 2004; Eid & Diener, 1999; Rabbit et al., 2001). Whereas intraindividual change can be further conceptualized as a measure of 'accumulated' changes in cognitive functioning, IIV in cognitive functioning may be considered more 'dynamic' and may be an individual factor predictive of other outcomes (Nesselroade & Ram, 2004; Ram & Gerstorf, 2009; Ram et al., 2011). Indeed, Ram and colleagues, as well as others, promote the measurement of IIV as a lens into 'dynamic processes', indicative of adaptation to external and internal influences (e.g., regulation), and plasticity or the possibility for change, for example (see Ram & Gerstorf, 2009).

Ongoing work measuring the association of IIV and cognitive abilities has found mixed associations between IIV and individual level of cognitive functioning. In some studies, IIV was found to be associated with lower cognitive functioning (e.g., Bielak, Hultsch, Strauss, MacDonald, & Hunter, 2010; Fuentes et al., 2001; Lövdén, Li, Shing, Lindenberger, 2007; MacDonald et al., 2003). Results seemed to support the theory that IIV was an indicator of risk or vulnerability, perhaps in relation to underlying neurological functioning, and could be considered a marker for cognitive decline

(Fuentes et al., 2001; Lövdén et al., 2007; MacDonald et al., 2003). Though much of this work has considered reaction time tasks, associations between reaction time IIV and declines in cognitive functioning abilities have been observed, such as perceptual speed, working memory, fluid reasoning, and episodic memory (Bielak et al., 2010; Hultsch, MacDonald, & Dixon, 2002; Lövdén et al., 2007; MacDonald et al., 2003). Yet, others have found that IIV is not uniformly associated with lower performance across cognitive tasks. For example, in several studies, older adults who exhibited greater task-specific IIV performed better on processing speed, inductive reasoning, attention, and memory (Allaire & Marsiske, 2005; Dzierzewski et al., 2013; Hofland, Willis, & Baltes, 1981; Yang, Reed, Russo, Wilkinson, 2009). These differences in results across types of cognitive abilities may suggest that different types of IIV may be assessed.

Two types of IIV in cognitive tasks have been proposed, distinguishing between 'adaptive' IIV and 'maladaptive' IIV (Allaire & Marsiske, 2005; Li et al., 2004). Namely, the associations of IIV with mean level cognitive performance characterizes each type of IIV, such that 'adaptive' IIV is associated with higher performance and 'maladaptive' IIV is associated with lower performance. Reaction time IIV is inversely related to white matter (WM) volume in the brain, independent of age, such that individuals with higher WM volume tend to show less IIV (Jackson, Balota, Duchek, Head, 2012; Walhovd & Fjell, 2007). For reaction time tasks, lower IIV may signal underlying maladaptive cognitive and neurological processes and be more related to the integrity of the central nervous system, particularly because these tasks tend to provide few opportunities for trial-to-trial improvement. One study found an association between higher IIV with

smaller WM volume independent of mean level performance on an episodic memory task (Lövdén et al., 2013). For other cognitive domains, 'adaptive' IIV may be evident on tasks that allow for practice and improvement, and may be a signal of 'cognitive plasticity', or an individual's capacity to learn and change (Lövdén, Backman, Lindenberger, Schaefer, & Schmiedek, 2010). The conceptualization of IIV as an indicator of cognitive plasticity is a not an entirely new perspective (Hofland et al., 1981), particularly as there has been great interest in understanding if and under what conditions older adults may be able to experience cognitive gains from practice (Green & Bavelier, 2008).

The conceptualization of 'adaptive' IIV or cognitive plasticity is more consistent with observations in early childhood developmental research. The microgenetic method, characterized by a great number (or density) of observations in a short amount of time, has been used to examine children's development in cognition and the use of cognitive strategies (Siegler & Crowley, 1991). As an alternative to cross-sectional or longitudinal experiments, this method seeks to more readily capture change in cognition as change occurs, rather than simply observing the differences before and after the change or capturing glimpses of these changes at longitudinal waves. Of course, one of the proposed difficulties in the early cognitive development literature would be foreseeing when change will occur. In studies of older adults, quite different processes may be at work when IIV is examined over multiple trials in one hour, versus over days, weeks, or even months (Martin & Hofer, 2004). Yet, understanding how cognitive aging and IIV are inter-related will likely provide insight regarding processes that influence both.

As noted, a distinction has been made in the literature with regards to the different types of variation in cognitive performance observed among older adults. To further understand how different levels of intraindividual cognitive performance may relate to one another, longitudinal change across age can be further conceptualized as occurring on the macrotime scale of development, while IIV across a few days (for example) is on a microtime scale (Ram & Gerstorf, 2009). Besides indexes of IIV that provide a single calculated score of variation, other conceptualizations of microtime variation in cognitive performance have examined cognitive plasticity much in the same way that longitudinal aging is examined, by fitting growth models to multiple occasions of cognitive assessments albeit in a very short time frame (Ram et al., 2011). Using this method, longitudinal trajectories of cognitive aging (i.e. macrotime) were found to predict short-term cognitive plasticity (i.e. microtime) (Ram et al., 2011). Coupled with other work using IIV to predict cognitive aging, these results speak to a bidirectional relationship between adult cognitive development on both macrotime and microtime scales.

The larger social and economic contexts in which individuals live, characterized more broadly as SES, are important across the lifespan for various aspects of development, including cognitive performance (Boyce, 2007; Fors, Lennartsson, & Lundberg, 2009; Kaplan et al., 2001). Additionally, though a composite measure can be created from multiple indicators of SES, there is work suggesting that different aspects of SES such as education, occupation, and income each uniquely predict cognitive performance and cognitive decline in older adults (Karlamangla et al., 2009; Lee, Buring,

Cook, & Grodstein, 2006; Mortensen et al., 2014). More recently, subjective social status has been linked to physical health and functional decline in older adults (Chen, Covinsky, Cenzer, Adler, & Williams, 2012; Hu et al., 2005). Though this work has yet to examine the relation of subjective social status to cognition, it does highlight the further distinction between objective versus subjective SES measures as important to individual aging outcomes. By examining whether contextual factors of SES predictive of longitudinal, intraindividual cognitive performance and cognitive aging are also at play in microtime change for cognitive IIV, we may gain an understanding how this same factors may predict individual differences in IIV.

Study Aims

The current study assessed cognitive performance in a sample of older adults across seven days to investigate the association of subjective and objective measures of SES with intraindividual variability and individual differences in cognitive plasticity. Specifically, we evaluated the unique predictive contributions of subjective social status to indices of variability and plasticity (cf. Allaire & Marsiske, 2005; Ram et al., 2011) beyond objective measures of SES, which included level of education, occupation, and household income. Particularly, we hypothesize that beyond functioning as a self-reported composite measure of SES, subjective social status may serve as a unique measure of psychosocial vulnerability or resiliency (Cundiff et al., 2013). We hypothesized that both objective and subjective measures of SES would be associated with intraindividual variability in cognitive performance. Additionally, we predicted that both objective and subjective measures of SES would be associated with cognitive

‘plasticity’, or learning gains, over a week of daily cognitive tasks assessing memory and inductive reasoning.

Methods

Sample

A total of 67 individuals were recruited for the current study. The analysis sample for the present study includes 45 participants who completed a baseline survey questionnaire, a Burst protocol training session, and up to 7 days of the Burst protocol. The analysis sample was comprised of 15 men and 30 women, ages ranging from 60 to 83 years old (*M*=66.28, *SD*=6.02). 34 participants were recruited via the Amazon website Mechanical Turk (www.mturk.com), now widely used for human subjects research and found to be a viable source for obtaining reliable date from a relatively diverse pool of users also known as Mturk Workers who complete tasks for compensation (Buhrmester, Kwang, and Gosling, 2011; Rand, 2012). The other 11 participants were recruited as volunteers via fliers posted at local senior centers, senior living communities, and other public locations in the inland Southern California area.

For the analysis sample, the median level of education was high school graduate or equivalency (GED) diploma recipient. The reported median yearly household income was in the $20,000 to $40,000 range. As shown in Table 3.2, Mturk as compared to in-person participants did not differ significantly on mean age or mean level of education, but did differ significantly on yearly household income such that Mturk participants were higher-income compared to in-person participants. The completion rate of all 7 days of the Burst protocol was 89.13%. The remaining 10.87% completed from 2 to 6 days.

Sample Attrition. After initial recruitment, of 67 individuals who participated in the baseline questionnaire and/or training on the Burst measures, 21 participants chose not to continue with the study. One participant was excluded from the analyses due to missingness on key predictors, bringing the total sample attrition for the current study to 22. Of note, 16 of the participants that dropped from the study were initially recruited from Mturk. As determined by t-tests (results not shown), individuals providing baseline data (n=21) but not included in the study did not differ significantly on mean age, household income, education level, occupation level, self rated-health, depression, from participants included in the analyses. There was a significant mean difference on subjective social status, with individuals remaining in the study reporting on average about one level lower on the scale [$t(64)=-2.30$, $p=0.025$].

Procedure

The current study was modeled after the single-subject, repeated measures 'Burst' design, which in this case, involved an initial training day followed by a 7-day Burst week in which participants self-administered measures, including three timed cognitive tasks (Allaire & Marsiske, 2005; Ram et al., 2011). Participants were provided with an information sheet explaining the full eight-day procedure, with the option to stop participation at any time for any reason during the eight days. Participants were asked to complete a baseline survey as an assessment of participants' socioeconomic status, health, and socio-emotional functioning prior to the Burst week. Participants were also asked to complete the Burst protocol training session (before the start of the 7 days) in which participants were guided through detailed instructions on how to self-administer

and complete each measure and timed cognitive task. In addition to the cognitive tasks, each day of the Burst workbooks included a daily mood assessment (Emmons & Diener, 1985), daily measures of exercise and health (Watson, 1988), and quality of sleep questions (Buysse, Reynolds, Monk, Berman, Kupfer, 1989).

For the Mturk participants, the baseline survey, training, and the 7-day Burst tasks were all completed online via participants' accepting HITs (Human Intelligence Task) posted on Mturk, and linking to a survey website. Each participant completed at total of 9 HITs, beginning with the baseline survey, and were compensated $1.00 per completed HIT. Each day, participants were notified via Mturk that a new HIT was posted. The 7-day Burst tasks were adapted for online use from paper-pencil Daily Mental Exercise Workbooks (Allaire & Marsiske, 2005). For the training session, each task included additional, detailed text instructions modeled after the instructions that would have otherwise been provided by a proctor (as described below). Additionally, participants were provided with an email via which the main investigator could be contacted with questions or concerns. The cognitive tasks were electronically timed using a survey website timer feature. Participants were able to complete the tasks on the survey website via their own computer or tablet device.

