Neuroeconomics and Aging

Palo Alto, California
March 31–April 1, 2006

WORKSHOP SUMMARY

National Institute on Aging
Behavioral and Social Research Program

For Administrative Use

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National Institute on Aging
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Executive Summary

There has been a noticeable trend in the growing number and complexity of economically relevant decisions being faced by middle-aged and older adults, especially regarding pension and benefit issues, portfolio investment choices, health management, pharmaceuticals, and health insurance options. These can be cognitively challenging decisions, and the dizzying array of options faced by the decision maker can – at any age – adversely affect people's abilities to absorb, process, and weigh information. Meanwhile, the choices people make with regard to savings, investment, and health care can have a profound impact on their well being in later life. This trend, therefore, motivates the need for a greater understanding of how cognitive, motivational, and emotional processes in decision making influence economic behavior at different life stages, and particularly in middle to late adulthood when many of these decisions are made. Our current understanding of how changes in emotional, cognitive, and physical capacities at different life stages, in combination with life course changes in motivation and goals, impact economic behaviors at different life stages remains limited. Even less is known about changes in the neurobiological underpinnings of these interactions.

Recent efforts in neuroeconomics, that apply the theories and methodologies of behavioral economics, game theory, psychology, and cognitive, social and affective neuroscience to the study of economic behaviors, are beginning to shed light on the neurobiological basis of these kinds of complex decision making processes. Neuroeconomics has the goal of understanding the psychological mechanisms that guide economic behaviors and the neurobiological mechanisms that underlie them. Fueled by methodological advances in neuroscience, including the development of neuroimaging technologies such as functional Magnetic Resonance Imaging (fMRI), the neuroeconomics approach provides opportunities for a systematic investigation of the neurobiological mechanisms involved in a wide array of economically relevant behaviors such as reward processing, temporal discounting, subjective and objective valuation, overconfidence, delay of gratification, decision-making under risk and uncertainty, and affective influences on choice. Recent neuroeconomic research has also focused on social phenomena involved in the motivation of economic behavior including altruistic punishment, cooperation, competition, fairness, persuasion, trust and reciprocity. These functions implicate the involvement of neural mechanisms associated with reward processing, motivation, affect, and social cognition.

To date, there has been little investigation of these phenomena in the context of aging, despite the rapid accumulation of knowledge about age-related changes in the cognitive, motivational and affective processes believed to influence economic behavior. It is therefore not surprising

that understanding age-related changes in motivation and socioemotional influences on decision making are among the top research priorities identified in a recent National Research Council report commissioned by BSR from the Committee on Aging Frontiers in Social Psychology, Personality, and Adult Developmental Psychology, entitled "When I'm 64", (Carstensen & Hartel, 2006). The present workshop is motivated by the desire to extend the neuroeconomics approach to behavioral and social research on aging, creating the opportunity to explore how the neurobiological changes associated with aging influence or are influenced by these social, emotional, cognitive, and motivational factors, and to improve our predictive models of life course economic behavior by revealing the neurobiological mechanisms involved.

Within this context, the Behavioral and Social Research (BSR) Program of the National Institute on Aging (NIA) convened an exploratory workshop to share ideas about neuroeconomics and aging around a set of defined workshop goals. Presentations from experts in aging research in areas of social, cognitive, and personality psychology; cognitive and affective neuroscience; decision-making; and health and retirement economics framed the discussion of how the neuroeconomics perspective can be applied most fruitfully to issues of relevance to aging. Specifically, how can collaborative work on the neuroeconomics of aging develop across the disciplines of psychology, economics and neuroscience? What are the research gaps and opportunities for advancing neuroeconomics research on aging, as well as methodological challenges and potential solutions? Are there longitudinal studies that should be initiated or lifecourse neuroeconomic models that should be applied to aging issues? How can BSR define program goals for neuroeconomics of aging research to facilitate development of better lifecourse economic models, psychological theories, and applications to targeted aging issues?

The workshop presentations highlighted the importance of affect and motivation on judgments, probability perception, and decision-making, and they underscored the potential contributions that behavioral scientists could make to improve the measurement of utility (an abstract concept representing subjective well-being or satisfaction used by economists) and cognitive functioning in large population surveys. Insight on methodological and interpretive issues involved in neuroimaging of older adults was provided, and there was discussion of how to forge links between the neuroscience laboratory and field-based population research. Findings related to health care and retirement economics and aging were highlighted. These presentations and discussions are summarized below. A list of recommended readings provided by presenters is included as Attachment B.

Emerging Themes

Several underlying themes permeated the discussion, including the following:

Age differences in affect/emotion
Affect, a valenced feeling that gives meaning to information, may be an internal "common currency" used to assess the relative value of choice options. Affective information may become more salient as we age. The role of emotion and affective information in guiding economic decision making was the focus of several presentations at the workshop (Carstensen, Slovic, Mather), and understanding the role of emotion or affect in choice is an important emerging theme at the interface of psychology, economics and neuroscience.

Age differences in affective/experiential and deliberative processes have important theoretical implications for judgment and decision theory and important pragmatic implications for older-adult economic decision-making. In some situations, age-related adaptive processes, including motivated selectivity in the use of deliberative capacity, an increased focus on emotional goals, and greater experience, may moderate age-related cognitive declines and possibly produce better decisions for older adults. Indeed, it has been shown that healthy older adults report greater emotional control, experience the same or greater well-being, and demonstrate greater emotional understanding and refinement than their younger counterparts. However, the dynamic range of physiological response to emotionally evocative stimuli declines with age, particularly in the cardiovascular system. If visceral sensations also lessen with age, this may reduce the impact affective signals that convey important information for decision making. Evidence also exists that older adults use their cognitive resources to regulate their emotions. There is some evidence of a "positivity effect," with chronological age associated with heightened attention to emotional gratification and the emotional aspects of life, and with accentuated attention and memory for positive information. Yet older age is also a time when cognitive processes are declining in efficiency. It remains an open question how these factors interact in complex domains such as economic decision-making.

Neuroimaging the aging brain

While standard observational experiments lend insight to cognitive processes in old age, advances in neuroimaging, including diffusion tensor imaging and fMRI, have become increasingly valuable tools for the study of the neurobiological correlates of these processes. Neuroimaging studies of cognition indicate that older and younger adults show different activation patterns when performing the same cognitive tasks, including task-specific under-activation of some brain areas, recruitment of additional brain areas, and bilateral rather than unilateral activation in older compared to younger adults. These kinds of findings have variously been cited as evidence of either age-related decline or of compensation and plasticity in the aging brain.[1] As neuroimaging results continue to shed light on our understanding of the cognitive changes associated with normal aging, a growing appreciation of the challenges that neuroimaging techniques pose for research on aging is emerging. Of particular importance is the need to understand how age-related differences in vascular properties influence properties of the MR signal. In addition, practical issues, such as age-related differences in head motion and tolerance for time in the scanner, have the potential to influence neuroimaging data. It is important to consider the implications of these and related problems for neuroimaging investigations in older adults, and it is especially important to distinguish age-related changes in neuroimaging measurement from age-related changes in underlying brain function.

The need for cross-disciplinary fertilization

To best enable cross-disciplinary work, it was felt that researchers need to examine what neuroeconomics can contribute to aging studies and, likewise, what aging studies can contribute to neuroeconomics. Neuroeconomics can offer a characterization of the processes involved in economic behavior and a set of tools for studying how these processes change over the life cycle. As a complement to this, research on aging offers insights into age differences in the underlying cognitive, affective and motivational processes that impact economic decision making, and can provide a menu of life-cycle economic behaviors that need to be understood. Development of a

common language can be advanced by improving our understanding how economic decision-making is coded and processed in the brain, by testing computational models of these processes, and by increasing our knowledge of age differences in performance on a wide variety of behavioral economic, game theoretic, and social exchange tasks. Appreciation by economists of the many facets and dimensions of the emotional response and of the variety of possible affective influences on economic behavior, on the one hand, and appreciation by psychologists and neuroscientists of the details of economic models and the structure of economic institutions, on the other hand, would help to advance the discussion.

The need for external validity

Two types of external validity—population validity and task validity—are required to ensure high-quality data. The limitations of current studies include the focus on relatively high-functioning older adults who are not a representative sample of the population; also, there are confounding effects with individual differences that may be overcome with a larger sample. Large surveys such as Health and Retirement Study, which has an excellent longitudinal sample on whom a variety of cognitive measures have been taken, and for whom a wealth of information about actual economic behaviors exists, could be a valuable resource for investigators in neuroeconomics. In addition, an identified battery of tasks to be studied is crucial to understanding how decision-making processes change over the life cycle and how this affects economic behavior. Are there any "golden standards" that should be followed at the intersection of neuroeconomics and aging, without which data will not be valid? For example, if a cash incentive is not used, it is likely that the cognitive process will not represent a real economic transaction. Workshop participants agreed that this is critical to the justification of the research.

