

Health and Cognition in Aging Research

Duane F. Alwin¹ and Scott M. Hofer²

¹Department of Sociology and Center for Life Course and Longitudinal Studies, College of the Liberal Arts, Pennsylvania State University, University Park.

²Department of Psychology and Center on Aging, University of Victoria, British Columbia.

THIS supplemental issue of *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* is based on papers presented at a conference on “Cognition, Health, and Aging: Integrating Perspectives across Disciplines” held at Pennsylvania State University, October 30–31, 2009. This conference focused on discussing new research findings and methodological approaches regarding the interplay of the dynamics of biological factors in cognitive and related outcomes and associated physiological changes that are linked to cognitive aging, including sensory and disease-related changes. We attracted an outstanding group of researchers doing work in these areas, across several disciplines—biology, epidemiology, demography, developmental psychology, gerontology, neuropsychology, and sociology—to consider how best to measure these processes and model relevant data in ways that sort out aggregate population trends and individual-level age-related changes in health and cognitive functioning.

RATIONALE

There is an emerging consensus that a multidisciplinary theoretical approach is necessary to understand the nature of processes of cognitive aging; however, the implementation of this objective has not been fully achieved. The National Research Council (NRC, 2000) report *The Aging Mind*, for example, suggested that while “progress is being made by behavioral science, cognitive science and neuroscience researchers in understanding cognitive changes during the aging process . . . what is being learned from each research perspective has not fully penetrated the work of researchers proceeding from other perspectives” (NRC, 2000, p. 9). The committee argued that (a) cognitive aging results from the conjunction of changes in neural structures, behavioral contexts, and “somatic events (e.g., nonneurological disease, sensory–motor changes)” (NRC, 2000, p. 10); (b) cognitive change results from the mutual influence of neural function and environmental factors across the entire life span and that “certain somatic processes, such as cardiovascular disease and sensory–motor changes, may affect cognitive function indirectly through their direct effects on brain functioning” (NRC, 2000, p. 10); and (c) neurological changes resulting in cognitive aging “may not be as uniform or as profound as once believed” and that the role of adaptation is important (NRC, 2000, p. 10). In addition to the potential interaction between neural and behavioral

mechanisms in cognitive aging, the committee conceded that cultural and social environments may offer opportunities for adaptation and new growth (NRC, 2000, p. 10).

Although the NRC committee stressed a multidisciplinary approach and sought particularly “to identify research opportunities that would link behavioral science, cognitive science, and neuroscience approaches to cognition and aging in new ways,” the research aims they emphasized are not the only important challenges (NRC, 2000, p. 12). In particular, the committee had little to say about the contributions of the social, economic, and demographic approaches to the study health and cognition, although they mentioned there are other research directions and additional ways of formulating a research agenda to advance knowledge in the study of cognitive aging (NRC, 2000, p. 12).

Consistent with the work of the NRC Committee and building upon previous efforts aimed at promoting interdisciplinary research (see Hofer & Alwin, 2008), the purpose of the 2009 Penn State conference was to examine six areas of research occurring across disciplines that are significant to understanding aging-related changes in health and cognition: (a) What are the key theoretical questions and models that address the interplay between health and cognitive change in later life? (b) How do population processes impact our knowledge and inference about health and cognitive aging? (c) How can we distinguish pathological from normative processes in cognitive change? (d) What are the critical life course events and experiences in early life that contribute to health and cognition in later life? (e) What are the critical life course events and experiences in middle adulthood that contribute to health and cognition in later life? and (f) What are the best measures and methods for studying change in cognition and health? We would not claim that the conference papers, presentations, and discussions answered all of these questions, but we believed that the overall results of this activity produced an array of contributions that warranted publication. While many of the papers provide new empirical contributions to addressing these questions, many of them also emphasize new approaches for integrating perspectives across disciplines in research on cognition, health, and aging. In the following, we summarize the key contributions of the papers presented at the conference, many of which are published in the present supplementary issue.

