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Memory and Aging in Context

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Much research has indicated that aging is accompanied by decrements in memory performance across a wide variety of tasks and situations. A dominant perspective is that these age differences reflect normative changes in the integrity and efficiency of the information-processing system. Contextual perspectives of development, however, argue for consideration of a broader constellation of factors as determinants of both intraindividual change and interindividual variation in memory functioning. The validity of the contextual perspective in characterizing the relationship between aging and memory is examined through a review of studies exploring a variety of alternative mechanisms associated with age differences in performance. It is concluded that a more multidimensional approach to the study of aging and memory is warranted.

Keywords: aging, memory, context, cognition, life span development

Interest in the relationship between aging and cognitive functioning has grown tremendously during the past 30 years. Within this field, the effect of aging on memory has traditionally been the most widely researched topic. Much theory and research in this area has its roots in the information-processing framework (e.g., Craik, 1977; Kausler, 1991; Zacks, Hasher, & Li, 2000), with specific hypotheses and explanatory mechanisms that dominate the field being derived from or couched within this framework. Investigations conceived within this framework have typically focused on linking age differences in memory performance to changes in either specific structures or the efficiency of processing and control mechanisms. For example, dominant theoretical orientations have linked aging declines in memory to cognitive slowing (Salthouse, 1996), problems in inhibitory functions (Hasher & Zacks, 1988), reductions in processing resources (Craik, 1986), and deficits in reflective processes (Johnson, Reeder, Raye, & Mitchell, 2002; Mitchell, Johnson, Raye, Mather, & D'Esposito, 2000).

The extension of the information-processing framework to the study of aging has proven extremely useful in terms of theory building, the formulation of diagnostic and analytic tools for dissecting age differences in memory performance, and the assessment of normative variations in performance across individuals from different age groups. The manner in which this framework has been operationalized in studies of aging and memory also has limitations, however, and the dominance of this operationalization may have led to an incomplete understanding and characterization of memory effects associated with aging.

In practice, many studies of aging and memory within the information-processing tradition mimic the logic of traditional experimental psychology. Individuals are tested on tasks that are relatively stripped down in terms of familiarity or meaningfulness in order to assess basic aspects of functioning while controlling for extraneous influences. In addition, little attention is paid to sample characteristics other than for control purposes. Performance in individuals of different ages is then compared to examine the relationship between age and cognitive functioning. Several implicit assumptions underlie this approach (Hertzog, 1996; Hertzog & Dixon, 1996; Kausler, 1991; Labouvie-Vief & Schell, 1982). Primary among these are that skills assessed in isolation are representative of those used across contexts, that there is commonality in the structures and functions of this system across individuals, and that the effects of aging on this system are relatively universal across individuals. In addition, the common use of extreme age-groups designs and a focus on decrements in this research reflects an assumption that age is a useful marker for some general, age-correlated process that negatively affects the integrity of the information-processing system. Some have further argued that these combined attributes are consistent with an implicit assumption that aging reflects an ontogenetic process based in the deterioration of biological structures undergirding memory (e.g., Hertzog, 1996; Hess & Blanchard-Fields, 1996; Kausler, 1991; Labouvie-Vief & Schell, 1982). Note, however, that many researchers who study aging adopt a more functional approach (e.g., Craik, 1986) without making explicit linkages to biological factors.

The focus on decrements in memory and universal patterns of aging-related change has resulted in the relative neglect of alternative mechanisms that might account for normative and nonnormative patterns of age-related variability. This has led to a rather unidimensional research approach that often neglects the adaptive nature of cognition as well as contextual factors that may contribute to and moderate observed age differences in memory performance.

This approach contrasts with another influential framework for the study of aging: the life span perspective (Baltes, 1987). A central component of this view is the assertion that age-related changes in behavior are multidimensional and multidirectional, with development characterized at all points of the life span by both gains and losses. Implicit in this assertion is the assumption

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of multiple determinants of performance and behavior change. The life span perspective also emphasizes the adaptive nature of development as individuals adjust their behavior in response to normative and nonnormative changes in life events. This adaptive functioning may result not only in gains as new behaviors are acquired or existing behaviors become more efficient to deal with new circumstances but also in losses as behaviors are replaced or de-emphasized in response to these same circumstances.

Taken together, these assumptions lead to several important implications for the study of aging and memory. First, an emphasis on decrements may both fail to identify stability or progressions that reflect adaptive processes as well as misinterpret the bases for observed age differences in performance. Second, the adaptive nature of development suggests that the specific form of the behavior, including the context in which it is examined, needs to be considered in assessing and interpreting age differences in performance. Third, there may be significant individual variability in the nature of aging-related change as individuals experience and respond to unique life circumstances.

The goal of the present review is to examine the empirical literature on aging and memory and evaluate the support for a contextual view. Note that discussion of aging and memory from this perspective is not new (e.g., Labouvie-Vief & Schell, 1982). Only recently, however, has sufficient research accumulated to permit a reasonable examination of the validity of a contextual approach.

The Nature of Contextual Influences

From a life span contextualist perspective (e.g., Baltes, Cornelius, & Nesselroade, 1979), context effects on behavior and behavior change can be conceptualized in terms of interactions between an individual's characteristics and the environment in which he or she functions. It is the assumed pluralism of these characteristics and the implication of multiple influences that represent the complementary contributions from adopting a contextualist perspective in the study of aging and memory. Context can be defined as the set of variables that affect memory performance in a given situation. When considering the nature of such variables, it is instructive to revisit Jenkins's (1979) tetrahedral model of memory experiments, which was originally developed to emphasize the sensitivity of memory to context. In this model, performance in a given situation is determined by interactions between four categories of variables: participant characteristics, the cognitive strategy necessary for performance, the nature of the materials to be remembered, and the criterial task used to assess performance.

For the present consideration of context, primary interest centers on how participant characteristics are conceptualized and how they might interact with the other three factors. In the typical laboratory study of memory and aging, the participant characteristic of interest is age, which is hypothesized to covary with changes in some basic mechanism undergirding memory performance (e.g., processing resources). Factors on the other three dimensions are then varied systematically to test the validity of the hypothesized aging-related function. There are several limitations regarding this and similar instantiations of Jenkins's (1979) model and the treatment of context in the aging literature. Primary among these is the focus on change in a single factor—assumed to be based in a relatively universal developmental process—as the main determinant of aging-related variability in performance. This focus also affects the conceptualization and operationalization of variables on the other three dimensions of the tetrahedron, thereby limiting the potential examination of alternative explanatory mechanisms. A more complete understanding of aging and memory could be achieved by considering a wider array of factors that affect performance at both the proximal and distal levels.