Based on the group discussion, potential areas of study included the effect of manipulation of time horizon on such activities as spending/savings behavior; the addition of affective categories to information displays to add meaning and enable older adults to process information more easily; and how "institutions" can be manipulated to facilitate or otherwise influence decision processes. The complexity of many real world economic decisions was emphasized (the recent Medicare Part D website served as one example), and research was encouraged to understand how the presentation of economic choices impacts the decision-making of older adults.

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[1] Reuter-Lorenz, P.A. (2002). New visions of the aging mind and brain. *Trends in Cognitive Sciences,* 6 (9), 394-400.

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SUMMARY OF PROCEEDINGS[1]

Introduction

The National Institute on Aging (NIA)'s Behavioral and Social Research (BSR) Program has begun to advance a research agenda on promising avenues for aging research in the emerging field of neuroeconomics, particularly interdisciplinary research that addresses interactions among psychological, physiological, social, and economic factors that influence how older adults negotiate important life decisions related to retirement, Medicare, and health care management. A July 2004 seminar, Decision-Making and Aging, represented the first of an initial round of discussions on these topics, followed by two teleconferences on Neuroeconomics and Aging on August 12 and 26, 2005, respectively, that served as interim steps initiated by the NIA and BSR, and a November 29, 2005, National Academies Workshop on Decision-Making Needs of Older Adults. The NIA continued this dialogue on March 31, 2006, with an exploratory workshop on Neuroeconomics and Aging with invited experts and observers in the areas of decision science, cognitive, affective and social neuroscience, emotion and personality psychology, and economics, to stimulate discussion of how to apply a neuroeconomics perspective fruitfully to issues of relevance to aging. (The list of workshop participants is included as Appendix A.) The workshop represented an effort to develop a common language across disciplines, bring to light differing perspectives on methodology, and foster cross-disciplinary work. The exploratory workshop participants were asked to consider the current state of research in the area of neuroeconomics and aging, as well as opportunities for research advances and how research goals might best be realized.

The workshop format was informally structured to allow each invited expert to present his or her own findings and viewpoint in a 40-minute talk, followed immediately by a 20-minute discussion of each perspective. The workshop also allowed ample time for discussion of common themes and future research directions.

Dr. Lis Nielsen, NIA BSR, and Dr. Antonio Rangel, Director of the Stanford Neuroeconomics Laboratory, co-hosted the workshop and guided the discussion. In her opening remarks, Nielsen emphasized that the goal of the workshop was to promote dialogue on identifying fruitful avenues for research in Neuroeconomics of Aging. Nielsen began the workshop by describing the organizational structure of the BSR program at the NIA, emphasizing the program's goals to

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[1] This meeting summary was prepared by Rose Li and Associates, Inc. (rose@roseliassociates.com). This version has benefited from helpful comments by Jeff Elias and Lis Nielsen. The findings and views reported in this document reflect both individual and collective opinions of the workshop participants and not necessarily those of the National Institute on Aging, National Institutes of Health, or the U.S. Department of Health and Human Services.

support collaborative efforts on topics such as Neuroeconomics of Aging that allow BSR to draw on expertise in a wide range of disciplines and to promote integration and linkage across disciplines and topical areas. An overarching goal of workshops such as this is to encourage greater collaboration and exchange.

The NIA has been engaging in a dialogue with researchers in neuroeconomics, both formally and informally, to encourage application of their investigations to issues of relevance to aging. These initiatives include pilot research in neuroeconomics at NIA Demography and Roybal centers, the NIA neuroeconomics teleconferences of August 2005, the present Neuroeconomics and Aging Workshop of March 2006, and the upcoming seminar on Neuroeconomics and Aging in July 2006, which is part of the National Science Foundation -sponsored Stanford Summer School on Neuroeconomics. The BSR is holding concurrent workshops on decision-making and aging and other related initiatives.

Nielsen presented some background, intriguing findings, and opportunities for aging research in the emerging field of neuroeconomics. Neuroeconomic investigations have the potential to shed light on how the biological, social, and psychological changes associated with normal aging influence complex economic behaviors such as investment planning, advance directives, susceptibility to fraud, age-appropriate marketing strategies, and motivation of behavioral change. Understanding how middle aged and older adults make economic choices, and the constraints on those choices posed by health status, social context, and factors associated with chronological age or changes in time horizons may also have implications for how we evaluate and promote well-being in older adults. In the long term, advancing our knowledge of age-related changes in economic behavior and motivation may ultimately guide the structuring of decision-supportive interventions and policies affecting the choices that individuals make as they approach the end of life.

Nielsen identified four research opportunities in the Neuroeconomics of Aging:

1. *Age-related change in reward processing.* Are there age-related change in reward processing, and what are their implications for economic choice and for measurement of subjective well-being in older age?
2. *Discounting and intertemporal choice.* What are the neurobiological mechanisms underlying discounting and intertemporal choice, and how to they affect savings and planning behaviors?
3. *Social and contextual factors influencing economic behaviors of older adults.* How does age interact with social and contextual influences; are there age differences in trust, reciprocity, cooperation, and competition?
4. *Methodological innovations.* The development of techniques for measuring economic choices of relevance to older adults in the laboratory, field, and neuroimaging environments.

While research on these general themes is ongoing in a variety of Neuroeconomics laboratories, very little of this work is focusing on aging.

Nielsen stated that the goals of the workshop were to: (1) Promote interest in lifespan developmental applications of basic research in neuroeconomics; (2) develop a common language and collaborations across the disciplines of economics, psychology, neuroscience, and

aging; (3) identify research gaps and opportunities as well as methodological challenges and potential solutions; and (4) facilitate development of better lifecourse economic models, psychological theories, and applications to targeted aging issues. Interdisciplinary models may influence social, financial, and health-related decisions affecting the well-being of adults and the elderly (such as important life decisions related to retirement, Medicare, and health care management) and inform the development and refinement of integrative lifespan economic theories of utility, learning, and strategic choice.

Invited Perspectives

Laura L. Carstensen, Ph.D., Stanford University
Emotion, Motivation, and Aging

Motivational changes across the lifespan can have profound implications for decision-making. According to the socioemotional selectivity theory, humans are uniquely able to monitor time—including lifetime—and do so at both conscious and subconscious levels. Goals always are set in temporal contexts. Because chronological age is associated with time left in life, goals should change across the lifespan (Carstensen, 1993; Carstensen et al., 1999). When time is perceived as expansive (as it typically is in youth), people are interested in acquiring knowledge, meeting new people, and taking chances; on the other hand, when time is perceived as being constrained in some way (i.e., as it is for AIDS patients), people tend to focus on the present, investing in sure things, deepening relationships, living in the moment, and savoring life.

A number of postulates stem from this theory: (1) perceived constraints on time motivate people to pursue emotionally meaningful goals; (2) motivation to pursue emotionally meaningful goals directs cognitive resources to emotional information; and (3) focusing on emotionally meaningful goals is good for well-being. Research suggests that it is likely that emotional functioning improves into late adulthood and is at least maintained in old age. Indeed, older adults have the lowest rates of virtually all psychological disorders, as compared to younger adults. Older people report that they can control their emotions more effectively, experience more mixed emotions, and feel negative emotions for shorter durations. Even in the midst of cognitive decline, there appears to be an improvement in the emotional system, at least in terms of regulating emotion.

While emotion and cognition cannot be delineated clearly, emotion is inherent in all cognitive functions as captured in the observation that “categories exist because some objects and events matter and others [do] not” (Zajonc, 1997). Of particular relevance to the psychology of aging is the notion that, to the extent that the categories that matter change with age, we may see systematic changes in cognitive processing as a function of these motivational factors.

A number of empirical studies demonstrate how emotions may matter. In one study, Carstensen presented two sets of advertisements that were identical in terms of their graphic design but differed in terms of the promises they made—i.e., one set focused on the future, acquiring new knowledge, and on widening one’s horizons, and the other focused on emotional experiences in the present moment. Whereas the framing of the ad made no difference for the younger adults,

older people clearly preferred the more emotional ads. They also were able to remember these slogans better than the knowledge-related slogans and were more likely to remember the products associated with emotional slogans (Fung & Carstensen, 2003). In a subsequent experiment, the researchers asked old and young subjects to imagine that they had just received a phone call from their physician virtually ensuring them that they will live another 20 years in good health. Based upon this assumption, the groups were again shown the advertisements; when subject to the new, time-expanded condition, older subjects no longer significantly preferred the emotional ads over the knowledge-related ads. Carstensen and her colleagues concluded the following with regard to time horizons: When time horizons are manipulated experimentally, preferences change systematically. Younger people show preferences similar to older people when time horizons are shortened and older people show preferences similar to the young when time horizons are expanded. When natural time-shortening occurrences such as personal illnesses, epidemics, political upheavals, or terrorism prime endings, preferences of the young come to resemble those of the old.

In a number of laboratory studies, Carstensen and her colleagues have found evidence of a "positivity effect," i.e., preference for negative information in attention and memory in youth shifts; at advanced ages positive information is relatively accentuated. She noted that she does not use the term positivity "bias," because the effect is driven as much by younger people's preference for negative information as older adults' preference for positive information. In several studies, accuracy is found to be the same when comparing older and younger adults.

