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# Emerging perspectives in social neuroscience and neuroeconomics of aging

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**This article introduces the special issue of 'Social Cognitive and Affective Neuroscience' on Aging Research, and offers a broad conceptual and methodological framework for considering advances in life course research in social neuroscience and neuroeconomics. The authors highlight key areas of inquiry where aging research is raising new insights about how to conceptualize and examine critical questions about the links between cognition, emotion and motivation in social and economic behavior, as well as challenges that need to be addressed when taking a life course perspective in these fields. They also point to several emerging approaches that hold the potential for addressing these challenges, through bridging approaches from laboratory and population-based science, bridging inquiry across life stages and expanding measurement of core psychological phenotypes.**

**Keywords:** aging; life course



## INTRODUCTION

The fields of social neuroscience and neuroeconomics have experienced rapid growth over the past decade, yet little research has focused on issues related to midlife or older age. In light of the profound demographic changes occurring in our society, this is an important research gap. The past century witnessed a near doubling of life expectancy, and it is projected that in <50 years, there will be close to 90 million Americans aged ≥65 years (Federal Interagency Forum on Aging-Related Statistics, 2010). We are on the brink of profound demographic changes both in the USA and the world at large (see: http://www.prb.org/Articles/2011/agingpopulationclocks.aspx).

Though many people are living longer, older age is still marked by disruptions of important social relationships due to economic factors such as retirement and relocation, and health-related factors such as illness, disability and death of social network members. With age, people are more likely to become socially isolated, and the number of individuals living alone continues to grow in all age groups in the USA. (Cacioppo *et al.*, 2006). Meanwhile, emerging findings from experimental research (e.g. Kiecolt-Glaser *et al.*, 1997; Epel *et al.*, 2004), complemented by considerable epidemiological evidence (House *et al.*, 1988; Uchino *et al.*, 1996; Singer and Ryff, 1999; Coyne *et al.*, 2001; Barnett *et al.*, 2005; Cacioppo *et al.*, 2006; Hawkley *et al.*, 2006) demonstrate that being in socially supportive relationships improves one's odds of avoiding or surviving illness and reduces mortality, while being lonely, isolated or in poor-quality relationships greatly increases those risks. Recent findings from the National Social Life Health and Aging Study (NSHAP; http://www.norc.org/nshap) indicate that both perceived social isolation (loneliness) and social disconnectedness exert independent effects on health in older ages (Cornwell and Waite, 2009). Together, these findings suggest that social behaviors and features of the social environment can support healthy aging and provide motivation to investigate potential psychological, social, genetic and neurobiological mechanisms and pathways responsible for beneficial social effects (National Institute on Aging, 2007a).

At the same time, recent psychological research suggests that socioemotional function is maintained or improves in older age, in contrast to most cognitive functions, which show longitudinal decline. These findings, in turn, have spawned growing interest in basic social neuroscience questions related to age-related changes in the neurobiological underpinnings of social and emotional behaviors and the goals that shape behavior as we age. One major question confronting researchers now is the extent to which age-related socioemotional profiles are due to motivational changes or to underlying changes in the aging brain.

The fact that people are living longer also means that important financial and health decisions must be made later in life, a period when people typically experience declines in physical and cognitive function and reductions in financial and social assets. These age-related psychological and neurobiological changes may affect decisions by altering the interplay of affect, cognition and social motives that lead to decision behaviors. In the health domain alone, decisions range from the selection of insurance plans, treatment protocols and care providers in the near term, to planning for

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future needs related to long term and end of life care. These decisions can be both cognitively and emotionally challenging and evoke multiple—and sometimes conflicting—motives. Often, these decisions are negotiated through social interactions, adding an additional layer of complexity to understanding the process. These issues have highlighted the need to advance aging research in neuroeconomics to improve our understanding of the psychological and neurobiological mechanisms that shape decision making by and for older adults (National Institute on Aging, 2006b).

### Integrative aging research on social, emotional and economic behavior

In recent years, along with growth in the fields of social neuroscience and neuroeconomics, there have been advances in integrative approaches (linking behavior, social context, neuroscience, genetics) to the study of social, emotional and economic behaviors in aging.[1] Social and economic behavior draws on a broad range of abilities, motivation and experience (Bechara, 2004; Coricelli *et al.* 2007; Sanfey, 2007; Rilling *et al.*, 2008). For instance, the simple act of making a choice involves not only the act of choosing, but also requires representing the potential options and assigning value to each one (Rangel *et al.*, 2008). Thus, it is not enough to know that the cognitive abilities relevant for a particular financial decision task decline with age to predict how younger and older adults might complete the task differently. One must also attend to age differences in motivation and experience. Furthermore, aging trajectories differ among individuals, with some facing diseases such as Alzheimer's whereas others remain healthy into their 10th decade and beyond (Hitt *et al.*, 1999). Researchers are now beginning to explore which aspects of social and economic behaviors improve or are preserved in normal aging, whether there are particular areas of decline, and what social, psychological, genetic or neurobiological factors predict age-related changes. For example, new research is underway exploring the psychological and neurobiological underpinnings of social cognition, decision making and emotional behaviors in older age, and their relation to individual differences in cognitive function (e.g. Krendl *et al*, 2009; Mell *et al.*, 2009; Ritchey *et al.*, 2010; Samanez-Larkin *et al.*, 2010). Other research takes a life course perspective on the study of how social and individual factors impact emotional, social and economic behavior in later life, with the potential to improve our understanding of the factors that support and maintain trajectories of successful, adaptive aging (e.g. Gruenewald *et al.*, 2008; Carstensen *et al.*, 2010; Moffitt *et al.*, 2011). In addition, advances in basic research on the behavioral and neurobiological correlates of core capacities such as self-regulation and intertemporal choice have implications for how investments and tradeoffs in a range of social, health-related and financial domains play out over the life course (e.g. Hare *et al.*, 2009; Figner *et al.*, 2010).

In this special issue, 10 papers showcasing advances in social and affective neuroscience and neuroeconomics of aging are presented. Together, they highlight key areas of inquiry where aging research is raising new insights about how to conceptualize and examine critical questions about the links between cognition, emotion and motivation in social and economic behavior.

In this introductory article, we focus on several challenges that the fields of social neuroscience and neuroeconomics will need to address in the future, if important life course perspectives are to be integrated into the field. We also point to several emerging approaches that hold the potential for addressing these challenges, through bridging approaches from laboratory and population-based science, bridging inquiry across life stages and expanding measurement of core psychological phenotypes. The ideas presented here represent a synthesis of perspectives presented in discussions at a number of exploratory workshops convened by the National Institute on Aging[2] the perspectives of the co-editors of this special issue, and those of the authors of the papers contained herein.