For the in-person participants, a trained proctor guided participants through a paper-pencil workbook identical to the workbooks prepared for the 7-day Burst tasks. During training, participants listened to detailed instructions from the proctor prior to the completion of each task. In-person participants were also given a digital kitchen timer (model: Taylor Digit Timer 5842-21) and were trained on how to utilize the timer to self-

administer the 3 cognitive tasks each day. Participants were also given a phone number at which the main investigator could be contacted with questions or concerns. Additionally, participants were given the option of providing their contact information to receive a reminder to return their workbooks to the investigators prior to the end of the week. Workbooks were organized and numbered Day 1 to Day 7 and given to each participant with an instruction manual at the completion off the training session. In-person participants did not receive individual monetary compensation. However, at the conclusion of the study, a local business gift card was raffled for each recruitment site in the amount of $20. Participants who wished to be considered for the gift card provided their name and phone number on a separate form to be to be used as the raffle entry. The timer used to complete the exercises was given to the participants for their personal use after completing the study.

All participants were instructed to find a quiet place where one workbook or online HIT task could be completed per day at about the same time each day. The participants recorded the time and date they begin the workbook/task on the first page, and recorded the time and date they completed the workbook/task on the last page (this was also done by the Mturk participants on the online version). For in-person participants, completed workbooks were returned via a secure, locked drop safe at the senior centers or senior living communities, or returned via USPS in pre-stamped, pre-addressed envelopes.

Measures

Cognitive measures. Each Burst workbook contained three cognitive tasks that participants completed at training and then subsequently completed once a day over 7 days. Tasks included a list memory task (Rey, 1941), Letter Series Test (Thurstone, 1962) a measure of inductive reasoning, a measure of perceptual speed via Number Comparison (Ekstrom, French, Harman, & Derman, 1976). Eight alternate forms of the cognitive measures, for training and each day of the Burst, were provided and prepared as described in Allaire & Marsiske (2005). Table 3.1 includes cognitive task descriptions, abridged task instructions, and example items for each task. As previously described, all tasks were self-administered by participants after completing training either via an online task or with an in-person proctor. For regression and growth curve analyses, total scores on each task were rescaled to percent correct to aid in interpretation.

Socioeconomic status measures. Measures of objective SES included level of education, household income level, and Hollingshead occupational prestige ratings. Level of education was assessed using a 7-point scale (0=Elementary school; 1=Middle school; 2=High school Diploma or (GED); 3=some college, community college, or other secondary school; 4=Bachelor's degree; 5=Masters/MBA; 6=Ph.D., M.D., law degree). Household income was assessed using the following 6 income brackets: (Less than $10,000); ($10,000 to $20,000); ($20,000 to $40,000); ($40,000 to $60,000); ($60,000-$80,000); and ($80,000 or more). Participants provided descriptions of their main occupation for the main part of their life, which were then scored based on Hollingshead occupational scale (Hollingshead, 1975). Occupations were rated from 1 to 9 based on

the Hollingshead scoring using 1970s census coding, with a score of 9 indicating the highest ranked occupations. Occupational scores in the current sample ranges from 0 (for housewife) to 9, with a median score of 6 (*SD*=2.27).

The MacArthur Scale of Subjective Social Status was used as a measure of subjective SES (Adler et al., 2000). Participants were asked to endorse his or her level in society along the image of a 10-rung ladder, with the top of the ladder representing the most well-off individuals in society and the bottom of the ladder representing the most impoverished (Operario, Adler, & Williams, 2004). This measure has demonstrated construct validity with related measures (Cundiff, Smith, Uchino, & Berg, 2013) and adequate test-retest reliability (Operario, Adler, and Williams, 2004). Participants reported SubjSS on a range of 1 to 8, with the median SubjSS of 4 (*SD*=1.93). As reported in Table 3.2, Mturk participants and in-person participants did not significantly differ on reported SubjSS. All socioeconomic status measures were centered at their median value for regression and growth curve analyses.

Covariates. Participants reported on physical and mental health measures to account for possible mediation of SES effects on cognitive performance. Participants reported height (in inches) and weight (in pounds) that was then used to calculate Body Mass Index (BMI; *M*=28.03*, SD*=7.45). BMI was centered at 25 for analyses to reflect healthy BMI as the reference. A self-rated health (SRH) scale was used to assess health using three questions regarding health status (Svedberg et al., 2005). Individuals used a 3-point scale (i.e. 1=bad, 2=reasonable, 3=good) to rate their own current health, their current health compared to their health five years prior, their own health compared to

peers, and whether their health status impedes their activities. Higher ratings on the items reflect a favorable SRH status. Responses to each item were standardized then summed to create a SRH score. Most participants endorsed a positive SRH, and due to negative skew, scores were reflected and square-rooted (Tabachnick and Fidell, 2007). The transformed SRH scores range from 1.00 to 3.72 (*M*=2.20, *SD*=0.63). SRH was centered at the mean for analyses.

The Center for Epidemiological Studies Depression Scale (CES-D Scale) was used to measure depressive symptomatology in participants. The 20-item scale has been shown as suitable for use with the general population, and similar reliability scores have been found across subgroups, including differing education levels, both sexes, and Black and White individuals (Radloff, 1977). An individual endorsed on a 20-item list how he or she has felt or behaved in the past week, with four options ranging from 0="Rarely or None of the Time (Less than 1 Day)" to 3="Most or All of the Time (5-7 Days)". Positive direction items were reverse scored, and all items were summed, with higher scores indicating higher depressive symptomology. Mturk and in-person participants did not differ significantly from each other on depression scores (pooled *M*=16.56, *SD*=13.25), though overall the sample may be characterized as higher than average score on the CESD, with an average total score about 2 fold higher than other US samples (e.g., Sutin et al., 2013). CESD scores were centered at 12, which is of subclinical relevance (note that 16 and above is of clinical relevance for community dwelling elderly; Lewinsohn et al., 1997).

Analytical Approach

Mean Cognitive Performance: Each participant's mean cognitive performance across the 7-day Burst week was calculated for each cognitive task. This was done by summing available cognitive scores and dividing by the number of measurements occasions (days) completed by each participant over the 7 days. Table 3.2 shows the t-tests for Mturk versus in-person mean performance differences on the cognitive tasks, showing no statistically significant differences in mean performance for List Memory and Letter Series. Though the mean differences between the two participant subsamples was only trend significant for Number Comparisons, no further analyses were conducted with this task. Specifically, simple examination of the differences in mean performance and variances that differed in direction from the other two tasks, with the (higher income) Mechanical Turk participants showing poorer performance and smaller variance, led to the conclusion that the task may have been more difficult to perform on screen than with paper and pencil.

Intraindividual variability (IRI): To obtain a measure of within-person variability for cognitive performance across the 7-day Burst assessment, Proc MIXED in SAS 9.3 (SAS Institute, Cary, NC) was used to fit growth curve models and obtain Empirical Bayes estimates of individual intercept (centered on day 3 of the Burst week), linear slope (day), and quadratic (day^2) effects for each person's cognitive performance across the 7-day Burst tasks, adjusted for age centered at 60 (for the minimum age requirement for participants). Each person's predicted cognitive scores (based on the model estimates) were then subtracted from their observed score for each day of measurement to

obtain the residual scores. For each participant, the residuals scores were squared then summed across the week. This squared-summed residual was then divided by the number of occasions (days) the individual completed the cognitive task. Finally, the resulting mean squared residual for each person was square-rooted to obtain the IRI score (cf. Allaire & Marsiske, 2005).

To determine if objective and subjective SES measures predicted intraindividual variability as quantified by the IRI scores, a series of regression analyses were done in Proc REG in SAS 9.3 for each cognitive task. Models were fit as follows: Model 1 regressed SubjSS on the IRI score, controlling for age and sex effects. Model 2 added level of education, level of household income, and occupational level as objective measures of SES to the regression. Finally, for exploratory purposes given we reached a limit of ratio of sample size to predictors of 5:1 (i.e., 45:9), Model 3 added BMI, SRH, and CESD to consider possible mediation of physical and mental well-being effects on intraindividual variability that may account for observed associations between SES and IRI.

Plasticity: To assess individual cognitive 'plasticity' or gains across the 7-day Burst week, growth curve analyses were fit to individuals' cognitive performance scores across the week, using SAS Proc Mixed 9.3 with full maximum likelihood option, to assess level of performance (centered on day 3), linear slope (day), and rate of change (day^2) (see Ram et al., 2011). Unconditional growth models were fit separately for each cognitive task to determine if a quadratic model fit the data better than a linear and a linear better than a model of no change. Chi-square difference tests were performed on

the deviances statistics of the nested growth models with the difference in the number of parameters reflecting the improvement in fit (Singer & Willet, 2003). As models were centered on day 3, the intercept of the model can be interpreted as cognitive performance on the third day of the Burst week.

To assess whether objective and subjective SES measures predicted individual cognitive plasticity across a week (and to mirror the theoretical approach with the regression analyses), predictors were entered to into the model for each cognitive task as follows: The unconditional model included the intercept term (day 3), linear term (day), and in the case of Letter Series, the quadratic term (day^2). To control for sex and age effects, these were entered on each term on Model 1. For Model 2, median-centered SubjSS was entered as a subjective SES predictor on each term. Model 3 level of education, level of household income, and occupational level as objective measures of SES to each term. Finally, Model 4 added BMI, SRH, and CESD to control for possible effects of physical and mental health effects on cognitive performance that may mediate the relationship between SES and cognitive plasticity.

Results

Cognitive Performance Trajectories

Individual plots of participant performance for the cognitive tasks, List Memory and Letter Series, are shown in Figures 3.1-3.2. Overall individuals showed gains in performance across the week, but with variability across the days. For both tasks, unconditional growth curve analyses determined that at least a model of linear growth was superior to a model suggesting no change (both $p < .0022$). Moreover, for Letter

Series, a quadratic model fit the data significantly better than a linear model ($\Delta\chi^2$ (4) = 21.81, $p < .00022$): on average, day3 performance was at 52.30% correct, the linear increase on day3 was 2.54%, while the quadratic rate suggested a deceleration in gains of -0.64% across days (see Table 3.3). For the List Memory, the quadratic term was not significant ($\Delta\chi^2$ (4) = 0.94, $p > .91$) and hence the linear model was retained (see Table 3.3): on average, day3 performance was at 58.42% correct and the daily linear increase in performance was 1.02% across days. The random effects on growth parameters were non-zero though not individually significant; the linear variance term for List Memory was at trend ($p < .10$). We proceeded given the terms were non-zero, but note caution with respect to plasticity analyses.

