CHAPTER 18

Cognitive Development in Adulthood and Aging

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Overview Of Cognitive Aging: Approaches, Perspectives, And Processes

Patterns of Cognitive Aging

The area of developmental research focusing on the study of cognitive changes in adulthood is known as the field of cognitive aging. The orienting question for this field is: *How, why, and when does cognition change with aging*? The main components of this question are highlighted. First, the term *cognition* is used broadly and inclusively in this chapter to accommodate multiple aspects, dimensions, theories, and measures of a variety of mental activities executed by the brain. These include, but are not limited to, classes of activities known as intelligence, memory, attention, reasoning, speed, executive functions, problem solving, and wisdom. Second, the term *change* is used broadly and inclusively to accommodate several theories, phenomena, directions, and research designs. Thus, the present approach permits consideration of structural, stage-like, or incremental cognitive changes with aging, as investigated (a) under the aegis of any developmental theory or approach and (b) with any of numerous legitimate time-structured research designs. No assumptions are made about the nature of cognitive developmental change with aging, but it is important, as elsewhere in lifespan studies, to attend to (if not focus on) actual intraindividual changes. Third, the term *aging* is used broadly and inclusively to reflect processes occurring throughout adulthood. It is a neutral term referring to "changes with age that occur during adulthood" regardless of the direction, quality, or rate of the changes. Notably, aging is not tantamount to decline. Finally, as articulated elsewhere (e.g., Baltes, 1987; Dixon, Small, MacDonald, & McArdle, in press), it is important to pursue questions that point to *how* (description), *why* (explanation), and *when* (at what lifespan inflection points) substantial changes in group and individual cognitive trajectories occur.

Substantial changes refer to those developments that are not only detectable but also descriptively informative, theoretically meaningful, or clinically significant.

Cognitive aging (the field) is a particularly active and vibrant domain of research, one that is at the crossroads of both classic questions and novel trends. Several brief examples of each of the paths leading to this crossroads may be useful. First, classic questions about cognitive aging revolve around core developmental issues such as directionality (i.e., whether adult cognitive changes are gains, losses, or maintenance), universality (i.e., the extent to which there are individual differences in profiles of changes throughout adulthood), and reversibility (i.e., whether experience or intervention may promote recovery or improvement in functioning). For more than a century scholars have wondered about whether the lengthening adult life span would be ineluctably accompanied by diminishing cognitive, social, institutional, and other resources (Baltes, Lindenberger, & Staudinger, 2006; Birren & Schroots, 2001). Moreover, because contemporary (western) adulthood represents about 75% of the normal expected life span, few adults would fail to have a vested interest in the cognitive changes they might expect as they grow through their middle and into their later years. Second, novel trends reflect influences that are easily and importantly incorporated into research on cognitive aging–as is the case for earlier periods of life. Recent trends include methodological advances, such as the means of detecting and analyzing structure, change, and variability (e.g., Hofer & Sliwinski, 2006; McArdle, 2009). Other novel trends in cognitive aging are often adapted from neighboring disciplines and given new clothing in the context of understanding long-term change. Among notable developments are such integrated topics as metamemory and memory compensation (e.g., Dixon & de Frias, 2007; Hoogenhouts, van der Elst, de Groot, van Boxtel, & Jolles, 2010), neurobiological, neurodegenerative, and neurogenetic influences (e.g., Bäckman & Nyberg, 2010; National

Institute on Aging, 2008), other biomarker and health modulators (Anstey, 2008; Spiro & Brady, 2008), psychosocial, motivational, and emotional influences (e.g., Heckhausen, Wrosch, & Schulz, 2010), social, interactive, and collaborative contexts (e.g., Dixon, 2011a; Gerstof, Hoppmann, Anstey & Luszcz, 2009; Rauers, Riediger, Schmiedek, & Lindenberger, 2011), interventions and training (Lövdén, Bäckman, Lindenberger, Schaefer, & Schmiedek, 2010), and successful or healthy directions of cognitive aging (Baltes & Baltes, 1990; Dixon, 2010). Overall, how, why, and when cognition changes with aging are seen as integrated developmental questions—questions that reflect classic developmental issues and relate to numerous neighboring developmental processes. Indeed, issues considered in the study of cognitive aging go to the heart of our view of both the human life course, in general, and of developing (aging) adults, in particular.

Although it may be used in different ways and to accomplish different goals, cognition is no less important in late adulthood than in early and middle adulthood. Not only is it a basis of one's achievements and competence, but it contributes to—or detracts from—one's sense of self-efficacy and the efficiency with which one (a) engages in life planning and life management and (b) pursues, achieves, or re-evaluates life goals (Heckhausen et al., 2010). Therefore, it is instructive to briefly compare the basic stories told about cognitive development during the first 20 or so years of life, on the one hand, and during the remaining 50 (or so) years of life, on the other. Obviously, the stories told of infant, child, adolescent, and even early adult cognitive development are generally optimistic. Cognition during these years is progressing and growing, channelled in part by the typical social worlds and the rapidly maturing neurobiological substrate. From early life, cognitive potential is being realized, steadily if not ineluctably. For normally developing individuals there are some differences in level of performance attained and in the rate at which growth occurs, but virtually no differences in the direction of change. Although cognition improves from early infancy, around early adulthood the story of lifespan cognitive development evidently changes. The word “evidently” is used because there is some controversy about the range and causes of aging-related changes in cognition. There is, however, little remaining controversy regarding the fact that there is substantial and necessary cognitive decline (see Craik & Salthouse, 2007). Nevertheless, an important theme in cognitive aging is one of individual differences in profiles, rates, and causes of change. Increasingly, researchers are attending to questions concerning such issues as whether people differ in when they start to decline, whether processes differ in rate of decline, what processes are maintained and for how long, how normal decline differs from that associated with neurodegenerative diseases (e.g., Alzheimer’s disease), and the extent to which this decline affects individuals’ everyday lives. A common proposal is that individual differences in cognitive development are greater in late life than in early life. Research in cognitive aging is ideally suited to investigating how, why, and when such individual differences in change patterns occur.

Approaches to the Field of Cognitive Aging

How is research conducted in the field of cognitive aging? As with other areas of developmental science, we attempt to answer questions about the how, when, and why of cognitive aging by implementing time-structured research designs. In its most global rendition, time-structured research includes any design that implicitly (and only indirectly) or explicitly (and directly) examines intraindividual (within-person) change. The well-known distinction between (and relative strengths and weaknesses of) cross-sectional (e.g., comparing different age groups) and longitudinal (e.g., following the same individuals over time) designs will not be further discussed in this chapter. Nevertheless, as with other developmental areas, these methodological issues loom large in the history of theoretical and clinical cognitive aging research. We will note one important and relatively recent aspect of the methodological approaches to describing and understanding cognitive aging. A principal goal of this field is to identify the independent, interactive, and confluence of factors that contribute to (or compromise) cognitive "health" in aging. Among the many challenges researchers face in trying to attain this goal, two may be mentioned in this chapter: Relevant influences or factors (a) are associated with multiple disciplines (biology, neurobiology, health, pharmacology, neuropsychology, lifestyle, genetics, sociology) and (b) operate across the longest period of developmental activity and vulnerability in the lifespan (some 50 or more years). In recent years, some cognitive aging researchers have adapted and merged methodological techniques from epidemiology (e.g., risk factors, protection factors) and longitudinal research (intraindividual change, individual variability and differences, multiple trajectories, multiple outcomes). Accordingly, a number of large-scale longitudinal studies (LSLS) have emerged, contributing continuing data from a variety of constituent areas of lifespan development (Dixon, 2010; Hultsch, 2004). In this way, actual changes and statuses (including normal decline, clinical or accelerated decline, maintenance or stability, or even improvements or gains) can be linked to precursors (and interactions among precursors) from multiple contributing domains. Although there are others meriting attention, two LSLS will be mentioned in passing in the following section (i.e., Seattle Longitudinal Study, Victoria Longitudinal Study; Dixon & de Frias, 2004; Schaie, 1996).

In the remainder of this chapter we summarize (quite) selected aspects of the field of cognitive aging. Reflecting the breadth of the field, we have elected to focus on several clusters or processes of cognitive functioning. Naturally, this results in numerous unattended processes.

Interested readers may turn to several recent volumes of collected works in which scholars have reviewed a variety of processes of cognitive aging in much more detail (e.g., Craik & Salthouse, 2007; Dixon, Bäckman, & Nilsson, 2004; Hofer & Alwin, 2008). Two long-standing areas of study in cognitive aging are intelligence and memory. In the next section, we begin by briefly reviewing enduring perspectives and new approaches to scholarship in these areas. Subsequently, we introduce the growing topic in cognitive aging of biological and health influences. Next, we highlight recent developments in integrating emotional and psychosocial elements into the understanding of cognitive aging. Finally, we offer notes on a topic of growing interest in the field, specifically, the extent to which there is evidence of potential, resilience, or sustained success in cognitive aging.

Intelligence And Memory: Classic Clusters Of Processes

Overview of Intellectual Aging: A Century of Programmatic Research

Like other major categories of developmental processes, cognition can be viewed from numerous related and even overlapping perspectives. From one such perspective, the focus is on cognition as intelligence or intellectual ability. There is a long tradition of research on intelligence and a surprisingly long (and still pertinent) history of research on intellectual aging (e.g., Kirkpatrick, 1903; Sanford, 1902; Weisenburg, Roe, & McBride, 1936; see Dixon, Kramer, & Baltes, 1985, for a brief history of the early years). Research on the aging of intellectual abilities typically uses procedures adapted from research on *psychometric intelligence*. This means that intelligence is measured by multiple tests, each of which may be composed of more than one scale or subtest. Each subtest measures a relatively unique aspect of intelligence. There are a variety of statistical means through which the uniqueness of the subtests can be evaluated. In addition, however, the subtests typically should be linked both conceptually and empirically.