## SOCIAL NEUROSCIENCE AND NEUROECONOMICS VIEWED THROUGH AN AGING LENS

### What are the critical tasks of a theory of psychological aging?

From the perspective of the aging individual, the critical psychological tasks of aging include maintaining a sense of self, autonomy, purpose and social connectedness, in addition to maintaining health and functional independence (Ryff, 1995). These psychological tasks require coordinated cognitive and socioemotional functions. Historically, however, much work in psychology of aging has examined cognitive and socioemotional processes separately, with a heavy focus in cognitive psychology and cognitive neuroscience on understanding the roots of age-related cognitive decline and dementia. This approach, though fruitful for many purposes, tends to reify disciplinary silos within psychology and obscure important connections between domains of psychological functioning.

Recent work in social and personality psychology of aging reveals how trajectories of social and emotional function differ from that of cognitive function over the life span, with most evidence suggesting that socioemotional abilities, including interpersonal problem solving, and the ability to experience emotion and process emotionally salient information in both social and nonsocial contexts is largely preserved in older age (Charles and Carstensen, 2009). At the

[1]The National Institute on Aging has supported new research in Social Neuroscience and Neuroeconomics of Aging under two institute-sponsored RFAs (Neuroeconomics of Aging RFA-AG-06-011 and Social Neuroscience of Aging RFA-AG-09-006) as well as through participation in Social Neuroscience RFAs from the National Institute on Drug Abuse and the National Institute on Mental Health (RFA-DA- 06-004 and RFA-MH-08-070). Several of the research recommendations from these previous solicitations are echoed in this article.

[2]The ideas emerging from discussions at exploratory workshops convened by the National Institute on Aging represent the views of workshop participants and are not considered formal recommendations of the National Institute on Aging.

same time, with advancing age, core capacities in both physical and cognitive domains decline (Mather, 2010). Specifically, fluid cognitive capacities, like verbal episodic memory and processing speed, decline in efficiency, along with perceptual and motor abilities that support navigation in the physical environment. On the plus side, additional years of experience increase world knowledge and domain-specific expertise, to some extent buffering the functional impact of these age-related deficits. The fact that education, cognitive engagement and physical fitness, along with social integration and stress resilience, may also buffer the impact of aging on cognitive function, serves to underscore the many intersections of mechanisms underlying socioemotional and cognitive function in the aging mind.

Important new insights into cognitive aging have emerged, somewhat unexpectedly, from social and personality psychology and affective science. For instance, older adults' memory performance is enhanced if the purpose of a memory test corresponds to relevant affective goals (Rahhal *et al.*, 2002), but is impaired under conditions of stereotype threat (Hess *et al.*, 2003). A growing body of research documents that older age is also characterized by improvements in emotion regulation (Carstensen, 2006; Urry and Gross, 2010). Age-related improvements in emotion regulation are surprising given that emotion regulation is typically considered dependent on executive control processes (Ochsner and Gross, 2005), and executive control declines with age. This puzzle has prompted a deeper consideration of how factors like engagement, goals and motivation explain the tradeoffs and compromises individuals make as they seek to achieve the critical tasks of aging (e.g. Mather and Carstensen, 2005; Scheibe and Carstensen, 2010). As emphasized by leading theories of socioemotional aging, such as Socioemotional Selectivity Theory (Carstensen *et al.*, 1999; Carstensen, 2006), Strength and Vulnerability Integration Theory (Charles, 2010) and the Motivational Theory of Life-Span Development (Heckhausen *et al.*, 2010) motivation may play a key role in driving age-related psychological and behavioral change. In general, older adults are viewed as selectively devoting cognitive resources to promote important goals, such as maintaining emotional equilibrium, social harmony or satisfactory levels of social and role functioning, potentially paying cognitive costs as a consequence. There is even some evidence that increasing reliance on these strategies may automate certain forms of regulation, making emotional control less costly for older adults under some circumstances (Scheibe and Blanchard-Fields, 2009).

Thus older age is characterized by a distinct set of motives that contrast sharply with the goals important for earlier phases of life. For example, the drive to maintain emotional balance that predominates in older age is under-prioritized in adolescents, who are more motivated to expand social and experiential horizons, and it may continue to take a backseat in early adulthood and midlife, when nurturing families and careers typically takes priority over other concerns. It has been proposed that in these earlier life phases, exploratory behavior and desires for certain forms of social interaction may have a stronger impact on behavior than during older age, which may partially explain greater risk-taking, particularly in peer contexts, observed in adolescents compared to older adults (Casey *et al.*, 2008; Ernst *et al.*, 2009).

For aging research, and life course research in general, reintegrating constructs of motivation into investigations of cognitive and affective function, is likely to be fruitful in future inquiry. To advance this goal, the field will require an appreciation of life course 'typical' social goals and behaviors, grounded in an understanding of the adaptive tasks individuals face at every life stage. In addition, researchers will need to consider whether and how life stage shapes the context for the expression of these motives, and the implications this will have for individual differences in how these processes unfold over time to shape trajectories of health and behavior. As proposed by Socioemotional Selectivity Theory (Carstensen *et al.*, 1999; Carstensen, 2006), changes in social motives will impact the structure of social networks and choices of social partners, thereby changing the very nature of the environments in which social motives are expressed.

Research in social neuroscience and neuroeconomics of aging has the potential for guiding this endeavor. Motivation is central to questions such as how different features of social and economic incentives and contexts are integrated and processed by the brain to drive and constrain behavior. Notably, social neuroscience emphasizes the critical role of social motives and processes in shaping human brain evolution and development, highlighting the fundamentally social nature of core aspects of emotional and cognitive functioning (Cacioppo *et al.*, 2002). At the level of the species, social co-operation has recently been proposed as one of the major driving processes in evolution (Nowak, 2006). At the individual level, it has been argued that the desire for interpersonal attachments is a fundamental human motive that activates behavior, influences cognition and emotion and leads to ill effects on health and well-being if left unsatisfied (Baumeister and Leary, 1995)

Social neuroscience research can also address whether social behaviors and emotional dispositions change with age because of underlying changes in neurobiological function or whether changes in social motives alter neurobiological processes. There is little evidence to date to suggest that the brain areas supporting emotional and social function are particularly compromised in aging. For instance, the amygdala declines less in structural volume with age than most other brain regions (Good *et al.*, 2001; Allen *et al.*, 2005; Grieve *et al.*, 2005; Walhovd *et al.*, 2005; Brabec *et al.*, 2010) and emotional processing associated with the amygdala seems to decline little with age (Kryla-Lighthall and Mather, 2009). Moreover, older and younger adults show similar advantages in detecting emotionally arousing stimuli (Mather and Knight, 2006; Knight *et al.*, 2007; Leclerc and Kensinger, 2008). Yet the brain does change with age, as described below, and a critical task for social neuroscience and neuroeconomics of aging (and for theories of psychological aging more generally) will be to understand how the age-related brain changes interact with motivational changes and changes in cognitive and emotional function to shape social and economic behaviors over developmental time.