SES associations with intraindividual variability and plasticity

The purpose of the current study was to assess the association of objective and subjective measures of SES with intraindividual variability and plasticity on cognitive tasks. Particular interest was taken in examining the association of SubjSS on cognitive outcomes, and as such, each set of regression and growth curve analyses modeled this association after controlling for initial age and sex effects but prior to entering objective SES and physical and mental health indicators to determine the unique contribution of SubjSES to cognitive outcomes, then determine if the relationship remained after entering subsequent predictors.

SES & Variability. Table 3.4 shows the correlations between the individual residual index (IRI) for each cognitive task and measures of cognitive performance across the week. Additionally, the table also includes the analyses for correlations of the IRI

score with the predictors entered into the regression analyses. Mean performance across the week was negatively correlated with the IRI score, such that individuals with higher IRI had lower mean performance for List memory (r = -0.43, p=.003) and similarly for Letter Series (r = -0.24, p=*.108*) although not statistically significant. We also show, for comparison, the correlations of IRI measures with the Empirical Bayes estimates of intercept, indicating performance level on day3, and change slopes indicative of plasticity. The correlations of the respective IRI measures with the intercepts are reduced compared to mean performance levels given that IRI is calculated from the residuals of a fitted growth model.

Age was positively associated with IRI for both List Memory (r=0.85, p<.001) and Letter Series (r=0.62, p<.001) such that older individuals showed more variability on cognitive performance. SubjSS was positively correlated with IRI for List Memory (r=0.32, p=.031) and at trend with Letter Series (r=0.28, p=.061) such that individuals with a higher SubjSS showed more variability on cognitive performance across the Burst week. These respective correlations are comparable to the association between the two IRI indices among List Memory and Letter Series (r=0.27, p<.08; See Appendix Table A2) For List Memory, occupational level showed small negative associations with IRI (r=-0.21, p=.16) suggesting that individuals with higher occupational status showed less IRI, though this association was not statistically significant. For Letter Series, educational level (r=0.17, p=.26) and household income level (r=0.23, p=.121) were both positively associated with IRI, suggesting individuals with higher levels of both objective SES measures exhibited higher IRI on the task, though the associations were not statistically

significant. These correlational associations may speak to a complex relationship between SES indicators and cognitive intraindividual variability outcomes. Hence, while SES indicators are small to moderately positively correlated (see Appendix Table A2), associations of occupational level with IRI show a negative trend, while for SubjSS the associations with IRI show positive trends. Indeed, Occupation and SubjSS show the lowest correlation among the SES indices (r = 0.16, *p*=.31).

Table 3.5 shows the regression results for List Memory. In Model 1, age and sex were significant predictors of the IRI score, with older individuals and women showing more variability in List Memory performance. The predictor of interest, SubjSS, was a significant predictor of IRI for memory as well, B=0.52 (*se*=0.26, *p*=.045) with a partial $R^2 = 0.024$, with individuals above the median SubjSS showing greater variability in List Memory performance. For Model 2, household income level and occupational level did not significantly predict variation in the IRI score, and education level showed a trend association, B=0.95 (*se*=0.50, *p*=.066). As shown Table 3.4, including objective measures of SES resulted in the association between SubjSS and List Memory IRI to go to trend significance, B=0.55 (*se*=0.32, *p*=.093). For Model 3, the measures of physical and mental health did not significantly predict variation in the IRI score and the indeed the adjusted R^2 was not improved.

Table 3.6 shows the regression results for Letter Series. In Model 1, age was a significant predictor of the IRI score, with older individuals showing more variability on the Letter Series performance. The predictor of interest, SubjSS, was associated with Letter Series IRI such that individuals with higher than median level SubjSS showed

greater variability, though this relationship was not statistically significant (*p*=.235). For Model 2, educational level had a trend association with Letter Series IRI such that individuals above median education level (i.e. some college or post high school training) showed more variation in performance B=0.81(*se*=0.42, *p*=.063). For Model 3, physical and mental health measures were not significantly associated with Letter Series IRI. But of note, the addition of these predictors led to the association between household income and IRI to becoming statistically significant, such that those with household incomes above the median predicted greater variability of performance on the Letter Series task, B=0.74 (*se*=0.35, *p*=.044).

SES & Plasticity. Table 3.7 shows the fixed effects for each of the models fit in the cognitive plasticity growth curve analyses for List Memory. The List Memory model intercept was centered on day 3 performances and included a linear term (day). For Model 1 and Model 2, the main predictor of intercept was age, with older adults performing at lower levels for memory with Model 2 showing a -1.15% change in cognitive score per every year change in age (*p*=.005). The linear term (day) became non-significant when including age in the model. In Model 4, CESD was a significant predictor of level, with the fixed effect showing a -0.58% decrease in performance level per unit increase in CESD (*p*=.001). Measures of SES were not found to be significant predictors of cognitive plasticity for List Memory. Overall, the best-fitting model as supported by fit indices was Model 1, including age and sex, which improved the fit over the unconditional model [$\Delta\chi^2(4) = 10.3$, $p = .0356$].

Table 3.8 shows the fixed effects for each of the models fit in the cognitive plasticity growth curve analyses for Letter Series. The model for Letter Series was centered on day 3, and included both the linear term (day) and quadratic term (day^2) in the analyses. Neither age, sex, nor SubjSS significantly predicted plasticity when entered into Models 1 and 2 respectively. Model 3 shows a significant effect of household income level on the linear term (day) such that individuals gained 0.66% on performance per unit change in education above the median level (p=.038). Model 4 shows no statistically significant predictors on the intercept, on the linear term, or for quadratic change. As shown in Table 3.8, a few indicators of SES do show trend significance as predictors of level and change for List Series cognitive plasticity, and inability to identify predictors of level and change may be related to sample size. Consistent with this, the best-fitting model as supported by fit indices, was the unconditional model.

Discussion

The current study assessed cognitive performance in 45 older adults over 7 days to investigate the association of subjective and objective measures of SES with intraindividual variability and individual differences in cognitive plasticity. Specifically, we evaluated the unique predictive contributions of subjective social status to short-term cognitive outcomes beyond objective measures of SES, which included level of education, occupation, and household income. In addition to functioning as a self-reported composite measure of SES, subjective social status seems to be a unique measure of psychosocial vulnerability or resiliency (Cundiff et al., 2013). We hypothesized that both objective and subjective measures of SES would be associated

with intraindividual variability in cognitive performance. Additionally, we predicted that both objective and subjective measures of SES would be associated with cognitive 'plasticity', or learning gains, over 7 days of cognitive tasks assessing memory and inductive reasoning, the latter which can be characterized as a 'fluid' measure of intelligence (Cattell, 1963; Horn & Cattell, 1966).

Initial analyses examining the correlations between cognitive outcomes and key predictors of SES indicate complex relationships among individual characteristics in short-term cognitive functioning, age, and SES. For both memory performance and inductive reasoning, intraindividual variability (IRI) was negatively correlated with mean performance across the week, suggesting that more variation in cognitive performance over the week was associated with a lower level of overall performance. This would suggest evidence of 'maladaptive' intraindividual variability (IIV) as it is associated with lower performance (Allaire & Marsiske, 2005; Li et al., 2004). This negative association, particularly for inductive reasoning, is inconsistent with reported correlations for these tasks in Allaire & Marsiske (2005). In their study, in the first 30 days of their 60-day study the associations were positive and significant between mean performance and intraindividual variability (i.e. IRI); however, after 30 days for Letters Series the correlations reversed and became negative in the last 30 days of the study, albeit non-significantly. Hence, variability in performance initially was a benefit but after appreciable experience with the task variability was a detriment. Our study followed individuals across 7 not 60 days, however, it suggests that length of exposure may moderate associations between performance and variability. Notably, participants in the

Allaire & Marsiske (2005) study were exposed to 14 different (randomly assigned) alternate forms across the 60-day period of testing whereas our participants were exposed to 7 unique alternate forms across the 7-day burst.

In the current study intraindividual variability was moderately to strongly correlated with age for both memory performance and inductive reasoning such that older adults showed greater variability in performance across the week. This finding is broadly consistent with previous work indicating that intraindividual variability is positively associated with age and is an important marker of cognitive aging (MacDonald, Hultsch, and Dixon, 2003). For memory performance, intraindividual variability was found to be positively associated with subjective social status, suggesting that individuals with higher subjective social status exhibited more variability in cognitive performance. Regression analyses indicated that subjective SES significantly predicted intraindividual variability after controlling for age effects, such that individuals with higher than median subjective social status exhibited more variation in performance on List Memory across the week. Though this association became trend with the inclusion of objective measures of SES, education also showed a similar trend association with intraindividual variability. These results seem to hint that level of SES may be predictive of intraindividual variability in memory performance for older adults.

For inductive reasoning, intraindividual variability was found to be positively associated with both objective and subjective measures of SES. Income and education both predicted greater variability in memory performance across the week, though associations were not statistically significant. Subjective SES showed a similar

association, with trend significance. Regression analyses indicated that subjective social status did not predict intraindividual variability after controlling for the effects of age. Household income level emerged as a significant predictor of short-term variability in inductive reasoning after including level of education in the model and controlling for BMI, self-rated health, and depressive symptoms. These results seem to indicate that higher than median level of household income, controlling for all other SES indices covariates and mediators, is predictive of higher variability in cognitive performance.

Growth models were used to evaluate whether subjective and objective measures of SES predicted cognitive plasticity, or gains in scores across the week, for both memory performance and inductive reasoning. Though a predictive association has been found between cognitive plasticity on older adult's later cognitive trajectories (Ram et al., 2011), these cognitive plasticity characteristics have been largely unexamined with regards to possible predictors. For memory performance, growth curve models suggested a slight linear increase in individual performance scores across the week. For inductive reasoning, growth curve models suggested a quadratic trend in performance. Neither objective nor subjective measures of SES were able to significantly predict cognitive plasticity in the current analyses based on model fit indices, though the final model suggested possible trend significance of SES indicators with level of performance and change for inductive reasoning.

There were important limitations to the current study. Even when associations were observed between SES measures and intraindividual variability, conclusions are difficult to make due to most results being trend or non-significant, which may have been

partly due to the current small sample size of the study. Additionally, small sample size may have contributed to the null findings regarding the association between SES and cognitive plasticity, as there were relatively few individuals providing data relative to the number of key predictors included in the growth models. Additionally, individuals who dropped from the study were more likely to report higher subjective social status at baseline assessment, and as these individuals did not differ significantly on level of education and level of income, it is likely that important variation in subjective social status was truncated due to attrition. Last, we note that the analysis sample demonstrated a high average level of depressed symptoms compared to population-based samples (Sutin et al., 2013), and could moderate variability and plasticity in cognitive performance and alter associations with SES indices. Adjusting for depressive symptoms did not seem, however, to alter observed associations, by and large, but sample size limited further explorations of moderation.