Contemporary psychometric approaches to adult intellectual development employ multidimensional theories of intelligence. Therefore, they also use intelligence tests in which performance on multiple scales or dimensions may be tested. Using multiple scales of intelligence allows the investigator to examine the extent to which dimensions of intelligence change similarly or differently across adulthood. The psychometric approach to intellectual aging has a long and illustrious history (Horn & Cattell, 1966; Schaie, 1990).

Historically, a typical expectation about intellectual aging came to be that intelligence would increase until early adulthood and then decline through late adulthood. This pattern can be portrayed in an inverted-U-shaped curve. Botwinick (1977) referred to this curve as the classic pattern of intellectual aging, partly because it was so frequently supported in the literature up to the mid-1900s. Interestingly, however, even the earliest theories and research did not lead to the unequivocal conclusion that intelligence inevitably and universally declined after early adulthood. Contemporary research has confirmed some of the prescient early theorists, who operated without the benefit of modern technology, contemporary theories, or even much research data. Several examples illustrate this point. First, important issues of age fairness (in testing procedures) and late life potential and plasticity (through training) were identified early by Kirkpatrick (1903). Second, another enduring issue raised about 100 years ago is the potentially close connection between the aging body and the aging mind. For example, Sanford (1902) noted that intellectual decline was likely associated with the inevitable physical decline that accompanies late life. Thus, Sanford anticipated some aspects of contemporary theories focusing on the roles of physiological, neurological, health, and sensory factors (e.g., Anstey, 2008; Baltes et al., 2006; Dixon, 2011a; Spiro & Brady, 2008). Third, some observers have historically raised the question of whether and how older adults could avoid, postpone, or overcome seemingly inevitable aging-related changes. For example, Sanford (1902) speculated that some maintenance of performance levels is possible if aging adults made an effort to maintain them by, for example, continuing challenging activities, an idea of considerable currency even today for both normal aging and neurodegenerative diseases (e.g., Fratiglioni & Wang, 2007; Stern, 2007). Fourth, potentially vast individual differences, aging-related patterns and trajectories were highlighted early (e.g., Weisenburg et al., 1936), with some attention to the varying ages of peak performance, implying interindividual differences in rates of growth and decline, as well as final performance level (e.g., Baltes et al., 2006; McArdle, 2009).

The next era in intellectual aging research began in the 1960s and 1970s. For example, John Horn and Raymond Cattell began developing an alternative view to the classic aging pattern. Horn and Cattell (1966) collected a variety of intelligence-test data from adults of varying ages. Rather than interpreting the scores from each of the tests, or even collapsing across categories of tests (such as Verbal and Performance), Horn and Cattell evaluated the underlying dimensions or factors of intelligence. Specifically, Horn and Cattell (1966; Horn, 1982) identified two major dimensions of intelligence. These dimensions of intellectual abilities were called *fluid intelligence* (Gf) and *crystallized intelligence* (Gc). Fluid intelligence reflected the level of intellectual competence associated with casual learning processes. This learning is assessed by performance on novel, usually nonverbal tests. Crystallized intelligence, on the other hand, reflects intellectual competence associated with intentional learning processes. This variety of learning is assessed by measures of knowledge and skills acquired during school and other cultural learning experiences. Most verbal tests tap processes thought to underlie crystallized intelligence. Because crystallized intelligence indexes life-long accumulation of cultural knowledge, it should show a pattern of maintenance or increase during the adult years.

According to the theory, fluid intelligence is more dependent on physiological functioning, including the neurological system, and is known to decline with aging even from the early 20s (e.g., Raz, 2004). Given the extent to which the neurological substrate becomes impaired, the ability to perform associated intellectual skills is undermined. Horn and Cattell have therefore provided the classic aging pattern with a potential theoretical explanation for the common observation of differential decline across the two dimensions. Biological and social-cultural influences remain important in understanding intellectual aging (e.g., Baltes et al., 2006).

Also in the 1960s and 1970s, longitudinal research in intellectual aging began emerging (Schaie, 1983). Although longitudinal investigations have the advantage of examining age *changes* rather than simply age *differences,* they have additional strengths and associated limitations (Schaie, 2009; Schaie & Hofer, 2001). For example, *selective sampling* and *selective attrition* factors are challenging but often manageable aspects of longitudinal designs (Hofer & Sliwinski, 2006; Hultsch, 2004; Schaie, 1996). Most notably in the study of intellectual aging, in 1950s and 1960s, Schaie (1996) began a carefully designed and exhaustive longitudinal and cohort-sequential study of intelligence in adulthood. With participants ranging in age from the 20s to the 70s, Schaie's Seattle Longitudinal Study tested participants at seven-year intervals. At each testing occasion, new participants were added and then followed in subsequent waves. Throughout his career, Schaie (1994, 1996, 2011) has emphasized that there are considerable individual differences in degree of decline and age at onset of decline. Indeed, up to age 70 some individuals do not decline at all. Some of these individuals even show modest gains for all of the intellectual abilities evaluated. Nevertheless, a prominent conclusion is that the age at which each ability peaks and the patterns of decline thereafter are quite different. For example, those abilities associated with fluid intelligence have earlier peaks and longer declines than those abilities associated with crystallized intelligence. Complementing historical researchers, Schaie and colleagues also provided advanced insights into applications, plasticity, risk and protection factors, health and other influences, as well as differences in aging associated with gender, generation, education and other conditions. Overall, the Seattle Longitudinal Study, along with other major longitudinal investigations of cognitive and intellectual aging, have made prodigious contributions to this field. For example, in one study, Schaie (1990) reported that over 70% of 60-year-olds and over 50% of 81-year-olds declined on only one ability over the previous seven years. Thus, intellectual declines occur with aging, but not appreciably until quite late in life, and then not uniformly across dimensions of intelligence.

Overview of Memory Aging: Classic Processes and New Perspectives

If research on intellectual aging is characterized principally by psychometric assumptions and procedures, research on memory and aging is typically conducted by implementing one or more of a wide range of clinical and experimental tasks and techniques in the service of answering a broad range of specific questions. To be sure, all prominent developmental research designs— that is, those that compare age groups (cross-sectionally) or those that follow samples across time (longitudinally)—may be enacted with either psychometric or experimental-based tasks. In the case of memory, the bulk of extant research has been cross-sectional and quasi-experimental in nature, but there are a growing number of examples of change-oriented, longitudinal studies populating the scholarly literature. Thus, at the most general level the motivating issues of memory and aging research are similar to those propelling scholarship in intelligence and aging. These include (a) the perennial questions of how, why, and when memory changes with aging, (b) whether aging-related changes may be characterized as gains, losses, or both, and (c) what accounts for differences in performance (changes and trajectories) as observed across time, age, task, and individuals (Dixon et al., in press).

Overall, research on memory and aging is focused on processes through which individuals may recall previously experienced events or information, the extent to which these processes change with advancing age, and the conditions, correlates, or predictors of such changes. Reflecting the sheer volume of research in this field, numerous reviews of memory and aging have been published in recent decades (see Craik & Salthouse, 2007; Naveh-Benjamin & Ohta, in press; Schaie & Willis, 2011). Of all aspects of cognitive aging, memory may be the one that has most captivated general human interest and academic attention. Many reviewers begin by noting that (a) memory is viewed as a functional, if not essential, tool of successful development; (b) memory is one of the most frequently mentioned complaints of older adults; (c) memory loss is one of the most feared signs and implications of aging; and (d) many adults believe that, whereas memory abilities improve through childhood, they decline with aging. For these and other reasons, researchers and lay adults are profoundly interested in whether, how, why, and when their and others' memory abilities change (decline) throughout adulthood (Dixon et al., in press).

Systems of memory and aging. Over the last several decades, research on memory and aging reveals provocative patterns of results. Whereas some tasks are associated with robust findings of age-related deficits, other tasks are associated with less pronounced losses or even equivalent performance by younger and older adults. Tasks typically associated with losses require processing or manipulations of complex, difficult, speeded, multi-modal features (Naveh-Benjamin & Ohta, in press). The less common tasks associated with relatively unimpaired performance may reflect acquired facts and knowledge or familiar situations with substantial environmental or human support. Although others are available, one well-developed theoretical treatment of memory per se has proven helpful in organizing these disparate results. Specifically, the *memory systems perspective* has been especially influential in research on memory and aging (Nyberg et al., 2003; Schacter & Tulving, 1994). Positing that there are up to five systems of memory, a central goal of this perspective is to explicate the organization of the systems. A memory system is defined as a set of related processes, linked by common brain mechanisms, information processes, and operational principles (Schacter & Tulving, 1994). For this overview chapter, we focus on two of the systems briefly and summarize some principal findings with respect to aging.