To test the positivity effect, Carstensen and her colleagues presented subjects with visual stimuli that were positive, negative, and neutral, and then asked them to recollect the images. Older people were more than twice as likely to remember positive images over negative images and they remembered even fewer of the neutral images. Young people remembered more of the images and were equally likely to remember negative and positive images. They were less likely to remember neutral images. Middle-aged people remembered more of the positive images over any other age group and remembered slightly fewer of the negative images than the younger age group. Middle-aged people in the study also remembered fewer of the neutral images than their younger counterparts. The most common response among older people regarding how to deal with negative emotional issues is to "just not think about it." Studies of amygdala activity appear to confirm this phenomenon.

In a second study on selective attention, subjects were shown multiple images (a pair of faces: one positive or negative, and one neutral) at one time for a duration of one second. A dot then appeared over one of the faces, and they were asked to identify over which of the faces the dot appeared. Subjects were faster to respond if they were looking at the image already when the dot appeared. Data from the study indicated that older subjects were faster to respond when the dot was above the positive faces rather than the negative faces, suggesting that older people most often look toward the positive and away from the negative.

Carstensen then discussed affective working memory studies. Affective working memory maintains a representation of an emotion in the absence of the immediate elicitors to form goal-directed behavior. A recent study examined affective working memory with negatively valenced information compared to a brightness working memory task (Mikels & Reuter-Lorenz, 2004).

There is some reason to suspect that there may be distinct neural subsystems underpinning affective working memory versus working memory for other types of information. The study addressed the question of whether affective working memory is better for positive rather than negative information. In the study, participants see an image; it disappears; there is a retention period; another image appears; and then the participant is to report which image was the most intensely negative. In the brightness study, photographs were shown that varied in brightness. In each task, the participants were asked to hold the feeling state and then make a comparison with the new information. Older adults did not perform as well as younger adults on the brightness trial; however, in the study that compared affective (emotional) images, there was no main effect of age in working memory. What Carstensen found more interesting was that in the valence condition, where pairs of negative and positive images were compared, there was an absolute advantage of older people over younger people in the positive trials, while there was an absolute advantage of younger over older people in the negative trials.

A recent study examined the positivity effect in autobiographical memory by going back to an order of nuns who had completed an extensive questionnaire 15 years earlier. In 1987, the School Sisters of St. Francis completed a 26-page questionnaire about their physical, social, and emotional lives. In 2002, they were re-contacted and asked to complete the questionnaire again—"as you completed it in 1987." By the time of the second questionnaire, the ages of the nuns ranged from 52 to over 100 years. The researchers used a quasi-experimental design to see if they could eliminate the positivity effect by having the participants focus either on being accurate, or on how they felt while completing the survey, or giving no instructions whatsoever. They embedded several prompts throughout the questionnaire, reminding them to be as accurate as possible or to pay attention to their feelings. Both older control participants and participants who were focused on emotional states showed a tendency to remember the past more positively than they originally reported in 1987. In contrast, both younger control participants and participants who were focused on accuracy tended to remember the past more negatively than originally reported (Kennedy, Mather & Carstensen 2004).

Carstensen then asked whether such findings have implications for decisions about health care. Can you improve people's ability to make decisions about healthcare plans based on their feelings about the plan? She presented some preliminary data on a study she and her colleagues have recently begun, asking participants to rely on their feelings to choose among emotionally valenced health-related statements about two options from four domains (i.e., health care plans, treatments, primary care physicians, and home care aides) rather than attempt to remember all of the information. The task goal was to choose between one of two weighted alternatives; in each, one was a better option. There were two between-subject conditions: a remember condition and an affective condition. Subjects were asked to rate how well they remembered an option (e.g., HealthNow) or how they felt about that option; then they were asked to make a choice. Preliminary data from this study suggest that older people perform better when they are updating how they feel about the plan rather than focusing on what they remember about the plan. What Carstensen found notable here is that the age effect disappears in the condition where the participants focus on feeling.

The findings from these studies have a number of implications for decision-making. There is suggestive evidence that older people are deferring decisions that are emotionally charged.

Researchers are concerned that decisions could be influenced by biased recollections of the past, favoring the positive—which can place older adults at a disadvantage. In studies in which choice options are presented, older people tend to look longer at positive, rather than negative, options. If the emotional system is improving across adulthood and deliberate cognitive processes are declining in efficiency, it remains an open question whether older adults can and should be encouraged to rely upon intuitive, emotional processes to improve their decision-making skills.

In the ensuing discussion, there was speculation that older adults may recall more positive images simply because it takes longer to process negative information (as in the dot probe experiment) rather than because they selectively attend to the positive. Could it be that negative images are deemed irrelevant or suppressed? According to Dr. Mara Mather, imaging studies show more frontal and less amygdala activation in older adults. Carstensen believes that there is something deliberative about the behavior; that the more automatic the subjects' attention, the more likely they are to see the dot.

The concept of time horizon and the manipulation of time horizon are very important in economic policy. Yet, Dr. Michael Hurd observed, no studies have been done yet to examine the effect of manipulation of time horizon on spending and savings behavior. If consumption is required for exploration of the world (the goal preference of younger adults) how do we encourage savings behavior? Hurd noted that the finding that young people generally do not plan to save is not a new trend, but a historically accurate characteristic of younger adults. People in their 50s are better prepared financially than people in any other generation and save at the highest rates.

Dr. Robert Willis was struck by the parallels of the psychological models to the human capital theoretical framework that economists use. An investment in new knowledge and learning provides competence that is reflected in capital stock accumulation and rewarded in markets, followed by declining investment rates. He suggested that it may be worthwhile to look at the two models together.

Dr. Paul Slovic observed a widening of distribution in that some older people do not decline much in terms of physical performance tasks, while others decline rapidly. He noted that the subjects in the studies discussed by Carstensen are relatively high-functioning and may have greater ability with cognitive tasks too, which may color our sense of the results. Carstensen stated that the higher-performing people show the positivity effect more than the lower-performing people. While she acknowledged that there were relatively high-functioning people in the studies, the investigators were careful to recruit a mix of two-thirds white collar and one-third blue collar with minority representation. No class, race, or gender differences were found. There have been no gender interactions by age in studies demonstrating the positivity effect.

Experimental economists cautioned that institutional effects can be subtle; how do these affect factors such as emotional state and perceptions of time? How does our environment influence how older adults feel, and how can we create better environments where their lives may be improved? For example, can rules about how you buy and sell in an auction-like environment be designed better for the elderly? What kinds of questions or simple tasks might be incorporated to identify changes across the population and their influence on motivation? How does the

environment affect a person's perception of time, particularly with respect to retirement decisions, health care decisions, and so on? It also was noted that preferences change over time, but people need to plan or make decisions about their old age at a younger age. One suggestion for reconciling this was manipulation via a short time horizon.

Another participant asked whether the positivity effect changes with cognitive resource changes. Dr. David Laibson suggested that interventions causing older adults to think emotionally might hinder rather than help them, if, indeed, negative emotions get ignored in calculations, resulting in problematic decisions and outcomes. The decision to "go with your gut" is not always a good decision. Thus, it may be better to look at other interventions that would undo the bias about negative emotions.

Robert W. Levenson, Ph.D., University of California at Berkeley
Social Neuroscience, Psychophysiology, and Aging

Dr. Robert Levenson began by providing some background information on emotion and the emotional response. A physiological emotional reaction is brief, and can be observed when an antecedent event, such as loss, matches a prototype and invokes an emotional response. To capture emotional responses in the laboratory, Levenson has employed a number of different techniques including having people relive emotional memories, using emotionally evocative films to elicit response in people, asking subjects to make emotional faces, and examining social interactions.

Levenson presented a videotape of one experiment, in which a subject viewed a film of a person working in a woodshop who suffered a serious accident (the antecedent event). The brevity of the emotional response was evident in the facial expression of the subject. This short duration distinguishes an emotional response from moods, emotional traits, or emotional pathologies, as proposed by Paul Ekman (1986). The emotional response occurs in waves rather than steady states, and it readily crosses internal and external boundaries—many of the subject's reactions occurred after the screen went blank. Stimulation inside the system activates the emotional response a few seconds after the event has passed. The psychophysiological approach provides evidence that emotions are organized rather than chaotic. When we are in an emotional state, facial behavior is correlated perfectly with peaks of emotion, sweat gland activity, and heart rate.

Emotions are critically important in aging, helping to establish and maintain social relationships, which are closely connected to health and well-being. Emotion is intimately involved in critical psychological processes that are impacted by age (e.g., memory, learning, attention/perception), assuming an important role in late-life "wisdom," and is altered by many dementing disorders. Unlike many other areas of human functioning, emotions do not show unrelenting decline with age. Rather, many aspects of emotional functioning are relatively preserved in healthy elders, and some aspects may even show improvement in late life (e.g., use of positive emotion to regulate conflictive social interaction). Emotional dysfunction is a prominent feature of many dementing disorders, especially in those aspects that require monitoring of self, others, and social situations.