THEORETICAL ISSUES

The agenda of the conference focused on addressing several of the key theoretical questions about the interplay between changes in health and changes in cognitive function in older age. A central theme involved the question of the adequacy of traditional disciplinary perspectives brought to bear on these questions or whether an interdisciplinary approach was necessary. Researchers have raised several hypotheses to explain the apparent decline in cognitive functioning with increased aging, often bounded by disciplinary biases. The first of these, which is popular among biological aging specialists, posits that cognitive decline is the result of a more general “process of neurological decline” that affects both cognitive and sensory functioning. Cognitive decline is, thus, simply one manifestation of a more general neurological decline. A second set of explanatory factors involves “overall age-related declines in specific organ function” that lead to increases in the onset of illnesses or impairments and risks of experiencing multiple illnesses or impairments. Research drawing on this perspective focuses on diseases processes per se, such as the onset and maintenance of diabetes, and their consequences for cognitive functioning. Third, cognitive decline may be related directly to other age-related functional limitations, particularly in sensory function and physical health. Finally, historical and cultural differences among age groups in levels of crystallized intelligence (measured by differences in schooling levels) may account for between-person age differences and declines in measures of cognitive functioning and its covariates in older age.

The paper by Avron Spiro and Christopher Brady in this issue, “Integrating Health into Cognitive Aging Research: Toward a Preventive Cognitive Neuroscience of Aging,” considers various pathways through which health (and disease) is related to brain and cognition and how these may be altered by aging. The guiding theme of this paper is that diseases either caused by or associated with aging play a larger role in age-related cognitive changes than is often acknowledged. In particular, vascular changes associated with aging can have substantial effects on various cognitive functioning. The paper articulates the authors’ experiences with several large-scale longitudinal studies of aging, describing various methods for collecting health information, of using such information in theory-guided analyses to examine cognitive changes, and they present several examples of how various health processes affect cognitive functioning in distinct ways.

The paper by Marcus Richards and Stephani Hatch, “A Life Course Approach to the Development of Mental Skills,” argues that a wide range of early life factors influence cognitive and socioemotional development. This influence begins with genes, followed by the obstetric and perinatal environments, leading to the postnatal world of material home conditions and rearing. Through this complex web of early influences, an emerging sense of habitus and the unique and complex effects

of education, cognitive, and socioemotional functions gradually fuse into life skills that promote mastery and wisdom in mature adulthood and later life. Surrounding this integrative developmental process, cognitive function and mental health directly track across the life course, although discontinuities in both can also occur, particularly in mental health. The authors demonstrate that the long-term influence of early life on cognitive aging and later mental health is largely mediated by the effects of these early factors on cognitive and socioemotional development and by the process of education.

Increased interest in human “healthspan” has developed alongside inquiry into healthy aging. The concept of healthspan, or “healthy life expectancy,” the portion of the life span spent in relatively good health, as distinct from a decline phase in cognitive and functional capabilities prior to death or associated with disease, underlies much of gerontological and life-span developmental research. Decisions regarding the appropriate measurement of health (e.g., disease, health indicators, disability, impairment) are critical for modeling health-related changes and healthspan, and these models of health-related change, in turn, are necessary for understanding of aging-related changes more generally (e.g., cognitive and physical capabilities). Although it is often apparent when people have left their healthspan and entered a period of health-related decline, it is not clear how many comorbidities, or which particular morbidities, or even if it is only “unmanaged” morbidities, that delineate the healthspan. Furthermore, the aging literature has seen steady expansion of the conceptualization of “healthy or successful aging” to encompass morbidity, functional autonomy, frailty, mental health, and social engagement within a broad multidimensional construct. However, no clear consensus exists on the operationalization of these concepts or even on the basic terminology. Furthermore, it is unlikely a single approach can meet the needs of medical researchers, demographers, gerontologists, life-span development researchers, and aging individuals. Several interrelated definitions might be preferred. One important question for addressing changes related to aging, health, and healthspan has to do with the construction of individual trajectories and change-points for health and functioning across the life span. Which operationalizations of health, healthy aging, or successful aging would yield scores suitable for the study of individual trajectories and intra-individual change? How are comorbidities best addressed? Which operationalizations might be applied in some of the existing longitudinal studies of aging?

The paper by Andrea Piccinin and colleagues, “An Evaluation of Analytical Approaches for Understanding Change in Cognition in the Context of Aging and Health,” reviews research that has examined the relationship between health and cognition, providing a summary of the operationalization of health and methodological approaches used. Given the mean age trends in both domains in cross-sectional data, they emphasize the importance of focusing on within-person

change in health and cognition. In particular, they note that the use of longitudinal methods does not guarantee focus on within-person aspects of the data. Attention to assumptions regarding the equivalence of cross-sectional and longitudinal information and to “careful analysis of within-person change and variation in a highly multivariate context” is essential.