First, episodic memory refers to memory for personally experienced events or information. Everyday examples are bountiful: trying to remember the names of people one has met at a party, where one parked the car, a conversation or joke one heard, the location of an object in a spatial arrangement, an anecdote one read in a newspaper, or an unwritten list of items to purchase at a store. It is thought to be the latest developing memory system, and some reviewers have suggested that it is correspondingly among the first to begin showing signs of aging-related decline. Indeed, cross-sectional research using a variety of episodic memory tasks (e.g., memory for digits, words, non-words, pictures, objects, faces) and procedures (e.g., free recall) has observed that older adults commonly perform worse than younger adults. Much recent research has targeted potential exacerbating or modulating factors associated with aging, such as neural vulnerability, health status, biological vitality, lifestyle activities, education, gender, environmental support, collaborative condition, and ecological relevance of the task (e.g., Baltes & Staudinger, 1996; Dixon et al., in press; Herlitz & Rehnman, 2008; Naveh-Benjamin & Ohta, in press). Although no evidence has been marshalled to dispute persuasively the conclusion that episodic memory performance generally declines with advancing age, some cross-sectional (e.g., Nilsson et al., 1997) and longitudinal (Dixon et al., 2004) research has indicated that the magnitude of some aging-related change may be more gradual than precipitous for normally aging adults, at least until the mid-70s. In addition, the extent of individual differences in trajectories, as modulated by numerous intrinsic and extrinsic factors, is substantial.

Second, semantic memory is expressed through the acquisition and retention of generic facts, knowledge, and beliefs. In research, it is evaluated by administering tests of general world knowledge, facts, words, concepts, and associations. As such, it is similar to the domain represented by crystallized intelligence. The typical cross-sectional finding for semantic memory is that older adults may remember as much information of this sort as do younger adults. For example, normal older adults, through extended cultural and educational experiences, may possess knowledge bases regarding world facts (sports, celebrities, geographical information, political lore) that are superior to those of younger adults. In addition, vocabulary performance of older adults is often similar to or better than that of younger adults. Thus, older adults display similar knowledge structures or associative networks. Nevertheless, some studies have suggested that older adults may access such information more slowly and with more frequent blockages than do younger adults. In a large cross-sectional study, only small differences were observed across the ages of 35 to 80 years (Bäckman & Nilsson, 1996). Moreover, recent longitudinal analyses have observed modest changes (but dramatic individual variability in change) over substantial longitudinal periods and broad bands of adulthood (e.g., 55-95 years; Dixon et al., in press).

Selected emerging topics in memory and aging. Memory, like intelligence, is a multidimensional construct. As with other multidimensional constructs of interest in developmental psychology, differentiable dimensions may reveal distinct developmental patterns. Researchers continue to explore with increasing ingenuity each of the clusters of memory phenomena. In addition, many researchers push the boundaries of these memory systems as they apply to aging by considering ever-broader ranges of memory phenomena, as well as diverse correlates and predictors. In this section, we briefly note a few trends in memory and aging research, selecting for somewhat more discussion two of these domains. Among the promising new trends in memory and aging research is the ever-increasing attention that biological influences are receiving. This is an entirely logical development, if only because the brain is a crucial site of activation that is representative of memory and other cognitive processes. Structural and functional changes in the brain are related to, if not predictive of, cognitive performance in adults (e.g., Cabeza, Nyberg, & Park, 2005; Raz et al., 2005; Reuter-Lorenz & Lustig, 2005). Also within a broader biological level, much current research in memory and aging has focused on the extent to which genetic status, as well as physiological, sensory, and physical health changes, may have an effect on cognitive functioning in late life (Dixon, 2011a; Wahlin, 2004). (We address the latter issues in a subsequent section.)

Additional new foci of memory and aging research include the following four promising topics. First, researchers have come to focus closely on the interactions of social and cultural contexts of aging with cognitive and memory performances among older adults (e.g., Park, Nisbett, & Hedden, 1999; Schaie, 2011; Schaie & Carstensen, 2006). Second, adults of all ages often wonder about their memory—how it works or does not work, why one remembers some things but not others, and whether memory skills will change over the life course. The term *metamemory* refers to such cognitions about memory—thinking about how, why, and whether memory works. Specific aspects of metamemory include knowledge of memory functioning, insight into memory changes or impairment, awareness of current memory processes, beliefs about and interpretations of memory skills and demands, memory-related affect and motivation, and the role such metamemory functions may play in shaping everyday memory behaviours (e.g., effort, self-efficacy, compensatory processes) (Hertzog & Hultsch, 2000; Hoogenhouts et al., 2010).

Third, for several decades researchers in a surprising variety of fields have addressed aspects of everyday memory activity that appear to operate in the influential context of other individuals. Many observers have noted the frequency with which everyday adult cognitive activity occurs in interactive contexts (e.g., Clancey, 1997; Greeno, 1998). A collaborative context frequently envelops cognitive performance in modern life. Everyday examples of collaborative cognition include (a) family groups or lineages reconstructing stories from their shared past; (b) spouses enlisted to help remember important appointments, duties, or dates; and (c) strangers in unknown cities consulted in order to solve way-finding or map-reading problems (Dixon, 2011b; Strough & Margrett, 2002). Lurking behind this observation is the contention that collaboration may lead to functional performance outcomes, practical solutions, and improved performance. Of particular importance in cognitive aging research is the possibility that the strategic deployment or use of human cognitive aids (other individuals) may be a means of compensating for individual-level aging-related losses or deficits. In other literatures the phenomenon has been also called collective, situated, group, socially shared, or interactive cognition (e.g., Baltes & Staudinger, 1996). Some evidence for notable collaborative benefit may be observed when researchers attend to collaborative expertise, multidimensional outcomes, measurement of actual collaborative processes, and comparisons accommodated to memory-impaired or vulnerable groups (e.g., Dixon & Gould, 1998). In particular, evidence has accumulated that expert older collaborators (long-term married couples) may be able to solve complicated memory problems at levels not otherwise expected for such individuals through cooperative mechanisms that resemble compensatory devices (Baltes & Staudinger, 1996; Dixon, 2011b; Gagnon & Dixon, 2008; Rauers et al., 2011). This is a growing and promising area of both basic and applied research in memory and aging.

Fourth, the classical sense of memory—and all the examples just noted—refer to remembering events that have occurred in the past. There is, however, a common class of memory activities that refer to future events. Among the plethora of everyday memory experiences are those in which one must remember to carry out an action in the future, such as remembering to take medication, keep an appointment, give a message to a colleague, pick up a loaf of bread on the return trip home, or perform an errand such as mailing a letter. This class of memory has become known as *prospective memory*. Accordingly, it is contrasted with the sizable set of memory activities for past events, which from this perspective, may be classified as *retrospective memory*. Thus, retrospective memory includes the principal memory systems, episodic and semantic memory, as discussed above. Although memory and aging research has been predominantly interested in retrospective memory phenomena, in recent years prospective memory has become a salient research topic (McDaniel & Einstein, 2008; see also previous version of the present chapter, Dixon & Cohen, 2003).

Like retrospective memory, the aging of prospective memory has been studied with both naturalistic and experimental procedures. In a groundbreaking naturalistic study, Moscovitch (1982) instructed younger and older adults to call an experimenter at prearranged times throughout a period of several days. The intriguing results indicated that older adults' prospective memory performance was actually better than that of the younger adults. Further investigation revealed an unexpected potential explanation; namely, older adults were motivated to perform such tasks and were more likely to use reminders (e.g., written notes) as a way of remembering the intention of phoning the experimenter (but see also the early study by Dobbs & Rule, 1987). Eventually, prospective memory tasks were divided into two subsets (e.g., Einstein, McDaniel, Richardson, & Guynn, 1995): Event-based (situations in which an external event acts as a trigger for some previously encoded intention) or time-based (situations in which the appropriateness of an action or intention is determined by the passage of time). The provocative aging-related observation was that time-based tasks (which require more self-initiated processing) produced more negative aging-related effects than did event-based tasks (McDaniel & Einstein, 2008). Event-based prospective memory is believed to involve spontaneous retrieval. As no resources are dedicated to monitoring memory, a specific event will act as a cue and prospective memory is spontaneously remembered (Henry, MacLeod, Phillips, & Crawford, 2004; McDaniel, Guynn, Einstein, & Breneiser, 2004). However, a variety of complexities has appeared (McDaniel & Einstein, 2007). Due to the everyday importance of "remembering to remember," continued prospective memory research is imperative.

Biological And Health Influences On Cognitive Aging

Considering Biological and Cognitive Vitality

Have you ever noticed that the cognitive vitality of some aging individuals seems to evade the grasp (even ravages) of time? Undaunted, such successfully aging adults maintain a high level of mental activity and acuity into later years of life, even as other people their age experience gradual, or in some cases, precipitous decline. In addition to "super" or "elite" aging adults, there is a less dramatic but no less important wide distribution of biologically and cognitively healthy aging adults. If we consider cognitive vitality to be one of many manifestations of biological integrity, we can imagine a "biological age" for cognitively advantaged older adults, which could be several years "younger" than their corresponding chronological age. This intriguing potential dissociation between chronological age and biological/cognitive vitality has captured the attention of scientists and the lay public. Two general observations are offered. First, an individual's cognitive status and rate of decline is not always consistent with that individual's chronological age (Birren, 1999). That is, the passage of time (or years of age) is not inextricably tied up with, or synonymous to, processes of physiological decline associated with normal aging. Second, on a population level, there exists broad heterogeneity in the natural history of aging. People of the same age may differ considerably in cognitive and biological vitality (Anstey, 2008; Baltes & Willis, 1977; Dixon, 2011a).