Proximal influences can be thought of as characteristics of the individual having a relatively direct impact on performance at a given point in time. Intraindividual change in performance over time in a given situation can be understood in terms of changes in the constellation of both quantitative (e.g., speed, practice) and qualitative (e.g., goals, knowledge) performance-relevant characteristics of the individual. In contrast, distal factors have a more indirect impact through their determination of the level and form of proximal influences. Common patterns of intraindividual change both within and across cohorts are based in stable age-graded distal influences (e.g., participation in culturally based educational, family, and occupational roles) that have relatively systematic effects on the development of proximal influences. Proximal influences on performance may also be affected by nonnormative distal factors (e.g., unique educational and occupational experiences, health status), thereby accounting for interindividual variability in patterns of intraindividual change.

In sum, a life span perspective argues for examining age differences in memory in the context of multiple normative and nonnormative influences on performance. Context effects can be studied empirically by examining the generality of presumed normative patterns of aging-related decline in memory across: (a) task conditions designed to tap into multiple proximal factors that reflect age-graded influences on performance and (b) life circumstances (i.e., distal factors) that affect these proximal influences. It is important to note at this juncture that the information-processing framework is not inconsistent with a life span approach to the study of memory and aging. In fact, it easily accommodates the study of context, as reflected in models of social cognition that incorporate the influence of goals and emotions (see Chaiken & Trope, 1999). Concerns arise more from its operationalization (e.g., failure to consider alternative or multiple influences on performance) rather than from the framework itself.

Present Goals

The primary goal of this review is to examine evidence relevant to understanding the role of context in determining aging effects on memory performance. Because a major focus here is an examination of the viability of alternative accounts for observed age differences, I begin by briefly discussing the primary characteristics of aging effects on memory as identified in traditional laboratory studies. Evidence regarding the biological bases of such effects is discussed next, with particular interest in the degree to which support exists for age differences in memory being tied to normative variations in biological structures or functions. A review of research examining the mediating and moderating impact of context on age differences in memory performance follows, with three conditions being placed on studies included in this review. First, only investigations of explicit memory performance are included. As noted below, this type of memory is associated with the greatest age-related variation in performance and thus is of primary interest. Second, research is only included if it examines episodic memory, that is, studies in which participants are presented with some type of material to remember at a particular time and place and then are tested for their memory of that episode. Other types of memory research (e.g., autobiographical, very long term) relevant to a contextualist perspective are excluded because of the added complexity of control and validity issues in such studies. Related conceptual treatments that focus on this work can be found elsewhere (e.g., Pasupathi, 2001; Ross, 1989; Weldon, 2001). Finally, studies are only included if the impact of context—broadly defined—can be examined or reasonably inferred independently of age. This would include, for example, experimental studies that manipulate the nature of the task or materials to gauge the impact of presumed proximal influences on performance and correlational and prospective studies that measure variables tied to distal influences (e.g., domain-relevant experience, engagement in cognitively complex activities).

Age Differences in Memory Performance

To facilitate the discussion of contextual influences on age differences in performance, I find it useful to provide a general characterization of aging effects on memory as identified in research from within the information-processing tradition. The goal here is not to provide an exhaustive overview given the existence of several excellent recent reviews of this literature (e.g., Craik, 2000; Prull, Gabrieli, & Bunge, 2000; Zacks et al., 2000). Rather, an attempt is made to identify general aspects of memory that are associated with aging and that might then be examined in relation to context.

As noted earlier, empirical research on aging and memory has proceeded from within the context of a few well-specified frameworks (e.g., Craik, 1986; Hasher & Zacks, 1988; Johnson et al., 2002; Salthouse, 1996). These perspectives have in common the notion that aging affects either the capacity to perform operations or the efficiency of the actual operations, which in turn reduces the functional capacity of working memory. A reasonable way to characterize these age effects is in terms of impairments in controlled processing mechanisms. Specifically, the components of functioning hypothesized to be affected by aging—self-initiation of memory operations (Craik, 1986), monitoring and controlling the contents of working memory (Hasher & Zacks, 1988; Johnson et al., 2002), and performing when resource demands are great (Salthouse, 1996)—are all characteristics typically associated with controlled processing (e.g., Shiffrin & Schneider, 1977). Consistent with this interpretation, recent perspectives on cognitive aging based in changing neuromodulation processes suggest that many of these difficulties have their roots in the same underlying mechanism (e.g., Braver et al., 2001; Li & Lindenberger, 1999).

Findings from laboratory-based studies of aging and memory are generally consistent with this perspective, as evidenced by several meta-analytic reviews of the literature. These have found that age effects on memory performance increase in strength as the complexity of the task or the processing demands increase. Verhaeghen, Marcoen, and Goossens (1993) found that the effect size associated with short-term memory span tasks that contain both a processing and storage component ($d = 0.81$) was larger than that associated with span tasks with minimal processing demands ($d = 0.48$; see also Verhaeghen & Salthouse, 1997). Related results were obtained by Spencer and Raz (1995), who found that the average effect size associated with age was greater when memory was assessed through recall ($d = 1.01$) rather than recognition ($d = 0.57$). The former type of test is assumed to require more effort and strategic behavior than the latter. Age effects were also significantly greater under intentional ($d = 0.62$) than under incidental ($d = 0.42$) encoding conditions, with the former typically being associated with more self-initiated strategic processing. Similar age differences between recall ($d = 0.97$) and recognition ($d = 0.50$) were obtained by La Voie and Light (1994) using a different sample of studies. In addition, effect sizes associated with age for both of these types of tasks, which assess explicit memory and thus relate to conscious control, are greater than those observed for implicit memory tasks (item priming: $d = 0.21$; associative priming: $d = 0.22$), in which performance is thought to rely heavily on automatic memory functions (Light, Prull, La Voie, & Healy, 2000).

In sum, the results of quantitative analyses of findings from studies of aging and memory are consistent with the notion that age-related decrements in performance are greatest when the task requires the efficient use of controlled processing mechanisms to support performance. Specifically, the size of the observed age effects in any given task increases along with the degree to which effortful, self-initiated, or strategic behavior are involved in supporting performance.

Biological Bases of Age Differences in Memory

Recently, there has been growing interest in linking aging-related variations in memory to underlying changes in neural systems. Although such relationships have always been of interest, the development and availability of increasingly sophisticated neuroimaging tools during the last 10 years has resulted in the ability to more directly examine these linkages in vivo. Much of the focus in neuroimaging studies of aging has been on the prefrontal cortex (PFC), which has been linked to executive functions associated with the strategic component of memory and working memory (e.g., Moscovitch & Winocur, 2002; Shimamura, 2002). Research has repeatedly demonstrated that damage to the frontal lobes negatively impacts memory functioning, especially that involving strategic behavior (for a review, see Gabrieli, 1998). Given the similarity of such effects to those described above, it has been suggested that aging might involve a specific negative impact on the PFC. This has come to be termed the frontal lobe hypothesis of cognitive aging (e.g., Shimamura, 1990).