POPULATION PROCESSES

Several of the conference papers suggested that in order to study patterns of aging with respect to cognition and healthspan, a demographic perspective is essential. Health and cognition are characteristics of the members of a population, akin to other social and demographic characteristics, and in recent decades, the conceptualization of population health has extended beyond measures of mortality (e.g., life expectancy, infant mortality) to include specific health measures such as the incidence or prevalence of morbid conditions or summary measures of health (Lamb & Siegel, 2004). Our assessment is that cognitive function should be considered an aspect of the larger conception of health and certainly one that includes adaptation to the environment a central component of health (see Larson, 1999). Population composition and population processes not only affect aggregate population trends in health and cognition (and their interrelationship) but they also play an important part in understanding the nature of the processes affecting estimates of within-person change (or aging) in health and cognition. Virtually, all we know about cognitive aging was learned from studies conducted on persons born before the past quarter century—one might even argue that this generalization could be extended to those born in the past one half of the previous century. If historical factors influence the nature of health and cognitive change, then it is reasonable to ask whether our current knowledge is applicable to the cohorts born after World War II (often referred to as “the Baby Boom cohorts”) and whether we can any more entertain the idea that processes of cognitive aging revealed from past studies apply to these future cohorts. In short, to what populations do our present state of knowledge regarding age-related trajectories of cognitive performance apply (see Baltes, Cornelius, & Nesselroade, 1979)? One of the important components of population aging is declining mortality rates, and thus, the naturally occurring question is whether old age can sustain cognitive function as well? Aging is not a disease process, but it is associated with both functional decline and increased susceptibility to illness and death from specific diseases. Signs of typical aging need not result in greater susceptibility to death. But with advanced age also comes weakened ability to fight off such diseases of cancer and infections, even as cognitive decline that reduces memory, speed of processing, and the like occurs as well. When advances are made in curing or forestalling the diseases that tend to result in death to older people, this then

means that an even larger proportion of people survive into advanced old age. Thus, although one may forestall physical functional decline and the susceptibility to illness and death from specific diseases, there may be no counterpart in the area of cognitive functioning.

The upward 20th century trends in IQ, education, and mental work suggest that age-specific levels of cognitive function among seniors should be rising strongly across cohorts. However, there is little sign of such a trend, and some recent analyses suggest the opposite, showing greater relative declines in the newer cohorts. Demographic interpretations of this anomaly often refer to survival effects. Technological and economic development lower the extent of cognitive function needed for survival. As a result, individuals with poor cognitive function survive longer in newer cohorts, diminishing the average levels of old age function. The contribution by John Mirowsky, “Cognitive Decline and the Default American Lifestyle,” explores additional forces that may be suppressing or countervailing the gains from higher IQs, longer schooling, and more engaging work. Specifically, Mirowsky argues that the same technological and economic trends that are lowering the threshold level of cognitive function needed to survive also are lowering the physical activity demanded in daily life. Cognitive function is, ultimately, brain function, and the progressive substitution of mechanical power for human physical activity is undermining the physical fitness needed to preserve cognitive function. As the physical abilities required by daily life decline, so do the levels of those abilities. Business and technology provide substitutes for the vanishing abilities, which further reduce the physical demands. As the social norms and built environment adapt to ever lower physical abilities, they begin to discourage the activities that create the abilities. Walking and bicycling become impractical and dangerous. Desk work allows little movement. Stairways are designed and located for emergency use. Maintaining physical function requires ever more determination to overcome the default lifestyle. With ever diminishing demands, though, fewer individuals realize the extent of their own impairment.

BIOLOGICAL CONTRIBUTIONS

Research dealing with chronic disease and cognitive function has typically not explicitly dealt with neurological disease, as opposed to chronic “physical disease” and life style or health promotion factors. Dementia, and particularly Alzheimer’s disease (AD), is one of the major causes of disability and declining function and quality of life among the oldest in the population. From a disciplinary perspective, the study of cognitive aging and dementia has proceeded independently. Researchers who study AD and other dementias almost exclusively deal with patient populations that have been diagnosed—little research is aimed at the precursors of the diseases processes that presumably

lead to a clinical diagnosis. On the other side, researchers interested in understanding what they consider “normal” or “healthy” aging do not always explicitly deal with neural patterns thought to result from disease processes. Often researchers interested in “normal aging” attempt to eliminate the influence of dementia by screening out impaired individuals with mental status exams. This strategy is only partially successful, and even in select, highly screened samples of older adults, a substantial proportion of older participants may be at the very early stages of preclinical dementia and influence cognitive estimates of cognitive performance and age effects.