These observations make clear that although chronological aging generally approximates biological aging across the lifetime, the relationship is often less than perfect (e.g., MacDonald, Dixon, Cohen, & Hazlitt, 2004; Nakamura & Miyao, 2007). In addition, neither biological age nor chronological age is an intrinsically theoretically or empirically sufficient predictor of cognitive aging trajectories (Anstey, 2008; Wahlin, MacDonald, de Frias, Nilsson, & Dixon, 2006). Researchers use the terms biological vitality and cognitive vitality to refer to the cumulative, interactional, functional effect that both stressors (risk factors) and salubrious influences (protection factors) have within an individual or population. As contrasted with chronological age (an index of the passage of time), biological age (or BioAge) is a quantified composite of one or more indicators of biological vitality, and therefore of potential value in descriptive and explanatory developmental research (MacDonald et al., 2004). In its application to cognitive aging, it is based on the idea that even normal cognitive decline happens as a result of both broadly influential and highly idiosyncratic impetuses of change, which are not always tied simply or unambiguously to the passage of time. Although a valid marker of the passage of life time, chronological age offers no immediate or unambiguous indication of the mechanisms responsible for cognitive development (Baltes & Willis, 1977; Dixon, 2011a). Instead, chronological age is best viewed as a proxy for underlying mechanisms of cognitive aging that systematically emerge and develop across the continuum of time. Nevertheless, chronological age may also serve some useful descriptive and clinical purposes in cognitive aging research. These include: (a) classifying clusters of older adults likely to be similar in cohort-related experience and (b) serving as one valid factor (along with years of education) for sorting adults into normative or clinical comparison groups. However, the broad heterogeneity of cognitive status among people of similar ages underscores the relatively weak relationship between cognitive development and chronological age—at least in adulthood and aging.

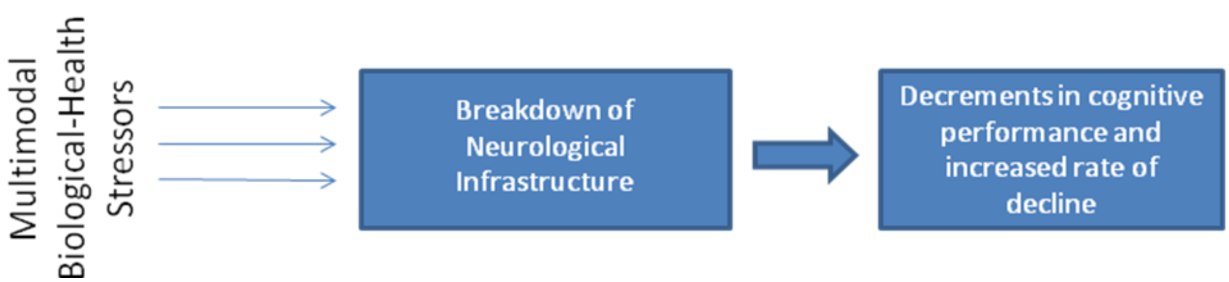
Cognitive development in adulthood is critically influenced by manifold factors. Although such factors may emerge relatively predictably or normatively in early life, they appear less systematically across adulthood, and perhaps even stochastically—unevenly, non-deterministically across individuals—in later life. That is, the vital interplay of non-normative risk and protection factors can influence cognitive aging directly, indirectly, interactively, and cumulatively. Well-known in lifespan theory is the notion that normative changes (age-graded, history-graded) may show relatively strong correlations with chronological age, but non-normative influences are less strongly associated with particular ages (Baltes et al., 2006). Regarding influential history-graded trends, differential patterns for successive cohorts may be related to industrialization, biological fitness, and aging-related diseases (e.g., Type 2 diabetes). One example related to cognitive aging is the veritable epidemic in the prevalence of Type 2 diabetes in the current historical era, in both western and other countries (e.g., India; Ramachandran et al., 2004). Notably, Type 2 diabetes is a known risk factor for cognitive decline and neurodegenerative disease (McFall, Geall, Fischer, Dolcos, & Dixon, 2010). As it is even related to Alzheimer's disease pathology, Type 2 diabetes may be involved in the initiation of neuritic plaque deposition (Matsuzaki et al., 2010). Type 2 diabetes, and biological changes associated with it, is an example of a history-graded health or social changes that may have notable cognitive consequences for a growing proportion of aging adults. Accordingly, in cognitive aging research a variety of functional, neural, and health biological markers have been examined as representing BioAge, a potential index with theoretical and clinical implications (Anstey, 2008; Dixon, 2011a; Spiro & Brady, 2008; Nakamura & Miyao, 2007).

Tracking Biological Age, Chronological Age, and Cognitive Aging

Ideally, BioAge would reflect, if not track, the summation of, and interaction between, risk factors or stressors (including genetic/epigenetic influences, other conditions, diseases, and adverse environmental events) and protective (including more salubrious genotypes and lifestyles) factors, and balances this with the individual's overall cognitive resilience to stressors (see Dixon, 2011a). In order to identify and then track BioAge, researchers have suggested that biological markers (biomarkers) can be any factor (e.g., neurological, genetic/epigenetic, anthropometric, sensory, or cognitive) that follows a trajectory of change corresponding to the functional or pathological trajectory of an individual or specific group. Some time-varying biomarkers may show lead-lag relationships with markers of the emerging functional or pathological statuses to which they are related, such that changes in the biomarker precede changes in the functional or pathological trajectory it tracks. If lead-lag relationships are reliably observed across samples, they can be used by clinicians and researchers to predict (and perhaps prevent) adverse cognitive aging events and accelerated decline trajectories. For example, identification of a set of biomarkers that could predict Alzheimer's disease could result in delays and reduced prevalence of the disease (e.g., Brookmeyer, Gray, & Kawas, 1998; Fratiglioni & Wang, 2007). In general, any effective intervention must involve early identification of the disease-related changes which precede irreversible neurological or cognitive changes (Anstey, Lipnicki, & Low, 2008; Frank et al., 2003). Interestingly, individuals faced with similar health conditions may fare very differently in terms of functional and cognitive outcomes, reflecting the existence of interindividual differences in biological-health supporting resources (e.g., protective genotypes, coping strategies) and subsequent probability of fending off cognitive decline (Treiber, 2010). One example of this has been noted in Alzheimer's research wherein it has long been known that some non-demented older adults upon autopsy present with significant development of amyloid plaques and neurofibrillary tangles –the biological hallmarks of Alzheimer's disease – yet in life did not show the typical cognitive deficits of the disease (Scarmeas & Stern, 2003). This suggests that the effects of neurological deterioration on cognitive performance may be offset by factors or resources supporting cognitive reserve (Stern, 2007), a term used to refer to the availability of biological (e.g., genetic), cultural (e.g., social support), personal (coping strategies), or cognitive (strategic) resources that effectively support cognitive functioning and abate decline. With aging, cognitive reserve may be contributed through, for example, exercise (Dik, Deeg, Visser, & Jonker, 2003), cognitively stimulating leisure activities activity (Hall et al., 2009), and education and complex occupations (Stern, 2007).

Mechanisms of Functional Biomarkers Affecting Cognitive Aging

Accelerated cognitive changes with aging may occur as a result of stress or damage to underlying neurological substrates. As noted earlier, however, the factors affecting the integrity of the neurological substrates and thereby influencing cognitive changes are multimodal. They may even be relatively distal, in that some may stem from biological (e.g., genetic) and health (e.g., disease) domains, as well as behavioral, social, environmental and institutional dimensions (Baltes et al., 2006; Spiro & Brady, 2008). For the present chapter, we note that the degree of aging-related neurological vulnerability can be affected by both proximal (neurological) and distal (biological-health) changes and stressors (Anstey, 2008). With aging, the greater the neurological vulnerability, the weaker may be the neurological infrastructure that supports specific aspects of cognitive functioning (e.g., memory, executive functions). Neurological deterioration is thought to be a key factor underpinning detrimental cognitive changes and the rate at which these changes occur. This temporal distal-to-proximal process is displayed in Figure 1. BioAge is one way of representing the extent of functional stressors from relevant biological and health modalities, any number of which might affect neurological integrity. Thus, the concept of



[Fig 1]

BioAge naturally situates even relatively distal physiological and health factors as legitimate and potentially important foci of longitudinal and epidemiological investigations of cognitive aging, and it emphasizes the dynamic relationships among functional physiological integrity, health burden, and neurocognitive vitality (Anstey, 2008; Dixon, 2011a; Spiro & Brady, 2008). In addition, some aspects of cognitive performance may serve as biomarkers for others (especially more complex aspects; Anstey, 2008). Recently identified biomarkers relevant to cognitive aging include (a) markers of homeostatic control and dysregulation (e.g., systemic inflammation, Gorlick, 2010; low levels of insulin-like growth factor- 1, Aleman & Torres-Alemán, 2009), (b) functional markers (e.g., grip strength, pulmonary functioning; Finkel et al., 2003; MacDonald et al., 2004), (c) blood pressure (hypertension; Tzourio, Durouil, Ducimetière, & Alpérovitch, 1999), (d) sensory functioning (vision and hearing, Baltes & Lindenberger, 1997; olfaction, Olofsson et al., 2009), and genetic/epigenetic influences (Deary, Wright, Harris, Whalley, & Starr, 204; National Institute on Aging, 2008).