Much current inquiry in aging research is focused on determining whether age-related changes in social and economic behavior can be fully explained by understanding the interaction of core affective and cognitive processes, or whether an additional layer of explanation, invoking constructs of motivation and core social adaptations is required. The brain, of course, is not required to respect distinctions among our commonsense notions of cognition, motivation and affect, and further research is needed to determine the extent to which evolution has organized neural function in line with these notions (Barrett, 2009).

## Age-related changes in emotion and motivation

Traditionally, research on decision making has focused on the cognitive aspects of making choices. But recent research indicates that emotion plays a fundamental role in shaping people's decisions, shaping how risk is assessed and the utility of decision options (Loewenstein *et al.*, 2001; Slovic *et al.*, 2004; Bechara and Damasio, 2005; Hermalin and Isen, 2008). Emotion processes are also integral to effective social interactions, as people need to interpret others' emotions and regulate their own emotional responses while interacting with others (Lopes *et al.*, 2004; Beer *et al.*, 2006; Canli and Lesch, 2007).

Thus, research with younger participants indicates that understanding emotion's influence is critical for understanding social and economic behaviors. However, the role of emotion is even more important to consider when trying to understand age differences in social and economic behaviors, as age-related change in emotional processes are likely to influence social interactions (e.g. Birditt and Fingerman, 2005) and decision making (Mather, 2006; Peters *et al.*, 2007). For instance, self-reported negative affect declines through most of adult life whereas positive affect remains more constant (Carstensen *et al.*, 2000; Charles *et al.*, 2001). Older adults appear to solve emotionally salient and interpersonal problems more effectively than younger adults do (Blanchard-Fields, 2007). They also report having more emotional control than their younger counterparts (Gross, 2001). One potential explanation for these age-related improvements in emotional experience and control is that emotional goals gain importance with age, leading older adults to devote more resources to emotionally meaningful goals. Laura Carstensen's Socioemotional Selectivity Theory argues that as perceived time left in life diminishes, people's goals shift from prioritizing information seeking when there is plenty of time available, to prioritizing emotional goals when time feels more limited (Carstensen *et al.*, 2000). In addition to future time perspective, past experience seems to contribute to older adults' more effective strategies when solving everyday problems that involve interpersonal and emotional issues (Blanchard-Fields, 2007).

## When, for whom and why is the positivity effect evident?

If older adults are chronically more focused on regulating emotion, this goal should affect what they pay attention to and remember. Consistent with this idea, a number of studies have found age by valence interactions in which older adults favor negative stimuli less compared with positive stimuli in their attention and memory than younger adults (for reviews see Mather and Carstensen, 2005; Scheibe and Carstensen, 2010). This interaction is known as the positivity effect. The positivity effect has important implications for decision making. For instance, older adults have been found to spend a larger proportion of their time examining the positive than the negative features of choice options (Mather *et al.*, 2005; Löckenhoff and Carstensen, 2007), a shift that could influence which options are selected.

Although age by valence interactions indicating a positivity effect have been seen in many studies (for reviews see Mather and Carstensen, 2005; Scheibe and Carstensen, 2010), there also are some studies that reveal no age by valence interactions, and a meta-analysis of studies of emotion revealed that older adults showed a significantly lower negativity preference in recognition memory than younger adults, but no other significant age differences on other measures (Murphy and Isaacowitz, 2008). What might account for when the positivity effect is seen and when it is not?

One basic issue is that the positivity effect tends to appear with a medium effect size. For instance, in Charles *et al.*'s (2003) experiments, the $\eta^2$ values for the significant age by valence interactions in recall and recognition ranged from 0.04 to 0.09. Cohen (1988) categorized $\eta^2$ values of 0.02 as small, 0.06 as medium and 0.14 as large, and estimates that 62 subjects per group are necessary to have 80% power to detect medium effect sizes. Most studies examining age differences in emotional attention and memory do not include this many subjects, and so it would be expected that some of these studies would fail to find significant age by valence interactions.

However, beyond the simple question of statistical power, there are also theoretical reasons to expect the positivity effect to appear in some situations and not in others if it is indeed a result of older adults' greater focus on regulating emotion. Regulating emotions requires cognitive control mechanisms to selectively attend and remember (Ochsner and Gross, 2005), and so older adults who are better at cognitive control should be more effective at implementing emotion regulation goals. Studies that have examined individual differences in cognitive control among older adults have found that those with higher scores show larger positivity effects in memory (Mather and Knight, 2005;

Petrican *et al.*, 2008) and appear to be better able to avoid mood declines by avoiding looking at angry faces (Isaacowitz *et al.*, 2009). Furthermore, giving older adults a cognitive load with a secondary task while they view emotional pictures can reverse their positivity effect in attention (Knight *et al.*, 2007) and later memory (Mather and Knight, 2005).

Thus, when cognitive resources are devoted to other tasks or an older adult has weak cognitive control in general, positivity effects should be less likely to be seen. In addition, motivational goals should have more of an influence over the more subjective or malleable aspects of memory. Consistent with this are findings that older adults are more likely to show positivity effects in their response biases or reconstructive processes than in recognition signal detection measures (Fernandes *et al.*, 2008; Kapucu *et al.*, 2008; Thapar and Rouder, 2009; Werheid *et al.*, 2010) and when retrieval can rely on gist or familiarity than when it relies on specific details (Kensinger *et al.*, 2007; Spaniol *et al.*, 2008). In addition, motivational manipulations can eliminate older adults' positive orientation in search strategies and recall (Kennedy *et al.*, 2004; Löckenhoff and Carstensen, 2007), suggesting that the positivity effect is sensitive to task demands such as instructions to focus on particular features of information or situations.

Variability across contexts and an effect size that is only moderate may account for the lack of strong age differences in positivity and negativity preferences in Murphy and Isaacowitz's (2008) meta-analysis. Another factor that may be relevant is that this meta-analysis faced the challenge of a relatively small literature and so the authors included studies that only tested younger adults as well as those that tested both younger and older adults. Thus, they included 67 articles that had younger adults but only 31 articles that included older adults. As emotional stimuli vary widely, it is possible that the studies that only had younger adults in them differed in the stimuli and procedures they used in ways that may have increased or decreased the potency of the emotions evoked. For instance, researchers may try to avoid including sexually explicit stimuli among their positive stimuli when testing older adults.