One of the issues addressed by the conference was whether, when we consider “processes of aging,” we can distinguish between disease processes and “normal” aging processes? The paper included here by Stuart MacDonald and his collaborators, “Linking Biological and Cognitive Aging: Toward Improving Characterizations of Developmental Time,” directly confronts the question of the relationship of “biological aging” and “cognitive aging.” They argue that chronological age represents the most frequently employed predictor or index in life-span developmental research. Seminal arguments qualifying this practice have been raised for at least the past five decades. Specifically, theorists have identified problems that are both statistical (e.g., population average changes with age) and conceptual (e.g., merely knowing that chronological age is associated with cognitive impairment says nothing about specific or general mechanisms underlying age-related cognitive impairment in nature). Thus, chronological age appears best conceived as a proxy for true mechanistic changes that influence cognition across time. The present discussion revisits the important goal of seeking more effective conceptual and operational definitions of developmental time. By de-emphasizing chronological age, the authors explore both static and dynamic biological or physiological markers that arguably could reflect more process-specific mechanisms underlying cognitive changes in late life. Using data from three samples of the Victoria Longitudinal Study, MacDonald and colleagues explore the time-varying covariation between change in theoretically relevant biomarkers of cognition and developmental change across a continuum of cognitive outcome measures (e.g., executive functions, episodic and semantic memory). Thus, the focus of this contribution concerns the within-person dynamics of biological and cognitive aging, rather than between-person statics of biocognitive differences. Developing core criteria for the selection of biomarkers from a variety of physiological systems and establishing corresponding psychometric properties represents an important next step for continuing research in this area. To the extent, they successfully identify biomarkers that distinguish normal cognitive decline from accelerated decline or impairment, future research may be better able to focus on early detection and intervention, as opposed to postdiagnosis treatment, remedial operations, or palliative care.

The paper by Robert Stawski, David Almeida, and their colleagues, “Associations between Cognitive Function and Naturally Occurring Daily Cortisol During Middle Adulthood: Timing is Everything,” notes that much stress–cognition research has focused on links between cortisol and performance-based assessments of cognitive function. Previous work, however, has focused on the assessment of cortisol in very controlled ways (i.e., response to experimental stress/challenge), providing little evidence regarding associations between the naturally occurring diurnal rhythms of cortisol and cognitive function. Using data from the Midlife in the United States (MIDUS) survey and the National Study of Daily Experiences, they examined associations between cognitive function and the diurnal rhythm of cortisol throughout adulthood and old age. A sample of men and women completed a battery of tasks assessing cognitive function via telephone and provided saliva samples upon waking, 30 min after waking, at lunchtime, and at bedtime on four consecutive days. Results revealed that having a steeper morning rise was associated with higher cognitive function but only among older adults. Additionally, having a flatter afternoon decline was associated with lower levels of cognitive function regardless of age. Results also revealed that associations between the morning rise, afternoon decline, and cognitive function were specific to tasks reflecting frontal lobe function. Together, links between naturally occurring cortisol rhythms and cognition appear to depend on age, time of day, and type of cognitive function.

The paper by H el ene Payette and her colleagues, “Trajectories of Physical Function Decline and Psychological Functioning: The Quebec Longitudinal Study on Nutrition and Successful Aging (NuAge),” argues that depressive symptoms and poor nutritional status have been associated with declines in physical capacity, in particular within the conceptual framework of cognitive frailty. However, it is not clear whether they exert independent effects and potential of interaction among these two variables has not been studied. Furthermore, very few prospective data are currently available to understand these relationships in the course of aging. Three-year follow-up data from community-living and well-functioning men and women participating in the longitudinal study NuAge were used for these analyses. Individual growth models were used to describe personal trajectories of physical performance over a three-year period along with conditional growth models to investigate how changes in nutritional risk and depressive symptoms affect these trajectories. Statistically significant declines were observed in physical performance over time, and both nutritional risk and depressive symptoms significantly influence these changes after adjustment for age, sex, education, and chronic conditions. Nutrition and depression are potentially modifiable independent determinants of the evolution of physical capacity during aging, suggesting potential avenues for evidence-based health promotion interventions for older adults.