In sum, within the last two decades, increased attention has been given to the search for variables that mark theoretically significant precursors or “causes” of cognitive changes with aging. Since the 1960s, some observers have suggested that in order to better understand the multiple influences on cognitive aging, chronological age may be more usefully integrated with theoretically relevant markers of neurological, biological, and health changes (e.g., Baltes & Willis, 1977; Birren, 1999; Dixon, 2011a). Emerging research on the operationalization of BioAge has increasingly been linked to the understanding of typical cognitive trajectories across adulthood and aging and to the identification of clinically significant groups and individuals, such as those at an increased risk for cognitive decline in later years of life (e.g., Nakamura & Miyao, 2007). Many challenges remain prior to the availability of a single valid and replicable index of BioAge, but the research path to that point will be paved with novel results pertaining to the biological and health context of cognitive aging. Theoretical and methodological developments in this aspect of cognitive aging will contribute to developing biomarker composites that better reflect the reality of multimodal and interdependent processes affecting cognitive development. In this vein, future investigation of BioAge will no doubt focus on increasingly sophisticated theoretical and methodological integration of diverse biomarkers.

Emotional And Affective Influences On Cognitive Aging

A "Paradox" of Aging

The topic of emotional and affective influences on cognitive aging is relatively new (Blanchard-Fields, 2007). If traditional cognitive aging research focused on relatively pure renditions of specific cognitive processes (e.g., reasoning, episodic memory) and their interrelations (e.g., speed and executive function influences on complex cognitive changes with aging), more recent efforts have been devoted to placing these changes in several important contexts. These contexts, which are also changing with aging, include domains known as neurological, functional-biological, and health (as described in the previous section), but also affect-personality (the topic of this section). This ongoing (upward and downward) contextualizing of cognitive aging has led to (a) significant descriptive and explanatory advances, and (b) an expanded interest in aspects of aging that may be maintained or even improved with aging (Baltes & Baltes, 1990). Among these may be some emotional and affective processes, which appear to undergo little decline during adulthood (Blanchard-Fields, 2007). One simple example is the observation that many older adults report that they are both generally satisfied with their lives and experience relatively high levels of emotional well-being, despite that fact that later life is associated with increasing physical ailments, psychological stress, social losses, and increased dependency. This phenomenon, characterized by maintained or improved subjective emotional experience in late life, has been called the *"paradox" of aging* **(**Carstensen, Isaacowitz, & Charles, 1999; Mather, 2004). Naturally, these apparent improvements in emotional well-being are general trends across people, not guarantees to individuals. A predictable set of risk factors or stressors—including dispositional tendencies, life events, and individuals' management of such events—can influence whether emotional life improves or deteriorates with age. Nevertheless, some research suggests that reasonably high levels of emotional well-being are possible (and may even not be exceptional) for many adults in late life.

In this section, we turn attention to this putative paradox, and link it to cognitive aging. We begin with the simple question: How is it that older adults can have emotionally gratifying lives in the face of significant neurobiological, biological, health, and cognitive losses? Put another way, we have asked earlier: Are there intriguing possibilities lurking behind or between the robust declines associated with aging (Dixon, 2003)? As others have put it: Are there gains throughout the aging process and what might they be (Baltes, 1987; Baltes et al., 2006)? In this section, we sketch the intriguing provisional answers by integrating perspectives from the fields of lifespan development, emotion and personality psychology, cognitive aging, and cognitive neuroscience.

Emotion-Cognition Relationships in Aging

Emotional well-being refers to the subjective experience of positive and negative emotions. It is defined in terms of life satisfaction, happiness, or the balance between positive and negative emotions (Charles & Carstensen, 2009). A large body of research indicates that negative affect decreases and positive affect increases or remains stable throughout the life span (Carstensen et al., 1999; Carstensen, Mikels, & Mather, 2006). For example, when asked at random intervals during the week about their emotions, older adults report less negative emotional experience than younger adults (Carstensen, Pasupathi, Mayr, & Nessloroade, 2000) and less negative affect (Diehl & Hay, 2007). From a clinical perspective, older adults have lower rates of depression and anxiety disorders compared with younger adults, indicating cohort differences that may reflect an aging-related decrease in negative affect (e.g., Jorm, 2000; Kryla-Lighthall & Mather, 2009). Indeed, a 23-year longitudinal study including almost 3000 participants from four different generations showed that negative affect decreased across the lifespan (Charles, Reynolds, & Gatz, 2001). A different pattern emerged for positive affect: Over time, frequency of positive affect remained stable across the younger and middle-aged cohorts but declined slightly among the oldest participants, who began the study in their early sixties and continued participating into their mid-eighties. Other longitudinal and cross-sectional studies generally parallel these findings, showing sustained levels (Kurland, Gill, Patrick, Larson, & Phelan, 2006) or gradual increases (Gross et al., 1997; Mroczek & Kolarz, 1998) of positive affect, at least until the mid-sixties (whereupon it slightly decreases). It is important to note that these decreases rarely get to the level of positive affect of younger adults, suggesting that emotional well-being is relatively well-preserved even among the oldest old (Jopp & Rott, 2006).

Given the well-known co-morbidities and losses of aging, an important question is how older adults maintain relatively high levels of emotional well-being. Theories of emotional-motivational lifespan development propose that motivational and experiential changes associated with adult development and aging—including a greater focus on emotion regulation—help older adults achieve heightened emotional experience. For example, the Selective Optimization with Compensation model (Baltes & Baltes, 1990) and the Dynamic Integration Theory (Labouvie-Vief, 2003) conceptualize emotional-motivational changes as compensatory means to adapt to declining resources with age (see also Heckhausen et al., 2010). In this chapter, we focus on the Social Selectivity Theory (SST) of emotional aging, which emphasizes motivational changes as selective processes caused by shrinking time horizons (Carstensen, 1993, 2006; Carstensen et al., 1999). According to this theory, a limited future time perspective in older adults promotes a focus on optimizing emotional satisfaction in the present moment through goal readjustment. Older adults' focus shifts from emotionally riskier goals associated with information seeking, knowledge building, and social exploration, to mood-enhancement goals that provide immediate gratification and focus on emotional maintenance, emotional experience, and the seeking of meaning. In the last decade, researchers have begun to examine the consequences of this motivational shift for cognitive processing. Specifically, recent evidence suggests that the focus on mood-enhancement goals may help older adults become more sensitive to positive information and less sensitive to (or avoidant of) negative information, a phenomenon termed the *positivity effect* or *bias* (Carstensen et al., 2006). One possible explanation, which has recently received much attention, is that older adults may develop an increasing focus on regulating emotions and an increasing competence to do so (Blanchard-Fields, 2007; Carstensen, 2006; Carstensen, Fung, & Charles, 2003).

The Role of Emotion Regulation in Cognitive Aging

A growing body of research suggests that adults' ability to regulate, consciously or unconsciously, which emotions they have and how they experience and express them remains stable and in some aspects may improve across adulthood (Charles & Carstensen, 2007; Gross, 1998; St. Jacques, Dolcos, & Cabeza, 2009). As compared to their younger counterparts, older adults (a) display less physiological arousal when experiencing negative emotions (Levenson, Carstensen, Friesen, & Ekman, 1991; Tsai, Levenson, & Carstensen. 2000), (b) recover more quickly from negative emotional states, (c) are less likely to respond to verbal slights with anger (Charles & Carstensen, 2008), (d) maintain positive emotional states longer than younger adults

(Carstensen et al., 2000), and (e) report superior emotional control with less effort (e.g., Charles & Carstensen, 2008; Scheibe & Blanchard-Fields, 2009). Higher levels of emotional well-being in older adults are likely achieved by using emotion regulation strategies that target emotional experiences before they occur (Charles & Carstensen, 2007), thus decreasing the severity of the stressors (Charles & Almeida, 2007). It is possible that the life-long experience and practice in dealing with emotional situations could increase older adults' procedural knowledge about how to handle emotional situations.

The implementation of emotion regulation goals requires cognitive control abilities such as focusing attention, maintaining attention in the face of distraction, and reappraisal or suppression of unwanted thoughts and memories. It also requires the integrity of the neural circuits involved in emotion processing and regulation. Indeed, older adults seem to use selective attention to achieve emotion regulation goals even very early in processing, before explicit appraisals can occur, therefore focusing on and subsequently processing more positive than negative information. Studies using eye tracking technology show that older adults (a) tend to look toward positive images and away from negative ones (Isaacowitz, Wadlinger, Goren, & Wilson, 2006a, 2006b; Knight et al., 2007), and (b) show less of a negativity bias in their sustained attention than younger adults (Rösler et al., 2005). Importantly, this tendency to attend to more positive information with aging is not necessarily "caused" by intrinsic age differences in emotion detection abilities (see Hahn, Carlson, Singer, & Gronlund, 2006; Knight et al., 2007; Mather & Knight, 2006; Rösler et al., 2005). Instead, it is associated with older adults' selective tendency to focus on information consistent with their goals and away from goal-irrelevant information (Kryla-Lighthall & Mather, 2009).

Age-related positivity effects have also been documented in episodic and autobiographical memory (Mather, 2004). For example, compared to younger adults, older adults (a) show a reduction in memory for negative relative to neutral images (St. Jacques et al., 2009), (b) tend to recall less negative information and more positive information (Charles, Mather & Carstensen, 2003; Mather, 2006; Mather & Carstensen, 2005), and (c) recall their own past more positively than they had initially reported (Kennedy, Mather, & Carstensen, 2004; Ready, Weinberger, & Jones, 2007). Even negative memories are recalled more positively among older than younger adults (Comblain, D'Argembeau, & Van der Linden, 2005). Notably, the positivity bias in older adults' memory is not caused by "gating out" negative affect when they have low cognitive control abilities (e.g., Labouvie-Vief, 2005), as research indicates that older adults with the best cognitive control function are the most positively biased (Kryla-Lighthall & Mather, 2009). Rather it is possible that older people, aware of shrinking time horizons, become more motivated to preserve their emotional balance, which shifts attention to the positive aspects of life (Charles & Carstensen, 2009).