We were able to successfully launch the daily cognitive burst measures on an online platform, for the first time, for memory and reasoning tasks. However, the processing speed task did not translate to the online context in the manner expected. SES indices tended to be higher in the Mechanical Turk participants, particularly income, yet they showed poorer average performance on the Number Comparisons task and smaller variance compared to in-person participants. Further examinations of this task as performed online and in-person are warranted.

Summary and Conclusions

Day-to-day environmental context is likely important to older adults' cognitive functioning. As socioeconomic status (SES) has been found to predict cognitive trajectories across age, the current study sought to examine whether these same environmental factors had evident concurrent effects on day-to-day variations in cognitive performance as well. We found positive correlational and predictive associations between subjective social status and intraindividual variability in memory performance. Additionally, level of income was predictive of intraindividual variability in inductive reasoning. As the literature indicates that higher variability can signal either adaptive or maladaptive processes, conclusions regarding the implications of these associations are difficult to make due to the negative association of intraindividual variability with mean level of performance and the positive association of intraindividual variability with age. For now, the current study seems to indicate that individual level predictors such as subjective and objective levels of SES may be able to predict individual difference sin short-term measures of cognitive performance. Further studies should evaluate these associations using either larger sample sizes or more occasions of measurement. Additionally, future studies should also examine the association of SES indicators with intraindividual variability across a wider array of cognitive tasks to assess any differences in these associations between 'fluid' versus 'crystallized' intelligence.

Table 3.1

Sample Items from cognitive tasks included in the Burst Daily Mental Exercise Workbooks

Task	Description of Task	Abridged Instructions	Example Item
List Memory from Rey's Auditory Verbal Learning Task (Rey, 1941)	A list of 15 common words is given for one-minute study, followed by one-minute recall.	Study the list of words. (15 common words presented such as radio, dog, bucket, etc.)	Write down as many words as you can remember. _____ _____
Letter Series Test (Thurstone, 1962)	A 90-second task to compare number strings ranging from three to thirteen digits in length, indicating which items are a match.	Select the letter that comes next in the series of letters.	1) b b c d d e f f g h h Options: b d g h i
Number Comparison Test (Ekstrom et al., 1976)	A 4-minute task to complete as many alphabetic pattern series as possible, with thirty items total.	Put an X on the line between the numbers that are **not** the same.	8383679 _____ 8384679 412 _____ 412 17634 _____ 17624

Table 3.2

T-tests for mean differences on Predictors and Mean Task Cognitive Performances by Participant Subsamples

	In-Person (N=11)		Mechanical Turk (N=34)				
Variable	*M*	*SD*	*M*	*SD*	*t*	df	*p*
Age	66.92	5.77	66.07	6.17	0.41	43	0.69
Subjective Social Status	4.27	1.49	4.74	2.06	-0.69	43	0.50
Education Level	3.18	0.75	3.53	1.19	-0.91	43	0.37
Household Income Level	1.55	1.57	2.85	1.33	-2.71	43	0.01
Occupation Level	5.09	1.87	5.91	2.38	-1.04	43	0.30
BMI	29.96	5.33	27.41	7.98	0.99	43	0.33
Self-Rated Health	-0.59	3.49	0.33	2.76	-0.90	43	0.37
CESD	19.27	12.67	15.68	13.50	0.78	43	0.44
List Memory	8.92	2.38	8.86	2.61	0.07	43	0.95
Letter Series	12.37	4.63	16.39	6.80	-1.82	43	0.08
Number Comparison	18.72	7.07	14.31	3.14	2.00	11.31	0.07 [S]

[S] Satterthwaite t value reported due to heterogeneity of variances ($p < .0004$).

Table 3.3

Parameters (se) from Best-Fitting Unconditional Growth Model

Fixed Effects	List Memory		Letter Series	
Intercept (performance on day3)	58.42 (2.47)	**	52.30 (3.16)	**
Linear (day-3)	1.02 (0.33)	**	2.54 (-0.64)	**
Quadratic $(\text{day-3})^2$	--		-0.64 (0.14)	**
Radom Effects				
σ^2_I	257.8 (58.08)	**	429.14 (94.94)	**
σ^2_L	1.32 (1.03)	†	1.12 (1.53)	
σ^2_Q	--		0.02 (0.2)	
$\sigma_{I,S}$	-.16 (5.40)		13.24 (8.57)	
$\sigma_{I,Q}$	--		-1.17 (2.95)	
σ_{LQ}	--		0.01 (0.46)	
$\sigma_{Residual}$	89.69 (8.7)	**	65.75 (7.11)	**
N Observations	301		301	

Note. I = intercept, L = linear slope, Q = Quadratic.
** $p < .01$ * $p < .05$ † $p < .10$

Table 3.4

Correlations with individual residual index (IRI) by task

	List Memory IRI	Letter Series IRI
Mean Performance	-0.43 **	-0.24
Intercept[P]	-0.11	-0.13
Linear Change[P]	0.01	0.01
Quadratic Change[P]	-	0.14
Age	0.85 **	0.62 **
Education Level	0.01	0.17
Household Income Level	0.01	0.23
Occupation Level	-0.21	-0.09
Subjective Social Status	0.32 *	0.28 †
BMI	-0.11	-0.24
Self-Rated Health	0.15	-0.09
CESD	-0.06	-0.10

[P] Empirical Bayes (EB) estimates from plasticity growth curve analyses
** $p < .01$ * $p < .05$ † $p < .10$

Table 3.5

List Memory: B (se) for SES and covariates predicting short-term variability (IRI) over 7-day Burst

Fixed Effects	Model 1		Model 2		Model 3	
Intercept Term	4.98 (0.72)	**	4.38 (0.82)	**	4.60 (0.93)	**
Age	0.89 (0.08)	**	0.89 (0.08)	**	0.88 (0.09)	**
Sex	2.32 (1.02)	*	2.97 (1.04)	**	3.08 (1.11)	**
Subjective Social Status	0.53 (0.26)	*	0.55 (0.32)	†	0.57 (0.35)	
Household Income Level	-		-0.34 (0.40)		-0.43 (0.45)	
Education Level	-		0.95 (0.50)	†	0.97 (0.53)	†
Occupation Level	-		-0.29 (0.23)		-0.28 (0.24)	
BMI	-		-		-0.01 (0.07)	
Self-Rated Health	-		-		0.35 (0.94)	
CESD	-		-		-0.02(0.04)	
Total R^2	0.77		0.80		0.80	
Adjusted R^2	0.75		0.77		0.75	
SubjSS Semi-Partial r^2	0.024	*	0.023	†	0.024	

Note. IRI = Intraindividual residual index
**p < .01 * p < .05 † p < .10

Table 3.6

Letter Series: B (se) for SES and covariates predicting short-term variability (IRI) over 7-day Burst

Fixed Effects	Model 1	Model 2	Model 3
Intercept Term	6.94 (0.62) **	6.10 (0.69) **	6.17 (0.73) **
Age	0.33 (0.07) **	0.37 (0.07) **	0.40 (0.07) **
Sex	-0.05 (0.87)	0.35 (0.87)	-0.19 (0.87)
Subjective Social Status	0.25 (0.22)	-0.13 (0.27)	-0.33 (0.28)
Household Income Level	-	0.56 (0.34)	0.74 (0.35) *
Education Level	-	0.81 (0.42) †	0.63 (0.41)
Occupation Level	-	-0.16 (0.20)	-0.20 (0.19)
BMI	-	-	-0.07 (0.06)
Self-Rated Health	-	-	-1.20 (0.74)
CESD	-	-	0.02 (0.03)
Total R^2	0.41	0.49	0.56
Adjusted R^2	0.36	0.41	0.45
SubjSS Semi-Partial r^2	0.021	0.021	0.021

Note. IRI = Intraindividual residual index
**p < .01 * p < .05 † p < .10

Table 3.7

List Memory: Estimated Fixed Effects (se) for Plasticity over 7-day Burst

Fixed Effects	Unconditional Model	Model 1	Model 2	Model 3	Model 4
Effects on Intercept					
Intercept Term (Day 3)	58.42 (2.47) **	64.59 (3.41) **	64.34 (3.40) **	63.09 (3.80) **	64.35 (3.62) **
Age	-	-1.09 (0.38) **	-1.15 (0.38) **	-0.91 (0.39) *	-0.68 (0.36) †
Sex	-	4.07 (4.78)	4.53 (4.78)	4.48 (4.80)	4.68 (4.32)
Subjective Social Status	-	-	0.90 (1.21)	-0.48 (1.49)	-1.29 (1.38)
Household Income Level	-	-	-	1.50 (1.87)	-0.51 (1.76)
Education Level	-	-	-	1.73 (2.32)	1.81 (2.05)
Occupation Level	-	-	-	1.11 (1.09)	1.18 (0.95)
BMI	-	-	-	-	0.47 (0.28)
Self-Rated Health	-	-	-	-	-5.89 (3.64)
CESD	-	-	-	-	-0.58 (0.17) **
Effects on Linear Change					
Linear term (Day3)	1.02 (0.33) **	0.63 (0.49)	0.63 (0.49)	0.11 (0.53)	0.13 (0.57)
Age	-	0.04 (0.05)	0.04 (0.05)	0.04 (0.05)	0.01 (0.06)
Sex	-	0.76 (0.68)	0.75 (0.69)	1.03 (0.68)	1.15 (0.68)
Subjective Social Status	-	-	-0.01 (0.18)	-0.23 (0.21)	-0.13 (0.22)
Household Income Level	-	-	-	0.47 (0.26) †	0.50 (0.28) †
Education Level	-	-	-	0.33 (0.33)	0.35 (0.33)
Occupation Level	-	-	-	-0.33 (0.16) *	-0.31(0.15) *
BMI	-	-	-	-	-0.01 (0.04)
Self-Rated Health	-	-	-	-	0.75 (0.59)
CESD	-	-	-	-	0.02 (0.03)

Fixed Effects	Unconditional Model	Model 1	Model 2	Model 3	Model 4
Fit Statistics					
-2 Log Likelihood	2356.5	2346.2	2345.6	2335.9	2321.5
AIC	2368.5	2366.2	2369.6	2371.9	2369.5
AICC	2368.8	2367.0	2370.7	2374.4	2373.9
BIC	2379.3	2384.3	2391.3	2404.5	2412.9