LIFE COURSE CONTRIBUTIONS—EARLY CHILDHOOD

Recent theorizing motivated by the life course perspective (employed principally in demography, epidemiology, and sociology) has emphasized the view that understanding human development is advanced by taking a long-term perspective and that levels of cognitive functioning and cognitive change in adulthood may be linked developmentally to events and experiences in early life (see the paper by Marcus Richards and Stephanie Hatch in this issue). Research has explored the early life social pathways through which differences in adult cognitive functioning emerge, including nutrition and healthy brain development; early socioeconomic experiences, such as the experience of poverty and hunger; and exposure to education. Because of their obvious link to cognitive development early in life, questions naturally arise concerning the relative roles of early developmental statuses versus educational attainments in promoting healthy aging and sustained cognitive functioning. What are the critical life course events and experiences in early life that contribute to patterns of health change and cognitive aging in later adulthood?

The paper by Robert Hauser and Alberto Palloni, “Adolescent IQ and Survival in the Wisconsin Longitudinal Study” begins with the observation that long-term studies of early cognitive ability (IQ) and survival have documented a robust relationship between those two variables. Such studies have, for the most part, been remarkably silent on explanations for that relationship. Published explanations range from suggestions that raw intelligence may be a “fundamental cause” of mortality, that it “enhances individuals’ care of their own health because it represents learning, reasoning, and problem-solving skills useful in preventing chronic disease and accidental injury,” to findings that the association between measured IQ and mortality largely reflect its correlation with educational and economic success. In this analysis of data from the Wisconsin Longitudinal Study, Hauser and Palloni look at the association between measured IQ and survival across the life span in light of the relationship between measured IQ and grades in secondary school. They find that, net of social and economic origins, high school grades have a much larger effect than measured IQ, and the association between measured IQ and survival turns negative once high school grades are controlled. That is, the association between IQ and health is fully explained by its correlation with evaluations of academic performance in secondary school. Moreover, the fact that girls are similar in IQ to boys, but earn higher grades in school, partly explains the gender differential in survival. This finding suggests that survival is largely explained by normative behaviors, that is, doing the right thing in the right way at the right time, and such behaviors are well established by late adolescence.

LIFE COURSE CONTRIBUTIONS—EARLY ADULTHOOD AND MIDLIFE

Relative to research on development in childhood and aging-related change in later life, the early and middle

adulthood period has not been well studied in terms of health and cognitive change. Indeed, few longitudinal studies have focused on midlife, with prior emphasizing pathology for understanding early cognitive change. There are some indications, from studies of cognitive training and social and intellectual engagement, that many adults experience cognitive growth in middle and later life with the possibility of a reduction in the risk of later cognitive decline. One likely possibility is that social status has an impact on later life health and cognitive functioning through health behaviors and reduced exposures to risk factors during early and middle adulthood. Midlife is a critical period for studying the interface between early adulthood and late life events, specifically between early life experiences and health- and aging-related changes in later life. What are the critical experiences in early adulthood and midlife that contribute to patterns of health change and cognitive aging in later adulthood? Specifically, what is it about social statuses (e.g., schooling, occupation, income, and wealth) that contribute to health and cognitive aging?

In line with these themes, the paper by Mary Haan and her collaborators, “Life-span Socioeconomic Trajectory, Nativity, and Cognitive Aging in Mexican Americans: The Sacramento Area Latino Study on Aging,” argues that education comprises an early life experience that influences brain development and is consistently associated with better performance on cognitive tests in late life. Understanding this link is complicated by socioeconomic sequelae from early education, such as income and occupation. Parental education generally predicts the educational experience of offspring. Both nativity and immigration represent environmental contexts that are inextricably linked to socioeconomic, cultural, and physical factors, which ultimately influence late life health. Thus, the effect of early childhood socioeconomic status (SES) on late life cognitive performance may be mediated by educational attainment of the participant and modified by nativity and immigration. Haan’s analysis compares the association between childhood SES measured as mother’s or father’s education and performance on a standardized version of a delayed wordlist recall test in the Mexican Health and Aging Study and the Sacramento Area Latino Study on Aging. Lower parental education as a measure of childhood SES may be associated with lower cognitive performance. The effects of parental education on cognitive performance are clearly mediated by participant education and modified by nativity and immigration status. Early socioeconomic and cultural environments appear to be an important factor in late life memory loss.

The role of emotional factors is important because older persons are frequently exposed to high levels of stress. The paper by Hannie Comijs and her colleagues, “Accumulated and Differential Effects of Life Events on Cognitive Decline in Older Persons,” uses data from the Longitudinal Aging Study Amsterdam to investigate whether stressful life events have a negative impact on cognitive function,

both its level and rate of decline. They found a relationship between some life events, such as death of a relative, but only for poorly functioning older adults. On the other hand, more chronic stressors, such as the illness of a partner or relative, were associated with better cognitive functioning. They also show that there is a link between genes and the relationship between stress and cognitive function. Extending the theme of the link between emotional and cognitive functioning to the micro-daily level, the paper by Robert Stawski and his collaborators, "Intraindividual Coupling of Daily Stressors and Cognitive Interference in Old Age," further examines how cognitive interference is associated with measured daily stress and negative affect. Their results support the need for further theoretical work linking stress, emotion, and cognitive functioning.