Affect and Emotion in Brain and Cognitive Aging

Overall, brain imaging research supports the behavioral findings indicating that emotion regulation requires cognitive control. Emotion regulation involves three main brain regions: the amygdala, the prefrontal cortex, and the anterior cingulate. The amygdala is a region responsible for the rapid identification and processing of emotional information, and is preserved with aging, as compared with most other brain regions (Grieve, Clark, Williams, Peduto, & Gordon, 2005; Mather, 2004; Mu, Xie, Wen, Weng, & Shuyun, 1999). The prefrontal cortex and the anterior cingulate are involved in higher-order cognitive processing, allowing for the flexible and situation-dependent responses necessary in emotion regulation (Ochsner & Gross, 2007). How is it neurally possible that regulation improves with aging, given that the prefrontal cortex and the anterior cingulate deteriorate significantly with advancing age (Greenwood, 2000; Raz, 2000, 2005; Resnick, Pham, Kraut, Zonderman, & Davatzikos, 2003; West, 1996)? Research suggests that motivation may compensate for structural decline. Even though prefrontal regions suffer from age-related structural decline, these same regions may be recruited to selectively meet the motivational demands of older adults (Kryla-Lighthall & Mather, 2009). Thus, older adults seem to compensate for age-related neural deficits by recruiting more cognitive resources through their emotion regulation efforts. Evidence shows that older adults may compensate for the disruption of the cognitive control network by recruiting additional frontal resources (Gutchess et al., 2007) and developing increased functional connectivity between the amygdala and anterior cingulate (St. Jacques, Dolcos, & Cabeza, 2010). In addition to the integrity of the neural circuits involved in emotion processing, personality characteristics, life events, as well as an individual's reaction to such events can all influence whether emotional life improves or deteriorates with age (Charles & Carstensen, 2009).

In addition to increased motivation to maintain emotional well-being, older adults may also have gained valuable experience in coping with difficult events in their lives, enhancing their expertise in social and emotional regulation (e.g., Blanchard-Fields, 2007; Magai 2001). This expertise in the pragmatics of life can serve to limit some older adults' exposure to potentially negative experiences (Birditt & Fingerman, 2005), and to appraise negative stressors as less severe (Charles & Almeida, 2007). However, not all older adults confronted with chronic illnesses, stressful life events, or chronic psychosocial distress, benefit from this experience. Older (and younger) adults may be confronted with situations in which emotion-regulation strategies, such as avoidance or distraction, are ineffective or impossible to employ. Aging increases the likelihood of experiencing stressors such as illnesses, physical restrictions, and social losses—any one of which may become chronic, uncontrollable, and impossible to avoid. Despite such adverse accumulating circumstances seemingly related to higher rates of negative affect (Caswell et al., 2003; Charles & Almeida, 2006; Mitra, Wilber, Allen, & Walker, 2005), many older adults continue to report relatively high levels of positive affect and relatively low levels of negative affect, as compared with younger adults (Piazza, Charles, & Almeida, 2007). Naturally, there are limits to the positivity effect, such as high levels of stress or severe distress (e.g., neuroticism) (Charles & Almeida, 2006; Piazza et al., 2007).

The tendency to experience distress, neuroticism, negative affectivity, or emotional instability is associated with a variety of negative outcomes in later life, including cognitive decline (e.g., Charles & Almeida, 2006; Charles, Gatz, Kato, & Pedersen, 2008; Mroczek & Kolarz, 1998; Mroczek & Spiro, 2007; Wilson, Schneider, et al., 2007). Although severe negative affect (such as neuroticism) tends to decrease, possibly reaching a lower plateau in old age (Mroczek & Spiro, 2005; Roberts, Robins, Caspi, & Trzesniewski, 2003), a growing number of studies suggest that adults who score high on neuroticism do not experience age-related benefits in emotional functioning. For example, they do not experience decreases in negative affect over time, in contrast to the patterns evident for their same-aged peers (Charles et al., 2001; Griffin, Mroczek, & Spiro, 2006), and they may even be more sensitive and reactive to negative stressors (i.e., the “kindling effect”; Mroczek & Almeida, 2004; Mroczek, Spiro, Griffin, & Neupert, 2006). Given the typical losses associated with aging, greater sensitivity to negative stimuli may also have adverse cognitive repercussions for such individuals (Griffin et al., 2006), including increased risk for cognitive decline (Johansson et al., 2010; Wilson et al., 2006; Wilson, Schneider, et al.,2007).

Older adults with a history of stressful life events, post-traumatic stress disorder, and high neuroticism also have an increased risk of developing mild cognitive impairment (Wilson et al., 2005; Wilson, Schneider, et al., 2007) and Alzheimer's disease (Wilson et al., 2003; Wilson et al., 2006). For instance, in women, high levels of psychological stress in midlife may increase the risk of developing dementia later in life (Johansson et al., 2010). Moreover, among older persons without manifest cognitive impairment, higher levels of neuroticism may be associated with increased incidence of mild cognitive impairment during up to 12 years of annual follow-up. One hypothesis for this effect is that chronic distress factors may compromise the limbic structures that regulate stress-related behavior and memory systems, increasing the likelihood that traditional neuropathologic lesions are expressed as cognitive impairment (Wilson, Arnold, Schneider, Li, & Bennett, 2007; Wilson, Schneider et al., 2007)

Overall, in contrast to commonly observed age-related deficits and the general gradual declines associated with physical and cognitive aging, emotional well-being does not uniformly decline during adulthood. Instead, it is preserved and even shows areas of improvement. Theoretical and empirical work on emotional functioning suggests that although older adults certainly face losses and challenges, they also have psychological resources available to compensate for, or moderate, losses in functioning. Shifts in cognitive processing of emotional stimuli and changes in emotional functioning with age, such as enhanced motivation to regulate emotions and increased competence to do so, may help aging individuals face late-life challenges and experience emotional well-being that is equal (or superior) to that of younger adults. However, under certain circumstances, such as prolonged and unavoidable stress or high levels of neuroticism, emotional well-being in older age appears to be compromised. This suggests that a clear step towards better understanding of well-being in late life is further delineation of the integral relationships among emotions, personality, and cognition.

Potential For Sustained Cognitive Health In Aging

Toward a Balanced Concept of "Gains" in Cognitive Aging

In this chapter, our sampling of several bodies of research on cognitive aging has revealed that despite robust evidence of gradual decline in performance, there may be some room for guardedly optimistic interpretations. Among the multidimensional constructs and processes considered to be the mechanics of cognitive aging, even the fundamental processes of intelligence and memory offer some opportunity to observe mixed aging-related trajectories and patterns (Baltes et al., 2006; Dixon et al., in press). Recent collections of reviews of basic processes (such as those closely linked to neurobiological aging) evaluate principally the magnitudes and rates of decline for a broad range of neurocognitive and complex cognitive functioning. Given the robust and near-universal decline in basic and constituent cognitive processes, it is not surprising that recent collections devote little attention to the rare exceptions, including cognitive maintenance or growth (Craik & Salthouse, 2007; Dixon et al., 2004; Hofer & Alwin, 2008). Nevertheless, the overall balance between the gains and losses of cognitive aging continues to be an issue of vigorous debate (e.g., Baltes, 1987; Baltes et al., 2006; Dixon, 2000; Park & Reuter-Lorenz, 2009). Why is this the case? Perhaps the most compelling reason was identified long ago by Salthouse (1990). He noted that one of the most vexatious challenges facing cognitive aging researchers is to reconcile (on the one hand) what we have learned about cognitive decline from laboratory and psychometric research with (on the other hand) the common observation that many older adults are quite competent in cognitively demanding everyday leisure and professional activities. How can older adults—all of whom will have experienced at least detectable decline in a variety of fundamental biological, neurological, and cognitive processes—still perform well as world political leaders, CEOs of large corporations, scientists and engineers, novelists and poets, expert bridge and chess players, composers and painters, and a variety of other complex roles? In brief, there must be some aspects or processes of cognitive aging that are not definitively represented or determined by commonly researched domains. In this section we review briefly some of the possible scenarios for observing the sparing or optimization of cognitive potential in young adulthood, midlife, and beyond.

With most empirically investigated psychological processes, aging-related changes may follow multiple (and individualized) directions. This is the case, despite the fact that many biologically based processes are in decline throughout middle and late adulthood. In fact, the presence of much potential multidirectionality has been identified as one of the major challenges and principles of lifespan studies (Baltes, 1987; Baltes et al., 2006). Accordingly, this descriptive possibility also urges research on explanatory mechanisms. What could be the means through which inevitable aging-related risk factors could be avoided or minimized in some lives, or through which scarce aging-related protection or supportive factors could be accumulated or optimized for long-term healthy outcomes (Dixon, 2010)? It has been argued that development is a concept that contains multiple possible directions—as widely varied as these directions can be (i.e., that between gains and losses) (e.g., Baltes, 1987).