There is evidence that older adults experience greater emotional control (Lawton, et al., 1992); the same or greater well-being (Stacey & Gatz, 1991); greater emotional understanding (Labouvie-Vief, et al., 1989); and greater emotional refinement (poignancy, reminiscence; Molinari & Reichlin, 1984) – all of which counters the "classic" view that old age is a time of dampened emotionality. Older adults also experience more sources of pleasure and fewer sources of conflict than their younger counterparts. In addition, during marital studies on emotion in problem-area discussions, older couples expressed more affection, while middle-aged couples expressed more anger, belligerence, and whining.

Comparisons of emotional physiology between young (ages 18 through 30) and old (ages 71 through 83) subjects showed reduced dynamic range in heart beats per minute with age. Visceral sensations are lessened with age, relaying fewer signals to react or respond quickly to a dangerous or important occurrence. A question is whether age-related decisions could be mediated by these kinds of reductions in visceral response. One participant questioned the idea that there is less visceral input with age because for older adults, there is the same percentage of dynamic range in changing heart rate. Differences in visceral response by age may be more important in novel contexts as opposed to more familiar circumstances.

In one study, couples in long-term marriages, newlyweds, recent divorcees, and pastoral counselors demonstrated greater accuracy in judging the marital satisfaction and stability of ten couples discussing a marital problem for 3 minutes than marital researchers and marital therapists (Ebling & Levenson, 2003). Based on his observations from the videos, Levenson surmised that the ability to use humor and affection in discussing problems attenuates conflicts.

Levenson next discussed two social neuroscience approaches to studying emotion and dementia: (1) the "activated brain" approach where brain scans (e.g., fMRI, EEG, ERP, MEG) of normal subjects reveal regions of brain activation; and (2) the "damaged brain" approach which enables examination of behavior in an unconstrained way, usually of patients with lesions or neurodegeneration, using conventional measures of behavior, subjective experience, language, and peripheral physiology. After pointing out the anatomical locations of social brain activity, Levenson concluded that most action occurs in the fronto-temporal parts of the brain. It is therefore of interest to understand their functions by looking at the effects of frontotemporal lobar degeneration (FTLD).

In patients with FTLD, there is a rapid progression of tissue loss. As the disease progresses, cognitive functioning is relatively preserved, but patients begin changing emotionally. While they have emotions, they show a loss of empathy and emotional understanding. Many are misdiagnosed with depression. Patients with FTLD show a loss of self-conscious emotion in which no secondary emotion, like embarrassment or laughter after initial startle response, is observed. Attempts by FTLD patients to regulate emotion (i.e., minimize or suppress a response to an acoustic startle) results in an inappropriate response. Different dementias have different effects on emotion. For example, unlike patients with FTLD, Alzheimer's Disease patients appear to have intact emotional processing and to demonstrate a sense of self. FTLD patients cannot recruit the rational processes needed for making appropriate decisions.

One participant observed that the relationships among the limbic system, reward system, and the cortex and frontal lobe in terms of decision making and pleasure are integrated systems. An interesting research question is how these relationships might change with age. The progression of an injury may alter relational systems, although the change may be subtle. How an imprinted emotional memory, which is stored differently than temporary memories, changes over time, is another interesting question.

Panel on Decision-Making and Aging

Mara Mather, Ph.D., University of California at Santa Cruz

Mather focused on aging and emotional goals and implications for risk seeking. She echoed a theme from earlier presentations that as older adults' time perspective shifts in old age, they focus more on emotional goals and that compared with younger adults, older adults show a positivity effect in attention and memory. Mather is interested in the mechanism underlying these changes in older adults: Is the positivity effect the result of goal-directed strategic processes, or is it a serendipitous side effect of age-related decline? If older adults have emotional goals, how is it that they will implement them in their attention and memory? They need executive resources and cognitive control; they need to be able to inhibit the things they want to inhibit and selectively attend the positive. The paradox of this is that the ability to exert executive control declines with age. Mather proposed that older adults, who exhibit these effects, are likely to be those who have the highest cognitive control of all groups and are best able to implement their goals.

To test this hypothesis, Mather initiated two studies. In the first, two groups of subjects were asked to watch pictures in a slideshow on a computer screen. In giving one group a divided-attention task, Mather's goal was to reduce access to cognitive resources, with the expectation that doing so would attenuate the positivity effect. Under full attention (the control condition), there was an age-by-valence interaction. In the divided-attention group, for younger adults the divided-attention task did not affect which valence was most memorable, but the valence of older adults' memories appeared to be affected by the availability of attentional resources (Mather & Knight, 2005).

The positivity effect actually reversed under reduced availability of cognitive resources. In the study, dividing attention eliminated younger adults' negativity effect, while nearly 70 percent of what the older adults remembered consisted of negative pictures. This may be explained by the idea of ironic processes and mental control, e.g., if people are told not to think of white bears, they can do this fairly easily if their minds are focused on doing so; but when distracted, thoughts of white bears flood in (Wegner, 1994). Thus, there may be a cost if older adults are trying to avoid the negative and they are not at that moment able to implement the goal.

In a second study, Mather and her team used eye-tracking to study patterns that occur in the moment when the information is encoded. Subjects were shown pairs of pictures with different valences; e.g., negative and neutral images were shown in a block next to positive and neutral faces. In younger adults, a negativity effect disappeared under divided attention, which may indicate that younger adults have a goal of focusing on the negative. This is consistent with previous findings, based on younger adults, of a perception that "bad" is stronger than "good"

(Baumeister, Bratslavsky, Fickenauer & Vohs, 2001). Older adults followed the same pattern as in the first study: there was an increased negativity effect with divided attention. Mather concluded that even though the first fixation for all age groups is on the emotional picture (with an attention preference on pictures that represent threat), older adults use their subsequent attention for different purposes than younger adults because they have different goals. She contended that the positivity effect in attention and memory among older adults is the result of strategic processes.

Mather then discussed potential implications of goal-directed emotion regulation processes on risky decisions. Previous laboratory studies reveal few consistent age differences. There is limited evidence of increased risk aversion on the Iowa Gambling Task (Denberg, et al., 2001; MacPherson, et al., 2002; Sanfey, et al., 2003; Wood, et al., 2005). However, one consistent finding is an increase in decision avoidance (Mather, 2006). Older adults prefer not to make difficult decisions themselves, and their problem-solving strategies tend to be more avoidant than those of younger adults.

For most choices, regret or satisfaction with the outcome is where the emotional action is. Regret is largely determined by the counterfactuals that are most likely to come to mind. When forecasting future emotions, sure-thing options provide the most concrete counterfactual. Thus, a focus on avoiding regret should lead older adults to favor alternatives with known positive outcomes over alternatives with uncertain positive or negative outcomes. When presented with "sure-thing" and risky options with similar expected values, older subjects generally preferred the sure-thing option, which is consistent with older adults' use of cognitive resources for emotion regulation purposes in their attention and memory. This emotion regulation focus may also influence decision search, variety seeking, and memory for decisions (e.g., Mather & Johnson, 2000; Mather, Knight, & McCaffrey, 2005). Mather posed three questions for further study: (1) Can older adults' tendency to choose the sure-thing option be explained by the affect heuristic or emotion regulation? (2) How might this tendency affect loss aversion? And (3) How do age changes relate to changes in the brain? One point of discussion involved the definition of a goal and the widely held belief that individuals have subconscious goals.

Paul Slovic, Ph.D., and Ellen Peters, Ph.D., University of Oregon

Dr. Paul Slovic identified three categories of characteristics affecting decision-making competence, drawn from the Person-Task Fit Framework by Finucane and Lees (2005): task, decision-maker, and context. Slovic focused on just a few of these characteristics: framing (task characteristic); speed of processing, age, and numeracy (decision-maker characteristics); decision support (context characteristic); and comprehension and affective fluency (decision-making competence).

According to the Comprehension Index (Hibbard, et al., 2001; Finucane, et al., 2002), which reflects the number of errors made out of 35 decision tasks involving interpretation of tables and graphs, comprehension errors increase with age, and there is a high percentage of error (especially above age 80) among the elderly even for acquiring information. This finding suggests the need to address the fact that a high percentage of older patients will not be able to comprehend information presented in graphical or tabular format. The range of decision making

competence increases with age, making individual differences particularly important in older adults.

Slovic emphasized Montague's theory of a common internal currency to assess the relative value of events, like drinking water versus searching for predators (Montague & Berns, 2002). Recent work has shown that fluctuations in the delivery of the neurotransmitter dopamine may represent one such common currency. The dopamine system is well designed to handle the kinds of decisions that an early human would have encountered; however, it is grossly inadequate in many situations, such as drug-abuse situations, that have arisen in modern society.

At the psychological level, the "common currency" may be affect, a valenced feeling (e.g., goodness or badness) associated with a stimulus. Although it may be very faint, it can strongly influence behavior. There are at least four functions of affect: It acts as a common currency, it acts as information, it acts as a spotlight, and it acts as a motivator of action. The meaning of information is closely linked with affective response. Affect conveys meaning upon information, and without affect, information lacks meaning and will not be used in judgment and decision-making. Affect is a key ingredient of rational behavior; it also sometimes leads to poor decision-making.

