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CHAPTER 11

MEMORY AGING: DEFICITS, BELIEFS, AND INTERVENTIONS

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> If any one faculty of our nature may be called more wonderful than the rest, I do think it is memory. There seems something more speakingly incomprehensible in the powers, the failures, the inequalities of memory, than in any other of our intelligences.
>
> *Jane Austen, Mansfield Park*

Of all mental faculties, memory is unique. It defines who we are and places our lives on a narrative continuum from birth to death. It helps to structure our days, it guides our daily tasks and goals, and it provides pleasurable interludes as we anticipate the future and recall the past. As a core, defining feature of the self (Birren & Schroots, 2006), memory takes on heightened meaning as we age. In the face of other losses that accumulate with age, memory can serve to preserve our sense of self and place in time. In normal aging, memory loss is minor and relatively inconsequential to functional well-being, other than passing annoyance at not being able to retrieve a name or a location from time to time. In non-normal or pathological aging, as characterized by Alzheimer's disease (AD), the loss of memory is severe and debilitating. In addition to functional disability, people with AD ultimately lose their sense of self. Connections to the past, to current events and relationships, and to what the future holds fade and ultimately disappear. Such a bleak fate for "the self" continues to spur researchers to look for causes and cures for normal and pathological memory failure. Current cutting-edge research examines the transition from normal to pathological memory aging, with particular emphasis on mild cognitive impairment (MCI) as a transitional phase and as an independent risk factor for AD. Concurrent efforts have focused on developing effective intervention and treatment programs aimed at biological, psychosocial, and cognitive levels. This chapter highlights current research on normative memory change with age, with a focus on self-regulation, self-efficacy, and memory maintenance and maximization. We also look at the special contexts of mild cognitive impairment and Alzheimer's disease, and close with an eye toward future directions in theory, research, and intervention.

Just when thought we couldn't bear another review of memory and aging, we find in fact that it's an exciting time for the field. New techniques in cognitive neuroscience (neuroimaging, diffusion tensor imaging; see chapter 1, this volume; Cabeza, 2001); sophisticated explanatory models (computational modeling, Buchler & Reder, 2007; self-regulated language processing, Stine-Morrow, Miller, & Hertzog, 2006), and compelling translational and training approaches (Camp, 2006; Skrajner & Camp, 2007; West, Bagwell, & Dark-Freudemann, 2008) are yielding new insights into memory aging. Renewed interest in lessons from life span research and the parallels between cognitive development and demise has emerged (Brehmer et al., 2008; Craik & Bialystok, 2006; Shing, Werkle-Bergner, Li, & Lindenberger, 2008). Research on emotion and its regulatory role in episodic and other forms of memory is yielding fascinating new data at both neurological and behavioral levels (Allen et al., 2005; Fernandes, Ross, Wiegand, & Schryer, 2008; St. Jacques, Dolcos, & Cabeza, 2009). Theory building and refinement continue apace (e.g., Allen et al.; Buchler & Reder), and the empirical corpus is expanding at exponential rates. There is keen interest in MCI and its boundaries at the normal and pathological edges of memory functioning, forcing a reexamination of whether normal and abnormal memory aging lie on a continuum or represent qualitatively distinct states (Bröder, Herwig, Teipel, & Fast, 2008; Craik, 2008; Lott, 1982; Morris & Cummings, 2005; Peng, 2003; Petersen & Bennett, 2005; Small, 2001).

In one empirical study of the continuum hypothesis, Bröder et al. (2008) found "globally decelerated learning" and "additional retrieval deficits" on free recall tests in people with MCI compared to healthy younger and older control participants on clustered word recall and recognition tasks across multiple trials. Older (OCG) and younger (YCG) control groups had comparable rates of learning (and that were positive trajectories) compared to the MCI group, who had a relatively flat curve. Examination of task components revealed similar processing by OCG and MCI groups at encoding and by OCG and YCG groups at retrieval. Despite comparable and suboptimal initial clustering ability at task onset in MCI and OCG participants, the OCG adults improved over trials and at rates comparable to YCG adults. MCIs did not improve over trials, thus exhibiting a serious learning deficit over trials.

Results such as these suggest that MCI is both similar to and distinct from normal aging.

ORIGINS OF MEMORY AGING RESEARCH: A RETURN TO ROOTS

Just over a century ago, G. Stanley Hall laid out the characteristics of adolescence (1904) and senescence (1922) in his seminal works on development and aging. Since then, youth has been considered the pinnacle of cognitive development—a point to which children rise and from which adults fall. Empirical work provides support for the idea of the young adult mind as a cognitive powerhouse, especially in terms of speed of processing (Kail, 1986, 1991a, 1991b; Kail & Park, 1994; Park et al., 2002; Salthouse, 1991). The young mind as standard or point of reference is also evident in work done in the 1930s and 1940s when the scientific study of children held sway over the field of psychology (Hirshbein, 2002). In the 1950s, research on aging in its own right began to systematically document changes—but only negative changes—associated with senescence, especially studies of reaction time and sensory abilities (Birren & Botwinick, 1955). These studies foreshadowed current speed of processing theories of cognitive and memory aging. The 1960s and 1970s witnessed the emergence of extended theoretical debates on cognitive ability in adulthood with corresponding empirical evidence to support both decline (Horn & Donaldson, 1976, 1977) and growth (Baltes & Schaie, 1974, 1976; Labouvie-Vief, 1976, 1977) perspectives. Youth remained the standard of intellectual functioning, however, and much of the field was characterized by documenting differences between extreme age groups (people in their 20s versus people in their 60s and 70s) with little attention to midlife and childhood as important markers of development. The 1980s and 1990s witnessed the emergence of competing and complementary models for studying aging, replete with evidence for various mediators (e.g., speed of processing, working memory) and moderators (e.g., strategy use) of age-related memory deficits.

Now, at the threshold of the 21st century, neuroimaging studies, computational and mathematical modeling, and refined methods and measures are producing new information on memory and aging at dizzying rates. And, ironically enough, researchers and theoreticians are casting an eye back to the origins of memory, in childhood, and taking a more expansive view than before. Once again, clues from infancy and childhood are informing the search for mechanisms of memory aging. Perlmutter (1978), for example, conducted a now classic application of metamemory in children to older adults, creating a taxonomy of metamemorial knowledge that laid the groundwork for subsequent studies of metamemory and aging (e.g., Dixon & Hultsch, 1983; but see Cavanaugh & Perlmutter, 1982, for a critique of nondevelopmental approaches to methodological extrapolations across the life span). Currently, Craik and Bialystock (2006) argue eloquently for an inverted-U shaped function to describe memory across the life span but with the caveat that aging memory is not simply a reversal or loss of capacity and skills learned in childhood but a reorganization of relevant representational and control components (see also Shing et al., 2008; Wingard, 1980). Gaultney, Kipp, and Kirk (2005) argue for maturational differences in the organization of memory processes and demonstrate that individual differences in working memory span predict memory recall but not strategy use in college students. Wingard (1980) reported developmental trends in strategy use among 4-year-old, 6-year-old, and 10-year-old children; college students; and older adults that indicate a life span increase in the use of semantically-based organizational strategies on free recall tasks. The youngest children (preschoolers) were more likely than older groups to use perceptual rather than semantic grouping strategies, and age differences in strategy use were not affected by age differences in capacity as measured by a digit-span task. These results are consistent with Gaultney et al. and Shing et al. who found age differences spanning childhood through adulthood in associative binding and effective use of memorization strategies. Furthermore, it is well known that increased speed of processing is related to cognitive development in childhood (Kail, 1986, 1991a, 1991b; Kail & Park, 1994), and decreased speed of processing is related to cognitive decline in adulthood (Salthouse, 1991). Zimmermann and Meier (2006) found that memory for prospective event-based tasks was worse in young children and older adults compared to adolescents and young adults. Thus, abundant data are emerging that support a more integrative life span developmental approach to studying and understanding memory functioning in the elderly.

MEMORY AGING: WHAT ARE THE PROBLEMS? WHAT IS PRESERVED?

Memory is multidimensional (Nilsson, 2003; Tulving, 2004), so it is unsurprising that some dimensions change more than others over the life span. This section reviews dimensions of memory that are relatively impaired and relatively spared.

Episodic and Semantic Memory

Working and episodic memory abilities are especially likely to decline in older adulthood (Verhaeghen, Marcoen, & Goossens, 1993), whereas semantic (Ronnlund, Nyberg, Bäckman, & Nilsson, 2005), text memory (Stine-Morrow, Soederberg Miller, Gagne, & Hertzog , 2008), and procedural memory abilities (Nilsson, 2003) are relatively preserved. Older adults have difficulty efficiently manipulating information in the active, "on-line" store (working memory) and are less skilled at remembering associations between items (episodic memory). Even some item-level information is particularly difficult for older adults, such as remembering names. Most adults experience these changes, and many don't like it. Complaints about forgetting and "having a bad memory" are common, even normative, in midlife. Proper names are especially vulnerable to retrieval difficulties, and the well-known experience of "almost knowing," the so-called tip-of-the-tongue (TOT) phenomenon, is practically universal by midlife (James, 2004; James, Fogler, & Tauber, 2008; Rendell, Castel, & Craik, 2005).