There is widespread evidence for average declines in cognitive and functional health with aging, yet there are large individual differences in the nature and patterns of these changes. Based on previous research findings, the paper by Stefan Agrigoroaei and Margie Lachman, "Cognitive Functioning in Midlife and Old Age: Combined Effects of Psychological and Behavioral Factors," identified several modifiable psychosocial and behavioral factors that could potentially account for interindividual differences in cognitive performance and changes in functional health: general sense of control, quality of social relationships, and frequency of physical and cognitive activities. In comparison to past research, which generally has focused on the separate effects of these factors, the goal of this study was to analyze their combined contribution. Using data from the MIDUS I and II studies, results support a prescription for a combination of psychosocial and behavioral factors to slow or compensate for changes with aging and suggest possibilities for promoting healthy aging by targeting lifestyle factors.

A growing body of research suggests that greater social engagement (referring broadly to both quantitative and qualitative aspects of social interaction) is associated with significantly lower risks for decline and dementia in older adults. While intriguing, this research has been limited in several significant respects, including a focus only on older adults (instead of age comparisons), singular aspects of social relationships (e.g., quantity of social relationships, amount of social activity, or quality of relationships) and assessments of social engagement at a single point in time. Using newly available cognitive data and longitudinal social engagement data from the MIDUS I and II studies, the paper by Teresa Seeman and her colleagues, "Histories of Social Engagement and Adult Cognition: Midlife in the U.S. Study addresses several questions about the role of social engagement in cognitive functioning. In cross-sectional data, greater social contact and support are associated with better cognitive functioning, whereas greater conflict is associated with lower cognitive functioning, and age-stratified analyses suggest that social conflict may be more strongly related to poorer cognition at the oldest ages. There is also

evidence of similarly patterned (though weaker) relationships at younger ages. The longitudinal social engagement data reveal both a relative stability in patterns of social engagement in adulthood and indicate that prior social engagement is also related to subsequent levels of cognition.

The paper by Brent Small and his collaborators, "Tracking Cognition-Health Changes from 55 to 95 Years of Age" provides a descriptive framework for considering some of these issues. Their analyses suggest that for many cognitive abilities, the declines associated with aging do not manifest themselves until after age 75 and as a modulating influence of the changing epidemiological context.

METHODOLOGICAL CONTRIBUTIONS

The interrelation of population processes, health status, and cognitive functioning requires the comprehensive assessment of health in an ecologically valid contextually relevant measurement design in large-scale longitudinal community-based samples. Knowledge of the relationship of aging to cognitive function is crucial to the understanding of the linkages between age and cohort-related socioeconomic, racial/ethnic, gender, and health disparities. Despite the great potential of current theories and methods, there are several serious limitations to generalizations about cognitive aging, raising concerns about projections that may be made about the future. This includes fundamental issues of measurement validity and reliability regarding the assessment and analysis of within-person change in cognitive capabilities in terms of health status and contextual (e.g., life experience) factors in older adults. The NRC Committee on Future Directions for Cognitive Research on Aging (NRC, 2000) stressed the importance of the development of an ecologically valid and comprehensive assessment of cognitive function, health status, sensory/motor functioning, and lifestyle/contextual factors in large-scale representative studies. How should we measure and model health and cognition in future studies of aging? What are the existing measures (including bio-measures) and models of health and cognition? and how can they be improved?

Several papers included in this issue address aspects of these problems. The paper by Eileen Crimmins and her collaborators, "Assessment of Cognition using Surveys and Neurological Methods: The Health and Retirement Study (HRS) and the Aging, Demographics, and Memory Study (ADAMS)," focuses on the assessment of cognitive status using survey approaches that have now become fairly standard. The HRS was the first nationally representative study to fully integrate the survey approach to measurement, using cognitive tests to classify respondents as cognitively impaired or not. The ADAMS study has assessed some of the same people using neuropsychological methods and diagnosed people as demented and having cognitive impairment without dementia. This paper examines the joint classification of subjects in the two studies to determine the characteristics of those who are classified differently.