Consistent with this hypothesis, research has shown that the PFC and associated subcortical connections experience disproportionate atrophy with age relative to other areas of the brain. For example, Raz (2000) reports a median correlation of $-.47$ between age and volume of the frontal cortex across studies examining this relationship. For comparison purposes, the same correlation was $-.35$ for the temporal lobe, $-.29$ for the parietal lobe, and $-.18$ for the occipital lobe. Relationships between PFC volume and memory performance have not been consistently observed, however (e.g., Head, Raz, Gunning-Dixon, Williamson, & Acker, 2002; Raz, Gunning-Dixon, Head, Dupuis, & Acker, 1998; Salat, Kaye, & Janowsky, 2002), perhaps because of the fact that volumetric assessments may not be sensitive indicators of changes in functioning that might reflect, for example, neurochemical processes (e.g., Arnsten, 1999; Li & Lindenberger, 1999; Volkow et al., 2000). Studies using functional neuroimaging techniques (e.g., functional magnetic resonance imaging) to examine cortical functioning have provided more consistent evidence with respect to the frontal lobe hypothesis. A common finding is that there is a reduction in activation with aging in left prefrontal cortical regions during encoding in a variety of memory tasks, including recognition memory for unfamiliar faces (Grady et al., 1995; Grady, Bernstein, Beig, & Siegenthaler, 2002) and words (Logan, Sanders, Snyder, Morris, & Buckner, 2002; Morcom, Good, Frackowiak, & Rugg, 2003), paired-associate learning (Anderson et al., 2000; Cabeza et al., 1997) and word recall (Stebbins et al., 2002), and verbal working memory tasks (Reuter-Lorenz et al., 2000). Aging-related reductions in right prefrontal cortical regions have also been observed for spatial (Reuter-Lorenz et al., 2000) and self-ordered and externally ordered (Haut, Kuwabara, Leach, & Callahan, 2000) working memory tasks.

Of particular interest, Anderson et al. (2000) found that younger adults who were required to divide their attention at encoding exhibited a reduction in left prefrontal activation similar to that observed in older adults. In addition, Daselaar, Veltman, Rombouts, Raaijmakers, and Jonker (2003a); Logan et al. (2002); and Stebbins et al. (2002) found that age differences in recruitment of frontal regions during encoding are eliminated when specific instructions were given to engage in semantic elaboration during encoding. Together, these findings suggest that reductions in frontal activation may reflect a general response to reduced cognitive resources. They also suggest that under-recruitment of frontal areas does not necessarily indicate an absolute constraint on memory functioning in older adults and may be reflective of age differences in approach to task or consistency of strategy use rather than ability (Daselaar et al., 2003a). It is not clear at present, however, whether such age effects reflect difficulties experienced by older adults in initiating such strategies or variations in interest levels or processing goals that may affect strategy selection. In support of the possible impact of task content on age differences in activation, Logan et al. (2002) found that older adults exhibited similar levels of frontal activation to that observed in young adults when encoding faces but reduced activation when encoding words. The increased activation associated with faces might reflect factors other than changing neural systems, such as goal-based changes in the salience of social stimuli with age in adulthood (e.g., Carstensen, 1993).

Whereas there appears to be an aging-related reduction in activation in areas of the frontal cortex that support memory functioning, many studies also demonstrate a concurrent increase in activation (relative to young adults) in other areas, especially in the analogous structure in the opposite hemisphere (e.g., Cabeza et al., 1997; Grady et al., 2002; Morcom et al., 2003; Reuter-Lorenz et al., 2000). It has been argued that aging-related reductions in hemispheric asymmetry during processing might reflect a form of compensation (Grady et al., 1995). This interpretation is supported by several findings in the literature, including demonstrations that enhanced memory performance in older adults is associated with bilateral activation (e.g., Morcom et al., 2003; Rosen et al., 2002) and that reductions in activation in older adults' occipital lobe activity during a working memory task were associated with increases in PFC activity (Cabeza et al., 2004).

Of further interest in these studies of PFC functions is the extent to which variations in cortical activation patterns are associated with age-related variation in memory performance. Several studies have shown correlations between activation in the frontal lobe and various aspects of older adults' memory performance, such as response times in a memory search task (Rypma & D'Esposito, 2000), face recognition (Grady et al., 2002), and immediate story recall and listening span (Stebbins et al., 2002). Unfortunately, there has been little attempt to examine the extent to which age differences in performance can be accounted for by activation levels.

In sum, the results of neuroimaging research have been generally supportive of the frontal lobe hypothesis. Aging has been shown to be associated with reductions in volume and activation levels of structures and circuits associated with the PFC, and these reductions are correlated with performance in memory-related tasks. There is some inconsistency across studies, which may reflect the use of different tasks with different demands on cognitive resources, resulting in variability in the obtained age effects as well as the areas of the brain supporting performance (Craik & Grady, 2002; Schiavetto, Köhler, Grady, Winocur, & Moscovitch, 2002). Some disagreement also exists concerning the source of these effects, in terms of whether they are reflective of processes specific to the frontal lobes or are sequelae of changes in other structures (e.g., Rubin, 1999) or networks (e.g., Greenwood, 2000). These alternative views are not necessarily inconsistent with the frontal lobe hypothesis, but they do suggest that identification of the locus of such effects—and concomitantly, our ability to identify normative changes in brain structures—is a complicated task.

Note that the goal of this section was not to provide an exhaustive review of this emergent and complex area but rather to briefly characterize the current state of our knowledge through representative studies (for more extensive reviews, see Cabeza, 2002; Craik & Grady, 2002; Prull et al., 2000; Raz, 2000). Note also that the focus on PFC does not imply that it is the only cortical structure associated with memory that is affected by aging. For example, limbic structures (e.g., hippocampus) also exhibit aging-related changes in both size (e.g., Raz et al., 1998) and function (Cabeza et al., 2004; Daselaar et al., 2003a; Daselaar, Veltman, Rombouts, Raaijmakers, & Jonker, 2003b; Morcom et al., 2003), although such changes may be exacerbated by abnormal processes (Raz, 2000). Rather, PFC studies were emphasized because of the association of this structure with both age and controlled processing (e.g., executive) functions.