Our focus in this chapter is primarily on episodic memory problems in older adults because they are the most commonly experienced and are the most common target of training, intervention, and remediation efforts. Many older adults are interested in opportunities to improve and optimize memory functioning; thus, basic research aimed at understanding the causes of episodic memory failures and applied research designed to enhance memory functioning is important.

Episodic memory, which falls under the more general domain of declarative memory, is unique because when compared with all types of memory, it shows the most consistent decline in adulthood, relative to semantic and procedural memory (Nilsson, 2003). Working memory also declines and is important because higher order cognitive abilities, including episodic memory, depend upon it. Semantic memory is important because impairments in semantic memory point to the type of serious memory disorders that characterize Alzheimer's disease; an intact semantic memory system also provides crucial support for episodic memory tasks. Yet, episodic memory is unique because it requires recollection of the rich array of details and context surrounding new learning. Whereas semantic memory is concerned with factual information, it is context-free: In most situations of recalling factual knowledge (e.g., even-numbered interstate highways run east and west and odd-numbered ones run north and south), it isn't important when, how, and from whom one learned that information. This kind of information is well-learned and relatively fail-proof with age. Likewise, procedural memory—skill-based memory, how to do things—is even more robust in old age, relative to episodic memory. According to Nilsson, scant attention has been paid to procedural memory in older adulthood, which is a bit surprising, given how important procedural memory is to well-being. It is often implicit in its execution and is what allows us to drive, cook, garden, fish, bicycle, play tennis, golf, play music, and so on. Beyond the daily and life-long pleasure that habitual, motoric procedural memory ability provides to individuals, skill-based memory is proving to be a valuable resource in interventions with AD patients (Zanetti et al., 2001).

Memory Complaints

Research on memory complaints initially attempted to map these complaints onto actual experiences of forgetting with mixed success, due to lack of control for relevant covariates (e.g., ability, depression), disparate measurement instruments, and samples of participants of divergent age ranges. Current work has moved beyond the question of veridicality to a different kind of prediction, focusing instead on the question of whether complaints are a risk factor for serious memory disorders. A review of clinical and population-based studies found that age (older), sex (female), education (fewer years), and cognitive status (poor) are related to increased complaints about memory, even when depression is controlled (Jonker, Geerlings, & Schmand, 2000). Cook and Marsiske (2006) reported confirmatory results, showing that subjective complaints of memory are correlated with MCI when controlling for differences in depression. Both studies employed more precise methods than past research on complaints. Cook and Marsiske argued that subjective complaints coexisting with depression may reflect increased awareness and concern over memory failures among individuals presenting with complaints. This argument is consistent with earlier work that memory complaints are related to trait neuroticism and to the memory self-efficacy subscales (Capacity, Change, Anxiety) of the Metamemory in Adulthood (MIA) questionnaire (Ponds & Jolles, 1996). Higher frequency of daily stressors is also related to self-reported memory failures in older adults (Neupert, Almeida, Mroczek, & Spiro, 2006) and particularly so when experienced by individuals high in trait neuroticism (Neupert, Mroczek, & Spiro, 2008).

Beliefs about memory, and lifestyle choices, such as engaging in mental and physical activities, may provide a buffer against cognitive decline in adulthood (Jopp & Hertzog, 2007). Some authors have argued for the protective effect of an active lifestyle on AD (Fratiglioni & Wang, 2007). Others have shown that strategic, positive coping and perceived complaints of memory are related to well-being in old age (Verhaeghen, Geraerts, & Marcoen, 2000). Memory training and intervention studies aimed at optimizing memory functioning in older adults are yielding promising outcomes that may translate to work with MCI and even AD patients, particularly those interventions aimed at boosting morale and optimizing well-being, even when actual memory gains are inconsequential. Those studies are reviewed later in the chapter. Next, we turn to the more serious memory problems associated with MCI and AD.

SERIOUS PROBLEMS: DEMENTIA AND MILD COGNITIVE IMPAIRMENT

Advances in technology and medicine since the early 20th century heralded increases in life expectancy and longevity, but ironically, brought about an increase in age-related problems. Currently, there are approximately 2 million people aged 90 or older in the United States (Kawas & Corrada, 2006); the numbers of those estimated to have dementia are expected to rise from 8.1 million to 24.3 million by 2040 (Ferri et al., 2005). Not surprisingly, Americans aged 55 and older have cited Alzheimer's disease as the most feared disease, followed by cancer and stroke (Gatz, 2007).

Dementia refers to a cluster of diseases that typically have their onset in late-middle to older adulthood and in which there is progressive cognitive and behavioral deterioration. Specifically, dementia patients have both episodic and major semantic memory dysfunctions, showing greater deterioration in tests requiring abstract reasoning and analytical problem solving than in tests of crystallized intelligence (Brayne, 2007; Spaan, Raaijmakers, & Jonker, 2005).

Alzheimer's Disease

Alzheimer's disease (AD) is the most common cause of dementia, affecting at least 15 million people globally, and is the fifth leading cause of death among older Americans (Alzheimer's Association, 2008; Matsuda, 2007). It gradually erodes one's memory, personality, and physical abilities. It is characterized by anterograde amnesia, retrograde amnesia, relative preservation of remote rather than recent events, decline in general intellectual function, wandering, depressive mood, physical aggression, as well as serious deficits in memory and self-orientation in both time and place (Hamuro et al., 2006; Westmacott, Freedman, Black, Stokes, & Moscovitch, 2004). Memory loss typically commences between 5 to 7 years prior to clinical diagnosis of dementia. Although the presence of amyloid plaques and neurofibrillary tangles is normative in older brains, excessive amounts of each are present in the brains of individuals with AD (Yamaguchi, 2007). Patients tend to exhibit relatively stable performance until a few years prior to diagnosis, at which point rapid cognitive decline begins. They are expected to exhibit approximately twice the cumulative decline expected in their age-peers without dementia during the 10 years preceding clinical diagnosis (Sliwinski, Hofer, Hall, Buschke, & Lipton, 2003).

Measures of cognition, mood, and neuropathology can be used in tandem to make probable diagnoses of AD, but a definitive diagnosis can only be made at autopsy. Because one of the initial symptoms of both dementia and normal aging is mild memory loss, detection is often difficult as many dementia patients are either unaware of or in denial regarding the severity of their forgetfulness (Urakami, 2007). While there are a variety of tests of cognition that can be used to detect dementia, the most successful are those that are sensitive to explicit memory tests requiring semantic processing and implicit memory tests from which repetition priming effects can be derived (Spaan et al., 2005).

Recently, the importance of subjective memory complaints has emerged as a preclinical symptom in dementia. Patients may begin noticing changes so subtle that they do not even merit medical attention. To date, the precise relationship between memory complaints and dementia is inconclusive, but memory complaints, even with the absence of objective memory deficits, may be indicative of the very earliest signs of dementia (Busse, Bischkopf, Riedel-Heller, & Angermeyer, 2003; Godbolt et al., 2005). Early and differential diagnosis is critical because although most dementias are irreversible, some can be reversed (e.g., hydrocephalus, thyroid dysfunction, vitamin B_{12} deficiency) or at least slowed with proper diagnosis and treatment. Chopard and colleagues (2007) present a promising new diagnostic approach based on empirical analyses of two screening measures administered to individuals with mild to moderate dementia and nondemented age-matched controls (age range 60 to 96 years). Current trends in dementia research include better assessment and understanding of "at-risk" states and are especially focused on mild cognitive impairment.

Mild Cognitive Impairment (MCI)

Though diagnostic criteria for MCI vary in details, it is generally characterized by the presence of five criteria: (1) subjective memory complaint, (2) preserved general intellectual function, (3) memory impairment assessed by cognitive testing, (4) normal daily life activity, and (5) no dementia (Instrumental Activities of Daily Living [IADL]; Bröder et al., 2008; Meguro, 2007; Petersen et al., 1997; Royall, 2005; Touchon & Portet, 2004). There are two distinct types of MCI, amnestic MCI (aMCI) and nonamnestic MCI (naMCI), which are further divided into subtypes based on the type of cognitive deficits present: *aMCI, single domain* pertains to isolated memory deficits, *aMCI, multiple domain* refers to impairment of other cognitive domains such as language and attention, and *naMCI, single domain* and *naMCI, multiple domain* involve impairment in noncognitive domains depending on the number of impaired domains (Burns & Zaudig, 2002; Davis & Rockwood, 2004; Morris & Cummings, 2005).