Several papers in this special issue examine issues related to the question of whether older adults show a shift in how the valence of information affects their processing. Van Reekum *et al.* (2011) examined physiological responses while participants viewed negative, neutral and positive pictures. They found that older adults showed less corrugator response, less eyeblink startle and more positive ratings of neutral pictures than did younger adults. Thus, it appears that, in comparison with younger adults, older adults were viewing the neutral pictures in a more positive light.

Based on the previous studies with younger adults, Lang and colleagues argued that positive pictures inhibit the startle response by activating the appetitive motivational system, whereas negative pictures potentiate the startle response by activating the aversive motivational system (Lang, 1995). However, van Reekum *et al.* found that this pattern of opposing startle effects for negative vs. positive arousing pictures was strongest in the youngest participants and was no longer present among the older group. A similar finding emerged in another recent study (Feng *et al.*, in press) that tested a group of older adults about 10 years older (mean age of 75 years) than the older group in van Reekum *et al.* In this study, the younger adults showed the standard startle pattern but the older adults showed a reversed pattern, with diminished startle during viewing negative pictures compared with positive or neutral pictures. This emerging evidence of an age-related reversal suggests that the Lang *et al.* explanation for the startle effects is inadequate, as older adults found the negative pictures aversive, yet showed diminished startle to them. This type of age difference is an example of how investigation of age differences can lead to insights into basic mechanisms that were missed when studying just a younger cohort.

Findings such as these that reveal age differences in physiological responses to emotional stimuli raise questions about age differences in emotion regulation. On surveys, older adults are more likely to endorse statements such as, 'I try hard to stay in a neutral state and to avoid emotional situations' (Lawton *et al.*, 1992) and report being better able to control their emotions than do younger adults (Gross *et al.*, 1997). These self-reports suggest that older adults focus more on regulating their emotions and feel more confident in their ability to do so than younger adults. Are such self-perceptions accurate? Do older adults excel at all types of emotion regulation or only some? Are there different factors predicting effective emotion regulation for younger and older adults? Current research is beginning to address these questions (Urry and Gross, 2010). One emerging theme is that older adults use passive emotion regulation strategies such as conflict avoidance or emotion suppression more than younger adults do (Birditt and Fingerman, 2005; Coats and Blanchard-Fields, 2008). Research with younger adults has revealed that a more active strategy—cognitive reappraisal—can be particularly effective at enhancing well-being in emotionally challenging situations (Gross and John, 2003). However, cognitive reappraisal is a cognitively demanding strategy, which might make it a less effective strategy for older adults.

In this issue, Seider *et al.* (2011) report that, when asked to watch sad films as though they were watching television, older adults have stronger subjective and physiological sadness responses to films than do younger adults, a finding seemingly at odds with the claim that emotion regulation improves with age, and that older adults focus more on the positive. This suggests to us a need to move beyond mere considerations of positive and negative valence, to examine age differences in response to discrete emotions and potential age-specific explanations for why particular emotions may be more or less salient. Future research is needed to understand whether younger and older adults differ in terms of their likelihood of attempting emotional regulation when exposed to sad stimuli or in how successfully they regulate their emotions when they are trying to do so. As Seider *et al.* (2011) emphasize, it is also important to place these findings in the broader context of Socioemotional Selectivity Theory and consider the functional role of discrete emotions in serving older adults goals, such as the maintenance of close personal relationships. Sadness may play a particularly useful role in this regard, fostering empathy and the expression of emotions that maintain social bonds.

Instead of examining spontaneous emotional reactions, Winecoff *et al.* (2011) instructed participants to reappraise the meaning of pictures on some trials and examined whether there are age differences in patterns of brain activation under these conditions, in order to directly test whether the capacity to regulate emotion is maintained in older adults. Both younger and older participants rated emotional pictures as more extremely emotional (positive or negative, depending on their valence) if they were instructed to experience the emotion conveyed by the picture than if they were instructed to reappraise the picture meaning. Both groups also showed a network of prefrontal regions that were more active during reappraise trials than during experience trials, and also showed reduced amygdala activity during reappraise trials than during experience trials. However, younger adults showed a larger effect of condition in the left inferior frontal gyrus, recruiting this area more than older adults did when regulating negative emotions. One particularly interesting finding from this study is that participants completed a battery of cognitive tests, including those tapping executive function, and performance on this battery predicted greater reduction in amygdala activity and activation in the left inferior frontal gyrus during the reappraisal trials. These correlations were seen across all participants and highlight the important role that cognitive abilities play in emotion regulation, regardless of age. Individual differences such as these may sometimes be more important than age differences at predicting behavior (see also Samanez Larkin *et al.*, 2010). Findings like this suggest the need to be cautious in drawing quick conclusions about across-the-board age differences in these functions (e.g. positivity effects, improvements in emotion regulation), and the need for additional research to continue to examine when and for whom such effects manifest. As outlined in the next section, individual differences in early life circumstances represent another critical factor influencing life course trajectories, potentially responsible for determining who shows a more positive psychological profile in aging, and who does not.

## The importance of a life course perspective

A key task for aging research is to understand the factors that determine who ages well and who ages poorly, whether the outcome in question is health, cognitive function, subjective well-being or economic security. Traditionally, most longitudinal studies of aging have begun when participants are aged $\geq$50 years, limiting the ability to identify casual factors at earlier stages in the life course. Increasingly, mounting evidence across a wide range of scientific domains indicates that many conditions associated with aging, including cognitive decline and chronic disease, have early life origins (Blackwell *et al.*, 2001; Barker, 2004; Wilson *et al.*, 2004, 2005; Crimmins and Finch, 2006). Candidate causal factors in the biological domain include maternal nutrition and exposure to infectious disease. In the psychosocial domain, early education, family environments, socioeconomic adversity, health behaviors and exposures to psychological stress represent potentially malleable targets for intervention, with the potential to allay long-term damage on physical health and psychological well-being.

From a neurobiological perspective, the allostatic load model offers a unifying framework for considering how factors early in life and across the life course manifest in physiological dysregulation that underlies disease states (McEwen and Seeman, 1999). Proponents of this model have argued that early exposures to stressors during critical developmental periods can set life-long maladaptive response styles in neuroregulatory systems. Alternatively, chronic stress exposure over the life course may result in wear and tear on regulatory systems, downgrading their capacity for maintaining balance over time. Both sorts of stressors may not manifest as disease risk or frank disability until much later down the road (Shonkoff *et al.*, 2009).