Taking the results of these studies together with the previous discussion of aging effects on memory, I am able to make several important observations in terms of informing a contextual perspective. First, aging has a disproportionate impact on neuronal loss in cortical areas supporting those memory functions most adversely affected by aging. This, along with other data indicating that declines in overall memory and cognitive functioning go hand-in-hand with declines in more basic sensory and motor functions (e.g., Christensen, Mackinnon, Korten, & Jorm, 2001; Lindenberger & Baltes, 1997; Salthouse, Hambrick, & McGuthry, 1998), suggests that aging-related changes in memory performance, to some extent, are based in systematic changes in underlying biological mechanisms. Second, at least some of this loss may be more representative of disease-related processes than of a normative, ontogenetic function. Third, there is not always a clear relationship between aging-related variation in structure and memory functioning. More consistent relationships have been observed when cortical function—rather than structure—has been examined. At the same time, however, the prediction of age differences in memory performance from indices of brain function is not perfect, suggesting that some aging-related variability in performance is unaccounted for by specific measures of biological functions. It is interesting to note that Raz (2000) indicated that the evidence for a relationship between declines in brain structure/function and performance is greatest for the most severe levels of memory impairment. This further suggests that there is significant age-related variation in memory performance among less severely impaired older adults that may not be easily accounted for by biological factors, at least as currently assessed. Finally, there appears to be an adaptive quality to the aging brain, as evidenced by apparent compensatory mechanisms in recruitment of brain activity as well as flexibility in functioning associated with critical regions undergirding effective memory functioning.

These last three points are particularly important for a contextual perspective. Specifically, although there does appear to be some biological basis for what might be characterized as normative declines in memory performance, there is also evidence of significant interindividual variation in the degree to which particular structures and functions are affected in later life. There is also evidence for the possibility of behavioral processes (e.g., strategy use) underlying some observed aging-related variation in performance. In the next two sections, evidence of contextual influences on intraindividual change and interindividual variability is reviewed.

Context and Intraindividual Variation

As noted earlier, a contextual perspective argues for a consideration of a broader set of influences on performance—both at the proximal and distal levels—than considered in the typical laboratory study of aging and memory. In this section, research is reviewed in an attempt to examine the general hypothesis that in addition to breakdowns in specific components of the information-processing system, other age-graded proximal influences may also result in systematic variations in memory functioning in adulthood. The review of relevant studies here centers on two general categories of such proximal influences. The first concerns the role of goals and motivation, with evidence being evaluated for the possibility that aging-related variability in memory performance may in part be related to adaptive changes in goals associated with development. The second relates to the social context, with discussion focusing on the general role played by cultural stereotypes of aging in determining older adults' memory performance.

Goals

It has been suggested here that much previous research on aging and memory focuses on factors that more or less influence performance—and, concomitantly, age differences therein—through their direct impact on the efficiency and integrity of the information-processing system. This emphasis on the "cold" aspects (e.g., mechanics) of cognition can be seen in studies that examine mechanisms and structures and their breakdown without consideration given to the context in which these mechanisms and structures operate. Labouvie-Vief and Schell (1982) have characterized this as a linear view of development, in which complex skills built on simpler processes systematically deteriorate as these processes weaken.

Age differences in memory performance may also be affected, however, by factors that influence the operation of this system. Until recently, there has been little focus on these "hot" aspects of cognition; that is, factors such as motivation, goals, and emotion that energize and direct the cognitive system. Such factors may be related to development in (what Labouvie-Vief and Schell (1982) have referred to as) a nonlinear form as changes in their level and nature (e.g., relative emphasis placed on different types of processing goals) influence the manner in which the information-processing system operates. There is evidence in the literature that adult development is associated with changes in these aspects of behavior. There is also evidence that these factors have an important influence on memory and cognitive performance (see Forgas, 2001). To the extent that studies of aging and memory fail to take them into account, research findings may only tell part of the story regarding the factors that determine age differences in memory performance.

In this section, primary consideration is given to the role of goals, which influence remembering in at least two different ways. First, individuals are more likely to expend effort in performing tasks that are consistent with personal goals (e.g., Fiske, Lin, & Neuberg, 1999), with increased effort likely to lead to enhanced levels of retention. Second, goals may influence the nature and focus of cognitive operations, resulting in the elevation or depression of memory for specific types of information (e.g., Chartrand & Bargh, 1996; Woike, Lavezzary, & Barsky, 2001). An important implication of such processes is that normative changes in goals may result in age differences in memory due to the nature of the operations engaged in rather than to the efficiency of these operations. In this section, evidence is reviewed in relation to the general hypothesis that developmental changes in goals will influence memory through their impact on (a) the nature of processing, (b) the type of information attended to, and (c) the engagement of cognitive resources.

In spite of the important role of goals in remembering in everyday life, most research has failed to adequately consider their impact on motivation and their role in determining age differences in performance. This failure may not necessarily reflect a belief that goals are unimportant. In fact, Hasher and Zacks (1988) explicitly discussed the possible influence of age-related variations in goals in their inhibition-based framework of cognitive aging. The manner in which the typical laboratory study of memory and aging is constructed, however, is consistent with the implicit assumptions that task-relevant goals do not vary with age, that personal goals will not systematically influence performance on the task at hand, and that task characteristics (e.g., instructions, materials) will activate the same goals in individuals across adulthood. An increasing number of research findings question the validity of these assumptions.

One of the first sets of studies to examine the relationship between goals and memory in adulthood was conducted by Adams and her colleagues (Adams, 1991; Adams, Labouvie-Vief, Hobart, & Dorosz, 1990; Adams, Smith, Nyquist, & Perlmutter, 1997; Adams, Smith, Pasupathi, & Vitolo, 2002). They argued that changes in social–cognitive goals associated with age-related circumstances (e.g., life tasks, roles) affect how young and older adults approach memory tasks, with age-related variation being most evident in situations involving complex materials similar to those encountered in everyday life. Adams proposed that, with age, goals associated with processing discourse become increasingly oriented toward interpretation (as opposed to veridical reproduction), integration of present with past, and transmission of knowledge, especially to members of younger generations. This perspective builds on theories of adult development (e.g., Labouvie-Vief, 1990; Mergler & Goldstein, 1983) that propose a shift in social–cognitive goals from knowledge acquisition in young adulthood, as one learns essential information about functioning in one's culture, to dissemination in late life, as one integrates existing knowledge and shares wisdom. She further argued that many laboratory studies misgauge the impact of aging on memory skills because of the mismatch between the goals of older adults and those of the experimenter. For example, the goal of most studies of memory is to assess ability by examining verbatim reproduction. Such a task may present a fair test of the dominant skills of young adulthood, given the context of knowledge acquisition—often for the benefit of authority figures (e.g., teachers, professors, bosses)—associated with this group. If older adults' goals are more oriented toward integration and transmission, however, such studies may misrepresent abilities by, for example, assessing performance in a context in which (a) the listener (i.e., experimenter) is already assumed to know the information, and (b) outcome measures fail to recognize the products of interpretation.