MCI is considered an unstable and heterogeneous condition in that some MCI patients revert back to "normal" and others progress into dementia (Davis & Rockwood, 2004). Some studies report conversion rates for MCI to AD ranging from 41% in 1 year to 26.6%–30.3% in 3 years (Amieva et al., 2004; Devanand et al., 2007). Others report that 35% of MCI cases revert back to normal (Apostolova et al., 2006). The heterogeneity of MCI may be attributable to interactions between individual genetic, physiological, and pathological differences (Mattson & Magnus, 2006; Richie, Artero & Touchon, 2001). Such differences may account for variability in MCI diagnosis as well as the delineation and definition of degrees of severity (Burns & Zaudig, 2002).

The instability of MCI has led to several theories concerning the possible conversion of MCI to more serious problems (Mariani, Monastero, & Mecocci, 2007). One view argues that there is no disease entity of MCI that would necessarily progress to cognitive deficit but rather, certain dementia diseases may have MCI characteristics or "MCI status" (Meguro, 2007). Others believe MCI is an intermediate stage between the normal cognitive aging and the very earliest manifestations of AD (Morris & Cummings, 2005). Indeed, the current MCI literature has primarily shown four main outcomes of MCI: (1) cognitive decline and/or progression to dementia, (2) death, (3) improvement in cognitive functioning, and (4) stability (Palmer, Fratiglioni, & Winblad, 2003).

It is generally assumed, however, that many MCI patients will convert to a form of dementia, particularly Alzheimer's disease. Although more highly developed memory ability and a higher level of education provide some protection against cognitive decline (Chodosh, Reuben, Albert, & Seeman, 2002), it has been shown that individuals with any cognitive impairment exhibit an accelerated progression to AD and other forms of dementia (Petersen & Bennett, 2005). Those who, in fact, progress to AD are characterized by poor performance on language-related intellectual functions, verbal memory deficits, depression, and poor global cognitive performance at baseline. The likelihood of conversion has also been predicted by a loss of functional ability that is secondary to the worsening of executive function (Gabryelewicz et al., 2007; Guarch, Marcos, Salamero, Gastó, & Blesa, 2008; Rozzini et al., 2007). Further, the neurobiology of MCI closely resembles that of clinically diagnosed AD: Both MCI and AD patients have an over-representation of the apolipoprotein E (ApoE) allele, volumetric loss in the entorhinal cortex and hippocampus, neural loss, increased brain markers of oxidative stress, cell cycle changes, and abnormalities of the cholinergic system, all of which support the theory that MCI is the prodromal stage of AD (Morris & Cummings, 2005).

The transition from MCI to dementia is difficult to reliably detect, and thus, biomarkers and risk factors are important to identify. It has been shown that presence of ApoE, deposits of amyloid beta protein (Aβ42), increased levels of the protein tau, hypometabolism in the right temporo-parietal cortex, and white matter lesions are all predictive of the conversion from MCI to dementia (Arai, 2005; Burns & Zaudig, 2002; Petersen & Bennett, 2005; Sepe-Monti et al., 2007). Detection of these biomarkers paired with consistent, impaired cognitive performance, documentation of rate and nature of change in cognition, and neuroimaging results are more reliable than static measurement of these features in diagnosing MCI (Godbolt et al., 2005; Salmon & Hodges, 2005).

A diagnosis of MCI is central in identifying groups of at-risk individuals for further cognitive decline (Bischkopf, Busse, & Angermeyer, 2002; Burns & Zaudig, 2002; Ishikawa & Ikeda, 2007). Future research must focus on developing standardized, reliable, and valid diagnostic criteria in order to more fully understand the course of MCI and its outcomes, prevalence, and predictors. By fully understanding MCI pathology and epidemiology, steps toward effective treatments can be implemented. There is a progressive reduction of neurogenesis (growth of new neurons) and a significant degree of cortical atrophy over a life span (Klempin & Kempermann, 2007). Neurodegeneration has been attributed to the degradation of myelin integrity beginning with white matter in youth and gray matter in middle age (Elderkin-Thompson, Ballmaier, Hellemann, Pham, & Kumar, 2008; Kramer et al., 2007). Age-related atrophy is most prominent in the hippocampus and frontal lobes (particularly the prefrontal cortex), primarily responsible for memory and coordination of executive control functions, respectively (Cabeza, 2002; Elderkin-Thompson et al., 2008; Gluck, Myers, Nicolle, & Johnson, 2006; Head, Rodrigue, Kennedy, & Raz, 2008). These frontal-striatal and medial-temporal circuits are especially important for encoding and retrieval of information and are thus vital to memory formation (Gabrieli, 1998; Head et al., 2008; Stebbins et al., 2002). Activation of such circuits, however, weakens with age due to volumetric loss, hypometabolism, and decreases in blood flow (Kensinger, Brierley, Medford, Growdon, & Corkin, 2002).

Older brains appear to compensate for losses and reductions in neuronal matter and integrity. Cabeza (2002) reported age-related decreases in prefrontal activity and increases in left prefrontal cortical activity during cognitive tasks. Age-related differences in memory ability are associated with significant shrinkage in brain areas (e.g., prefrontal cortex, hippocampus, caudate nucleus) that are associated with higher level functioning and memory (Head et al., 2008; Stebbins et al., 2002). Recent research shows that hippocampal atrophy in normal adults is correlated with future development of AD (Gluck et al., 2006). Focus on the hippocampus as a source of normative and non-normative age-related memory deficits has intensified in recent years, due in part to complementary work at both theoretical (Naveh-Benjamin, 2000) and methodological (Cabeza, 2001; Raz, 2006) levels. We turn now to normative memory loss.

NORMATIVE AGE-RELATED MEMORY LOSS: THEORIES, MEDIATORS, AND MODERATORS

This section presents a select overview of explanations for memory deficits associated with aging, including models and hypotheses that test those variables that seem particularly compelling to us for understanding how memory works in adulthood.

The Associative-Binding Hypothesis

One of the more compelling current theories of episodic memory deficits in older adults is the associative-binding hypothesis (Naveh-Benjamin, 2000), which states that memory for the contextual information associated with item information is compromised in older adults. In a recent meta-analysis of episodic memory impairments in older adults, Old and Naveh-Benjamin (2008a) reported that older adults demonstrate poorer memory for associative information than item information and that this effect is more pronounced in intentional, explicit memory instructions versus incidental, implicit instructions. Others have also reported that older adults are better at remembering content than context and single units of information versus associations among those units (Chalfonte & Johnson, 1996; Spencer & Raz, 1995). In both recall and recognition memory tests for person–action pairs, Old and Naveh-Benjamin (2008b) showed that older adults had better recall for persons and actions alone versus retrieving them together and had higher false alarm rates for the associative material than for the action and person information alone. James and colleagues (2008) replicated this effect with face–name and face–occupation stimulus pairs. Younger adults retrieved more faces, names, occupations, and combination associations than older adults. Older adults were particularly poor at retrieving face–name associations. These studies demonstrate the difficulty older adults have in making new connections between units of information.

Additional support for the associative-binding deficit is provided by research on age differences on the *concreteness effect.* The concreteness effect refers to the relatively greater recall of concrete words over abstract words. Peters and Daum (2008) showed that the effect is smaller for older adults compared to younger and middle-aged adults, and they argued that it was due to the inability of older adults to form connecting images between two words and to capitalize upon vivid associations using imagery and other semantic-based encoding support. This explanation is consistent with the associative-binding hypothesis. Peters and Daum's use of a "know" (incidential, implicit processes) versus "remember" (intentional, explicit processes) recollection paradigm yielded support for the associative-binding hypothesis as an explanation for the diminished concreteness effect in older adults as well as more general age-related episodic memory loss.

Thus, to summarize, older adults are better at remembering separate units of information (pigeon, tree) but have difficulty integrating material that connects or binds units (The pigeon flew from the tree.). Moreover, research suggests that the neural basis for this deficit resides in the hippocampus and its related structures. Even when units are especially rich in associative content, as in the case of concrete words, older adults are more challenged than younger adults at making connections. The associative-binding hypothesis has received extensive empirical support and is thus considered one of the dominant current explanations for age-related episodic memory deficits.