Slovic next discussed Epstein's (1994) two modes of thinking associated respectively with the experiential and analytic systems. Reliance on feelings appears to increase with innumeracy, cognitive load, stress, older age, and affect-rich outcomes and images. Affective information may become more important as we age, according to Carstensen's Socioemotional Selectivity Theory (1992) and Labouvie-Vief's Dynamic Integration Theory (2003), which hold that age-related cognitive limitations cause a shift and that there is an increase in disruptions from emotionally arousing stimuli, particularly to less resource-demanding positive information. Affect has been linked to such activities as evaluating gambles, travel destination preferences, risk perception, and marketing.

A study on affect, evaluability, and attractiveness of simple gambles underscores the importance of contextual factors in determining affect and preference and that meaning, utility, and weighting of even very familiar and "well-understood" monetary outcomes is not fixed, but depends greatly on contextual factors, e.g., whether the probability or the payoff are evaluable.

With respect to numeracy, the ability to understand and use basic probability and mathematical concepts, studies have found that lower numeracy is linked with lower comprehension, greater framing effects in decisions, greater influence of direct (and irrelevant) sources of affect and emotion in decisions, and the drawing of less meaning from numbers. The ability to understand numbers influences the precision of feelings about probabilistic information, the extent to which irrelevant affect influences choices, the accessibility and influence of nonsalient frames of the same number, and the degree to which affect is elicited through a comparison of numbers. For example, both younger and older people with less ability to understand numbers, respond differently to the likelihood of an adverse event expressed as a relative frequency (e.g. "1 out of 100") and the likelihood expressed as a probability (e.g. a 1 percent chance). The frequency representation seems riskier to them, perhaps because it promotes imagery of "the one...." In

contrast, highly numerate people do not respond differently to the two frames, perhaps because they translate effortlessly between them.

Judgment and decision skills can be improved by restructuring the task or environment to correct known biases. Illustrating his point with examples of visual illusions, Slovic emphasized that perception, as good as it is, sometimes goes wrong. Decision aids such as coding affect in information displays may help older adults process information more effectively; for example, affective categories add meaning to a complex data display such as a table showing patient satisfaction with doctor communication. In this example, affective categories influenced choices, whereas a table with only category lines did not, showing that highlighting affective elements can help the elderly interpret information. Participants slower in speed of processing were helped more by the affective coding on the categories.

Slovic concluded by raising numerous directions for behavioral and neuroscience researchers to pursue collaboratively. These included whether neurological techniques can be applied to study evaluability; the brain response to "10 percent" versus "10 out of 100"; and more generally, analytic versus affective processes in the brain. How does brain activity differ in high- versus low-numerate people as they make judgments and decisions? Some challenges to this area of study include the need for repetition in fMRI studies and complexities of sampling in studies of older adults.

From an economic standpoint, Willis observed that the decision reflects personal preference and the rate could be construed as evidence of what that probability might be, and so people who are highly numerate seem to be adept at converting evidence into meaningful pieces for decision making. For the low numerate, there appears to be more of a disconnect—in these cases, affect seems to be driving numeracy (or vice versa). Numeracy may not be the correct label; something else may be occurring. It also was observed that the notion of affect may play into some recent neural mechanisms used to describe choice.

Laibson commented that in economics, research methodology requires consistency and compatibility between incentives and behavior. He emphasized the need for real incentives and for ensuring that incentives are introduced at the correct points in the study, and that incentives are truly motivating risk-averse as opposed to risk-seeking behavior.

Timothy Salthouse, Ph.D., University of Virginia
Cognitive Research on Aging

In his presentation, Dr. Timothy Salthouse intended to achieve two goals: (1) to provide a brief summary of what is currently known about the relation between age and cognitive functioning; and (2) to describe a research strategy designed to ensure cumulative progress by investigating age differences in new variables and constructs, such as those concerned with economic decision-making, in the context of what already has been established. He began by highlighting some of the common assumptions about aging that have proven to be misperceptions: That aging primarily affects memory; that only small effects are observed; that these effects are observed only in some people; and that they are not longitudinal but cross-sectional. He then proceeded to address each assumption in turn.

Regarding age effects on memory, Salthouse showed data on a variety of cognitive tests that were administered in different ways representing different cognitive abilities (four tasks measured memory/recall of a removed past experience; matrix reasoning; spatial visualization; and perceptual speed). Age-related declines in each of the four types of tests indicate that age affects not just memory. He added that age-related declines in cognitive abilities do not occur only late in life. With a large enough sample, a decline in performance on such variables as speed and vocabulary already can be seen between ages 20 and 25.

It is not only small effects in age declines that are observed. Nationally representative samples for norms, Wexler studies, and Woodcock-Johnson tests all show the same downward trends with age in cross-sectional comparisons. In addition, data on cognitive abilities in people showed the same slope of decline from ages 8 to 18 as from ages 18 to 80. The annual declines in cognitive functioning are on par with other age-related physiological changes. In addition, age-related declines do not occur only for some people; Salthouse presented parallel age-related declines at all regions of the distribution for both low and high functioning populations. Declines in cognitive functioning also is not limited to people but is seen in animal models—with increased age, more difficulty is observed in terms of classical conditioning of eyeblinks in rabbits, water maze learning in mice, and learning without errors by dogs.

Age-related declines beginning in early adulthood are not just cross-sectional as longitudinal changes are observed. Salthouse noted that maturation and retest effects confound longitudinal studies; confounding may be prevented with variable retest intervals and multiple retests.

Different perspectives on the localization of age-related decline focus on the neuroanatomical region, processing stages, and organizational structure of abilities. Salthouse has been researching this latter perspective for the past 2 years. Almost all cognitive abilities are positively correlated with one another, so variables can be organized into a hierarchical structure of first- and second-order abilities (second-order latent constructs).

According to Salthouse, at least four separate types of possible causal mechanisms should be examined to explain age-related changes: (1) the common factor is a prefrontally mediated mechanism, perhaps related to a decrease in synchronization of neural signals or imbalance of neurotransmitters (e.g., dopamine-modulating signals); (2) improvement in vocabulary performance with age could be caused by increased experience and exposure to opportunities for new information; (3) speed performance, which may be related to efficiency of communication between different regions of the brain, degeneration of myelin, and/or impaired neural connectivity; and (4) memory performance is affected by the degradation of medial-temporal lobe and connecting circuits in the brain. The methodology of reducing the numbers of statistically unique influences enables researchers to be more parsimonious in developing explanations. True explanations should address why age-related effects happen and what the mechanisms are by which they operate. Salthouse proposed that a true cause of age-related cognitive change should alter the developmental trajectory of age-related cognitive change. Aging studies should be conducted over an extended time period. Although this is best studied through intervention, reliance on statistical mediation is often necessary to see a pattern over time.

Almost 100 years of research has been conducted on age and cognitive functioning; Salthouse stressed that it is important to ensure cumulative progress in order to move forward. We can establish cumulative progress by studying each new variable in the context of what is already known. Age affects the target variable, but it also is apparent that vocabulary, reasoning, and other factors have effects as well. With reference constructs, we can determine how much of the age-related effects are total and how much of the effect on the target variable is unique and statistically independent. If we do not ensure cumulative progress in the way described, Salthouse posits that we simply are using different labels to describe the same phenomena. In the discussion that followed, a participant asked whether the variable components would be weighted differently when examining the features of systems of abilities that matter in terms of economic outcomes versus health outcomes. For example, whether some abilities are more important for financial success remains to be studied. Another participant commented that when engaging in a decision-making task, many processes work separately but in parallel; however, they may share common causes. While there are shared influences, the cause of the influences is still ambiguous.

It was reiterated that older adults build on a large database of experiences in which a current experience is likened to another one, resulting in a generalized ability to draw from experience to make decisions. This is relevant for a great many economic behaviors. Questions for further study include whether experience can be measured and the extent to which experience overlaps with professional expertise.

Scott Huettel, Ph.D., Duke University
Neuroimaging the Aging Brain: Methodological Insights from Cognitive Neuroscience

Neuroimaging techniques have become increasingly critical for the study of brain structure and function. Over the past few years, there has been increasing interest in using these techniques—and in particular fMRI—for studying the brain changes accompanying normal aging. However, the simple translation of experimental methods from young to elderly subjects poses challenges for researchers. Because several neuroimaging techniques (e.g., fMRI and Positron Emission Tomography) assess concentrations of metabolites delivered through the vascular system, any age-related differences in vascular properties have the potential to influence neuroimaging data. It is important to consider the implications of this and related problems for the study of aging, and it is especially important to distinguish age-related changes in neuroimaging measurement from age-related changes in underlying brain function.