Two prominent aging-related cognitive processes summarized in this chapter (memory and intelligence) are excellent examples. As noted earlier, among the multiple memory systems are two (i.e., episodic, semantic) that may undergo somewhat different developmental changes with aging. Similarly, intelligence is comprised of multiple dimensions (e.g., crystallized, fluid), and these undergo rather different patterns of average changes with aging. Notably, there is much diversity or variability with memory and intellectual aging, and this is especially notable longitudinally as individuals follow quite different trajectories over time. From a developmental epidemiological perspective, among the principal challenges for cognitive aging researchers are to not only describe and document the cognitive losses that occur typically with aging, but also to articulate the mechanisms accounting for those losses. A great deal of evidence pertains to both of these enterprises, which ideally would be coordinated (Bäckman & Nyberg, 2010; Craik & Salthouse, 2007; Park & Reuter-Lorenz, 2009). Similarly, an important challenge in cognitive aging is to articulate and demonstrate examples of late-life maintenance, successes, or gains in cognitive performance. In what manner and by what means may there be long-term stability or improvement in psychological functioning with advancing age? Accordingly, several classes of examples have been offered, and we briefly review some of these in this chapter.

Specifically, one model proposes that given substantial and unavoidable losses in basic biological and cognitive functioning with aging, three main categories of qualified “gains” may be hypothesized (Dixon, 2000). These are (a) *gains qua gains*, or the possibility that some gains may emerge and continue independent of the constraints provided by surrounding aging-related losses; (b) *gains as losses of a lesser magnitude,* or the idea that some consolation or adjustment may be made given that some cognitive losses occur later than expected (personally or in stereotypes) or to an extent not as devastating as had been feared; and (c) *gains as a function of losses,* or the evident possibility that some psychological gains are linked to specific losses, occasioned by those losses, and that may even compensate partially for such losses, mitigating their detrimental effects (Dixon, 2000). Interestingly, the latter category includes many examples that operate both at a basic or neurological level of analysis as well as in strategic or plasticity modes. More recently, an explicit application of epidemiological principles has been explored for its merit in understanding "cognitive health" (i.e., healthy aging, successful aging) (Dixon, 2010; see also Park & Reuter-Lorenz, 2009). In sum, at many levels, cognitive aging appears to be multidirectional; this is the case even though much overall, inevitable, and fundamental loss (decline) occurs with aging. In the remaining sections we briefly review several modalities through which cognitive health may be maintained throughout adulthood.

Plasticity Through Enrichment, Training, and Experience

Under what circumstances can older adults experience selective maintenance or durable gains in cognitive health? Recent researchers have produced useful empirical information regarding plasticity effects with aging. Plasticity, like its corollary compensation, typically refers to adaptive changes in neural or cognitive functioning as related to (or a function of) mismatches between demands (task, environmental) and capacities (initial, diminished) (Bäckman & Dixon, 1992; Dixon, Garrett, & Bäckman, 2008; Lövdén et al., 2010; Reuter-Lorenz & Cappell, 2008). In a variety of healthy and vulnerable populations, such plasticity can be encouraged or channelled through deliberate intervention (e.g., training) or enriching experience (e.g., lifestyle activities). Regarding enrichment, differential effects on cognitive health in late life may be associated with both (a) naturally accumulated or active everyday levels of cognitive, physical, and social engagement (Small & McEvoy, 2008; Stern, 2007) and (b) interventions that increase the magnitude or focus of such categories of engagement (e.g., Fratiglioni & Wang, 2007; Hertzog, Kramer, Wilson & Lindenberger, 2009; Stine-Morrow & Basak, 2011). Some recent studies indicate maintenance of cognitive performance for older adults who have had complex work lives and higher levels of education, suggesting that such enhancements may be due in part to continuing practice of activities involving complex brain functions (Christensen, Anstey, Leach, & MacKinnon, 2008; Hertzog et al., 2009; Stern 2007). Regarding intervention, training studies indicate that although older adults show less cognitive improvement than younger adults, some improvement in performance on specifically trained skills may be observed (e.g., Ball et al., 2002; Dahlin, Stigsdotter Neely, Larsson, Bäckman, & Nyberg, 2008). Notably, training seems to be near-specific to the targeted domain; research continues to explore issues of transfer and generalizability (see Lustig, Shah, Seidler, & Reuter-Lorenz, 2009; Persson & Reuter-Lorenz, 2008). In addition, selected older adults who have experienced severe or pathological decline can occasionally benefit from specific and aggressive interventions (e.g., Edwards et al., 2005; Grandmaison & Simard, 2003). Theoretically, some degree of normally observed decline in cognitive aging may be due to disuse or lack of practice (Small & McEvoy, 2008). Some older adults may decline partly in association with diminished engagement in the social experiences and cultural contexts that help them practice cognitive skills and thereby maintain relevant and adaptive abilities. The implication is not, however, that there is no real cognitive decline, nor is it that simply by providing mental activities, physical exercises, or social support that all expected declines can be avoided. As we have seen elsewhere in this chapter, cognitive decline with aging is inevitable, but there is some degree of plasticity available to many older adults.

The “potential for potential” in late life is relevant not only to theorists and researchers interested in cognitive aging. It is also increasingly relevant to (a) politicians and policy makers who are preparing for the “rising tide” (Dudgeon, 2010) of an aging population and (b) almost everyone who knows someone who is nearing the retirement years or who plans to reach late life themselves. Why should so many people be interested in the fact that aging individuals retain the potential for cognitive health, including maintenance and growth? One demographic reason is that our population is increasingly an aging one. Larger numbers of people are reaching late life, and many, including probably a large proportion of the baby boomers, seem to be extending their potentially productive and competent lives into later decades (Baltes & Baltes, 1990). Many recent books have addressed precisely this issue and its implications, as the titles of several of them indicate: *Successful Aging* (Rowe & Kahn, 1998), *Vintage People – The Secrets of Successful Aging* (Old, 2000), *The Okinawa Program: How the World's Longest-Lived People Achieve Everlasting Health –And How you Can Too* (Willcox, Willcox, & Suzuki, 2002), *Mental Fitness for Life: 7 Steps to Healthy Aging* (Cusack & Thompson, 2005), *In Full Bloom: A Brain Education Guide for Successful Aging* (Lee & Jones, 2008), and *The Joys of Successful Aging: Living Your Days to the Fullest* (Sweeting, 2008). In addition, the technologically savvy older adults of the 21st century are consumers of memory enhancing games (e.g., Nintendo's *Brain Age*). Notably, recent intervention studies, such as the Experience Corps Program (Carlson et al., 2009), integrate cognitive, physical, and social engagement with promising results. These types of programs may provide a template for community use in the future. A recent web search of "training for retirees," led to over 2 million results, suggesting that adult education (and re-education) is indeed becoming important (Cusack & Thompson, 2003; Hori & Cusack, 2006). These and similar recent contributions explore the possibility that there is considerable cognitive potential in late life, as well as how such potential can be actuated, distributed, and preserved.

Wisdom

The study of wisdom is as old as the study of human thought or philosophy. Ptahhotep, Vizir to Pharaoh Issi (between 2870 and 2675 BC), wrote books intended to pass on the knowledge of his ancestors concerning rules of conduct for future generations (Brugman, 2006; Lichtheim, 1973). These passages spoke of the importance of truthfulness, self-control, and kindness to others. Although philosophers have struggled with the concept of wisdom for centuries, psychologists and other researchers in human development have addressed it only more recently. In the field of cognitive aging—especially the aspect of cognitive health and potential—wisdom is naturally of considerable interest. There are relatively few processes generally thought to improve substantially with advancing age. In principle, wisdom may be one such process.

What is wisdom, and how does one know if someone is wise? What are the signs of wisdom, and how might they be recognized? For research purposes, it is crucial to begin by defining wisdom such that it may be studied empirically. One important step was taken by Kekes (1983). In the course of an historical and philosophical analysis, Kekes argued that wisdom is required and may appear in the context of life problems for which there may be multiple considerations and even multiple solutions, each with a variety of potential ramifications. In everyday lives these include age-graded (expected) events, such as first job and marriage, as well as non-normative events, such as divorce or (unexpected) career changes. Given that the best advice for such complex decisions may not be the simplest or readily available, wisdom would be shown in analyses that considered the individual and his/her social milieu, the problem and its complementary issues, the cultural or historical circumstances, as well as the future and various strands of implications. Thus, wisdom involves a variety of cognitive skills assembled and focused on a problem of life (Baltes & Staudinger, 1993).

One early psychologist, G. Stanley Hall (1922), thought that wisdom could be one of the desirable characteristics of late adulthood. For Hall, wisdom included taking perspective, synthesizing significant factors of life, and moving toward higher levels. Erikson’s (1997) view portrayed wisdom as emanating from a late-life crisis between integrity and despair, from which one desired outcome might be some degree of wisdom. Contemporary psychological approaches build on ideas of decision making, compassion, altruism and insight, all in the context of related processes of reflection, emotional homeostasis, relativistic and tolerant thinking, and acceptance of uncertainty and ambiguity in life (Meeks & Jeste, 2009). In a related paradigm Staudinger, Kessler and Dörner (2006) identified two types of wisdom (a) general wisdom, based on the highest attainment of insight and judgment about the human condition and ways of negotiating a good life for the greater good, and (b) personal wisdom, which is identified as insight into one's own life based on personal history and self-reflection.