The Processing Resources Hypothesis

Several other paradigms offer plausible explanations for age-related memory deficits. One dominant theory is that depleted processing resources such as speed, attention, and inhibitory control are at the root of higher-order deficits in working memory and episodic memory (Craik & Byrd, 1982; Salthouse, 1991). Empirical work on the processing resources model of memory aging is vast and includes support for attentional control (Lindenberger, Marsiske, & Baltes, 2000; McDowd, 1997; McDowd & Craik, 1988; Schaefer, Krampe, Lindenberger, & Baltes, 2008), speed (Salthouse, 1993; Verhaeghen, 1999; Verhaeghen, Vandenbroucke, & Dierckx, 1998), and inhibitory control (Hasher, Chung, May, & Foong, 2002; Hasher & Zacks, 1988; Lustig, Hasher, & Zacks, 2007; but see Aslan, Bauml, & Pastotter, 2007). One study found that speed but not working memory mediated age differences in verbal recognition memory (Verhaeghen, 1999). In contrast, Hertzog, Dixon, Hultsch, and MacDonald (2003) found that negative change in episodic memory ability over a 6-year span was a function of both working memory and speed. Perceptual speed mediates age differences on paired-associates and free recall tasks of common nouns (Salthouse, 1993), and age differences in working memory are mediated primarily by processing speed (Salthouse & Babcock, 1991). Recent research confirms Salthouse's claim that processing speed is foundational to higher levels of cognitive functioning, even at the primary level of working memory. Specifically, Bailey, Dunlosky, and Hertzog (2009) found that age differences in processing speed explain age differences in working memory as measured by an operations-span task and a reading-span task.

Thus, to summarize, older adults process incoming information more slowly than younger adults. Older adults are also slower to integrate new information with existing information in the long-term, semantic store, as well as with other new information held briefly and concurrently in the working memory space. Episodic tasks that rely on making connections between related (or unrelated) items (the associative-binding hypothesis) are dependent upon these lower levels of processing and manipulation. The limited processing resources hypothesis is firmly established as a significant mediator of age-related memory deficits.

The Temporal Coding Hypothesis

A view consistent with both the associative-binding hypothesis and the processing resources hypothesis emphasizes impairment at the retrieval phase of recently learned information as the source of episodic memory impairment in older adults (Wingfield & Kahana, 2002). Both speed and association processes are implicated in this view. In their study, Wingfield and Kahana brought older and younger adults to a learning criterion of

100% in a category–exemplar recall task (e.g., furniture category with sofa, chair, table exemplars; animal category with goat, dog, bird exemplars). Younger and older adults had comparable rates of retrieval within categories, but older adults exhibited slowed responses when moving to the next or a new category to retrieve items from it. This suggests that older adults take longer to assess whether retrieval within a category is complete, and to remember or retrieve the next category itself to then commence retrieval of its items. When the categories are provided at retrieval, age differences in retrieval rates disappear. Taken together, these results suggest that retrieving newly learned categories and connecting them in a temporal order is a memory-demanding task with associative-binding components. Older adults' diminished ability to move efficiently between categories of items-to-be-retrieved is consistent with the associative-binding hypothesis.

In summary, one class of explanations for memory-related deficits in adulthood focuses on cognitive mechanisms such as speed, working memory, and encoding and retrieval processes. This class of mediator or explanatory variables is supported by empirical and theoretical work and, increasingly, neuroimaging data. At a different level of analysis, researchers have considered the impact of self-regulation and monitoring on memory functioning in adulthood. This domain of explanatory mechanisms includes strategy use, self-evaluative judgments about competencies (memory self-efficacy), and stereotypical beliefs about memory and aging. We turn to this research in the next sections.

Strategy Use

It is well known that being strategic when learning new information will aid subsequent recall. For example, grouping similar items together (e.g., cottage, condo, apartment; motorcycle, bicycle, scooter) at study helps to encode and retrieve those items. Children who are taught to use organizational strategies to remember lists of words recall more words on a subsequent memory test (and have higher self-efficacy for future memory tasks) than their untrained counterparts (Gaskill & Murphy, 2008). In a life span study of strategy use, Shing et al. (2008) showed that both children and older adults were deficient in strategy use on a word-pair recall task. Even with practice on the use of an elaborative visual imagery technique, older adults' performance did not improve (children's did). The failure of older adults to benefit from elaborative encoding processes is consistent with an associative-binding deficit (Naveh-Benjamin, 2000). Not all research supports the claim that strategy use is a viable explanation for age-related memory deficits. For example, Bailey and colleagues (2009) found no differences between younger and older adults' use of normatively effective strategies (e.g., imagery, rote repetition) and that processing speed but not strategy differences between age groups explained age deficits in working memory span. Although effective strategy use is related to working memory span performance (Bailey et al.), the evidence regarding strategy use as a causal mechanism for age-related learning deficits is mixed. Dunlosky, Hertzog, and Powell-Moman (2005) found that the quality of mediators does not vary by age group, but recall of mediators is poorer among older adults. It appears that younger adults (Verhaeghen & Marcoen, 1996) and children (Shing et al.) benefit more from instruction in the use of strategies to guide memory than do older adults, possibly due in part to an associative-binding deficit. We have argued elsewhere that older adults may be less likely to use strategies when memorizing because of low expectations for performance success and low self-confidence for the memory task (Berry, 1999; Berry & West, 1993; Cavanaugh, Feldman, & Hertzog, 1998; Cavanaugh & Green, 1990; West & Berry, 1994). Relevant work from this perspective is reviewed next.

Memory Beliefs and Self-Efficacy

Older adults are relatively less certain and more negative in their self-judgments of memory ability than younger adults, as indicated on several different measures of memory self-efficacy (Berry, West, & Dennehey, 1989; Desrichard & Kopetz, 2005; Gardiner, Luszcz, & Bryan, 1997; Hertzog, Dixon, & Hultsch, 1990; Rebok & Balcerak, 1989; West, Dennehy-Basile, & Norris, 1996). These data mirror the memory complaints that typify older adults' self-reports of everyday memory functioning reviewed earlier in this chapter. Higher levels of memory self-efficacy are related to better performance on memory tasks (Lachman, Andreoletti, & Pearman, 2006; McDonald-Miszczak, Gould, & Tychynski, 1999; Valentijn et al., 2006), but whether memory self-efficacy is a mediator of age-related deficits on memory tasks remains to be demonstrated. Among older adults, however, low memory self-efficacy is especially likely to hurt memory performance when the task is explicitly a memory task (Desrichard & Kopetz, 2005). Researchers are testing increasingly sophisticated models of the relation of self-efficacy to memory and other cognitive tasks (see Cervone, Artistico, & Berry, 2006, for a review). For example, Stine-Morrow, Shake, Miles, and Noh (2006) found that self-efficacy predicts accuracy on a reading test and that working memory and self-efficacy were related to task goals. An intriguing conclusion from this study is that memory monitoring may be resource-depleting for older adults. As such, it will be important to determine which components of successful memory outcomes are least depleting and most advantageous for older adults. A recent study on age differences in memory monitoring (Chua, Schacter, & Sperling, 2009) indicates that older adults' false sense of confidence (high confidence for misremembered information) demonstrates that older adults are less accurate in knowing what they know and don't know than are younger adults. These data suggest that, indeed, memory monitoring processes may be as problematic for older adults as memory recall itself (Stine-Morrow, Shake, et al., 2006; Stine-Morrow et al., 2008).

Research on beliefs about aging and their relevance to memory functioning is yielding intriguing new insights. Lineweaver, Bergner, and Hertzog (2009) have shown that memory beliefs are differentially attached to positive and negative "target" people in a person–perception paradigm. Young, middle-aged, and older adults believed memory decline was more likely among older (target) adults who exhibit negative personality characteristics (e.g., a grumpy, cautious) versus positive characteristics (e.g., an upbeat, engaged old woman). Thus, beliefs about memory decline in elderly adults may be more specific than universal.

Fine-grained analyses of the role of self-stereotyping and stereotype threat point to subtle influences of stereotypical beliefs on memory performance in older adults. Hess and colleagues (e.g., Hess & Hinson, 2006) and Hummert and colleagues (e.g., O'Brien & Hummert, 2006) have shown that adults at midlife are particularly susceptible to stereotypical information about memory aging, which interacts with self-identification processes (i.e., the extent to which one identifies with old age as a self-referent status). In the study by Hess and Hinson, midlife adults performed better on a memory task following exposure to negative stereotypes of aging. In stark contrast, O'Brien and Hummert found that midlife adults appeared to be more threatened by a comparison to older adults and performed worse on a memory recall task. Follow-up analyses indicated that this effect held only for those midlife adults who scored in the direction of "old" on an age identification measure. Thus, when stereotypes seem self-referent, they appear to be more likely to affect behavior, including memory.

In a related vein, older adults appear to be more sensitive to tasks that are framed as memory tasks versus nonmemory tasks. Desrichard and Kopetz (2005) found that "explicity" of an episodic memory task at instruction time moderated memory performance. Their participants performed a "running an errand" spatial memory task and were told either that their performance was an indicator of good memory abilities or good orientation abilities. Older adults with lower memory self-efficacy (MSE) were more affected by explicit memory instructions than those with higher MSE. MSE was correlated with memory performance in the former but not the latter group; it was not predictive when the task is nonexplicit. The memory nature of the task appeared to have activated self-evaluative processes in older adults, resulting in MSE ratings that were correlated with performance. Younger adults performed no differently under the two types of task instructions. Thus, when MSE is low and the memory component of a task is emphasized, memory performance is compromised in older adults.