** $p < .01$ * $p < .05$ † $p < .10$

Table 3.8

Letter Series: Estimated Fixed Effects (se) for Plasticity over 7-day Burst

Fixed Effects	Unconditional Model	Model 1	Model 2	Model 3	Model 4
Effects on Intercept					
Intercept Term (Day3)	52.30 (3.16) **	57.71 (4.70) **	58.20 (4.66) **	56.16 (5.30) **	59.90 (5.38) **
Age	-	-0.80 (0.52)	-0.67 (0.53)	-0.53 (0.54)	-0.37 (0.53)
Sex	-	-2.70 (6.57)	-3.60 (6.55)	-3.37 (6.68)	-2.64 (6.43)
Subjective Social Status	-	-	-1.83 (1.66)	-3.41 (2.08)	-4.16 (2.05) †
Household Income Level	-	-	-	3.14 (2.60)	0.04 (1.41)
Education Level	-	-	-	0.99 (3.23)	1.16 (3.05)
Occupation Level	-	-	-	-0.08 (1.52)	0.04 (1.41)
BMI	-	-	-	-	0.28 (0.42)
Self-Rated Health	-	-	-	-	-3.66 (5.42)
CESD	-	-	-	-	0.68 (0.25) **
Effects on Linear Change					
Linear term (Day-3)	2.54 (-0.64) **	3.19 (0.57) **	3.22 (0.58) **	2.95 (0.65) **	3.00 (0.71) **
Age	-	-0.09 (0.06)	-0.08 (0.06)	-0.06 (0.07)	-0.04 (0.07)
Sex	-	-0.73 (0.81)	-0.80 (0.82)	-0.85 (0.82)	-1.08 (0.85)
Subjective Social Status	-	-	-0.12 (0.21)	-0.38 (0.26)	-0.50 (0.27) †
Household Income Level	-	-	-	0.66 (0.32) *	-0.66 (0.35) †
Education Level	-	-	-	-0.06 (0.40)	-0.13 (0.41)
Occupation Level	-	-	-	-0.03 (0.19)	-0.05 (0.19)
BMI	-	-	-	-	-0.002 (0.06)
Self-Rated Health	-	-	-	-	-0.79 (0.72)
CESD	-	-	-	-	-0.01 (0.03)

Fixed Effects	Unconditional Model	Model 1	Model 2	Model 3	Model 4
Effects on Quadratic Change					
Quadratic term (Day-3)^2	-0.64 (0.14) **	-0.86 (0.20)	-0.84 (0.21) **	-0.88 (0.24) **	-0.80 (0.26) **
Age	-	0.03 (0.02)	0.03 (0.02)	0.04 (0.02)	0.02 (0.03)
Sex	-	0.25 (0.29)	0.22 (0.29)	0.32 (0.30)	0.45 (0.31)
Subjective Social Status	-	-	-0.04 (0.07)	-0.01 (0.09)	0.05 (0.10)
Household Income Level	-	-	-	-0.20 (0.12) †	-0.25 (0.13) †
Education Level	-	-	-	0.19 (0.15)	0.22 (0.15)
Occupation Level	-	-	-	0.02 (0.07)	0.04 (0.07)
BMI	-	-	-	-	0.01 (0.02)
Self-Rated Health	-	-	-	-	0.49 (0.26) †
CESD	-	-	-	-	-0.01 (0.01)
Fit Statistics					
-2 Log Likelihood	2299.4	2295.2	2292.3	2284.0	2277.2
AIC	2319.4	2325.2	2328.3	2338.0	2343.2
AICC	2320.1	2326.9	2330.7	2343.6	2351.6
BIC	2337.4	2352.3	2360.8	2386.8	2402.8

** $p < .01$ * $p < .05$ † $p < .10$

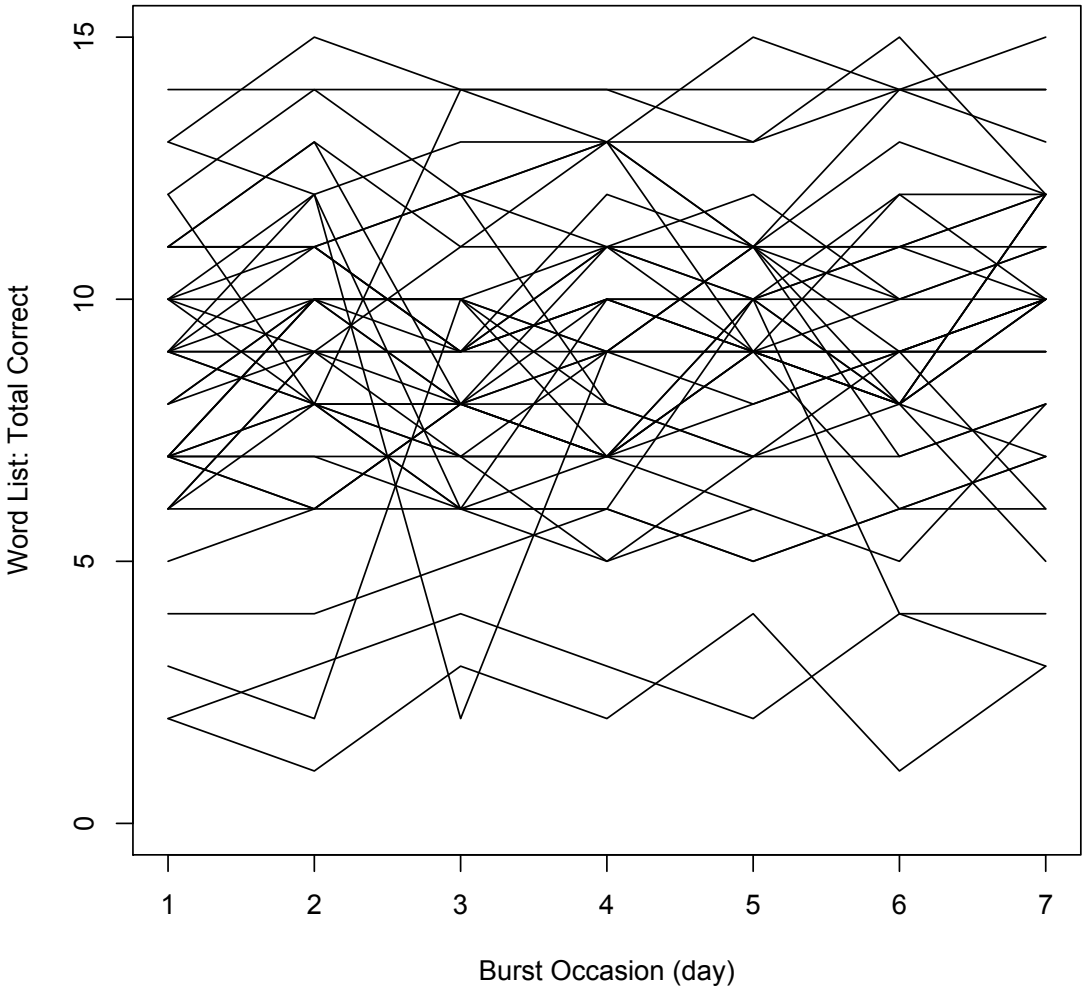

Figure 3.1. Individual performance on List Memory (N=45)

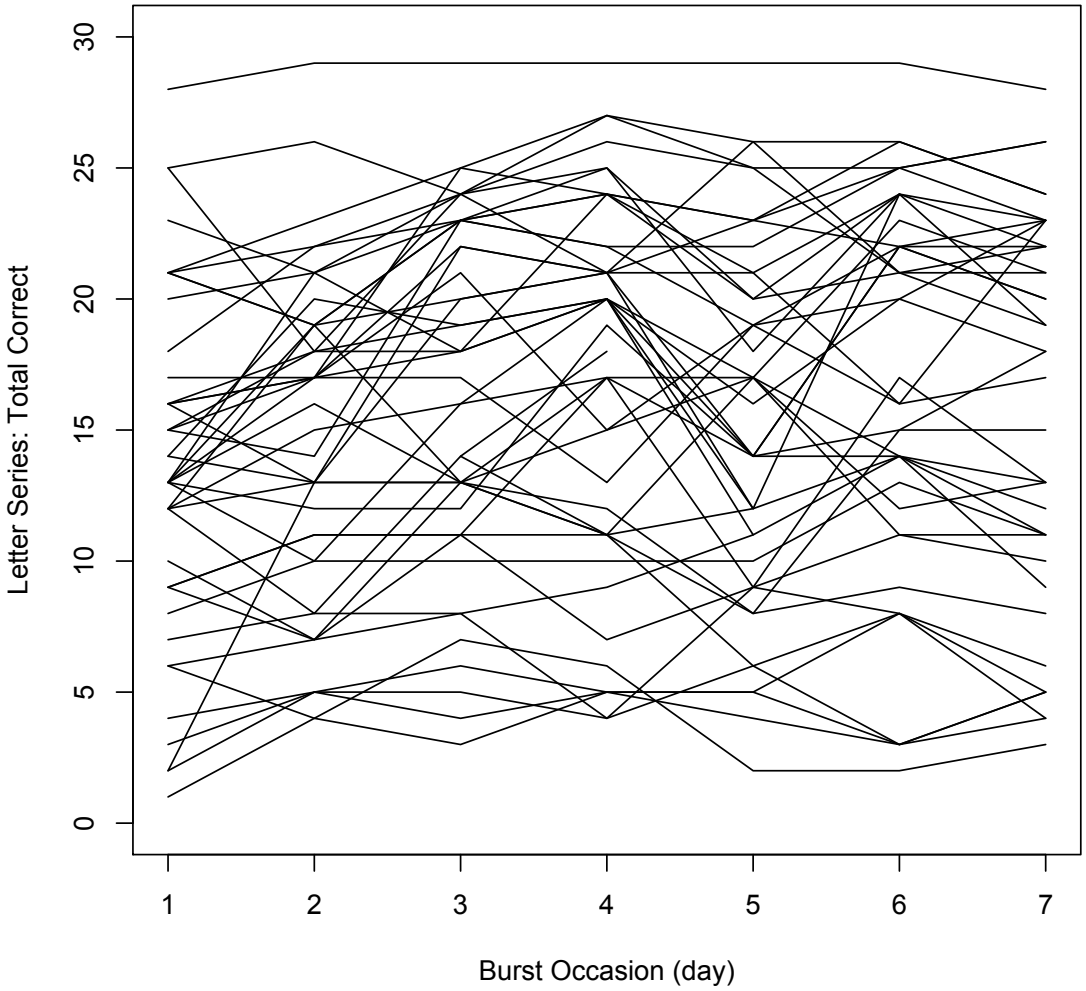

Figure 3.2. Individual performance on Letter Series (N=45)