The results of Adams's work appear to be consistent with this perspective. In several studies examining text recall (Adams, 1991; Adams et al., 1990), it was found that memory became more reconstructive from adolescence and young adulthood to midlife and old age. Specifically, the recall protocols of middle-aged and older adults contained a larger proportion of elaborations and metaphoric propositions than those of younger adults, which were dominated by verbatim reproduction of text propositions. Adams et al. (1990) also observed that these stylistic differences were most evident in unstructured situations (e.g., no guidance given regarding how to process the information). It is important to note that the observed age differences did not appear to simply reflect a shift to gist-based responses in later life to compensate for losses in memory for detail. In the Adams et al. (1990) study, there was little evidence of systematic relationships between production of specific text details and nonveridical propositions across age groups and instructional conditions. In addition, the latter types of propositions did not just reflect gist or summarization of text propositions but rather were the products of more complex inferential operations. Finally, Adams et al. (1997) found that the nature of age differences in memory performance was dependent on instructions, with each age group exhibiting superior recall to the other when task instructions were congruent with the hypothesized goals of that age group.

One additional study by Adams et al. (2002) provided further evidence for the importance of goals in determining age differences in memory performance. Young and older women were asked to learn a story to retell to either a young child or an experimenter. In the latter condition, which is analogous to standard laboratory testing situations, younger adults recalled more story propositions than did older adults. In contrast, older adults' recall was elevated and age differences in performance were eliminated when telling the story to a young child. The older women were also more likely than younger women to adjust the complexity of their recall in response to the listener. It is important to note that the variations across storytelling conditions could not be accounted for by factors such as study time and strategies used to learn the stories. Instead, the results suggest that older adults' recall is more sensitive to the retrieval context, with performance being enhanced when the testing context is consistent with the hypothesized social–cognitive goals of later life (i.e., information transmission). The fact that older adults performed on par with younger adults when the appropriate goals were activated also suggests that the use of a reconstructive style is not necessarily a reflection of low ability.

Recent work based on socioemotional selectivity theory (SST; Carstensen, 1993) is also consistent with the notion that developmental changes in goals have a systematic influence on the manner in which different-aged adults process information. SST proposes that the salience of knowledge-acquisition and affective social goals change through the course of adulthood as a function of changing perspectives of time. In early adulthood, knowledge acquisition goals tend to be highly salient as individuals prepare for adjustment to new roles and circumstances over a relatively expansive future life span. As perceptions of future time shorten in later adulthood, the importance of knowledge acquisition wanes and immediate emotional goals become more salient.

Several studies by Carstensen and colleagues provide evidence for the importance of this shift in social goals for understanding adult age differences in memory performance. For example, Carstensen and Turk-Charles (1994) had adults in four different age groups (20–29, 35–45, 53–67, and 70–83) read and recall stories containing both neutral and emotion-laden content. They found no age differences in overall recall, but the proportion of emotion-related story propositions recalled increased systematically with age, from approximately 20% in the youngest group to 35% in the oldest. This shift in the nature of the memory representation is suggestive of the aging-related increase in salience of emotional goals predicted by SST. Fung and Carstensen (2003) obtained similar results when they examined memory for different types of advertisements. Specifically, older adults exhibited greater preference for the emotional advertisements than did younger adults. In addition, older adults remembered more information from advertisements with emotional appeals than from control advertisements or those with knowledge-related appeals, whereas younger adults exhibited similar levels of memory regardless of the type of advertisement.

It is important to note that these age effects do not appear to simply reflect relative preservation of cortical structures such as the amygdala (see Raz, 2000), which has been shown to support the processing of emotional content (e.g., Hamann, Ely, Grafton, & Kilts, 1999). In a study of picture memory, Charles, Mather, and Carstensen (2003) found overall recall to decline with age, but older adults recalled more positive images than negative images, especially when the images contained people, whereas the young and middle-aged adults recalled similar amounts of each. In other words, the aging-related memorial advantage for emotional content was specific to positive information. This is consistent with the SST-derived prediction that there will be a specific focus on positive information in later life as older adults seek to optimize emotional experience.

Related findings have been obtained by Mather and Carstensen (2003), who found that, relative to younger adults, older adults exhibited a disproportionate attentional bias in favor of faces depicting positive emotions over those depicting negative emotions. This attentional bias was reflected in their superior memory for positive faces over neutral or negative faces; no such effect was observed for younger adults. Mather and Johnson (2000) also found this aging-related positivity bias when they examined source memory for positive and negative features of selected and unselected items in a decision-making task (e.g., choosing between job candidates). Relative to younger individuals, older adults displayed disproportionate source accuracy for positive features of the selected item and negative features of the unselected item. It is important to note that this bias was present when overall level of memory performance was controlled. Further, younger adults exhibited a similar bias when asked to focus on the emotional content of their choices. These two findings suggest that the positive bias exhibited by older adults was a reflection of processing style rather than a deficiency in encoding processes. This is further reinforced by the results of a recent functional magnetic resonance imaging study by Mather et al. (2004), in which they observed differential activation in the amygdala in response to positive versus negative information in older adults.

Although these studies provide a relatively cohesive set of findings supporting predictions derived from SST, a recent study by Kensinger, Brierly, Medford, Growdon, and Corkin (2002) did not find age differences in recall of positive versus negative information in both word and picture recall tasks. The reasons for this discrepancy with Charles et al. (2003), who used a similar task, may have to do with the facts that Kensinger et al. used intentional rather than incidental memorization instructions, and older adults saw each item twice for 5 s instead of once for 2 s. It may be that the study conditions used by Charles et al. were more likely to mimic the conditions of exposure in naturalistic situations and that the goal-related variations in processing across age groups are more likely to emerge under such conditions.

One of the central points suggested here is that aging-related changes in goals, such as those associated with SST, may in part account for observed age differences in memory performance that are normally characterized as deficits. Research examining source memory provides a case in point. In a series of studies, Hashtroudi, Johnson, and colleagues (Ferguson, Hashtroudi, & Johnson, 1992; Hashtroudi, Johnson, & Chrosniak, 1989, 1990) found that older adults have more difficulty than younger adults in identifying the source of items to be remembered as part of a memory task. These effects appeared traceable to the fact that older adults were less likely than younger adults to have encoded the distinctive perceptual information necessary for making source discriminations (Ferguson et al., 1992; Hashtroudi et al., 1990).

Of interest to the present theme is the fact that these researchers also found that older adults reported more thoughts, feelings, and evaluative comments about to-be-remembered items than did younger adults. Focusing on the affective aspects of an event is associated with poor source discrimination (Suengas & Johnson, 1988), suggesting that such a focus in older adults might contribute to their poorer source memory. Subsequent research found that age differences in source monitoring were significantly reduced or eliminated when individuals were instructed to focus on the factual content of the to-be-remembered information rather than on the affective content (Hashtroudi, Johnson, Vnek, & Ferguson, 1994) or when participants were required to focus on source information at encoding (Glisky, Rubin, & Davidson, 2001) or retrieval (Multhaup, 1995). Although the consistency of findings in the literature argue for real aging-related losses in source memory, these studies suggest that observed performance decrements may partially reflect mismatches between the requirements of the tasks (i.e., the basis for effective source discrimination) and the processing goals of the older adult (e.g., focus on affect). In support of such an interpretation, Rahhal, May, and Hasher (2002) found that age differences in performance disappeared when source discrimination was based on affective, conceptually based information rather than perceptual information. In other words, when the task requirements were congruent with the processing goals of older adults, age effects in source monitoring were attenuated.