In conclusion, memory self-efficacy, strategy use, and beliefs about memory are three components of a more comprehensive framework by which to study memory and aging that focuses on self-regulation, reviewed next.

Self-Regulation

Our beliefs about cognition, on-task behaviors (e.g., strategy use, monitoring, resource allocation), and affective responses are self-regulatory factors that can influence cognition (Stine-Morrow, Miller, & Hertzog, 2006). Seen as the exercise of agency on the part of the individual, self-regulation is a general phenomenon that has been extensively studied in many domains of function (Bandura, 1997; Carver & Scheier, 2001). There are theoretical models of the life span that primarily emphasize self-regulatory processes, although the authors do not identify these as self-regulatory models, for instance, the Selective, Optimization, and Compensation model (Baltes, Freund, & Li, 2005) or Craik's model of self-initiated processing (1994). Work focusing specifically on memory and aging in the context of self-regulation is relatively new and falls into two primary categories: (1) work showing that pre-existing self-evaluative beliefs (such as views of one's own self-efficacy or control) influence memory and responses to task goals and (2) work showing that manipulations of goals can improve performance outcomes. Although few scholars of strategies have couched their work in self-regulatory terms, we would also argue that intervention work with specific memory strategies is essentially teaching older adults to regulate their own cognitive outcomes.

To our knowledge, there is only one well-developed theoretical model of self-regulation of cognition in aging. Although that model focuses on discourse processing (Stine-Morrow, Miller, et al., 2006), the authors emphasize the extent to which older adults can modify their own performance outcomes. Such modification involves choices to allocate particular resources that will advance performance. These choices are constrained by ability, knowledge, motivation, specific interests, affect, feedback, and the particular demands of the task. Clearly, this kind of model may be applied broadly to many domains of cognitive function. Older adults may perform better on cognitively demanding memory tasks by maintaining positive affect and a more positive set of beliefs about their potential, by monitoring their own item-specific success, by allocating attentional or strategic resources to meet specific goals, and by responding appropriately to performance feedback derived from external or internal sources. Theoretically, a person's initial performance levels on a task may lead to generally positive or negative self-perceptions that will influence subsequent performance levels (Bandura, 1997). If unable to meet a goal, the individual might reduce effort or could allocate additional effort to the zone of proximal learning (those items she is most likely to learn, or those items that are nearly learned). Alternatively, poor performance on a first memory trial could lead to negative affect (e.g., self-doubt and anxiety), withdrawal from strong investment in the task (e.g., failure to employ memory strategies that are known and easily utilized), and poorer performance on all subsequent trials. In daily life, a withdrawal from memory challenge can result in forgetting how to use strategies and the loss of information-processing skills that are not regularly practiced. Subsequently, when a memory challenge cannot be avoided, the individual has lost both skill and self-confidence to tackle the task. This example clearly demonstrates that self-regulatory processes can be specific to the task context and involve beliefs about performance, affective reactions, and information-processing strategies (Stine-Morrow, Miller, et al., 2006). In this way, self-regulatory processes may be highly influential in determining how and when older adults can overcome memory deficits and perform well.

Beliefs are a central piece of the self-regulatory process. Beliefs about ability, such as self-efficacy or attributions, can serve to impair or enhance memory performance, depending on the context of testing; for example, age-stereotype activation can bring down the performance levels of older adults (Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005; Hess, Auman, Colcombe, & Rahhal, 2003). Active engagement in cognitive processing and allocation of resources to task goals may be controlled, in part, by beliefs (Miller & West, in press; Stine-Morrow, Shake, et al., 2006; West & Yassuda, 2004). Aging research on cognitive beliefs has emphasized the overall relationship between beliefs, metamemory, and performance (for reviews, see Berry, 1999; Cavanaugh & Green, 1990; Hertzog & Hultsch, 2000; Soederberg Miller & Lachman, 1999) as well as experimental paradigms, involving goal setting, stereotype activation, or other manipulations of beliefs (cf. Desrichard & Kopetz, 2005; Gardiner et al., 1997; Lachman, Weaver, Bandura, Elliott, & Lewkowicz, 1992; Levy, 1996; Miller & West, in press; Rahhal, Hasher, & Colcombe, 2001; Stein, Blanchard-Fields, & Hertzog, 2002; West, Thorn, & Bagwell, 2003). Beliefs about control, that is, feeling that one's performance is modifiable through one's own effort, or believing that individual "internal" effort is more important than external factors, are key to self-regulatory success (see chapter 8, this volume). Similarly, stereotypes about aging can also be influential in self-regulation (see chapter 6, this volume).

MAINTAINING AND MAXIMIZING FUNCTION

Many scholars have examined the conditions and circumstances that might help older adults to maintain rather than lose memory skills. A variety of paradigms have been employed to find ways to yield memory improvements for older adults. Early work addressed the basic question of whether older adults were able to improve memory at all (Poon, Walsh-Sweeney, & Fozard, 1980). More recent work has examined what kind of conditions lead to lasting improvement in daily memory (Rebok, Carlson, & Langbaum, 2007) and what particular individual differences might predict better outcomes (Bagwell & West, 2008). The extant scholarly research ranges from experimental studies examining the impact of different learning contexts—for example, intentional versus incidental learning (Kausler & Puckett, 1980) or everyday memory versus laboratory memory (West, 1986)—to highly complex multifactorial memory interventions designed to improve performance as well as self-perceptions of memory skill (Lachman et al., 1992; Valentijn et al., 2005; West et al., 2008).

There is no question that cognitive ability in general, and memory in particular, is relatively plastic in late life (Verhaeghen, 2000). Research has supported the value of cognitive engagement (Rebok et al., 2007; Schooler & Mulatu, 2001; Stine-Morrow, Parisi, Morrow, Greene, & Park, 2007) as well as the value of cognitive training for older adults (Ball et al., 2002; Camp, 1998; McDaniel, Einstein, & Jacoby, 2008). At the same time, there is very little evidence that any particular type of training or experimental manipulation can eliminate age differences, although age differences can certainly be reduced under encoding and retrieval conditions that provide supportive cuing (Kausler, 1994), such as recognition testing. One excellent portrayal of the nature of the age gap in potential for maximizing memory is work on testing-the-limits (Kliegl, Smith, & Baltes, 1989). This program of research showed that, while considerable plasticity exists in older adult memory skills, this plasticity is not as great as it is for younger individuals. Persons varying in age were provided with a sophisticated imagery mnemonic to assist in the learning of numbers and showed dramatic increases in the length of the digit series that they could memorize. Nevertheless, even with close to 40 hours of training, older adults remained significantly behind young adults in scores, supporting the notion that age-related information-processing changes set limits to the benefits of intervention (Kliegl et al., 1989).

Recognizing that older adults have processing limitations and are unlikely to avoid some degree of memory decline, we nevertheless maintain that understanding the factors that enhance memory performance for older adults and applying them in memory intervention programs may improve quality of life and increase self-esteem. Beyond these applied benefits, the scientific knowledge base will be strengthened by such research. Next, we review the memory training and goal regulation literature, as these topics are most likely to remain important in future work.

Goals Research

Goal setting has been investigated in relation to the self-regulatory models of memory processing introduced earlier. In the typical paradigm, an individual is given a specific performance goal, and score outcomes or on-task behaviors (e.g., strategy usage) are compared to that of a control group with no goal. Participants with a goal, whether self-set or established by an experimenter, may also be given feedback concerning their progress toward meeting the goal. It is clear that goals can change one's on-task behavior (Stine-Morrow, Shake, et al., 2006) and that having a goal leads to higher memory performance than studying without an explicit goal in mind (West, Bagwell, & Dark-Freudeman, 2005). These effects are not always the same in younger and older adults. At the same time, the benefit of goal setting is such that older adults with goals sometimes outperform younger adults in a control condition without goals or feedback (Stadtlander & Coyne, 1990).

Research on goal setting demonstrates that younger adults show a stronger response to having a goal than older adults. Across all types of goal-setting conditions, younger adults show significant memory gains, but older adult gains in response to goals are more limited in nature (West & Thorn, 2001; West, Welch, & Thorn, 2001). Looking across a series of list-learning studies conducted by West and colleagues, it appears that older adults require some indication of successful task progress in order to make goal-related gains (i.e., to realize memory test score improvements when given a memory goal). Signs of progress might include encouraging, positive feedback from the experimenter (West et al., 2005), or objective feedback showing that scores have exceeded goals (West et al., 2001), or a means by which the participant can easily observe increased scores on their own (West et al., 2003). Given that older adults tend to be less confident in their memory abilities, it is not surprising that willingness to invest effort to meet a performance goal might be affected by the outcome of such effort. When older adults are given objective feedback that shows a lack of success, then task engagement is reduced, resulting in poor performance (West et al., 2001). Not surprisingly, paradigms that tailor task difficulty to individual ability levels (using a baseline test) result in more consistent goal-related gains for older adults (e.g., West et al., 2003) than those that set the same standard goals for all participants (West & Thorn, 2001).