Appendix

Table A1

Correlations across tasks: Individual residual index (IRI), Empirical Bayes estimates of plasticity, and mean performance

	Letter Series					List Memory			
	IRI	Intercept^P	Linear Change^P	Quadratic Change^P	Mean Performance	IRI	Intercept^P	Linear Change^P	Mean Performance
Letter Series									
IRI	1								
Intercept^P	-0.14	1							
p	0.35								
Linear Change^P	0.07	0.80	1						
p	0.66	<.0001							
Quadratic Change^P	0.16	-0.61	-0.07	1					
p	0.31	<.0001	0.67						
Mean Performance	-0.15	1.00	0.81	-0.60	1				
p	0.32	<.0001	<.0001	<.0001					
List Memory									
IRI	0.27	-0.13	-0.05	0.23	-0.14	1			
p	0.08	0.39	0.75	0.14	0.37				
Intercept^P	-0.01	0.32	0.27	-0.19	0.32	-0.21	1		
p	0.96	0.04	0.08	0.21	0.03	0.18			
Linear Change^P	0.10	-0.42	-0.31	0.28	-0.42	0.06	0.05	1	
p	0.53	0.00	0.04	0.07	0.00	0.68	0.72		
Mean Performance	-0.02	0.32	0.27	-0.19	0.33	-0.20	0.99	0.06	1
p	0.88	0.03	0.08	0.21	0.03	0.19	<.0001	0.68	

Note. IRI = Intraindividual residual index.

Table A2

Correlations among SES measures

Measure	Education	Income	Occupation
Income	0.28†		
Occupation	0.31*	0.35*	
SubjSS	0.37*	0.56**	0.16

** $p < .01$ * $p < .05$ † $p < .10$

GENERAL DISCUSSION

Throughout our lives, we as individuals are embedded in a greater societal context via which we experience both proximal and distal factors that are salient to individual developmental outcomes, including cognition. Theoretical approaches and empirical evidence suggest that the relevance of environmental context to individual cognitive outcomes is a lifespan process, operating on both micro and macro timescales (Baltes, Staudinger, & Lindenberger, 1999; Bronfenbrenner, 2006; Elder, 1998). Though such methodological considerations have been deemed important to understanding micro and macro cognitive developmental processes in the child development literature (e.g., Siegler, 2007; Siegler & Crowley, 1991), more recent work in cognitive aging has noted the importance of including both time scales in on-going developmental studies of older adults as well (e.g., MacDonald et al., 2003; Ram et al., 2011). As such, the influence of socioeconomic status (SES) on cognitive functioning is likely a complex, lifespan process. The primary purpose of this dissertation was to examine the differential impacts of objective and subjective socioeconomic status on aging individuals' cognitive performance in daily life and across late life. Within the dissertation, two studies examined the following research questions:

- Will subjective aspects of SES inform us above and beyond objective measures of SES socio-emotional wellbeing, and health as to the impact of economic adversity on aging adults' longitudinal, late-life cognitive aging?

- Will subjective aspects of SES inform us above and beyond objective measures of SES, socio-emotional wellbeing, and health as to the impact of economic

adversity on aging adults' daily variability (plasticity and vulnerability) in cognitive functioning?

As presented in Chapter 1, Figure 1.2 depicts the guiding theoretical framework for the pathways via which subjective SES and objective SES may impact cognitive performance. Conceptually, the model acknowledges both direct and indirect effects of SES on cognition. More importantly, the model distinguishes between objective versus subjective SES as separate, influential pathways affecting cognitive outcomes. This dual conceptualization of SES is consistent with distinctions made in the bioecological model of development, which proposes that both objective and subjective environments may equally impact individual developmental outcomes (Bronfenbrenner & Morris, 2006). Additionally, this dual conceptualization of SES considers growing interest in the psychological assessment of an individual's perceptions regarding his or her own social standing and the effects of these perceptions on individual aging outcomes (Chen et al., 2012; Demakakos, Nazroo, Breeze, & Marmot, 2008).

Both objective and subjective measures of SES are associated with other individual characteristics, which likely contribute to the observed associations of SES (overall) with cognitive performance and cognitive aging. Previous work has found that lower SES is associated with negative health behaviors such as lower activity level and smoking (Eibner & Evans, 2005; Wister, 1996) though poor health does not fully explain cognitive decline among individuals of lower SES (Koster et al., 2005). Considering the psychosocial pathways, subjective social status does have associations with both objective measures of SES as well as measures of depressive symptoms and neuroticism,

but was still found to uniquely predict self-rated health (Cundiff et al., 2013). The model proposes that the effect of objective SES on cognition will likely be partially mediated by individual health behaviors, and that the effect of subjective SES on cognition will likely be partially mediated by emotional affect.

Summary of General Findings

Study 1. Two large samples were drawn from publically available data in the Health and Retirement Study (HRS) to examine (a) cross-sectional cognitive performance on episodic memory and fluid reasoning tasks and (b) longitudinal change in general cognitive functioning across 6 years. Initial analyses in the cross-sectional sample indicated that subjective social status positively predicted individual performance on episodic memory and fluid reasoning tasks. For memory ability, household income reduced the association between subjective SES and performance. Then, subsequent inclusion of years of education in the model fully accounted for the effects of concurrent subjective SES on memory performance. For fluid reasoning, including household income in the model reduced the effect of subjective social status to non-significance. Moreover, years of education above the median predicted higher performance for fluid reasoning, and accounted for the remaining positive association of subjective social status with performance. In the longitudinal sample, growth curve analyses suggested a small positive effect for each level of subjective social status to level of overall cognitive functioning at around age 68, though this boost waned by age 90. This effect was

maintained even while controlling for years of education, household income, BMI, self-rated health, and depressive symptoms.

Study 2. Daily cognitive functioning across episodic memory and fluid reasoning domains were examined in a sample of 45 older adults who completed an initial baseline questionnaire including assessment of objective and subjective SES indicators, and a 7-day 'burst' repeated-measures design including cognitive tasks self-administered once a day. Overall, findings suggested that intraindividual variance in cognitive functioning across 7 days was inversely related to overall mean performance for both episodic memory and fluid reasoning, such that individuals who showed more variability in performance tended to perform lower on cognitive tasks. Additionally, findings suggested that intraindividual variance in cognitive functioning is likely associated with both objective and subjective measures of socioeconomic status, though a number of the observed associations did not reach statistical significance.

Implications

The theory of bioecological development proposes that environmental and social contexts drive individual development via ongoing, sustained proximal processes (Bronfenbrenner & Morris, 2006). Additionally, the contexts that drive individual development can be both subjective and objective in nature. As such, part of our initial hypothesis was that subjective social status would predict cognitive performance above and beyond objective measures of SES, likely capturing subjective aspects of context not otherwise accounted for by objective SES measures. The current analyses from study 1

have several implications for the proposed relationship between SES and cognitive performance in older adults.

For study 1, cross-sectional analyses suggested that higher than median subjective social status predicted better performance on memory and fluid reasoning tasks, which persisted after including measures of objective SES in the model. Yet, contrary to our hypothesis, this association was no longer significant after the inclusion physical and mental health measures. Our findings in the cognitive domain are consistent with subjective social status findings in the health domain, in which subjective SES predicted physical functioning above and beyond objective SES in older adults (Hu, Adler, Goldman, Weinstein, and Seeman, 2005), though this subjective SES-cognition relationship became non-significant after controlling for possible health mediators. In part, the implication is that subjective social status may have differential influences on cognitive functioning, in part, via physical and mental functioning in older adults. It may very well be the case that an individual's subjective assessment of their SES does not capture unique contextual information regarding social and economic factors as relevant to concurrent cognitive outcomes for older adults, but largely operates via the same pathways as physical and mental health.

Yet, interestingly, we see a different story when considering the longitudinal analysis from the same population of older adults. As the guiding theoretical model proposed, health and mental health did have significant impacts on level of cognitive functioning, and mediated the observed relationships of objective and subjective SES with cognitive aging outcomes. Consistent with our hypothesis (but differing from the

cross-sectional results), even after controlling for possible physical and mental health covariates, subjective social status remained as a significant predictor of cognitive functioning and cognitive change above and beyond objective measures of SES. This would suggest that the effects of subjective social status on cognitive functioning may be more relevant to macro timescales of cognitive development and has unique impacts on intraindividual change rather than level of cognitive performance as assessed in a cross-sectional context. Moreover, the contribution of subjective SES may be particularly salient around and after retirement age, a period in which prior studies have suggested accelerating declines occur (e.g., Finkel et al., 2003). Even small offsets to hastening declines may have impacts on to later cognitive health (e.g., education offsets accelerating memory declines in those who develop incident dementia, cf. Hall et al., 2007).

Additionally, both the cross sectional and longitudinal analyses speak to how different indicators of SES may uniquely contribute to predicting cognition performance and cognitive aging outcomes. In the cross-sectional analyses, years of education gave the biggest boost in performance for both episodic memory and fluid reasoning as compared to income and subjective social status. Yet, both household income and subjective social status still had small, unique positive effects on both episodic memory and fluid reasoning after including education in the model. For the longitudinal analyses, subjective SES, income, and education each had a unique positive association with level of cognitive functioning (before including physical and mental health covariates), suggesting individuals received an additional boost in performance for being above the

median on each indicator of SES. Similar findings regarding independent effects among objective SES indicators on cognitive functioning were observed in work published with The Study of Assets and Health Dynamics Among the Oldest Old (AHEAD), which is now considered a cohort of the larger HRS (Karlamangla et al., 2009).

With regards to the association of SES with intraindividual variability as observed in study 2, conclusions and the posited implications are made tentatively, as various observed associations did not reach statistical significance. Subjective social status was significantly correlated with intraindividual variability in memory performance, suggesting that individuals with higher subjective social status showed more variability in cognitive performance across the week. Objective indicators of SES were not significantly correlated with intraindividual variability for either episodic memory or fluid reasoning. Yet, further analyses suggested that objective measures of SES may likely mediate this observed association between subjective SES and intraindividual variability in episodic memory as observed with level of performance in the cross-sectional analyses with the HRS.