The just described goal-related processes can be fruitfully understood using the model of selection, optimization, and compensation proposed by P. B. Baltes and Baltes (1990). This model assumes that development is associated with making choices among alternative goals and then optimizing the means for achieving selected goals. The changing nature of goals described in the work of Adams and Carstensen and their colleagues appears to reflect elective selection, whereby individuals focus on and commit to desired states (Freund & Baltes, 2002). An alternative type of selection identified by Freund and Baltes is loss-based, whereby individuals adjust goals in response to losses in the means for attaining those goals. Such loss-based selection effects may also be operative in determining age differences in memory performance. An example of such effects can be seen in work by Hess and colleagues, who have hypothesized that aging is associated with increasing selectivity in task engagement because of actual or perceived declines in cognitive resources (Hess, 2000; Hess, Germain, Rosenberg, Leclerc, & Hodges, 2005). That is, the costs associated with effortful or controlled processing result in older adults being more judicious than younger adults in their allocation of resources. Hess has further hypothesized that this aging-related resource conservation should be most apparent in situations of low relevance or meaningfulness to the individual, with age differences in task engagement decreasing as these factors increase.

This hypothesis was initially examined in a study of person memory by Hess, Follett, and McGee (1998). Previous research (Hess & Tate, 1991) had shown that the typically observed recall advantage for impression-inconsistent behaviors over consistent behaviors (i.e., inconsistency effect; Stangor & McMillan, 1992) was attenuated in later adulthood. This aging-related attenuation seemed in line with existing views of diminishing cognitive resources in later life in that superior memory for inconsistencies appears to reflect attempts to resolve them (Hastie, 1984), which in turn consumes more processing resources than the encoding of consistent behavioral information (e.g., Srull, 1981). Hess and Tate (1991) also found, however, that older adults benefited as much as younger adults when they engaged in inconsistency resolution; they just did it less frequently. Hess et al. (1998) hypothesized that older adults' resource allocation, as reflected in inconsistency resolution, might be affected by the meaningfulness of the task. They tested this idea by comparing person memory under standard impression formation instructions versus instructions to evaluate the target person's suitability for a specific job. Consistent with expectations, the age deficit observed in recall of inconsistent information under standard instructions was attenuated when the task was placed in a more meaningful context.

This research was extended in a subsequent study (Hess, Rosenberg, & Waters, 2001) that investigated the impact of two motivational factors—social accountability and personal relevance—on both impression formation and behavior recall. Consistent with the hypothesized increase in selectivity, Hess et al. found that age differences observed in the strength of the inconsistency effect in recall under standard test conditions were eliminated when participants were held publicly accountable for their responses. It was also observed that increasing the personal relevance of the target information resulted in more accurate, less schema-driven encoding of trait information by older adults, with the accuracy and specificity of this information being comparable to that of younger adults. In a related study, Chen (2004) also found that increasing accountability was associated with reduced age differences in source discrimination and that the impact of accountability on performance was greater for older than for younger adults.

Finally, in a more recent set of studies, Germain and Hess (2004) tested the hypothesis that disproportionate effects of distracting information on older adults' attention and comprehension of text (e.g., Carlson, Hasher, Connelly, & Zacks, 1995) would be moderated by personal relevance of the stimulus materials. They found that reading times, text memory, and memory for distracting information were all affected by personal relevance. Consistent with expectations, however, relevance was observed to have a disproportionate benefit on the performance of older adults.

In sum, the work reviewed here supports the hypothesis that aging-related variations in goal-related processes can affect observed age differences in memory performance. Although research in this area is only in its initial stages, the evidence presented suggests that adaptive changes in goals may influence the manner in which information is processed, what type of information is remembered, and whether cognitive resources are allocated to support performance. The suggestion here is not that variations in goals can account for all aging-related variance in performance. To the contrary, except in a few cases (e.g., Rahhal et al., 2002), older adults still exhibited lower levels of performance in studies examining goals. Rather, the case being made is that goals are one of a number of factors that determine observed age differences in memory, and studies of aging and memory may misrepresent older adults' abilities to the extent that they do not consider the interaction between goals and the test context in determining performance.

Several limitations also exist in the just discussed work with respect to goal-related processes. First, the reviewed studies typically do not explicitly assess goals. Instead, age differences are inferred from variations in the nature of responses in general or across test conditions. As research progresses in this area, it would be useful to examine the correspondence between independent assessments of goals and memory performance across age groups. In addition, this research is limited by current theory in terms of both describing the nature of changing goals in relation to adult development and explicating the relationship of such goals to memory functioning.

Social Context and Beliefs About Aging

Another set of factors that could potentially account for systematic intraindividual variation in memory functioning has to do with culturally shared belief systems. Within cultures, individuals tend to share a common set of beliefs about the aging process, including ideas concerning the abilities of individuals at different points in the life span. Such belief systems may influence development by affecting the manner in which society responds to individuals on the basis of their age, both at a microlevel (e.g., interpersonal interactions) and a macrolevel (e.g., public policies relating to work and retirement). Development may also be shaped by individuals internalizing age-relevant beliefs, which may affect memory performance by influencing perceptions of one's own ability and behaviors on the basis of these perceptions.

In this section, primary interest centers on examining evidence relevant to the general hypothesis that negative cultural views about aging will affect age differences in memory performance through their impact on both self-referent beliefs and stereotype activation. In particular, discussion is focused on (a) how these views might be translated into perceptions of and reactions to older adults as well as into self-relevant beliefs and cognitions and (b) the mechanisms by which beliefs and, more generally, aging stereotypes might ultimately influence behavior. Note that there are several excellent recent reviews of this literature (e.g., Berry, 1999; Hertzog & Hultsch, 2000; Hummert, 1999; Miller & Lachman, 1999). Thus, the focus in this section will be to use representative findings to illustrate the role of beliefs in determining age differences in memory rather than to provide an exhaustive review.

Beliefs about memory. Research on memory-related beliefs in relation to aging has been conducted from a wide range of perspectives, including the examination of stereotypes, control beliefs, and memory self-efficacy. Within this literature, Hertzog and Hultsch (2000) distinguish between two general categories. *Implicit beliefs* reflect the informal ideas that individuals have about the nature of memory and its developmental course as applied to most people. In contrast, *self-referent beliefs* reflect expectations about change in one's own ability and the factors that influence performance and change. Whereas the focus of these two types of beliefs varies, the results of research suggest a common theme; specifically, aging is associated with declining memory skills and reductions in the ability to control memory.