Self-regulatory beliefs such as self-efficacy, motivation, and control have been investigated in the goal-setting literature, with recent work expanding into the arena of memory and aging. Typically in this literature, individuals with goals remain more motivated (i.e., show higher effort, higher test scores, and willingness to work more) after extensive testing than those without goals, and this is true for both older and younger adults (e.g., West et al., 2001). Moreover, level of effort predicts goal-related gains (West, Dark-Freudeman, & Bagwell, 2009). Self-efficacy may also be an important factor in predicting responses to goals. Stine-Morrow, Shake, and colleagues (2006), for instance, demonstrated that self-efficacy scores derived from the capacity and change subscales of the Metamemory in Adulthood questionnaire (MIA; Dixon, Hultsch, & Hertzog, 1988) predicted "flexible processing in text memory" where individuals either focused on accuracy or efficiency, depending on the goal emphasized by task conditions. It is interesting to note that self-efficacy predicted processing even with working memory included in the predictive model as well. Further, the impact of self-efficacy was stronger for the older learners (Stine-Morrow, Shake, et al., 2006). Similarly, West and colleagues (2009) showed that the interaction of self-efficacy and goal condition, along with strategy usage, effort, and baseline recall scores, predicted gains across list-learning trials for older adults. Locus of control has also been examined, predicting goal-related gains for younger adults (West et al., 2009; West & Yassuda, 2004) and older adults (West & Yassuda, 2004). In general, self-regulatory factors of control beliefs, self-efficacy, and goal condition have consistently shown powerful impact on gains across trials.

The majority of goal-setting studies have looked at simple list-learning paradigms, although some have examined digit recall (Stadtlander & Coyne, 1990) or text recall (Stine-Morrow, Shake, et al., 2006). In the case of list learning, it appears that strategy usage is the primary mechanism for goal success. That is, both older and younger adults who are given a goal increase their usage of memory strategies (e.g., using categories) in order to achieve gains under goal conditions (West et al., 2009). In the shopping lists used thus far in this research, simple categories, such as fruits, meats, and beverages, can easily be identified and employed during encoding and retrieval by older adults. It is not clear whether older adults would accomplish as much under goal-setting conditions with tasks that required more sophisticated strategies, such as those requiring several steps in sequence (e.g., image–name match method for name recall). In the case of text recall, the data reveal that shifts in allocation of effort and attentional resources play a large role in goal-directed learning (Stine-Morrow, Shake, et al., 2006).

With text and list learning, younger adults consistently show score gains with goals, whereas older adults show such gains only under supportive conditions as noted previously, that is, with individualized task difficulty and conditions that provide "signs of progress" (West et al., 2009). Future research in this area would benefit from expansion of the types of cognitive skills investigated, including examination of goal effects on improvements in mental speed, reasoning, and a wider variety of memory tasks. Further, it is not yet clear whether older adults can successfully set their own memory goals for laboratory tasks with brief levels of experience or training (West et al., 2001), or how memory goals operate in daily life. If older adults could effectively set their own goals, this might be an invaluable skill for helping individuals to maintain training effects in the home, through regular practice of learned skills.

Memory Training

Moving beyond the simple provision of a goal, decades of research has examined the potential for memory intervention programs for older adults. This section examines the impact of training on performance and beliefs, durability of training effects, factors that influence the effectiveness of training, and how training may be applied to older adults with mild to severe cognitive impairment.

Comprehensive Group Memory Interventions

Early work in memory training often brought individual seniors into the laboratory for brief strategy instruction (e.g., Hultsch, 1969). In the 1980s, investigators chose a more comprehensive approach to intervention, providing up to 20 hours of training in group settings (e.g., Yesavage, Lapp, & Sheikh, 1989). Group training is more effective than individual training, and the inclusion of pretraining provides added benefits (Verhaeghen, Marcoen,& Goossens, 1992). Group intervention work has fallen into three categories: (1) focused on a single mnemonic technique, such as interactive imagery (Hill, Sheikh, & Yesavage, 1987; West & Crook, 1992) or targeting a specific memory task, such as name recall (see Yesavage et al., 1989) or number recall (e.g., Derwinger, Stigsdotter Neely, Persson, Hill, & Backman, 2003); (2) broad-based, offering a range of memory strategies, with the goal of improving memory performance on a variety of everyday memory materials, such as shopping lists, names, and stories (Ball et al., 2002; West et al., 2008); or (3) multifactorial in approach.

Multifactorial interventions include strategy training as well as other key elements that may bolster training impact, such as focusing on beliefs (Lachman et al., 1992; Valentijn et al., 2005; West et al., 2008), increasing everyday engagement (Rebok et al., 2007), training attentional strategies (Stigsdotter & Backman, 1989a; West et al., 2008; Yesavage & Rose, 1983), encouraging relaxation (Stigsdotter Neely & Backman, 1993a, 1993b; Yesavage, Shiekh, Tanke, & Hill, 1988), or educating trainees about memory aging (West et al., 2008). Briefer, problem-targeted versions of training do not yield the same benefits (Woolverton, Scogin, Shackelford, Black, & Duke, 2001). Stigsdotter and Backman (1989a) found that training on memory strategies alone (unifactorial training) improved the memory performance of older adults, but adding material on attention and relaxation produced pronounced improvements. Comprehensive multifactorial interventions have resulted in successful change on most memory measures (Flynn & Storandt, 1990; Scogin, Storandt, & Lott, 1985; Stigsdotter & Backman, 1989b; Stigsdotter Neely & Backman, 1993a, 1993b; Zarit, Cole, & Guider, 1981; Zarit, Gallagher, & Kramer, 1981). The most recent multifactorial program taught five strategies, didactically, over 6 weeks (West et al., 2008). In addition, trainees did extensive reading on memory and aging and all elements of the training program were designed to encourage positive beliefs about memory potential and increase memory activity levels in the home. Relative to a control group, the trainees improved on name and story recall at two levels of difficulty, used more memory strategies, and showed improvements in memory self-efficacy and control beliefs (West et al., 2008).

Maintenance and Transfer of Training Effects

One way to show the real-world impact of training is to show that gains are maintained over time. Memory improvement lasting only a few days or weeks is of limited value to older adults seeking to achieve real change in cognitive performance or stave off dementia. If trainees return to an unstimulating environment and do not practice trained strategies, it is unlikely their training experience will result in long-term gains (Rebok et al., 2007). Therefore, improvements made in training may not make a sustained difference in their everyday lives. Work with training of reasoning skills has demonstrated very good maintenance of training effects, up to 7 years (Willis et al., 2006), but for memory training, per se, the data are less optimistic.

One-month maintenance of training effects has been documented following self-paced video training of imagery techniques (West & Crook, 1992), self-taught memory skills training (Flynn & Storandt, 1990; Scogin et al., 1985), and multifactorial group training (Stigsdotter & Backman, 1989b; West et al., 2008). Results are more mixed regarding maintenance beyond 1 year following training. Many have failed to find long-term maintenance of training gains (Anschutz, Camp, Markley, & Kramer, 1987; Scogin & Bienias, 1988). However, there is some research suggesting that such long-term maintenance is possible. Stigsdotter and colleagues reported 6-month maintenance effects with a multifactorial memory training program and subsequently found that trainees maintained their improvements over 3 years later (Stigsdotter Neely & Backman, 1993a, 1993b). Additionally, results of the large-scale ACTIVE study also support the potential for long-term maintenance of training gains, showing 2-year maintenance of training gains (Ball et al., 2002) and, more recently, improvements maintained up to 5 years post-training (Willis et al., 2006).

The inability to transfer skills learned during training to tasks in other domains is a frequently reported limitation associated with training interventions (Derwinger et al., 2003; Rebok et al., 2007). The largest documented study of transfer to date has been the ACTIVE intervention (Ball et al., 2002). Participants were trained for memory, speed of processing, or inductive reasoning, or served in a wait-list control condition. All trainees improved in their specifically trained domain, but training effects did not transfer across domains in the initial investigation (Ball et al., 2002), for example, individuals trained in memory improved only on memory measures and not in speed or reasoning.