A significant number of people who are diagnosed as demented in ADAMS would be classified as cognitively intact in the HRS. Information on functioning as well as cognition needs to be considered in using survey data to classify individuals by functioning ability. In addition, particular attention needs to be paid to the role of proxy respondents in assessing cognitive status in surveys.

The paper by John Gallacher and Scott Hofer, "Generating Large-Scale Longitudinal Data Resources for Aging Research," argues that the challenges facing aging and health research require large-scale, collaborative, and flexible longitudinal research platforms. Achieving this by increasing the number of standalone studies is neither cost-efficient nor scientifically optimal. An alternative strategy of developing integrated multidisciplinary research platforms is explored as a resource for sustained large-scale population studies as well as a wide variety of nested studies. They discuss a range of approaches for developing large-scale data resources, with particular emphasis on a "lite-touch, low-tech, low-cost" approach for longitudinal research on aging-related issues.

Current clinical longitudinal research relies on data collection methods that are conceptually rooted in models tied to technologies that have not dramatically changed for many decades. Thus, almost all direct in-person data collection occurs during a relatively brief contact, such as a telephone call or clinic or home visit. In the case of data collected outside of direct contact, various versions of questionnaires and surveys act as proxy records for activities or events that have occurred during a predetermined window of time marked as either a discrete event, such as a fall or faint, or perceived as a slowly evolving or subacute syndrome such as memory loss or depression. In most cases, the data captured are based upon the volunteer's recall; in some instances, a proxy informant is used. Inaccuracies potentially introduced by these methods, along with the overall inherent intra-individual temporal variability of data captured infrequently and intermittently, render such methods less than ideal. Because of these shortcomings, the paper by Jeffrey Kaye, Shoshanna Maxwell, and their colleagues, "Intelligent Systems for Assessing Aging Change: Home-based, Unobtrusive and Continuous Assessment of Aging," argues that current approaches make it difficult to identify data or events with detailed temporal or spatial precision, and as a consequence limit their ecological validity. This paper describes a home-based approach to assessment enabling unprecedented ecologically valid research leading to improved estimates of functional cognition, activity, and behavior. Such data and the discoveries they enable may ultimately provide the basis for developing more effective health promoting environments and care for older adults.

FUTURE RESEARCH

Cognitive functioning and health are intrinsically dynamic processes involving different patterns of within-person

variability in functioning, which are inextricably linked to social context and the dynamics of life events and experiences. Knowledge of the relationship of aging to health and cognitive function is crucial to the understanding of the linkages between age-related socioeconomic, racial/ethnic, gender, and health disparities (e.g., Whitfield, Weidner, Clark, & Anderson, 2002; Williams & Wilson, 2001; Wray & Blaum, 2001). Despite the great potential of current theories and methods, there are several serious limitations to generalizations about cognitive aging, raising concerns about projections that may be made about the future. One of the strongest conclusions from the conference on "Cognition, Health, and Aging" is that processes of aging linked to cognition and those linked to health should be studied simultaneously, as part of the same set of processes.

A longstanding challenge in research on aging-related processes is distinguishing aging-related changes from changes related to health (e.g., Blumenthal, 2003; Newman & Ferrucci, 2009). As understanding of the link between cognition, health, and aging has improved, what were once considered normative cognitive aging effects have been attributed to nonnormative processes, such as preclinical changes related to dementia. For example, the development of preclinical dementia, subclinical cardiovascular disease, diabetes, and respiratory dysfunction all substantially affect rates of cognitive decline. Comorbidity increases with age, which compounds the difficulty of evaluating the relative importance of specific health and function-related changes, such as those associated with diabetes, hypertension, stroke, depression, and hearing loss. These conditions, though increasing in prevalence and severity with age, are not strongly correlated with chronological age in cross-sectional analysis but demonstrate that the identification of normative aging changes depends, to some degree, on the identification of nonnormative health changes.

Understanding cognitive aging requires that chronological age be viewed as exposure, in addition to serving as a gauge for aging processes, conveying the duration that individuals have been at risk for probabilistic changes in health. From this perspective, including aspects of health as explanatory variables will help to distinguish inferences regarding changes related to aging. There is still much to be learned from existing longitudinal studies. We encourage new collaborative and coordinated research efforts using existing longitudinal studies of aging to better understand changes in cognition related to health and aging (Hofer & Piccinin, 2009, 2010).