As a whole, these studies make a number of contributions to the current literature regarding the impact of SES on cognitive performance and cognitive aging. Consideration regarding the influences of subjective SES and objective SES in predicting cognitive outcomes on various developmental time scales indicate that specific contextual factors relevant to cognitive outcomes may differ based on concurrent versus longitudinal examination. This suggests that it is likely that objective and subjective contexts may operate along different environmental, behavioral, psychological pathways, but also

along different time scales with regards to their cumulative impact on older adults' cognitive performance and cognitive aging outcomes. Additionally, multiple indicators of SES such as income, years of education, or subjective social status, appear to provide unique information regarding the contexts that make up SES, and measuring each separately is important to understanding environmental and social influences on individual cognitive aging outcomes.

Future directions

In our current examination regarding the unique contributions of subjective SES in predicting cognitive outcomes in older adults, it is worth noting that while we often utilized two or three indicators of objective SES (e.g. household income, years of education, occupation ratings), we used one measure of subjective SES, subjective social status. In part, we chose to use subjective social status due to its availability in the HRS, but additionally with the intention of adding to the current literature regarding the association of subjective social status with differential individual outcomes as currently supported by the health and psychology literatures (Adler, Epel, Castellazzo, & Ickovis, 2000; Cundiff, Smith, Uchino, Berg, 2013; Operario, Alder, & Williams, 2004). This may have resulted in an overly conservative examination of subjective SES in the current study, as subjective social status was made to compete with several objective SES indicators in our models. Yet, we still observed small effects above and beyond these stringent tests. That being the case, we recommend that future studies evaluate the predictive benefits of multiple indictors for subjective SES in conjunction with the aforementioned objective SES indicators.

Our findings also suggest that both objective and subjective measures of SES each provide unique contributions to the assessment of individual's social, economic, and psychosocial contexts as predictive of older adults' level of cognitive performance and differential cognitive change. Of interest would be further examination of individuals divergent in either objective or subjective indicators SES, for example (1) an individual with low education but high occupational status or (2) a separate individual with high education but low subjective social status. Such individuals may provide further understanding with regards to the role of competing objective and subjective contexts driving developmental outcomes of interest, including but not limited to, cognitive aging.

Additionally, future research should strive to understand exactly what subjective SES represents for the individual and the psychosocial components that make up this construct. For example, self-rated health is another widely used subjective measure in the health, psychology, and gerontological literatures. An individual's assessment of his or her own health status has been demonstrated to predict morality above and beyond objective measures of assessed physical, mental, and cognitive health (e.g., DeSalvo, Bloser, Reynolds, He, & Muntner, 2005; Mossey & Shapiro, 1982) even in light of variations in meaning of health and salient health referents by culture, gender, age group, and socioeconomic status (DeSalvo et al., 2005; Hirve et al., 2014; Krause & Jay, 1994). At least in part, self-rated health seems to arise from an individual's own assessment of bodily sensations, health comparisons to important others, and age and culturally relevant functional status (Jylhä, 2009; Krause & Jay, 1994; Hirve et al., 2014).

Likewise, the current work suggests that subjective SES may provide unique information above and beyond objective SES with regards to day-to day regulation of cognitive functioning. Recent examination of subjective social status by Cundiff and colleagues (2011) indicates that subjective social status is associated with not only objective measures of SES, but also psychosocial vulnerabilities (e.g. depression, neuroticism, optimism/pessimism, and marital satisfaction). This over-arching link across economic, social, and psychosocial domains likely contributes to the predictive nature of subjective SES, in part providing a broad assessment of contexts and an individual's propensity for vulnerability or resilience within those contexts (likely bolstered by social as well as economic resources). This broad assessment may enable subjective SES to signal contexts that contribute to regulation or dysregulation of cognitive processes such as intraindividual variability important to developmental trajectories in older adults, namely cognitive aging and mortality (e.g., MacDonald, Hultsch, & Dixon, 2003; MacDonald, Hultsch, & Dixon, 2008). In turn, this highlights the importance noted here of considering the impacts of subjective and objective SES on both micro and macro developmental time scales.

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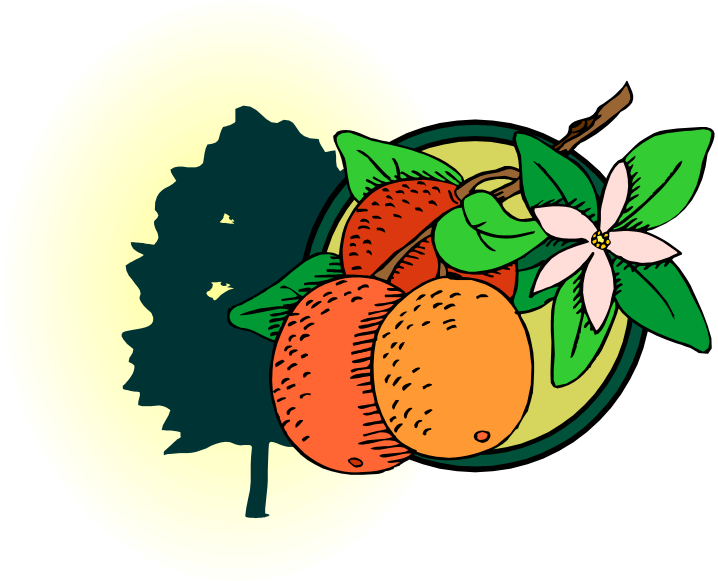
Appendices

Appendix 1. *Baseline Questionnaire: Study 2*

Appendix 2. *Training Day Workbook: Study 2*

Appendix 1. ***Baseline Questionnaire: Study 2***

Study of
Lifestyle, Healthy Living, and Aging



Questionnaire

The first few questions will be about your background.

1. What is your sex?
   - ☐ Male
   - ☐ Female

2. What is your date of birth?
   - ☐ Month: _____ Day:_____ Year:_____

3. What is your age? _____

4. What is your marital status?
   - ☐ Single
   - ☐ Married
   - ☐ Divorced
   - ☐ Widowed

5. What country were you born in? _____

6. What country was your father born in?_____

7. What country was your mother born in?_____

8. How many years have you been in the United States? _____

9. How many years of education did you complete? _____

10. What is the highest level of education you have completed?
    - ☐ Elementary school (or less)
    - ☐ Middle school or junior high
    - ☐ High School Diploma or Equivalency (GED)
    - ☐ Some college, community college, or other post high school training
    - ☐ Bachelors Degree
    - ☐ Masters/MBA
    - ☐ Doctoral degree, medical degree, law degree
    - ☐ Other (specify) _____

11. What has been your main occupation (for the longest period) of your life? Please be as specific as possible.

    _____

12. What is your ethnic background?

- ☐ White _____
- ☐ Black or African American _____
- ☐ Hispanic _____
- ☐ Asian _____
- ☐ Alaskan Native
- ☐ American Indian
- ☐ Native Hawaiian
- ☐ Pacific Islander
- ☐ Other: _____

13. Please indicate your birth father's ethnic background:

- ☐ White _____
- ☐ Black or African American _____
- ☐ Hispanic _____
- ☐ Asian _____
- ☐ Alaskan Native
- ☐ American Indian
- ☐ Native Hawaiian
- ☐ Pacific Islander
- ☐ Other: _____

14. Please indicate your birth mother's ethnic background:

- ☐ White _____
- ☐ Black or African American _____
- ☐ Hispanic _____
- ☐ Asian _____
- ☐ Alaskan Native
- ☐ American Indian
- ☐ Native Hawaiian
- ☐ Pacific Islander
- ☐ Other: _____

We are interested in your health and daily habits.

15. How tall are you (in inches)? _____

16. How much do you weigh (in pounds)? _____

17. During the past month, how would you rate your sleep quality overall? (Circle one)

    Very good Fairly good Fairly bad Very bad

The following questions ask about your smoking habits:

18. Have you smoked within the past 3 years?
    - ☐ No (skip to question 20)
    - ☐ Yes, but I quit in _____ (year)
    - ☐ Yes, every now and then (ex. At parties)
    - ☐ Yes, regularly

19. How much tobacco is your regular intake? Estimate as precisely as possible.
    - ☐ I smoke regularly _____ cigarettes/day
    - ☐ I smoke regularly _____ cigars/day
    - ☐ I smoke regularly _____ grams pipe tobacco/week
    - ☐ I snuff regularly _____ doses of snuff/week

The following questions ask about your caffeine and alcohol consumption habits:

20. How many cups of coffee do you drink per day? _____ cups of coffee

21. How many cups of tea do you usually drink per day? _____ cups of tea

22. Please check all that apply. Do you usually drink:
    - ☐ Black Tea
    - ☐ Green Tea
    - ☐ White Tea
    - ☐ Herbal Tea

23. Do you ever drink alcoholic beverages?
    - ☐ No (go to question 25)
    - ☐ Yes

24. If you replied yes to the previous question, please complete the chart below for the **number of drinks** in a typical month/week/day over the past year.

Alcoholic Beverage	Never	Per Month	Per Week	Per Day	Usually with meals? YES	/ NO
Example Response: Red Wine (4 oz glass)			*3*		*X*	
Beer (12 oz can or bottle)						
White Wine (4 oz glass)						
Red Wine (4 oz glass)						
Liquor/sprits (1 drink or 1.5 oz shot)						

25. How would you rate your general health status?
    - ☐ Good
    - ☐ Reasonable
    - ☐ Bad

26. How would you rate your health status compared to 5 years ago?
    - ☐ Better
    - ☐ About the same
    - ☐ Worse

27. How would you rate your health status compared to others in your age group?
    - ☐ Better
    - ☐ About the same
    - ☐ Worse

28. Do you think your health status prevents you from doing thinks you would like to do?
    - ☐ Not at all
    - ☐ Partially
    - ☐ To a great extent

Physical Activity: Choose one activity category below that best describes your usual pattern of daily physical activities, including activities related to house and family care, transportation, occupation, exercise and wellness, and leisure or recreation purposes.

- ☐ Inactive or little activity other than usual daily activities.
- ☐ Regularly (≥ 5 days a week) participate in physical activities requiring low levels of exertion that result in slight increases in breathing and heart rate for at least **10 minutes** at a time.
- ☐ Participate in aerobic exercises such as brisk walking, jogging or running, cycling, swimming, or vigorous sports at a comfortable pace or other activities requiring similar levels of exertion for **20 to 60 minutes** per week.
- ☐ Participate in aerobic exercises such as brisk walking, jogging, or running at a comfortable pace, or other activities requiring similar levels of exertion for **1 to 3 hours** per week.
- ☐ Participate in aerobic exercises such as brisk walking, jogging, or running at a comfortable pace, or other activities requiring similar levels of exertion for over **3 hours** per week.