Methodological and Structural Changes

The fMRI Blood-Oxygenation-Level-Dependent (BOLD) hemodynamic response originates in the neuron, where it is predicted by dendritic activity. Under normal conditions, there is a constant extraction of oxygen from red blood vessels, but when neurons are active, there is a surplus of oxygenated hemoglobin to that part of the brain, resulting in a decrease in the local concentration of deoxygenated hemoglobin. Because deoxygenated hemoglobin suppresses some forms of MRI signal, one can use MRI to measure changes in the concentration of deoxygenated hemoglobin and, in turn, brain function (fMRI).

Age-related structural changes in the cerebrovascular system may have functional consequences. These changes include thickening of vessel walls, hypertension, venous occlusions, changes in capillary structure, reduced blood flow, and reduced oxygen consumption. Studies have found that these structural changes probably do not influence the fMRI BOLD signal or BOLD refractory effects, while they do influence BOLD signal-to-noise ratio (SNR). Two studies have reported that younger adults have a better SNR than older adults, suggesting that age-related differences in brain activation may reflect differences in SNR, not cognition. It also was noted that head motion may have been a factor in the results; older adults tend to experience more head motion during imaging. To address problems for between-group comparisons, Huettel suggested Group by Condition testing and the use of parametric manipulations; if similar effects of the behavioral parameter are seen in both groups, one can have more confidence in the results.

Different brain regions show different patterns of lifespan change in brain volume; that is, not all regions show a decline. The frontal lobes exhibit a consistent gradual decline, the hippocampus shows a sharp decline after middle age, but visual cortex volume remains relatively constant. Huettel noted that white matter can be measured using a relatively new technique called diffusion tensor imaging (DTI). There is a decrease in white matter integrity as people age; this is significant because the integrity of white matter tracts often mediates performance.

Logistical issues that account for differences in experimental procedures with the elderly include reduced tolerance for time in the scanner (older adults generally tolerate sessions of 60 to 75 minutes in the scanner, whereas younger adults tolerate sessions of 75 to 90 minutes); more extensive head motion; reduced sensory abilities (difficulty attending to stimuli or processing it at a low level); reduced performance on many cognitive tasks; a biased subject sample (the typical elderly adult in studies discussed by Huettel is college educated, has no significant health problems, is taking only minimal medication, and has a college level vocabulary); and a different motivation for participating—financial incentives are not as important to the majority of older participants, who are motivated by the sense that they are advancing scientific knowledge.

Functional Changes

Huettel next discussed functional changes and the concept of selective versus non-selective deficits in brain function. Some brain responses change selectively, while others change in a more graded way. A second theme is the idea of functional compensation, in which a lack of behavioral changes in the elderly may be the result of changes in the underlying process. An example of selective deficits in a memory study shows that some areas of the brain improve with

age and others do not; the elderly showed attenuation of recollection-based activation in the hippocampus but enhancement of familiarity-based activation in the rhinal cortex. In contrast, in other systems where there are non-selective deficits, there is less extensive brain activation in older adults. Imaging studies show that in tasks involving memory and attention, some elderly adults rely on compensatory strategies to recruit the assistance of additional brain regions to maintain performance; in one study (Cabeza et al., 2002), high-performing older subjects show bilateral prefrontal brain activity, while low performers show activity only on one side. In tasks involving executive control, younger subjects recruit the prefrontal cortex, while older subjects recruit other regions, such as the thalamus and basal ganglia, which may reflect impaired functioning of the prefrontal cortex in this group. A number of methodological caveats were raised regarding compensation effects reported in the literature. Outcomes are dependent on the significance thresholds used for reporting brain activity; depending on where these thresholds are set (and there is no universal standard) older and younger adults may look more or less similar (Cabeza, 2002). Importantly in the context of this meeting, very little is known about the brain correlates of selective deficits and compensation in reward systems. The extent to which compensation may be present in reward systems in aging is a promising area for study, especially since the techniques and methodology are available.

During the discussion that followed, Dr. Brian Knutson observed that new developments in imaging have changed the field considerably, with unprecedented depth of neuroimage resolution on a second-to-second basis. Whereas 10 years ago subcortical areas could not be seen, today there is a coherent accumulation of knowledge about what brain areas to observe when subjects are making decisions. Now it is time for application with older adults. The “super elderly” is not an unreasonable place to start as they may provide a benchmark for comparing with other groups that may exhibit functional deficiencies.

Because of some of the technical difficulties with imaging and older adults (e.g., tolerance for and immobilization in scanner), participants were interested in approaches that can be applied to facilitate study of older subjects. To obtain an adequate imaging signal, an experiment must be repeated several times, raising questions about brain activation to activities that cannot be repeated, such as one-shot economic exchanges. Knutson stated the possibility of breaking research questions into subgroups so that new knowledge can be obtained in a systematic way. Care also should be exercised not to draw conclusions prematurely; others emphasized the importance of reporting observed relations between activation across different areas of the brain.

Participants discussed the problem of individual differences. In addition to vascular differences, there are tissue composition differences that likely have effects on individual differences. Discussion revealed that more knowledge is needed about differences in neurotransmitters or variation of firing rates in relation to brain efficiency.

Other suggestions for further study included comparing people who have done well vs. poorly economically and examining brain activity for monetary incentive tasks. It would be helpful to know if no precise variable is found that differentiates these groups. It also would be of value to measure impulsivity versus conscientiousness, and the effect of education on the brain.

Alan M. Garber, M.D., Ph.D., Stanford University
Decision Challenges in Health Care

Older Americans face several difficult health-related decisions that impose cognitive and emotional burdens. Among them are the selection of high-quality health care providers, choices of specific medical treatments, decisions regarding the aggressiveness of end-of-life care, and selection of health plans (supplemental insurance, Medicare Part D drug plans). Because there is no perfect treatment for any given condition, the costs, benefits, and side effects of each must be weighed against the others. A patient's decision whether to undergo surgery, for example, is not driven solely by medical considerations and hence subject primarily to expert physician judgment, but also by patient preferences, so patient decision making cannot be entirely delegated.

In his presentation, Dr. Alan Garber briefly described projects on health decisions being performed by the Stanford's Roybal Center, the Center on Advancing Decision Making in Aging, which provides seed funding for relatively junior investigators; and related NIA-supported research at Stanford University. Current projects include efforts to incorporate health preferences of older adults into the electronic medical record by integrating a decision tool to guide patient choice (Amar Das); work in affective forecasting and decision-making in older adults (Knutson); research on age differences in the processing of health care information (Joseph Mikels); and a study on age differences in emotional and cognitive decision-making (Ian Gotlib and Elaine R. Robertson). Of particular interest to this workshop is a project on risk-taking and financial decision-making in older adults being undertaken by Knutson, Gregory Larkin, and Camelia Kuhnen.

One of Garber's projects concerns both the personal and policy tradeoffs in Medicare coverage of different forms of care for serious illness, ranging from aggressive intensive care to "comfort" or palliative care. As part of this project, the Stanford group conducted a pilot study about cancer treatments, which are often expensive and toxic. The greatest expense of Medicare is in aggressive care. The researchers were interested in whether patients would want very aggressive care for terminal cancer, and whether they thought Medicare should pay for it. The goal of the study was to provide pilot data on individuals' basic preferences for medical treatments at the end of life under a common scenario, and their opinions on whether Medicare coverage ought to be available for these services, regardless of their own preferences. Subjects were Stanford alumni ranging in age from 20 to 87 years. They were given the following scenario: "Imagine that you have just received a diagnosis of pancreatic cancer, a serious life-threatening disease that can cause considerable discomfort and is difficult to treat. Your doctor tells you that without treatment it is unlikely that you will survive for more than a year." They were then asked to answer questions about four possible treatment options. Option 1 was a relatively new and untested treatment that would take 1 year to administer, is relatively painless, but has unknown side effects. Option 2 involved a traditional combination of chemotherapy and radiation therapy that would take 1 year to administer and has very uncomfortable side effects. Option 3 focused on comfort, including treatment of pain and discomfort, hospice care, and support for patients and their loved ones in managing their households and helping them stay in their homes as long as possible. Option 4 was hospital intensive care with life support at the end of life.

Subjects were asked how likely they were to want each option, and how strongly they felt that Medicare should cover each option. Different versions of the questionnaire were framed in terms of short versus long time perspective (number of additional years treatment might give the subject [1 or 10 years]), the life-or-death frame ("prolong your life" or "delay your death"), and the chance that the treatment would work ("relatively low" or "good").

Participants questioned whether framing in the context of other people versus the self would result in a different answer, and whether people are fully aware of what they are receiving for the cost of treatment. The meaningfulness of data depends on giving subjects benefit information about outcomes and efficacy in the framing of the questions. The outcome in all cases is death from pancreatic cancer, and the questions were designed to assess basic preferences for how one preferred to approach that ending, from a medical care perspective, as well as whether one felt that Medicare ought to make the other options available for those who preferred them.