More recent evidence has shown that training gains may transfer from one laboratory task to a similar type of task (e.g., from visual to auditory discrimination), or from a laboratory task to general assessments of everyday cognitive functioning (Bherer et al., 2006; Bottirolli, Cavallini, & Vecchi, 2008; Erickson et al., 2007; Mahncke et al., 2006; Willis et al., 2006; Wolinsky, Unverzagt, Smith, Jones, & Wright, 2006). Given the hundreds of interventions that have examined transfer, and the relatively few that have achieved it, transfer is not easy to achieve. Nevertheless, demonstrations of transfer are important because they suggest that the impact of training is broader than once believed and that training may have real-world consequences for older adults.

Individual Differences

An important question regarding training is "who benefits most?" (McKitrick et al., 1999; West & Tomer, 1989). Although a few studies have examined this issue, there is much yet to be discovered. Interindividual variability may obscure training effects (Schaffer & Poon, 1982). There is evidence suggesting that increased age may yield fewer training gains, although more studies of middle-aged participants would be needed to confirm this finding (Bissig & Lustig, 2007; Brooks, Friedman, Pearman, Gray, & Yesavage, 1999; Schaffer & Poon, 1982; Verhaeghen et al., 1992). Depression or anxiety is negatively related to the level of performance gains experienced by individual trainees, although anxiety reduction can benefit more anxious trainees (Schaffer & Poon, 1982; Yesavage et al., 1989). Lower cognitive status appears to be associated with reduced training impact (Yesavage, Sheikh, Friedman, & Tanke, 1990), and the benefits of higher education on training-related gains show mixed effects (Bagwell & West, 2008; Verhaeghen et al., 1992). Interestingly, certain personality traits may influence who benefits most from training, with evidence for the benefits of openness to experience (Gratzinger, Sheikh, Friedman, & Yesavage, 1990) and intuitiveness (Yesavage et al., 1989). Motivational factors may also be influential, in that self-generation of strategies works better than didactic training (Derwinger, Stigsdotter Neely, & Backman, 2005), and greater gains occur for those individuals who are more compliant with the training regimens (Bagwell & West, 2008). Similarly, a low sense of control over memory or a weaker perceived potential to change may reduce immediate and long-term gains (Elliott & Lachman, 1989; Erber, Abello, & Moninger, 1988; Valentijn et al., 2006; West, Welch, & Yassuda, 2000).

A number of scholars have recognized the importance of such individual differences in beliefs and have targeted their interventions to change both beliefs and memory. There is meta-analytic evidence that group-based training can improve self-evaluations of memory (Floyd & Scogin, 1997), however, many of the articles included in that review were studies that had no control group. Without a control group, changes in self-evaluative beliefs may be due to factors that were not part of the strategy training program, such as the social stimulation provided by attending a group workshop (Lachman et al., 1992; West et al., 2008). In studies using a control group, these training-related improvements in self-evaluation of memory have been reported: decreased memory concerns (Mohs et al., 1998; Zarit, Cole, et al., 1981; Zarit, Gallagher, et al., 1981), increased feelings of control over memory (Lachman et al., 1992; Turner & Pinkston, 1993), and improved memory self-efficacy (West et al., 2008). When they do occur, changes in beliefs are not always accompanied by performance change. Simply raising trainees' confidence in their memory ability is not sufficient to produce change in objective performance (Lachman et al., 1992). Likewise, learning a set of strategies to improve objective memory performance does not guarantee that participants will feel capable enough to apply these strategies in their daily lives or beyond the training period.

For instance, Best, Hamlett, and Davis (1992) compared a traditional strategic training approach with an "expectancy change" intervention intended only to change beliefs. The training group improved performance only, and the expectancy group showed only altered beliefs. In addition, the relationship between measures of memory complaints and actual performance was weak, suggesting that improved performance did not necessarily lead to changes in self-evaluative beliefs and vice versa. More recently, Valentijn and colleagues (2005) compared self-taught participants who used a training manual with collective training (small group meetings), where both groups received information on memory, aging, strategies, and self-efficacy. Their training showed improvement over controls only on a few of their performance measures, but participants did report less stress and anxiety related to memory following training. Other training studies have also shown partial success, reporting improvement on either beliefs or performance (e.g., Rebok & Balcerak, 1989; Zarit, Cole, et al., 1981). The most successful program to date, enhancing both beliefs and performance, integrated traditional skills training with elements designed to change beliefs. The program "emphasized potential at any age" and encouraged participants to set personal goals and "not to be concerned with achieving a high score" (West et al., 2008, p. 311). By focusing trainees on their potential for improvement, allowing them to set their own pace, and emphasizing the learning process, the researchers were able to increase participants' memory self-efficacy and sense of control while significantly improving memory strategies and test scores (West et al., 2008).

Self-Help Approaches to Memory Intervention

Advances in technology have added new promise to the development and dissemination of self-help training programs, potentially making memory performance available to a broader range of older adults who may have difficulty attending or financially affording a lengthy workshop (Rebok et al., 2007). Further, self-help training may encourage better practice of learned strategies because they are practiced in the home rather than in a class setting (Baldi, Plude, & Schwartz, 1996). Some researchers have even suggested that any mentally stimulating activity may benefit cognitive performance, including memory (Park, Gutchess, Meade, & Stine-Morrow, 2007; Rasmusson, Rebok, Bylsma, & Brandt, 1999; but cf. Salthouse, 2006). However, research on self-guided training has shown mixed results.

Several researchers have had success with improving memory scores via self-guided training presented in a manual or handbook (Andrewes, Kinsella, & Murphy, 1996; Hastings & West, in press; Scogin et al., 1985; Woolverton et al., 2001), on video (e.g., West & Crook, 1992) or on CD-ROM (e.g., Baldi et al., 1996). Rasmusson and colleagues (1999) showed that no single training mode surpassed others; participants in group-based, self-paced, and computer-based training all improved on a behavioral memory test. Although the results of self-guided training are encouraging, some interventions have not yielded significant memory gains following self-guided training (Flynn & Storandt, 1990; Rebok, Rasmusson, Bylsma, & Brandt, 1997), and few researchers have examined maintenance of self-help training effects over time (e.g., Baldi et al., 1996; West & Crook, 1992; Woolverton et al., 2001).

With respect to beliefs, few studies have addressed the potential for self-help training to impact beliefs (Rebok et al., 1997; Valentijn et al., 2005). Scogin, Prohaska, and Weeks (1998) found that both group- and self-guided training improved memory performance and subjective memory assessment (although there was no control group). In a self-guided study using two different audiotape programs, participants did not significantly improve memory, but there was a significant change in the belief that memory loss can be prevented through effort (Rebok et al., 1997). Other investigators were unable to significantly change memory beliefs via a self-help training approach (Scogin, Storandt, & Lott, 1985 Valentijn et al., 2005; Woolverton et al., 2001). In a recent study, a self-help version of a training program led to just as much memory test gain as a group-based intervention, however, results for beliefs were mixed, with a self-help manual leading to significant changes in locus of control, but not self-efficacy (Hastings & West, in press).

Therefore, past research on self-help training has shown mixed results both with respect to memory change and change in self-evaluative beliefs. It could be the case then that elements of the group environment, aside from strategy training, may be responsible for some of the improvements in memory beliefs associated with group-based programs. Nevertheless, investigators should continue to test self-help approaches. An effective self-help program could have important cognitive health consequences for many older adults who are immobile and/or cannot afford to attend group training sessions away from home. Further research should explore what aspects of group-based training are critical to performance and beliefs improvement, and how to successfully apply these aspects to self-help programs. It is likely that the Internet will prove useful in this area, as it will allow for virtual interaction with others and instructors, potentially providing a social environment that resembles an actual classroom.

Traditional memory training has provided clear benefits to cognitively healthy older adults in terms of changes in both beliefs and performance. General recognition of the established benefits of comprehensive group training and self-help training and increases in the older population have led to an explosion of new methods for memory intervention in the last few years. For example, scholars are combining memory training with exercise training, or providing increased engagement through life experiences, such as being a volunteer teacher (Park et al., 2007; Rebok et al., 2007). Such creative new approaches may yet yield the "gold standard" outcome that scholars have been seeking—gains in memory skill that transfer to daily life and are maintained over years.

At-Risk and Impaired Individuals

Just as perfecting self-help approaches to training may be key for bringing memory gains to large populations of older adults, targeting seniors who are at risk for dementia also represents an important arena for future training advances. Individuals with mild cognitive impairment (MCI) represent one-such high-risk group. Mild cognitive impairment, or MCI, has been defined as a transitional condition between normal aging and dementia (Bruscoli & Lovestone, 2004; Petersen et al., 1999). Once diagnosed with MCI, these individuals progress to Alzheimer's disease at a rate of about 10% each year, roughly five times the expected incidence of dementia in their healthy peers (Bruscoli & Lovestone, 2004). Because this population is likely to progress to dementia, and because the number of individuals with MCI will likely grow as the population ages (Petersen et al., 2008), it is important to assist these individuals to preserve independent functioning for as long as possible.