Several common symptoms or bodily sensations are listed below. Most people have experienced most of them at one time or another. We are currently interested in finding out how prevalent each symptom is among various groups of people. On the page below, write how frequently you experience each symptom. For all items, use the following scale:

A: Have never or almost never experienced the symptom
B: Less than 3 or 4 times per year
C: Every month or so
D: Every week or so
E: More than once every week

For example, if your eyes tend to water once every week or two, you would answer "D" next to question #1.

___1. Eyes water
___2. Itchy eyes or skin
___3. Ringing in ears
___4. Temporary deafness or hard of hearing
___5. Lump in throat
___6. Choking sensations
___7. Sneezing spells
___8. Running nose
___9. Congested nose
___10. Bleeding nose
___11. Asthma or wheezing
___12. Coughing
___13. Out of breath
___14. Swollen ankles
___15. Chest pains
___16. Racing heart
___17. Cold hands or feet even in hot weather
___18. Leg cramps
___19. Insomnia or difficulty sleeping
___20. Toothaches
___21. Upset stomach
___22. Indigestion
___23. Heartburn or gas
___24. Abdominal pain
___25. Diarrhea
___26. Constipation
___27. Hemorrhoids
___28. Swollen joints
___29. Stiff or sore muscles
___30. Back pains
___31. Sensitive or tender skin
___32. Face flushes
___33. Tightness in chest
___34. Skin breaks out in rash
___35. Acne or pimples on face
___36. Acne/pimples other than face
___37. Boils
___38. Sweat even in cold weather
___39. Strong reactions to insect bites
___40. Headaches
___41. Feeling pressure in head
___42. Hot flashes
___43. Chills
___44. Dizziness
___45. Feel faint
___46. Numbness or tingling in any part of body
___47. Twitching of eyelid
___48. Twitching other than eyelid
___49. Hands tremble or shake
___50. Stiff joints
___51. Sore muscles
___52. Sore throat
___53. Sunburn
___54. Nausea

We are interested in how people are getting along financially these days.

29. How would you compare your economic situation with others in your age group?
    - ☐ Better
    - ☐ About the same
    - ☐ Worse

30. Do you find difficulty in meeting general expenses like food, rent, bills, ect?
    - ☐ No
    - ☐ Yes

31. Do you usually have enough money for extra treats?
    - ☐ No
    - ☐ Yes

32. If you should suddenly get into an unexpected situation whereby you had to find $2,000 within a week, would you be able to do it?
    - ☐ No
    - ☐ Yes

33. Do you believe that in the future you will have sufficient money to cover your needs?
    - ☐ No
    - ☐ Yes

34. How well does your money cover your needs?
    - ☐ Very well
    - ☐ Quite well
    - ☐ Quite badly
    - ☐ Badly

35. Is your present economical situation preventing you from doing what you like to do?
    - ☐ Yes, to a great extent
    - ☐ Yes, to some extent
    - ☐ No

Think of this ladder as representing where people stand in the United States.
At the **top** of the ladder are the people who are the best off- those who have the most money, the most education and the most respected jobs. At the **bottom** are the people who are the worst off – who have the least money, least education, and the least respected jobs or no job. The higher up on you are on this ladder, the closer you are to the people at the very top; the lower you are, the closer you are to the people at the very bottom.

Where would you place yourself on this ladder?
Please place a large "**X**" on the rung where you think you stand at this time in your life, relative to other people in the United States.

The next questions are about income you receive.

36. Please indicate your income in the last calendar year before taxes and deductions.
    - ☐ Less than $10,000
    - ☐ $10,000 - $20,000
    - ☐ $20,000-$40,000
    - ☐ $40,000- $60,000
    - ☐ $60,000-$80,000
    - ☐ $80,000 or more

37. Please indicate your *total household income* (including yourself and/or partner) in the last calendar year before taxes and deductions.
    - ☐ Less than $10,000
    - ☐ $10,000 - $20,000
    - ☐ $20,000-$40,000
    - ☐ $40,000- $60,000
    - ☐ $60,000-$80,000
    - ☐ $80,000 or more

38. Please indicate below whether you received any income/assistance in the last calendar year form these sources (check all that apply):
    - ☐ Social Security Income (SSI)
    - ☐ Welfare income (other than SSI)
    - ☐ Retirement pension (non-military)
    - ☐ Veteran benefits
    - ☐ Military pension
    - ☐ Income from rental properties
    - ☐ Income from personal business or farm
    - ☐ Withdrawals from Individual Retirement Account (IRA) or KEOGH account
    - ☐ Annuity payments
    - ☐ Bond dividends/interest (non-government)
    - ☐ CDs, government bonds, treasury bills
    - ☐ Family loans
    - ☐ Other:_____

39. Indicate below other assets and savings you may have:

- ☐ Transportation
  - (please circle all that apply: car, truck, trailer, motor home, boat, airplane)
- ☐ Jewelry
- ☐ Money owed to you by others
- ☐ Land contracts or mortgages owed to you
- ☐ A collection for investment purposes
- ☐ Beneficiary to a trust or estate
- ☐ Other_____

40. Please indicate below any debts you may have (check all that apply):

- ☐ Home loan
- ☐ Car loan
- ☐ Personal loan
- ☐ Credit card balances
- ☐ Medical debts
- ☐ Life insurance policy loans
- ☐ Loans from relatives
- ☐ Other:_____

41. How many times during the past week have you felt as follows?

For each statement, please mark one of the 4 alternatives.

During the past week …	Never/ almost never	Rather seldom/ never	Quite often	Always/ almost always
a) I was bothered by things that usually don't worry me.	☐	☐	☐	☐
b) I did not feel like eating; my appetite was poor	☐	☐	☐	☐
c) I felt that I could not shake off the blues even with help from family and friends	☐	☐	☐	☐
d) I felt that I was just as good as other people	☐	☐	☐	☐
e) I had trouble keeping my mind on what I was doing	☐	☐	☐	☐
f) I felt depressed	☐	☐	☐	☐
g) I felt that everything I did was an effort	☐	☐	☐	☐
h) I felt hopeful about the future	☐	☐	☐	☐
i) I thought my life had been a failure	☐	☐	☐	☐
j) I felt fearful	☐	☐	☐	☐
k) My sleep was restless	☐	☐	☐	☐
l) I was happy	☐	☐	☐	☐
m) I talked less than usual	☐	☐	☐	☐
n) I felt lonely	☐	☐	☐	☐
o) People were unfriendly	☐	☐	☐	☐
p) I enjoyed life	☐	☐	☐	☐
q) I had crying spells	☐	☐	☐	☐
r) I felt sad	☐	☐	☐	☐
s) I felt that people dislike me	☐	☐	☐	☐
t) I could not get "going."	☐	☐	☐	☐

Thank you for your participation. Please bring this questionnaire to the research assistant.

Appendix 2. ***In-person Training Day Workbook: Study 2***

DAILY MENTAL EXERCISE BOOK: TRAINING

Try to complete this booklet as close as possible to 2 hours after you wake up in the morning. If for some reason you do not complete it at that time, go ahead and complete the workbook as soon as you can during the day.

- You will need the timer provided by the researcher.
- You will need a pen or pencil.
- You will need to find a quiet place you can complete **all** of the tasks without interruption. The tasks should take about 20 minutes.

Please indicate the date you worked on this test booklet:

_____
day/month/year

Please indicate the time of day that you started work on this booklet

_____AM or PM
(circle one)

Mood Assessment

Place an X in the box the best indicates your answer.

Think of how you felt yesterday. How often did you feel…

	Very Often	Often	Sometimes	Rarely	Never
happy					
frustrated					
blue					
that you were enjoying yourself					
worried					
satisfied					
angry					
joyful					
unhappy					
pleased					

Please turn the page and begin the next form.

Word List

Set your timer for **1 minute**.

When you are ready to begin, start the timer, turn the page and study the list of words.

Appendix page intentionally left blank.
Please refer to Table 3.1 for examples of List Memory items.

Write down as many of the words as you can remember.
DO NOT LOOK BACK AT THE LIST OF WORDS!

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

When you can't remember any more words please turn the page and begin the next form.

Appendix page intentionally left blank.
Please refer to Table 3.1 for an example of a Letter Series Test items.

Appendix page intentionally left blank.
Please refer to Table 3.1 for examples of Number Comparison Test items.

Concluding Questions

1. Did you exercise yesterday?
   - ☐ Yes
   - ☐ No

2. If so, what activity did you do? (be as specific as possible)

   _____

   _____

3. For how long did you maintain this activity? _____ minutes

4. What time did you go to bed last night?

   BED TIME: _____

5. What time did you get up this morning?

   GETTING UP TIME: _____

6. How many actual hours of sleep did you get last night?

   HOURS OF SLEEP: _____

7. How would you rate your sleep quality last night? (Circle one)

   Very good *Fairly good* *Fairly bad* *Very bad*

Concluding Questions

Several common symptoms or bodily sensations are listed below. Most people have experienced most of them at one time or another. For all items, use the following scale to describe your experience of these symptoms today:

1	2	3	4	5
very slightly or not at all	*a little*	*moderately*	*quite a bit*	*extremely*

___1. Eyes water
___2. Itchy eyes or skin
___3. Ringing in ears
___4. Temporary deafness or hard of hearing
___5. Lump in throat
___6. Choking sensations
___7. Sneezing spells
___8. Running nose
___9. Congested nose
___10. Bleeding nose
___11. Asthma or wheezing
___12. Coughing
___13. Out of breath
___14. Swollen ankles
___15. Chest pains
___16. Racing heart
___17. Cold hands or feet even in hot weather
___18. Leg cramps
___19. Insomnia or difficulty sleeping
___20. Toothaches
___21. Upset stomach
___22. Indigestion
___23. Heartburn or gas
___24. Abdominal pain
___25. Diarrhea
___26. Constipation
___27. Hemorrhoids
___28. Swollen joints
___29. Stiff or sore muscles
___30. Back pains
___31. Sensitive or tender skin
___32. Face flushes
___33. Tightness in chest
___34. Skin breaks out in rash
___35. Acne or pimples on face
___36. Acne/pimples other than face
___37. Boils
___38. Sweat even in cold weather
___39. Strong reactions to insect bites
___40. Headaches
___41. Feeling pressure in head
___42. Hot flashes
___43. Chills
___44. Dizziness
___45. Feel faint
___46. Numbness or tingling in any part of body
___47. Twitching of eyelid
___48. Twitching other than eyelid
___49. Hands tremble or shake
___50. Stiff joints
___51. Sore muscles
___52. Sore throat
___53. Sunburn
___54. Nausea

THANK YOU, you have completed the work booklet for today.

Please indicate the time of day you completed work on this booklet

AM or PM
(circle one)

Seal the booklet in the envelope provided.