In terms of study outcomes, Garber reported that middle-aged respondents were more likely to want the new treatment particularly when chances of success were good, whereas older adults did not show this change in preference. Age and framing of questions did not influence whether respondents wanted Medicare to pay for the new treatment. Middle aged respondents were also more likely to want the traditional treatment than other age groups, while this option was less preferred overall. Of interest was that more people wanted this option available through Medicare even when they did not want the treatment for themselves. The majority of subjects in each age group wanted comfort care, with this preference strongest among those for whom treatment options were presented as having a low chance of success. An even larger proportion in each age group wanted comfort care services covered under Medicare. Younger respondents were more likely to want intensive care services than older age groups, with a significant decline in this preference across cohorts. A similar age-related decline was evident in opinions about whether intensive care services should be covered by Medicare, with only 39 percent of the oldest group endorsing this view, compared to 51 percent and 61 percent in the middle- and younger aged groups, respectively. If the individual questionnaire framed treatments as "delaying death," rather than "prolonging life," intensive care services were preferred, a sort of inverse negative framing effect. It was pointed out that this would be an example of a reduction of a loss, in which case the preference does not agree with earlier theories of risk aversion in the elderly, however, the possible negative connotation of the term "prolonging" may have biased the results against the life frame.

Subjects also indicated their preference for type of Medicare plan; Garber described this process as a crude way of determining what people think the plan design should look like. The majority in all groups wanted a plan focusing on comfort and quality of life, while the percentage of those wanting a focus on hospital and treatment services regardless of life expectancy and quality-of -life concerns was much less, especially in the older adult group (only 11 percent). The second plan was meant to be similar to a traditional Medicare plan, where patients could receive unlimited aggressive care but with no guarantee that it would work. According to a *Wall Street Journal* poll, more-educated respondents would consider costs more in health care treatment decisions than would less-educated respondents.

In the final part of his presentation, Garber gave a "tour" of the Medicare Web site (http://www.medicare.gov/) to demonstrate the complex, cognitively burdensome decision tasks involved in the selection of Medicare Part D drug plans. While people can compare numerous drug plans (48 for the area near Stanford) on the Web site, the prescription search function, which calculates how much out-of-pocket one would pay in a year under different plans, only recognizes brand names of drugs, not their chemical or generic names. When four common prescription drugs were entered for a hypothetical patient, the total costs under plans presented as options were high, ranging from $1,500 to $5,000 per year. The goal of the comparison is to help patients make a choice based on risk, yet the Web site does not provide any modeling of scenarios, such as the need to change drugs or the development of a new illness.

During the discussion period, the point was made that the insurance component is relatively low and that what is really at risk is the patient's cost for the current year. A patient can always re-enroll in a different plan the following year. Other research suggests that once patients are enrolled in a plan, it takes a major event to change plans. It also was noted that if health care consumers were perfect at estimating costs, the insurance industry would not be viable since insurance models are based on probabilities of covered events.

One participant observed that the cost information on the Medicare Web site is presented in a way that requires some side calculations and that the estimated annual cost is actually more than it initially appears. Several participants observed that as they had not noticed this, it is likely that people who are cognitively impaired would be even less likely to notice this. Some felt that there are too many options, with many drug plans without name recognition in comparison to more well-known entities like the American Association of Retired Persons and recognized insurers. People often are not aware that many of the plans are offered by the same insurer.

Willis suggested that it might be beneficial to study a health care plan scenario where drugs for temporary illnesses were priced with subsidies and long-term use drugs for chronic conditions are offered at market prices, which could attract consumers who would use the drugs briefly and drive away others with chronic illnesses.

In conclusion, Garber stated that choices facing older Americans are likely to become more complex and more consequential, and it is increasingly important to improve the way that choices are framed to enable older people to make better decisions. When dealing with uncertainty, it is difficult to determine whether a choice is optimal or even successful. The Medicare Part D plan will steer people toward a default option because the preference of older adults often is to stay put and avoid making active choices in the face of complex decisions. Because the entity that controls the presentation of information has such a strong influence on the decisions, it is important to consider as well who should be allowed to play that role.

Retirement Economics and Aging

David Laibson, Ph.D., Harvard University
Neuroeconomics and Savings

Laibson discussed intertemporal decisions which play a central role in lifecycle planning. Such decision-making is affected by a preference for instant gratification. Recent research in neuroeconomics has identified the neural foundations of taste for instant gratification. Intertemporal choice models that incorporate this preference explain a wide range of behaviors, including procrastination, passivity, and undersaving. Results from a number of experiments suggest that people typically choose instant gratification in the present moment, but when choosing for the future, they show patience and select the healthier, normatively-recommended choice (Read & van Leeuwen, 1998; Read, Loewenstein, & Kalyanaraman, 1999).

The discounted utility function, which weights current utility flows more than future utility flows, reflects what economists call dynamic inconsistency. When a consumption opportunity is far away in time, consumers make patient choices, but these patient preferences reverse when the time for consumption actually arrives (i.e., preferences held at date t do not agree with preferences held at date t+1). For example, Akerlof's model of procrastination (1991) suggests that a plan to exercise tomorrow is a very attractive option because the effort cost of exercise is postponed into the future. Of course, perpetually planning to exercise tomorrow will not produce the desired outcome. Similar self-defeating behaviors are common, such as failing to make a 401(k) contribution or failing to stick to a plan of healthy eating.

A 2004 study (Choi, et al.) studied an active-decision enrollment system for 401(k) participation. Upon employment, employees were required to indicate whether they wanted or did not want to participate in the savings plan; being passive was not an option. This resulted in a marked increase in the participation rate, raising participation rates to 70 percent (from 40 percent). Madrian and Shea (2001) showed that automatic enrollment – with an opt-out option – also generates high levels of 401(k) participation. However, typical automatic enrollment systems have a low default savings rate of 2-3 percent of income. Participants overwhelmingly stay at the automatic enrollment default, even though the rate is not optimal. These findings argue for the imposition of deadlines to eliminate passivity or the adoption of automatic enrollment defaults with high savings rate.

Unsuccessful "solutions" to savings problems have included (1) paying employees to save in the form of employer matches and (2) financial education, which does not appear to be effective on its own. Choi, Laibson, and Madrian (2004) found that in a sample of seven companies, an average of half of employees over 59.5 years old were not fully exploiting their employer match, indicating an average loss of 1.6 percent of their salaries per year.

The effects of financial education are also disappointing, Employees who attend financial education seminar have good intentions to change their 401(k) savings behavior, but most do not

follow through. Consistent with this finding, the effect of scandals such as those at Enron and Worldcom do not induce net sales of employer stock at other companies.

Laibson discussed the underlying mechanisms that drive these phenomena. Why are preferences inconsistent? Is the mechanism adaptive, and how should it be modeled? Does it arise from a single time-preference mechanism, or is it the result of the interaction of multiple systems? Examinations of the analytic and emotional brain in an fMRI study indicate that time-discounting reflects the combined influence of two neural systems: The limbic and the fronto-parietal systems. These two systems are implicated separately in "emotional" and "analytic" brain processes, respectively. The limbic (emotional) brain does not value delayed rewards but creates a drive for instant gratification.

The agenda for future research should include age variation and how it can affect factors such as limbic drive, cortical control, learning and memory, and analytic cognition. Laibson presented a final example from a study of credit card "teaser" rates, showing how quickly different age groups learn how to exploit a complicated teaser rate offer. "Naïves" never seemed to learn how to avoid paying too much, while "sophisticates" learned immediately how to exploit the offer. People in midlife were the most successful in exploiting the credit card offer. It took longer for young adults to figure out what to do, Older adults were particularly vulnerable to making mistakes. One of the real challenges that lies ahead, Laibson contended, is to build a world that offers more protection against the bad financial offers that older adults receive.

In reaction to Laibson's presentation, workshop participants commented that many important financial incentives such as 401(k) and health care savings accounts are surprisingly underutilized by people who are not unsophisticated and who range in age. This may have to do with the way in which the information about these incentives is presented.

Robert Willis, Ph.D., University of Michigan
The Health and Retirement Study

Dr. Robert Willis sought to introduce psychologists and neuroscientists to the Health and Retirement Study (HRS) and to discuss features of the survey and findings from it that would be of particular interest to these scientific communities. After providing some background on the history, general purposes, overall design, and scientific productivity of the HRS, he reviewed the core content areas of the HRS, its evolution, and its steady-state design. The original HRS cohort was interviewed first in 1992 and included persons ages 51 to 61 at the time (born between 1931 and 1941), as well as spouses of age-eligible persons, with a longitudinal followup every 2 years. In 1998, a redesign merged the HRS with an older cohort of persons age 70+ in 1993 into a single study and added new cohorts to effect a steady state design. In 2004, the HRS was awarded additional funds from the Social Security Administration to conduct most interviews in person, which made the inclusion of performance measures possible. Today, cognitive issues and cognitive measures are playing an increasingly larger role in the study. Comparable studies inspired by the HRS have been developed in 17 countries in Europe and Asia. These include the English Longitudinal Study of Ageing (ELSA); the Survey of Health, Ageing, and Retirement in Europe (SHARE); the Mexican Health and Aging Study (MHAS); and the Korean Longitudinal Study of Aging (KLoSA). Japan and China may be next to develop similar studies.