In the psychological domain, the early life roots of later life social and economic outcomes have been traced to childhood abilities to self-regulate and maintain well-being. For example, childhood personality characteristics—particularly conscientiousness and social dependability—predict longevity (Friedman *et al.*, 1993, 1995). Longitudinal studies indicate that childhood personality can help predict the formation of social relationships, academic and occupational achievement, and health promoting behaviors (Caspi *et al.*, 2005). Associations between neuroticism measured in midlife with the later development of painful health conditions have also been demonstrated (Charles *et al.*, 2008). Personality traits like conscientiousness or neuroticism are relatively stable psychological predispositions that may influence health through a variety of pathways, including engagement in health behaviors, affective response styles, or selection into low or high-risk environments, to name a few. It is notable that higher education and occupational attainment, which are consistently associated with personality traits like conscientiousness and perseverance, are also strongly linked with better health and longer life expectancy (Singh and Siahpush, 2006; Meara *et al.*, 2008), suggesting a reliance on common self-regulatory capacities for both health and careers.

There remains much debate about how to measure these self-regulatory capacities or psychological predispositions across life stages, either at the behavioral or neurobiological level. Clear links between measures used with children and those appropriate for adults remain to be forged. As highlighted in the paper by Mischel and colleagues in this special issue (2011), there is great potential in following well-characterized early life cohorts into adulthood to examine relations between childhood control capabilities and later life psychological function. The goal is to capture more detailed behavioral and neuroscience assessments on these same individuals, in order to identify the core components of self-regulatory functions responsible for associations between childhood self-control and adaptive social functioning, occupational attainment and health promoting behaviors.

In the absence of performance or observational data from early life, retrospective approaches can also offer windows on life course processes. Supporting the idea that early experiences can produce lasting change in neuroregulatory systems, provocative research is emerging suggesting that early life socioeconomic disadvantage, retrospectively measured, is associated with reduced functional connectivity in brain areas associated with reward processing and impulse regulation in adulthood (Gianaros *et al.*, 2010). Novel findings based on the incorporation of retrospective measures of childhood health conditions into the Panel Study of Income Dynamics (PSID; http://psidonline.isr.umich.edu/Guide/), a premier source of data on economic well-being in American families, reveal that childhood psychological disorders (e.g. experience of drug/alcohol abuse, depression or other psychological disorders prior to age of 17 years) confer substantial economic costs later in life (Smith and Smith, 2010). The ability to retrospectively assess critical childhood factors offers an important opportunity to enhance our life course models of health and economic well-being, in the absence of surveys that cover the full life course. In this special issue, the paper by Taylor *et al.* (2011), using data from the Midlife in the USA study (MIDUS; http://www.midus.wisc.edu/), combines retrospective measures of early social environments with measures of diurnal cortisol profiles derived from daily diary assessments to demonstrate how family environments that are either too harsh or too protective may have long-term impacts on neuroregulatory systems, consistent with the allostatic load model. Addressing concerns about retrospective reports of family environments, these authors cite strong support in the child mental health literature for their validity, as well as data from the MIDUS twin sample in which separate reports obtained from twins on these early life factors are highly reliable.

We consider it critical for life course models of economic and social behavior to be informed by research on neurodevelopment and maturation, which characterizes the biological substrate for the emergence of age-specific patterns of motivated behavior. Active programs in both developmental neuroscience (Giedd *et al.*, 1999; Thompson *et al.*, 2000; Somerville and Casey, 2010) and cognitive neuroscience of aging (Raz *et al.*, 2010; Thambisetty *et al.*, 2010) are mapping the trajectories of maturation and change in both cortical and subcortical structures underlying cognitive, affective, and motivational (e.g. reward, threat, social) function. Recent research on adolescent neurodevelopment suggests that the relative timing of maturation of cognitive control (prefrontal cortical) and motivational (e.g. striatum) systems and their connectivity explains age-specific patterns of decision making and risk taking (Somerville and Casey, 2010). Building on the recently emerging body of neuroimaging work on adolescent decision making and reward processing, Ernst and colleagues (Ernst and Judge, 2009; Ernst *et al.*, 2009) have proposed a heuristic triadic systems neural model of motivated behavior to explain age-typical patterns of adolescent behavior, including risk- and novelty-seeking and the tendency to disregard negative consequences. This model describes the interplay of systems for approach (striatum), avoidance (amygdala) and regulatory control (prefrontal cortex) in guiding goal-oriented behavior (Ernst and Judge, 2009, Ernst *et al.*, 2009). Quite complementary to theories of socioemotional aging, these authors also highlight the critical role of context (e.g. incentives, social environments) in evoking behavior.

To date, longitudinal trajectories of brain development, maturation and eventual age-related change in systems for motivated behavior have not been mapped over the full life course in any one study. Most aging studies are cross-sectional or based on shorter spans of longitudinal follow-up (e.g. Raz *et al.*, 2010; Thambisetty *et al.*, 2010). These and other studies have identified age-related changes in a number of brain areas, including in loss of gray and white matter in prefrontal regions for executive control (Raz *et al.*, 1997; Salat *et al.*, 1999), volume reductions in the striatum (Raz *et al.*, 2003, 2010), and changes in the function of cortical–subcortical networks for cognitive control (Braver *et al.*, 2001; Mell *et al.*, 2009). But an integrative theory describing how these brain changes relate to behavioral and motivational profiles in older adults that include positivity effects, changes in social preferences and improvements in emotion regulation has not been developed. Recent research also cautions that conclusions about age-related trajectories in growth and decline in specific brain regions can be biased by factors such as the range of ages sampled (Fjell *et al.*, 2010), suggesting that accurate pictures of structural change will only emerge when participants are sampled across the full life span. These investigations also highlight the presence of individual variation in the size and rate of change of specific brain regions, both within a given age group and over time, as well as the influence of genetic, environmental and other health factors on individual trajectories of change.

### Individual differences vs age differences

These latter considerations underscore the point that the 'age-typical' neural and behavioral profiles can obscure the enormous variability that is observed at all life stages. For instance, in a study reported in this volume (Samanez-Larkin *et al.*, 2011) individuals whose activity in mesolimbic regions most closely tracked the expected value of options made more rational choices overall, even when controlling for age. One bit of accepted wisdom in the aging research community is that variability on just about any measure increases with age, underscoring that there are a range of aging trajectories that need to be understood (Christensen *et al.*, 1999; Hultsch *et al.*, 2002; de Frias *et al.*, 2007). Evidence is emerging to suggest that individual differences in brain volume measured early life may constitute early vulnerability markers for later life disorders or functional decline. For example, recent studies (Pitman *et al.*, 2006; Lupien *et al.*, 2007) have demonstrated that early life neural vulnerability (in the form of smaller hippocampal volume) may explain what has previously been thought to be age- or trauma exposure-related volumetric differences in adults with age-related cognitive impairment or PTSD, challenging long-held assumptions in the aging and psychopathology literature. This suggests that interventions designed to ameliorate these outcomes may need to target earlier stages of the life course, and may be optimally directed at individuals possessing distinct risk profiles.