Finally, consistent with the recommendations of the NRC's Committee on Future Directions for Cognitive Research on Aging (NRC, 2000), future research must produce an ecologically valid and comprehensive assessment of cognitive function, health status, sensory/motor functioning, and lifestyle/contextual factors within a relatively intensive and longitudinal measurement design. An optimal measurement instrument will permit on-site intensive

assessments of cognitive functioning and clinical evaluations and physical/biological measurement that can be used within the framework of a population-based demographically informed sampling strategy. This set of emphases is also consistent with the emergent orientation stressing the inclusion of biomeasurement in modern longitudinal surveys (Finch, Vaupel, & Kinsella, 2000; Weinstein, Vaupel, & Wachter, 2008). A comprehensive measurement battery including physiological and functional measures of health, in addition to long-term longitudinal assessments of individual health, cognitive, and demographic variables for nationally representative population samples, is essential for the future study of cognition, health, and aging.

FUNDING

Funding for the present supplemental issue was provided by support from the National Institute on Aging through the resources of the "Center on Population Health & Aging" (AG-P30-024395; PI: D. F. Alwin) at Penn State University, and the National Academies Keck Futures Initiative, "Health and Healthspan in Longitudinal Studies of Aging" (PI: S. M. Hofer).

ACKNOWLEDGMENTS

We acknowledge the work of Sherry L. Willis, Supplemental Issue Editor, for her outstanding contributions to this process, strictly maintaining objectivity and candor throughout. The editors also note that all papers included in this supplemental issue of *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* have been subjected to rigorous peer review consistent with the high editorial standards of the journal.

REFERENCES

- Baltes, P. B., Cornelius, S. W., & Nesselroade, J. R. (1979). Cohort effects in developmental psychology. In J. R. Nesselroade & P. B. Baltes (Eds.), *Longitudinal research in the study of behavior and development* (pp. 61–87). New York, NY: Academic Press.
- Blumenthal, H. T. (2003). The aging-disease dichotomy: True or false? *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences*, 58, 138–145.
- Finch, C. E., Vaupel, J. W., & Kinsella, K. (Eds.). (2000). *Cells and surveys: Should biological measures be included in social science research*. Committee on Population, Commission on Behavioral and Social Sciences and Education, National Research Council. Washington, DC: National Academy Press.
- Hofer, S. M., & Alwin, D. F. (Eds.). (2008). *Handbook of cognitive aging: Interdisciplinary perspectives*. Thousand Oaks, CA: Sage Publications.
- Hofer, S. M., & Piccinin, A. M. (2009). Integrative data analysis through coordination of measurement and analysis protocol across independent longitudinal studies. *Psychological Methods*, 14, 150–164. doi:10.1037/a0015566.
- Hofer, S. M., & Piccinin, A. M. (2010). Toward an integrative science of lifespan development and aging. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, 65, 269–278. doi:10.1093/geronb/gbq017.
- Lamb, V., & Siegel, J. (2004). Health demography. In J. S. Siegel & D. A. Swanson (Eds.), *The methods and materials of demography* (pp. 341–370). San Diego, CA: Elsevier Academic Press.
- Larson, J. S. (1999). The conceptualization of health. *Medical Care Research and Review*, 56, 123–136.
- National Research Council. (2000). *The aging mind: Opportunities in cognitive research*. Committee on Future Directions for Cognitive Research on Aging. Commission on Behavioral and Social Sciences and Education, National Research Council, Washington, DC: National Academy Press.
- Newman, A. B., & Ferrucci, L. (2009). Call for papers: Aging versus disease. *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences*, 64, 1163–1164. doi:10.1093/gerona/glp039.
- Weinstein, M., Vaupel, J. W., & Wachter, K. W. (Eds.). (2008). *Biosocial surveys*. Committee on Advances in Collecting and Utilizing Biological Indicators and Genetic Information in Social Science Surveys. Committee on Population, Division of Behavioral and Social Sciences and Education, National Research Council. Washington, DC: National Academies Press.
- Whitfield, K. E., Weidner, G., Clark, R., & Anderson, N. B. (2002). Sociodemographic diversity and behavioral medicine. *Journal of Consulting and Clinical Psychology*, 70, 463–481. doi:10.1037/0022-006X.70.3.463.
- Williams, D. R., & Wilson, C. M. (2001). Race, ethnicity, and aging. In R. H. Binstock & L. K. George (Eds.), *Handbook of aging and the social sciences* (pp. 160–178). New York, NY: Academic Press.
- Wray, L. A., & Blaum, C. S. (2001). Explaining the role of sex on disability: A population-based study. *The Gerontologist*, 41, 287–298. doi: 10.1093/geront/41.4.499