There is some controversy as to whether the memory ability of individuals with MCI is amenable to traditional intervention approaches. Yesavage and colleagues (1990) found that lower cognitive status was related to fewer treatment gains, and in one of the largest intervention studies to date, the ACTIVE intervention, MCI participants improved similarly to their normally functioning peers in the reasoning and speed training groups, but not in the memory training group (Unverzagt et al., 2007). As a result, the ACTIVE investigators suggested that older adults with MCI may have a neuropathological deficit that limits memory training impact. However, the ACTIVE study offered a fairly complex and intensive training program that was not designed specifically for more impaired seniors. Given that memory training has resulted in some success in mild dementia (Sitzer, Twamley, & Jeste, 2006), training modifications should be possible that will make interventions accessible for MCI.

There are promising data. McCoy (2004) found that participants with MCI were able to achieve 30-day performance gains similar to that of their cognitively healthy peers from practice alone. In addition, a handful of training interventions have suggested that older adults experiencing MCI can show performance-related gains (e.g., Cipriani, Bianchetti, & Trabucchi, 2006; Talassi et al., 2007; Werner, 2000). One such intervention by Belleville and colleagues (2006) offered training with organization, Method of Loci, imagery, and PQRST, which stands for Preview-Question-Read-Summarize-Test. The researchers reported significant improvement in delayed list recall and face–name recall for older adults with MCI, but no change in text recall.

One potential limitation in the MCI training literature to date is that only two programs to our knowledge have simultaneously aimed to improve both performance and beliefs (Rapp, Brenes, & Marsh, 2002; Troyer, Murphy, Anderson, Moscovitch, & Craik, 2008). Individuals with MCI not only have lower objective memory, but they also show lower subjective memory than their cognitively healthy peers (Cook & Marsiske, 2006; Jonker et al., 2000), so training programs aimed at improving both beliefs and performance may be needed for this population. A 6-week intervention by Rapp and colleagues (2002) found no change in laboratory tests of memory or self-reported use of memory strategies following training. However, trained participants did report more perceived control over memory following the intervention, suggesting that it may be possible to modify beliefs in individuals with MCI. A more recent 7-week intervention by Troyer and colleagues (2008) increased participants' knowledge and use of memory strategies, and these gains were maintained at 3-month follow-up, but the program did not successfully modify beliefs or performance. However, the Troyer intervention emphasized MCI and the risk of Alzheimer's disease early in the program, which could have reduced trainees' willingness to invest effort in retraining.

There is far more research on patients with Alzheimer's disease than those with MCI, partly due to the more recent categorization of MCI, and partly due to the perceived greater needs of the more impaired population. Attempts to use traditional strategy training with Alzheimer's patients have shown some success with mild dementia (Sitzer et al., 2006), but as the disease progresses, limitations in the learning skills of impaired individuals are caused by the degeneration of cells in the hippocampal area crucial for forming new memories. As limits on new learning increase, the best approach to training changes.

For individuals with more severe forms of dementia, and particularly those in nursing homes, the interventions are more similar to those used with patients suffering from memory impairment due to head injury, stroke, and other forms of brain damage. In each case, the goal is to maximize and/or effectively utilize residual skills. These methods include reminiscence therapy, which encourages patients to practice retrieving well-known information from semantic memory (e.g., Moos & Björn, 2006); spaced retrieval, which uses a systematic behavioral cuing process to implicitly build memory traces (e.g., Camp, 2006); repetition or structured practice (e.g., Hochhalter, Stevens, & Okonkwo, 2007); engagement with simple cognitive activities involving art or Montessori sensory skills (e.g., Malone & Camp, 2007); or some form of environmental support, such as a dictaphone, written or electronic organizers, lists, or learning to create obvious visible cues. For most individuals with severe memory difficulties, "external aids are probably the most helpful compensations for the greatest number of people and are most likely to be used in the long term" (Wilson, 1995, p. 176), although it can be challenging to train memory-impaired individuals to consistently use external aids.

In recent years, an exciting approach uses spaced retrieval methods for teaching patients particular information that it is important for them to know, for example, a room number, family phone number, doctor's name, or where to find the answer to a frequently asked question (Bourgeois et al., 2003; Camp, 2006). Recall for a specific item is cued repeatedly, beginning with a very small retention interval, possibly as little as a few seconds, depending on the patient's retention capacity, and the retention interval is increased systematically over time, depending on the success of retention. The spaced retrieval method was derived from basic memory research, showing that repetition of retrieval over successively longer intervals ("expanding rehearsal") is one of the best ways to learn in episodic memory (Landauer, 1989). In addition to helping patients recall specific information (Hawley & Cherry, 2004), the technique has also been used successfully to teach safe behavior and reduce behavioral problems in nursing homes (Camp, 2006; Camp, Bird, & Cherry, 2000). The success of this method may be due to the fact that it relies on repetition-priming effects to support memory using the less-impaired implicit memory system (Cherry, Simmons, & Camp, 1999). The method also has considerable practical value as it can be employed effectively, with minimal instruction, by caregivers and nursing home staff (Camp et al., 2000).

For individuals with more severe impairments, mixed results have occurred with traditional training programs. Research on MCI with traditional interventions shows promise, although this is a relatively new area of research (Belleville, 2008). Memory training has had some success with early Alzheimer's (Mimura & Komatsu, 2007; Sitzer et al., 2006), thus there is promise for intervening with MCI and possibly reducing the risk of future decline for MCI trainees. New approaches for this at-risk group might examine the benefits of programs that combine memory training with medications known to facilitate cognitive function in dementia (Yesavage et al., 2007) or combine strategy training with retraining of beliefs (West et al., 2008). For the most impaired group, those with Alzheimer's disease, or some other form of dementia, the more successful programs emphasize some kind of environmental support, regular use of residual cognitive skills, or techniques such as spaced retrieval that afford the opportunity to teach specific important information to individuals with limited new learning potential (Caltagirone et al., 2005).

Conclusions and Future Directions

We have reviewed current research and trends in memory aging, with a focus on explanatory models and mechanisms. There is intense interest in the field at present in identifying predictors of normative and non-normative memory aging, with concomitant efforts directed at preventing, slowing, and modulating the negative effects of neuropathological processes—as well as societal-cultural stereotypes—on memory ability in old age. Investigations of neurogenesis in the hippocampus and other aspects of the aging brain's plasticity at the molecular level (Jessberger & Gage, 2008) offer new possibilities for understanding the limits and potential of memory in late life. Research on the role of emotion and the amygdala in regulating and supporting episodic memory also suggests that this is relatively new and promising territory for understanding the affective mechanisms that control memory functioning in adulthood and old age (Allen et al., 2005) and, therefore, the possibility to exploit them in the service of memory.

Some evidence suggests that emotional memory is preserved in older adults and boosts declarative memory in the same manner as for younger adults (Denburg, Buchanan, Tranel, & Adolphs, 2003). The new generation of multifactorial memory training programs, reviewed in this chapter, has begun to incorporate positive affective instructional components with promising results (see West et al., 2005). The extent to which emotion may wield protective effects against failing memory abilities in older adulthood is not known. Some studies have found preserved emotional memory even in patients with Alzheimer's disease (Moayeri, Cahill, Jin, & Potkin, 2000), but other studies report that this preservation does not, in fact, boost subsequent memory recall in AD patients (Hamann, Monarch, & Goldstein, 2000). Zanetti et al. (2001) have shown that using techniques based on procedural memory abilities can be used to improve activities of daily living in individuals with mild to mild-moderate AD. Moreover, as reviewed earlier in this chapter, spaced-retrieval techniques have been shown to improve recall and simple memory associations in cognitively impaired individuals (Cherry et al., 1999). The success of such techniques can be attributed to the relative sparing of implicit memory processes in both normal aging and early stages of AD. Thus, research on those systems that are relatively spared in late life (e.g., emotion, implicit memory, procedural/skilled memory, semantic memory) will continue to inform and likely benefit ongoing intervention-based and memory-training research efforts.

Where will research on memory aging go next? Perhaps Jane Austen knew more about memory aging than we give her credit for. As she pointed out so eloquently in *Mansfield Park,* memory is rather enigmatic. At one level, contemporary memory researchers are still searching for elusive clues, according to one recent review (Dixon, Rust, Feltmate, & See, 2007). Dixon and colleagues challenge us to consider older adults' goals and how best to optimize memory functioning in late life. They point out that those goals should be realistic and personalized and, in the case of memory improvement, tailored to individual needs, abilities, and aspirations (see Buschkuehl et al., 2008; West et al., 2008, 2009). Although researchers will continue to investigate speed/accuracy dimensions of memory ability in adulthood, new studies of the personal function, purpose, and pleasure of remembering are emerging alongside more basic research programs. Austen would undoubtedly approve.

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