Indeed, there is growing evidence that early interventions to enhance socioemotional function offer long-term payoffs in cognitive, social and health domains. The recent application of novel econometric models to assess the impact of early life socioemotional education programs suggests that early investments reap benefits across a wide range of economic and social domains later in life (Heckman, 2006). These findings complement recent evidence from the Dunedin Multidisciplinary Health and Development Study (http://dunedinstudy.otago.ac.nz/), demonstrating that early childhood measures of self-control are associated with an impressive range of adult health, wealth and criminal behavior outcomes 30 years later (Moffitt *et al.*, 2011). Life course studies such as these have the potential to identify appropriate intervention targets in the life span for promoting adaptive social and economic functioning. It will be critical for life course research to identify where (and for whom) in the developmental and maturational trajectory, interventions to promote adaptive social and economic/health behavior will have their greatest impact.

Many well-characterized childhood samples, such as the Bing Nursery School sample (Mischel *et al.*, 2011), the Dunedin cohort and the Add Health cohort (http://www.cpc.unc.edu/projects/addhealth) are now entering midlife, a time when social, occupational and health trajectories start to diverge. Though it is too late to capture early neurobiological measures on these individuals, it will be important, going forward, to incorporate measures of midlife cognitive and emotional function and motivated behavior as benchmarks for studying later life change. These studies represent early life complements to large social science surveys such as the English Longitudinal Study on Ageing (ELSA; http://www.ifs.org.uk/elsa/) and the Health and Retirement Study (HRS; http://hrsonline.isr.umich.edu/) (see Steptoe, this issue), which capture rich data on social environments, health and economic outcomes of adults aged 50 years and older, and the MIDUS study, which captures a wide range of psychosocial and health information on adults across the full range of mid- to late-life. The potential of piecing together a comprehensive life course story by harmonizing data from multiple samples with compatible—but not completely overlapping—measures is currently being explored (e.g.: http://www.ialsa.org/). Such efforts offer a potential context for hypothesis generation and discovery to inform future study designs or to guide the addition of new measures to ongoing studies.

### *Age-appropriate tasks*

An important consideration that arises when extending studies across the life span or engaging in harmonization efforts across studies sampling different age groups concerns how to measure the same or similar constructs across multiple life stages. Particular social, cognitive or affective phenomena (such as self-control) may manifest in quite different ways over the life span, as the adaptive tasks of living may differ substantially by life stage. It is not appropriate to merely apply paradigms developed in college-aged samples to older adults, since many qualitative and quantitative differences exist between these groups and new behaviors emerge with age. Investigators interested in aging will be better served by considering first what is known about social cognition and emotional function in older adults, and about the particular social and economic challenges and motivations associated with the life stage under study. Laboratory tasks should be designed with socioemotional and motivational factors in mind, lest we draw erroneous conclusions about how age-related changes in the brain affect behavior (National Institute on Aging, 2007a).

This poses challenges for measurement, and requires that progress be made on understanding how to capture these age appropriate behaviors, and how to relate complementary behaviors across life stages to understand trajectories of socioemotional development. The field of social neuroscience currently lacks a toolbox of measures of social factors, such as attachment styles, inhibition, exploration, impulsivity and self-control that can be tracked across the life span. However, some of these data can be culled from existing longitudinal studies, and new studies can build these measures into their data collection (National Institute on Aging, 2007a). Similarly, the field of neuroeconomics lacks a complete characterization of the core processes required for adaptive decision-making in different situations and tools capable of assessing how these processes change over the life course. The economics and psychology of aging both offer insights into the kinds of behavioral changes that need explanation and the sorts of contexts in which they arise. For economic and social behaviors, just as with measures of cognitive and emotional function, a battery of benchmark tasks is needed to facilitate understanding whether and how decision-making processes and social interactions differ in their manifestation or fundamentally change over the life course (National Institute on Aging, 2006a).

This issue is being tackled head on by Mischel *et al.* (2011), as they seek to extend studies of childhood self-control into middle age and beyond, to map the broad behavioral phenotype of self-control to its constituent cognitive and affective sub-components measured in midlife, and to link these, in turn to the manifestation of these behaviors in social and economic domains as individuals age.

## EMERGING DIRECTIONS IN SOCIAL NEUROSCIENCE AND NEUROECONOMICS

### SCAN approaches for connecting social environments to health: laboratory—survey linkages

Several papers in this special issue provide examples of how links between laboratory and population sciences can be forged to elucidate issues in social neuroscience (Hawkley *et al.*, 2011; Taylor *et al.*, 2011). Steptoe (2011) highlights the advantages of this integration in his review of findings from the Whitehall II Study (http://www.ucl.ac.uk/whitehallII/) and the English Longitudinal Study of Ageing (ELSA), both large population-level studies that integrate performance and biomeasures with rich survey data on social and behavioral factors, permitting exploration of individual differences in pathways linking psychosocial factors to aging outcomes. Many NIA-supported studies, including ELSA, MIDUS, HRS, NSHAP, The Wisconsin Longitudinal Study (WLS) and The Chicago Health, Aging and Social Relations Study (CHASRS, see Hawkley *et al.*, 2011), are exceptionally rich in their assessments of psychosocial factors, social environments and behavioral, economic and health outcomes. Until recently, when these surveys began adding biomeasures, data on biologically derived disease markers from population-based samples were scarce. These new 'biosocial surveys' (National Research Council, 2008) offer opportunities for scientists to begin mapping causal trajectories from genes to brains to behavior to social environment and back again. Biosocial surveys permit not only the examination of risk factors for disease, but also of resilience factors on the pathways that support positive trajectories of aging. But they also raise challenges inherent in mapping across levels of analysis (Cacioppo *et al.*, 2008). As Steptoe (2011) emphasizes, the strength of these data sets lies in the repeated assessments of both psychosocial and biological parameters, allowing researchers to model temporal trajectories of change, and permitting tests of hypotheses about psychosocial factors in health and economic outcomes.

From the perspective of the population scientist, adopting lab-based approaches offers opportunities for honing in on mechanisms underlying links between psychosocial factors and health. Adapting the more expensive and time-consuming measures of the psychophysiology or neuroimaging laboratory to the survey world allows for exploration of dynamic processes in the causal pathways linking environments and individual characteristics to biology and behavior. From the perspective of the laboratory scientists, the challenge is to consider how to refine laboratory methods to make them more population-research friendly. It also prompts consideration of how to integrate survey-like measurements of well-being and social behaviors into laboratory paradigms, so we can test how laboratory findings translate into real world behaviors and outcomes of relevance to the aging population (National Institute on Aging, 2009).