Stereotypes about old age compose one type of belief in which these perceptions have been amply demonstrated. Within Western culture, a common component of these stereotypes is that aging is associated with negative cognitive attributes, such as slow thinking, senile behavior, and forgetfulness (e.g., Hummert, Garstka, Shaner, & Strahm, 1994). Whereas it is also true that aging stereotypes are multifaceted (e.g., Hummert et al., 1994) and that there are slight variations in content on the basis of experience with older adults (e.g., Luszcz & Fitzgerald, 1986) and age of the individual (e.g., Heckhausen, Dixon, & Baltes, 1989), it is also clear that negative aging stereotypes involving memory are present in adults of all ages (e.g., Heckhausen et al., 1989; Hummert et al., 1994).

These negative stereotypes affect how older individuals are viewed and reacted to by others. For example, memory failures in older adults are more likely to be viewed as reflections of mental difficulty than are the same failures in younger adults (e.g., Erber

& Rothberg, 1991; Erber, Szuchman, & Rothberg, 1990), resulting in more sympathetic reactions toward older than younger adults (Erber, Szuchman, & Prager, 1997). Hummert (1999) has further argued that cues associated with older adults' physical appearance and behavior may activate aging stereotypes in others, which in turn influence behavior toward these same individuals. For example, research has shown that many individuals use patronizing talk with older adults (e.g., Kemper, 1994; Ryan & Cole, 1990), even though it is viewed as demeaning and disrespectful (e.g., Ryan, Meredith, & Shantz, 1994). Stereotype-based treatment by others may heighten older adults' awareness of the aging-related beliefs held by these individuals as well as the fact that they are being viewed as members of the stereotyped group. Such treatment may serve as a mechanism through which stereotypes can influence older adults' memory performance, for example, through the impact of associated affective responses or activated belief systems (e.g., Cavanaugh, Feldman, & Hertzog, 1998).

These stereotypic beliefs about aging are also reflected in beliefs about oneself, both in terms of the level of one's abilities as well as the factors that underlie their operation and modification. For example, many studies using relatively varied assessment techniques have reported that older adults in general have lower self-efficacy beliefs about their memory than do younger or middle-aged adults (e.g., Berry & West, 1993; Berry, West, & Dennehy, 1989; Gilewski, Zelinski, & Schaie, 1990; Hultsch, Hertzog, & Dixon, 1987; R. L. West, Dennehy-Basile, & Norris, 1996). Similar findings have been obtained for control beliefs, where aging has been shown to be associated with an increase in beliefs about the lack of control over one's own cognitive and memory functioning, including the course of decline (e.g., Heckhausen & Baltes, 1991; Hertzog, McGuire, & Lineweaver, 1998; Hultsch et al., 1987; Lachman, 1986; Lachman, Bandura, Weaver, & Elliott, 1995; Lachman & McArthur, 1986). Hertzog and Hultsch (2000) noted that null findings regarding the relationship between an individual's age and self-referent beliefs about aging do exist in the literature but that such results are clearly in the minority.

Whereas there may be some legitimate basis for these variations in self-efficacy and control beliefs as people age, there is also evidence that society's implicit theories about aging may influence perceptions of change in areas where there is little evidence of change (Lineweaver & Hertzog, 1998; McDonald-Miszczak, Hertzog, & Hultsch, 1995; McFarland, Ross, & Giltrow, 1992). These implicit theories may also help to explain the oft-observed increase in memory complaints with age, but the frequent failure to find a relationship between memory complaints and actual performance in older adults (see Hess & Pullen, 1996; Miller & Lachman, 1999).

Memory-related beliefs and performance. The pervasiveness of stereotype-based beliefs within our culture is important from a contextual perspective, in that it suggests a potential age-graded mechanism underlying changes in memory performance. Support for such a mechanism would be obtained from research demonstrating that relationships exist between memory and self-referent beliefs of control and self-efficacy and that such associations account for age differences in performance. In general, individuals with higher control or self-efficacy beliefs perform better on a variety of everyday and laboratory memory tasks. For example, Cavanaugh and Poon (1989) tested young and older adults on immediate and delayed recall of words and text and found that 25%–53% of recall variance was accounted for by measures relating to control and self-efficacy after controlling for general ability. They also observed that the strength of the relationship between memory beliefs and performance was stronger in the older adults than in the young. Although this latter effect is not always observed, many studies (e.g., Berry et al., 1989; Hertzog et al., 1998; Lachman, Steinberg, & Trotter, 1987; Luszcz & Hinton, 1995; Riggs, Lachman, & Wingfield, 1997; R. L. West et al., 1996; Zelinski, Gilewski, & Anthony-Bergstone, 1990) have demonstrated similar relationships between beliefs and performance using a variety of responses (e.g., recall, recognition), materials (e.g., prose, words), and task contexts (e.g., laboratory, everyday). Whereas some researchers (e.g., Berry et al., 1989; Cavanaugh & Poon, 1989) have found that substantial amounts of performance variance (25%–53%) are accounted for by beliefs, the strength of this relationship is relatively modest (3%–15%) in many studies (see also Hertzog & Hultsch, 2000). This variability in results may be accounted for by differences in participant characteristics and by the specific assessments of beliefs and memory. For example, Berry et al. (1989) found that the amount of performance variance accounted for by self-efficacy beliefs was stronger for everyday-type memory tasks (e.g., remembering a grocery list) than for laboratory-type tasks (e.g., remembering a list of words), suggesting that experience may be an important component of this relationship. Variability may also be related to the specificity of the relationship between beliefs and the type of memory being studied (e.g., Hertzog, Dixon, & Hultsch, 1990).

Relationships between beliefs and memory have also been observed in longitudinal studies (e.g., Albert et al., 1995; Johansson, Allen-Burge, & Zarit, 1997; Lane & Zelinski, 2003; McDonald-Miszczak et al., 1995; Seeman, McAvay, Merrill, Albert, & Rodin, 1996) and studies involving multiple trials (e.g., Lachman et al., 1987), with higher control or self-efficacy beliefs at initial testing being associated with better performance or maintenance of ability at later times of test. In addition, older adults with higher self-efficacy beliefs have also been found to benefit more from memory training (Rebok & Balcerak, 1989).

These findings all suggest that a relationship between memory beliefs and performance does exist and that observed aging-related declines in memory may in part be accounted for by changing belief systems. Critical to such conclusions are examinations of the extent to which age differences in memory performance can be accounted for by variations in beliefs. Few studies have systematically investigated this question, however, with most testing belief–performance relationships within age groups. Hertzog et al. (1998) did examine beliefs as a mediator of age effects, using general memory self-efficacy beliefs and task-specific control attributions to predict free recall of a list of 40 words in a sample of individuals aged from 18 to 93. They found that age differences in these two types of beliefs indirectly influenced recall through strategy use. They also found that a significant amount of age-related variance in recall (about 75%) remained after controlling for beliefs. This finding is clearly consistent with a contextual view of aging and memory in demonstrating multiple potential determinants of age differences in performance.