In general, as indicated in a series of reviews, wisdom may be defined as showing good judgment about complex life problems. Recent investigators have explored empirically whether wisdom does indeed develop in late life and, if so, whether it is in fact an important aspect of successful and healthy aging. Wise decisions would therefore involve several ingredients, including balances between what one knows and what one does not know, between the academic and the practical, between the declarative and the procedural (Baltes & Staudinger, 1993; Brugman, 2006; Sternberg, 2003). How can wisdom be measured? After reviewing several attempts, Brugman (2006) summarized three types of wisdom measurement instruments: (a) problem solving scenarios or vignettes, (b) questionnaires that assess related aspects of metacognition or strategies, and (c) indirect measures such as theory-of-mind tasks. Methodological challenges are substantial, but progress has been made on selected fronts. One issue is of constant and uniform concern: To what extent is there empirical evidence that aging per se confers some advantages in actual performance on purported wisdom tasks? To date, this is not necessarily the case (Brugman, 2006), although with qualifications and alternative perspectives the question remains open and intriguing for researchers in cognitive aging (e.g., Scheibe, Kunzmann, & Baltes, 2007).

Compensation

The concept of compensation continues to be explored for its application in the field of cognitive aging, especially in light of new developments in neighbouring disciplines of cognitive rehabilitation and cognitive neuroscience, as supported by innovations in technical, conceptual, and methodological domains (e.g., Dixon et al., 2008; Reuter-Lorenz & Cappell, 2008). In its most basic psychological meaning, compensation refers to a set of mechanisms (biological, technological, psychological) through which individuals may continue to perform difficult or complex tasks despite having experienced deficits or decrements in relevant abilities typically required to perform such tasks (Bäckman & Dixon, 1992). As noted earlier, aging involves robust declines in fundamental sensory, motor, neurological, and cognitive abilities. Many of the typically declining cognitive abilities are contributory components of higher level cognitive, professional, or life skills. Some of these adaptive skills may be maintained into late life. One mechanism through which such maintenance can occur is compensation. Adults may be able to compensate for declines that they experience in even very basic components; they may continue to perform even complex skills (running governments or companies, composing or writing novels, conducting scientific research, driving) at competent, if not creative, levels. However, it is important to keep in mind that while compensation generally results in gains, there are sometimes losses involved as well (Dixon & Bäckman, 1995). For example, a theory currently being investigated, the effortfulness hypothesis, suggests that some memory loss observed in older adults is due to shifting resources in order to compensate for sensory deficits (see; McCoy et al., 2005; Wingfield, Tun, & McCoy, 2005).

Several forms of compensation have been identified (Bäckman & Dixon, 1992; Baltes & Baltes, 1990; Dixon & Bäckman, 1995; Reuter-Lorenz & Cappell, 2008; Salthouse, 1995). We focus only on selected aspects relevant to the current topic in cognitive aging. For older adults most forms of compensation begin with the experience of a mismatch between their available abilities and the requirements they either place upon themselves (as personal expectations) or accept as given by the community (environment) in which they operate. In addition, there is evidence that with normal cognitive aging automatic neural compensation may occur with or without this mismatch (Dixon et al., 2008; Reuter-Lorenz & Cappell, 2008). When the mismatch does occur it is possible that both automatic neural and compensatory mechanisms may activate concurrently. A key point is that by using one or more of the mechanisms or forms of compensation, the gap between ability and expected level of performance can be closed. In this way, a satisfactory level of performance for a given skill can be attained, and an individual's potential can be sustained, if not optimized. Compensation can occur in normal aging, but also as a form of recovery from brain injury or other pathogenic neurological conditions (e.g., Dixon et al., 2008; Wilson & Watson, 1996). Compensation is also a viable concept in recovery from a wide range of social and personal deficits and losses, many of which are quite pertinent to the study of cognitive aging (see Dixon & Bäckman, 1995).

What forms of compensation are applicable to aging in general, and to cognitive aging in particular? Like many evolving concepts, multiple perspectives on its precise nature have been offered. However, there seems to be some agreement that a handful of aspects of compensatory-type mechanisms may be active and relevant in cognitive aging. We summarize five forms that appear to cover many of the situations in which compensation might occur in late life (Dixon et al., 2008), but we readily acknowledge that there are different ways of carving out the conceptual space. The first form is known as remediation. One exampleis that of investing more time and effort when there is a deficit in learning or performing a target skill. For example, an older individual returning to school, may compensate for the gap between encountered environmental demands and skill level by putting more time and effort into studying. The second form of compensation, substitution, originates with a deficit in a specific skill that is declining with age, and that contributes to the ineffectiveness of some overarching skill performance (e.g., Salthouse, 1995). Substitution can occur in two ways (Dixon et al., 2008): (a) hidden or as yet not utilized skill can emerge (latent process substitution) or (b) a new skill can be learned and implemented (novel process substitution). Both mechanisms can be used to compensate for the declining skill. Salthouse's (1987, 1995) classic observation is that some successful older typists compensated for aging-related decrements in critical components of typing skill by possibly developing a substitutable mechanism, namely, eye-hand span.

A third compensatory process, assimilation, involves selection and optimization (Baltes & Baltes, 1990; Baltes et al., 2006; Marsiske, Lang, Baltes, & Baltes, 1995). One's development overall is facilitated by selecting different paths or goals when the original one is blocked or unattainable, a managing the loss-based selection (e.g., Freund & Riediger, 2003; Marsiske et al., 1995; Riediger, Li, & Lindenberger, 2006). A fourth category, known as accommodation, reflects processes in which one adjusts goals, priorities, and criteria of success in response to decreased skill level. Specifically, individuals may modify their goals (e.g., Brandtstädter, Rothermund, Kranz, & Kün, 2010) or lower their criteria of what constitutes successful performance (Dixon et al., 2008; Riediger et al., 2006). For example, older adults may modify personal expectations of performance such that it is no longer necessary to perform at quite the same level or with quite the same speed as they did when they were younger.

A fifth aging-related compensatory process may occur automatically, or in combination with other compensation processes, in response to normal aging or serious insult such as traumatic brain injury or stroke. Researchers have observed brain volume changes (shrinkage of some areas and thinning of others), decreases in dopamine receptors, and decreases in white matter integrity that are implicated in lowered cognitive performance as a result of aging (Park & Reuter-Lorenz, 2009). Neural compensation may be viewed in several simple ways, such as potentially increased sizes of neurons in the brain, new neuronal growth, or an over-production of brain chemicals (enzymes and neurotransmitters) that are used in effective learning and memory skills (see recent reviews for more detailed treatments, Dixon et al, 2008, Park & Reuter-Lorenz, 2009; Reuter-Lorenz & Cappell, 2008). In addition increased activitations in typical brain areas and the utilization of different areas of the brain have been observed in some older adults (Cabeza, Anderson, Lacantore, & McIntosh, 2002; Dennis & Cabeza, 2008). Compensation on a neural level may be due to the automatic reaction to normal aging or to conscious compensation process (see Cabeza et al., 2002; Dixon et al., 2008; Paquette et al., 2003; Paxton, Barch, Racine, & Braver, 2008).

Researchers have found that certain strategic mechanisms are used more often and are used differentially by groups of older adults in varying statuses of cognitive health (Dixon & de Frias, 2007; Garrett, Grady, & Hasher, 2010). For example, in one study cognitive healthy older adults used external memory aids and more investment of effort, while early Alzheimer's patients more often recruited other people (e.g., spouses, caregivers) to help them remember new information. Different cognitive status groups also have different patterns of use as time passes. Dixon and de Frias (2007) found that cognitively healthy older adults increased their use of compensatory mechanisms over a six-year period, whereas cognitively impaired older adults' compensation use decreased over the same period. Garrett and colleagues found older adults' compensation use increased (a) if their education level was not consistent with their IQ, (b) if they perceived more memory errors, or (c) if their stress levels were higher (Garrett et al., 2010).

Compensation may be an important mechanism of maintaining cognitive health with aging, a means of realizing and activating cognitive potential into late life (Baltes & Baltes, 1990; Dixon et al., 2008; Riediger et al., 2006). Increased use of compensatory mechanisms is perhaps not an achievement that will garner awards from historians or critics (as would the creative products of a renowned author or composer), and it may not be a success that brings the respect accorded to the wise sage. It is, however, a practical and functional process associated with both elite levels of technical and artistic performance and everyday or adaptive life skills such as driving, working, wayfinding, remembering, and performing various leisure activities (Dixon, 1995; Park & Reuter-Lorenz, 2009).

Conclusions

Cognitive aging is a vibrant field of the developmental sciences. The field of cognitive aging has become one of increasing theoretical complexity, methodological sophistication, interdisciplinary activity, and practical or clinical utility. Theoretical attention is given to diversity, directionality, multidimensionality, timing, context, and (of course) actual changes with aging. Also notable is the fact that the researchable contexts of cognitive aging extend from the distal biological to the proximal neurobiological, from the cognitive-psychological to the psychosocial-affective, and from the social-interactional to the historical and cultural. This may be one reason that so many large-scale, epidemiological, interdisciplinary longitudinal studies of cognitive aging are being undertaken in many corners of the globe (Hultsch, 2004). Because cognitive aging reflects a dynamic and complex set of developmental phenomena intrinsically involving processes at many levels of analysis, with methods and techniques originating in disparate disciplines, it is profitably studied from several complementary perspectives. In this chapter, we briefly illustrated several domains of research in cognitive aging, as well as selected emerging trends. Although numerous handbooks and primers are available covering a broader range with more detail (e.g., Craik & Salthouse, 2007), we trust that this brief overview represents principal facets of this much broader and rapidly growing area of developmental science.

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