There are a variety of methods for bringing the laboratory and the field together. One way is to embed experiments in surveys either in the home or over the telephone, as the HRS and MIDUS have done with measures of cognitive performance. Another way is to bring survey respondents into the laboratory for more detailed clinical and psychophysiological assessment, as in the MIDUS, CHASRS and ELSA cohorts, where participants are recruited from a large population-based sample to undergo a variety of stress reactivity, psychophysiological and affective neuroscience investigations in the lab.

MIDUS, the source of data for two papers in this special issue (Taylor *et al.*, 2011; van Reekum *et al.*, 2011) exemplifies this latter kind of design. MIDUS is unique in both the range and depth of assessments across multiple levels of analysis. It began in 1994 when the original 7000+ participants ranged in age from 25 to 74 years. From the beginning, MIDUS was innovative in its incorporation of embedded sub-studies of cognitive functioning and daily stress, and its inclusion of a national twin sample (998 pairs). In the 2004 longitudinal follow-up of nearly 5000 available participants, MIDUS added additional sub-studies involving detailed assessments of a comprehensive range of clinical biomarkers and extensive affective neuroscience assessments in large sub-samples (Ryff, 2011). The sheer numbers of participants available for testing hypotheses about risk and resilience pathways in aging, combined with the rich assessments of psychological, social and economic factors, make studies like MIDUS invaluable resources for testing hypotheses related to the fields of social neuroscience and neuroeconomics. The large sample sizes these studies offer will also be critical as these fields begin to examine genetic influences on economic and social behaviors. Data from MIDUS and the other population-based studies described here is publicly available through resources like the National Archive for Computerized Data on Aging (NACDA: http://www.icpsr.umich.edu/icpsrweb/NACDA/) for secondary analysis.

Several papers in this special issue highlight the potential of laboratory-survey integration for modeling relationships between behavior, environments and biology across both time and levels of analysis. As noted above, Taylor *et al.* (2011) combined MIDUS survey data with salivary cortisol data from daily diary assessments. The paper by Van Reekum *et al.* (2011) uses data from the MIDUS affective neuroscience project to test, for the first time in a large sample across a broad age range, age differences in psychophysiological reactivity to emotional stimuli. Future investigations have the potential to link MIDUS data across levels of analysis, as data from all of its projects become publicly available.

In the paper by Hawkley *et al.* (2011) in this issue, the linkage between laboratory and population-based research is forged in two ways. First, a large representative sample took part in an Internet experiment examining responses to ostracism in individuals across a broad age span. Second, this experiment was replicated in a subsample of older participants in the CHASRS. CHASRS, like ELSA and the HRS, focuses on an older age group (ages 50–71 years in CHASRS), and embeds laboratory protocols within the survey, bringing participants into the lab for detailed assessments that cannot be accomplished at home. The findings of a reduction in negative affectivity in response to ostracism among older adults in internet experiment was replicated in the oldest participants in the CHASRS sample (those aged ≥60 years), and extended to explore potential causal pathways for these effects based on other laboratory and survey assessments of social experiences and stressors, computer exposure, autonomic reactivity and physical pain (the only pathway with a significant impact on affective responses to ostracism).

Work with the CHASRS sample has focused extensively on loneliness as a risk factor for poor health outcomes in aging (Hawkley *et al.*, 2006, 2009; Cacioppo *et al.*, 2010). It has also been ground-breaking in the exploration of genetic pathways linking loneliness to health (Boomsma *et al.*, 2005; Cole *et al.* 2007). Among the challenges posed by the integration of genetic analyses with social and behavioral surveys are the following. First, most complex behaviors or behavioral phenotypes are likely to have multiple genes involved, and will also involve complex epigenetic effects. Second, the identification of appropriate social and economic phenotypes will need to be informed by an understanding of the biological pathways involved, i.e. pathways involving brain systems underlying core psychological functions recruited by these behaviors (National Institute on Aging, 2009).

### *Economic phenotypes*

Evidence continues to grow regarding specific genetic variants that affect specific social behaviors (Canli and Lesch, 2007; Donaldson and Young, 2008) and data are accumulating to suggest that social behaviors may induce or affect gene expression (Cole *et al.*, 2007; Robinson *et al.*, 2008; Champagne, 2010). The genetic complexity underlying social behaviors and findings indicating that genetic expression can be altered by the social environment necessitate using large scale longitudinal studies to answer several research questions. For example, what are the genetic and environmental antecedents of the ability to form social bonds and effectively use social support over the life course, or the ability to engage in adaptive decision making that supports both occupational and economic stability and healthy life spans? Future social neuroscience studies in imaging genetics may shed light on whether genetic effects on social processes are stable over the life course, how age-related neurobiological changes affect social processes, and which genes predict individual variation in social behaviors in later life. Advances in this area will require large samples, as well the development of laboratory tasks that are associated with real world social and economic behaviors (National Institute on Aging, 2009).

As research on the genetics of social behaviors develops, so does interest in advancing measurement of economic phenotypes, i.e. core cognitive, affective and behavioral components of economic behaviors, to enhance the potential for their application to genetic studies (National Institute on Aging, 2007b). Of particular interest are those economic behaviors related to health and economic outcomes in later life, such as educational attainment, risk-taking, job stability, health behavior initiation and maintenance, savings, insurance, etc. Candidate phenotypes include: present bias, response inhibition, gain or loss sensitivity, and aspects of cognitive control, risk aversion, loss aversion, and personality traits, such as conscientiousness. Ultimately, the aim is to equip the field with flexible measures (capable of application across laboratory and field contexts) that will facilitate exploration of genetic factors associated with individual variation in economic behaviors, enabling researchers to exploit opportunities created by the addition of genetics to large, population-based studies such as the NIA-funded Health and Retirement Study.

Currently, few studies use laboratory measures of social and economic behaviors to predict function in real world domains, and there is little evidence regarding the generalizability of social neuroscience and neuroeconomics laboratory findings to real-world social and economic behaviors. Increasingly, researchers may wish to exploit existing multilevel longitudinal studies that measure both social and economic behaviors and embed mini-experiments or collect biomeasures related to social behaviors, to bridge these gaps (National Institute on Aging, 2006b, 2009).