One important supplement of the HRS, which began in 2001, is an in-home substudy of dementia. The Aging, Demographics, and Memory Study (ADAMS) uses a stratified random sample based on survey measures of the risk of dementia involving three groups: (1) Those with high probability; (2) those for whom dementia is less certain; and (3) those who are apparently normal. The dementia assessment is conducted through case conference by an expert research group at Duke University that is familiar with these types of assessments. The sample population in ADAMS is very different than a typical clinic population, being usually 8 or 10 years younger.

New directions for the HRS include the addition of biomarkers that are major and multi-dimensional predictors of disease, death, and dysfunction; performance measures such as grip strength, timed walk, lung capacity, and blood pressure; a new psychosocial module; and new cognitive measures beginning in the HRS 2006 core survey, such as a repeat of the adaptive number series test given in 2004 with the addition of vocabulary and prospective memory measures.

International data on retirement trends and the influence of policy on these trends were discussed, and new data on retirement expectations from the HRS were presented. The long-term trend in the United States from 1850 to 1990 has been toward earlier retirement, but the trend toward lower labor-force participation at older ages is much sharper in a number of European countries than in the United States. International trends toward earlier retirement are related to incentives, as retirement policy shapes retirement behavior. The HRS has pioneered surveys about expectations on a wide variety of topics including survival to a given age, bequests, stock market returns, and work and retirement expectations. Researchers have used the work expectation questions in earlier waves and have found them to be useful predictors of actual work and retirement in later waves. There are signs of reversal of the long-term trend toward

early retirement seen from the 1850s through the mid-1980s; labor-force participation at older ages has been flat since then, and the "early boomer" cohort in the HRS (born 1948 through 1953) expects to work more than earlier cohorts.

Willis also presented research findings based on HRS data that show a strong correlation between health and wealth. A study on the economic consequences of a husband's death shows that widows are most subject to poverty, especially if they are widowed early. A study on predicted wealth based on the dynamic optimization model (adapting savings optimally throughout time) versus actual wealth shows that most people have more net worth than is "optimal" and that retirement savings are in fact adequate.

Finally, Willis described how the HRS is monitoring the new Medicare Prescription Drug program using a 2005 mail survey, the 2006 core survey, and planned future surveys. One mail survey conducted in the fall of 2005 asked respondents about their knowledge of Medicare Part D, how they were obtaining their information, and so on. An Internet panel in November 2006 during open enrollment will help design questions for people over age 65 who have experience with Medicare Part D and those under age 65 who have helped their parents or others make decisions about Part D. Findings from the 2005 survey suggest that the cognitive burden required to take advantage of Medicare Part D is related inversely to the cognitive capacity of eligible beneficiaries.

General Discussion

The issue of incentives for subject participation in neuroeconomics research was discussed. It was noted that incentives and rewards are forms of economic institutions, so perhaps it would be valuable for exploring the relationship between behavior and incentive structures in behavioral economic tasks. Some felt that equal payments to all subjects would not be as effective as offering different incentives based on performance.

The idea that older adults learn to master emotions by avoiding negative experiences generated further discussion. Levenson and Mather speculated that someone who avoids negative situations also will avoid risky choices or decisions altogether in cases where there is potential for a negative outcome. One participant described this behavior as quite rational, since avoidance in such cases may represent the best regulatory strategy for emotion. With non-confrontation the problem does not completely disappear, but many things do improve with avoidance, especially social situations. Another reason why the elderly often avoid making decisions on financial offers altogether is perhaps that they understand that they are not able to distinguish a good offer from a bad one, and avoidance may be the process by which older adults control for deficits in comprehension.

Additional discussion focused on the notion that as people age, there is both a reduction of processing speed and an increase in wisdom and knowledge. It may be worthwhile to think about decision tasks that study the processing of new information versus drawing on existing information. One idea that has not yet been addressed is the theory that people will make a better decision if they "sleep on it" rather than deciding in the moment; this may be studied in the lab.

It also was observed that given the many bad financial offers the elderly are given through the mail or on the telephone, and the fact that those most motivated to give them financial assistance are those who are profiting from them, the elderly do need to be activists. Older adults may also benefit from learning how to delegate decisions and who they can entrust with decisions. Policy prescriptions, specifically in terms of interventions to stem the flood of exploitative credit card offers made to older adults, also were discussed, although it is not clear that Government intervention is going to benefit the elderly. Just as is the case for policy makers, researchers must be careful not to inject value judgments on people's choices. For example, a person's wellbeing and happiness are not necessarily linked with their amount of savings.

Related to the measurement of wellbeing, it was observed that rather than studying emotions simply as "positive" or "negative," it may be worthwhile to differentiate them; for example, calm and exhilaration both can be classified as positive emotions. However the experience of these emotions may be differentially valued at different life stages. Researchers might also wish to take into account self-relevant emotions (e.g., shame, pride, embarrassment) that may have different impact on decision making at different times of life, for greater precision or predictability. These more complex and self-relevant emotions may account for occupational choice, selection of a mate, and so on. It was also emphasized that people often experience multiple emotions concurrently; even positive and negative emotions can be experienced together. It might be helpful to look at how these kinds of emotions and emotional blends could be measured better in decision making contexts.

Concluding Remarks

Rangel concluded the workshop with wrap-up remarks in which he presented goals and applications of neuroeconomics as topics for discussion. One of the main goals of neuroeconomics, he stated, is to decipher how the brain computes the solutions to different types of decision-making problems. Specifically, neuroeconomists want to know which variables are computed, how they interact, how they lead to choices, their neural basis, and whether the brain can solve the same decision-making problem in different modes. Another goal of neuroeconomists is to study how the brain computes its subjective experience of well-being, how these processes differ from the decision-making process, and how they affect decision-making processes. Lastly, neuroeconomists seek to understand the implications of this knowledge for all of the behavioral sciences and their applications. Development of a common language, he contended, can be achieved only by understanding how decision-making is coded and processed and after computational models have been thoroughly tested. He noted the need for common definitions of terms such as "emotion," which was used in several different ways throughout the workshop.

In terms of cross-disciplinary fertilization, what can neuroeconomics contribute to aging studies? Rangel emphasized the characterization of processes required for good decision-making in different situations, and the need to develop tools to study how these processes change over the life cycle. Likewise, what can aging studies contribute to neuroeconomics? We have developed a menu of life-cycle behavioral changes that need explanation. A second identified topic involved typology of processes and choice situations. In order to make sound choices, the brain needs to deploy multiple processes; therefore, we need to identify the minimal set of separate processes

required to understand decision-making. Different choices are likely to be solved using a different composition of these processes, so we also should identify a useful taxonomy of decision-making situations that will require study.

Rangel's third topic for discussion addressed which tasks should be selected and studied. Identifying a battery of benchmark tasks is crucial to understanding how decision-making processes change over the life cycle and how this affects decision-making performance. Finally, Rangel identified two types of external validity tests that are of concern: population validity and task validity. He asked whether there are any "golden standards" we should follow at the intersection of neuroeconomics and aging. For example, if there is no cash incentive, there is a good chance that the cognitive process will not be the same as it would be in a real economic transaction. The panel agreed that the degree to which decision contexts are realistic in the laboratory will be critical to the justification of the research and credibility of results.

In general discussion, the need for a taxonomy of decision processes was underscored. An important component of an effective model is a set of established tasks that control for such factors as framing effects. Key decision types—essential critical tasks that would impact the well-being of older adults—should be identified as well as how performance on these tasks changes over the age range.

Two kinds of influence on age-related changes in decision making were discussed: (1) That of institutions and (2) that of individual differences, such as IQ and processing speed. It was noted that institutions have been shown to trump individual differences and that "a world can be built" around people with lower cognitive abilities that will make them seem like better decision-makers. Thus, it may be worthwhile to concentrate on institutional change. Others emphasized that individual differences matter. The longitudinal data from the HRS are valuable for studying this. Evidence exists to show that inequality of cognitive abilities can have real economic costs, such as vulnerability to scams, which leads to those individuals having less money for health care plans and other necessities.

The issue of heterogeneity is an important one. There is tremendous variation in how most complex decisions, such as those about life savings, are made. Outcome data suggest that over half the population are good decision-makers. It was suggested that researchers obtain validation on a community-based population. It was noted that as the HRS already is established, a relatively inexpensive first step might be to give neuroeconomists access to the sample for imaging. It also was suggested to embed a smaller study into a larger survey, to obtain more precise measurements of covariates.

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APPENDIX A

National Institute on Aging
Workshop on Neuroeconomics and Aging
March 31–April 1, 2006

Workshop Participants

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APPENDIX B

National Institute on Aging
Workshop on Neuroeconomics and Aging

Recommended Readings

Scott Huettel recommends:

Cabeza, R., Nyberg, L., & Park, D. (2005). *Cognitive Neuroscience of Aging: Linking Cognitive and Cerebral Aging.* New York: Oxford University Press

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David Laibson recommends:

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Mara Mather recommends:

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Paul Slovic recommends:

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