## Links to real world behaviors

Advances in social neuroscience and neuroeconomics of aging have the potential to deepen our understanding how motivation, social roles and social and cultural context interact to influence everyday decisions. This issue is highlighted in the review by Weierich and colleagues in this issue (Weierich *et al.*, 2011) that examines the potential challenges older adults will face with financial decision making, given what is known about brain and psychological changes that typically occur in older age. As these authors recognize, ultimately, it is necessary to understand age differences in behavior in real-world contexts, not just in controlled laboratory contexts, and to consider how changing motives and emotional biases can work for or against individuals' best financial best interest. For instance, it is common financial advice to decrease the percentage of one's portfolio that is invested in risky assets as one approaches retirement. Thus, cultural norms about what one should do at different life stages may influence decisions along with individual differences in risk-seeking or other factors. The structure of institutions, such as procedures for enrollment in retirement accounts, can also determine behavior in ways that may trump individual decision-making biases (Carroll *et al.*, 2009). Weierich *et al.* (2011) argue that policies and recommendations aimed at guiding financial decision-making need to be informed by our understanding of inherent affective biases that may undercut individuals' ability to make choices in their own long-term best interest. These complementary considerations suggest to us that the translational potential of work examining the neural correlates of economic decision-making will be enhanced if both structural and person-level factors that impact individual choice are given equal consideration.

Focusing on real-world decision behaviors highlights the importance of designing interventions that can improve decisions. In this issue, Samanez-Larkin *et al.* (2011) designed interventions to improve performance in a laboratory investment task. Participants in their study had to choose between a bond and two risky stocks on each trial. In a baseline condition, they had to rely on learning from previous trials to make each new decision. While older and younger adults did not differ significantly in their explicit knowledge of which asset was the best investment, older adults made fewer optimal choices. After identifying a strong correlation between areas in the brain that encoded the expected value of the stocks and superior performance on the task, they designed an intervention that provided participants with visual cues that summarized the expected value of the different asset options. This intervention improved decisions for all participants, notably raising older adults' performance to the level of their younger counterparts. Further research extending these findings to real financial decision contexts could be quite valuable, though, as the authors note, not without challenge, since real world investment contexts are characterized by much more inherent uncertainty than these laboratory studies (Samanez-Larkin *et al.*, 2011).

If it is difficult to make decisions even when the information about the options is accurate, how can one cope with situations in which information should not be trusted? A common stereotype is that older adults are more susceptible to fraud than younger adults. However, survey research indicates the opposite—increasing age actually predicts less likelihood of having been a fraud victim (Titus *et al.*, 1995; Van Wyk and Benson, 1997; Van Wyk and Mason, 2001; Schoepfer & Piquero, 2009). For instance, older adults report fewer episodes of victimization such as falling for an offer of a free prize, giving out bank account or pin number information or being billed for more than a product cost (Schoepfer and Piquero, 2009). It is not clear what protective mechanisms lead to making older adults slightly less vulnerable to fraud; one possibility is having fewer distant social connections (Van Wyk and Mason, 2001). However, once approached, it is possible that older adults would be more vulnerable. In particular, those with certain types of cognitive decline may be especially likely to fall for scams. For instance, initial work indicates that a subset of older adults who perform poorly on a laboratory measure of decision making (the Iowa Gambling Task) also are more likely to be misled by deceptive advertising (Denburg *et al.*, 2007). Memory declines may also increase vulnerability to scams (Jacoby, 1999).

Older adults often must renegotiate family relationships as they require more care, and financial decision-making can become contentious. A recent survey of a representative sample of adults over the age of 60 years in the USA found that financial mistreatment perpetrated by a family member was reported more frequently (with 5.2% prevalence) than any other type of abuse, including neglect (Acierno *et al.*, 2010). This highlights how financial well-being can be intertwined with social and emotional factors.

Research is also needed to explore whether there are age differences or age-related changes in the influence of the presence or absence of others (advisors, family members, authority figures) on economic behavior, or on how qualitatively or proximally different social relationships impact economic behavior, and what are the neurobiological correlates of these effects (National Institute on Aging, 2006b). This will be particularly important in understanding how older adults and their families manage decisions related to retirement planning and health care for the management of chronic illness or at the end of life. As highlighted in the paper by Albrecht and colleagues in this issue (Albrecht *et al.*, 2011), individuals are more dispassionate and patient when making tradeoffs between immediate and delayed rewards for others than when making the same decisions for themselves. This difference was reflected in both behavioral choices and in the activation of brain areas engaged in emotion and reward-related processing. While a dispassionate perspective may seem optimal when making decisions on others' behalf, the authors caution that choices for others still exhibited a strong present bias. We note, in addition, that in some cases, a dispassionate perspective may not reflect the true preferences of the individual for whom the choice is made. Surrogate decision makers for older adults may need to make an extra effort to consider whether they are disregarding important affective or social goals relevant to the situation at hand, when making decisions on behalf of others.

## LOOKING AHEAD

A variety of opportunities exist for infusing social neuroscience and neuroeconomic research with a life course perspective. These include longitudinal investigations of how individual differences in social and economic behaviors influence trajectories of health, functionality and well-being over the life span. Of particular relevance to aging, there is a need to understand how motivated behaviors in social and economic domains, as well as their neurobiological underpinnings, develop and change over the life span. There is also a need to understand how changes in social contexts and networks at different life phases influence these processes. It will be important, in our view, to pay attention to the ways in which different task designs manipulate contextual and motivational features and the impact these have on behavior of different age groups. Little is known about the role of personality, self-control and motivation in shaping social interaction and creating the environments for the expression of these behaviors. It is also unknown whether individual differences in social and economic behaviors become more or less pronounced with age, or whether they manifest differently as a function of life stage, with different dispositions being more adaptive at different junctures (National Institute on Aging, 2006b, 2007a).

Advancing this agenda will require deeper investigations of neurodevelopmental and social processes that affect trajectories of aging. Also required will be studies exploring gene–environment correlations and interactions, including studies of the effects of aging on the selection of social environments and how this impacts functional aging, and studies that elucidate how social behaviors at different life stages influence gene expression and genetic influence (National Institute on Aging, 2009).

A convergence of perspectives across the behavioral, psychological and neural sciences supports our argument that important contributions to the social neuroscience and neuroeconomics of aging are likely to emerge from research that takes a life span approach to the study of neurobiological underpinnings of social and economic behavior. Advances are also likely to emerge through refinements in our ability to measure and identify phenotypes and endophenotypes of social and economic behaviors of relevance to aging. Progress in understanding individual differences in socioemotional and economic behaviors and outcomes will also require the integration of population- and laboratory-based approaches spanning the life course, where large samples offer rich individual variation in both traits and exposures, and longitudinal follow-ups permit mapping of trajectories over time. Such advances hold the potential for identifying appropriate life course targets for interventions designed to improve social integration, emotional well-being and economic security of older adults (National Institute on Aging, 2007a).

While life course approaches have been emphasized here, it is also important to remember the many individuals who are reaching old age and will be living longer than their predecessors, thanks to tremendous advances in medicine and public health. Work in neuroeconomics and social neuroscience of aging holds the potential to shape interventions that may ultimately improve and enhance these later years of life (National Institute on Aging, 2007a).

## Conflict of Interest

None declared.

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