A major problem with research in this area is the difficulty associated with demonstrating specific causal links between beliefs and performance. Whereas the emphasis in the present discussion has been on the pathway from beliefs to performance, it is also reasonable to assume that beliefs will change in response to ability (e.g., Lachman & Leff, 1989). One way to investigate the causal impact of beliefs on performance is through intervention studies. A recent meta-analysis of such research (Floyd & Scogin, 1997) demonstrated that training does result in improved beliefs about one's memory capabilities. Whereas this does not necessarily suggest that changes in beliefs will lead to changes in performance, it does indicate a linkage between the two that is sensitive to context (e.g., exposure to training). It is interesting to note that the size of the effect obtained in this analysis ($d = 0.19$) was substantially smaller than that ($d = 0.66$) obtained in another meta-analysis of training effects on memory performance (Verhaeghen, Marcoen, & Goossens, 1992). This suggests that such beliefs are well-ingrained in older adults and that alteration may be difficult or transient, even in the face of improvements in memory performance. It is important to note that several studies have demonstrated that memory training, either alone or accompanied by a focus on beliefs or goal-setting, can result in changes in memory-related beliefs along with improvements in performance (e.g., Lachman, Weaver, Bandura, Elliott, & Lewkowicz, 1992; R. L. West, Welch, & Thorn, 2001). The somewhat unsettled state of knowledge regarding causal linkages in this area is most likely related to the complexity of the reciprocal relation between these factors (e.g., Bandura, 1997; Berry, 1999; Lachman, 2000).

Whereas there is evidence in support of a relationship between beliefs and performance, the actual mechanisms of influence are still open to debate. Reasonably, motivation should mediate the relationship between control or self-efficacy beliefs and performance, and recent work by R. L. West and colleagues (R. L. West, Thorn, & Bagwell, 2003; R. L West et al., 2001) has demonstrated a relationship between self-efficacy beliefs, goals, and performance in older adults. Further work in this area would be useful in elucidating this relationship.

Stereotypes. An underlying assumption of much of the just discussed work is that memory beliefs are an indirect expression of Western stereotypes about the impact of aging on cognitive ability. Recently, researchers have begun to explore more direct linkages between aging stereotypes and performance that does not rely on the mediating influences of beliefs. For example, Levy and Langer (1994) tested young and older groups of Americans and Chinese for their beliefs about aging and then assessed memory performance (memory for dots in a spatial array, recall of activities associated with faces). It was found that age differences in memory were related to the degree to which individuals within each of these cultures displayed positive views of aging. Views toward aging were less positive in the Americans than the Chinese, and age differences in memory performance were larger in the former group. In addition, variations in culturally influenced beliefs about aging were found to account for a significant amount of variability in older adults' performance.

Yoon, Hasher, Feinberg, Rahhal, and Winocur (2000) attempted a conceptual replication of this study using Chinese Canadians and Anglophone Canadians. Similar to Levy and Langer (1994), they found that the former group had more positive views of aging than the latter and that culture moderated the impact of age on memory performance using a composite memory score. When performance on individual tests was examined, however, the interaction between age and culture on memory was only evident on two of four tests. In addition, these two tests assessed visual memory for characters that were similar to Chinese ideographs, leading Yoon et al. to suggest that the observed culture effect on memory may be more experience-based rather than reflective of variations in aging attitudes. This interpretation was further supported by their failure to find that positive attitudes about aging mediated the relationship between culture and aging.

Although Yoon et al. (2000) failed to completely replicate Levy and Langer's (1994) results, direct comparisons across studies are complicated by the use of different memory measures and the fact that the Chinese Canadians in Yoon et al.'s study had actually lived in Canada and thus were likely to experience exposure to Western aging attitudes and stereotypes. Interpretation of the Levy and Langer results is also complicated by potential selection factors associated with recruiting equivalent samples across cultures. Thus, although their findings are intriguing, it is clear that further work needs to be done to clarify the relationship between cultural stereotypes and memory.

One question that arises from this research concerns the specific mechanisms through which cultural stereotypes could influence performance. One possible avenue is through situational factors that affect awareness of one's aging status and, subsequently, affect performance through processes associated with the conscious activation of negative aging stereotypes. Steele's (1997) stereotype threat framework has been used to guide some initial work in this area. Within this framework, negative stereotypes about a group are assumed to have a detrimental impact on the behavior of group members when they are put in the position of potentially confirming that stereotype. Situational cues of which the individual is aware (e.g., participation in a memory experiment) are thought to activate stereotypes (e.g., old people have poor memories), which in turn may negatively impact performance because of increased anxiety or decreased effort.

Some support for the operation of stereotype threat in relation to aging has been observed. Two sets of studies have found that differences in memory performance between young and older adults were significantly reduced when the diagnostic value of the test with respect to the stereotyped ability (i.e., memory) was de-emphasized. Rahhal, Hasher, and Colcombe (2001) found that age differences in performance on a sentence memory task, obtained when participants were informed that the test was intended to examine their memory ability, were eliminated when the memory aspect of the task was de-emphasized. Similar effects were observed by Hess, Hinson, and Statham (2004) in a free-recall task when participants who were told the task was commonly used to assess the effects of aging on memory were compared with those who were not.

Hess, Auman, Colcombe, and Rahhal (2003) provided a more specific test of the stereotype threat framework in relation to memory performance. In this study, young and older adults were either explicitly informed about the positive or negative aspects of aging on memory, or they were told nothing. They were then given a free recall test for a list of words. Hess et al. obtained evidence for activation of the negative aging stereotype in the negative information condition but attenuation of its activation in the positive condition. They also found that older adults' free recall performance was affected by condition, with recall in the negative information group being about 70% of that in the positive group. The strength of this effect increased as investment in one's own memory ability increased, a finding consistent with expectations drawn from Steele's (1997) theory. Finally, the threat manipulation also affected older adults' strategy use, which partially mediated the impact of threat on recall performance. This suggests a specific mechanism through which threat operates.

Other research, however, suggests that stereotypes may have a more direct impact. There is a growing literature detailing the impact of implicit (i.e., without awareness) stereotype activation on performance in younger adults (see Wheeler & Petty, 2001). Important for present purposes is the finding that implicit activation of stereotypes relating to aging have resulted in younger adults acting in a manner that is consistent with the stereotype: walking slower (Bargh, Chen, & Burrows, 1996), remembering less (Dijksterhuis, Aarts, Bargh, & van Knippenberg, 2000), and responding more slowly (Dijksterhuis, Spears, & Lépinasse, 2001) than participants in a control condition. Bargh (1997) has suggested that such effects are based in ideomotor actions, whereby environmental cues directly activate stereotype-related behavioral tendencies with little conscious involvement. Similar stereotype activation effects would be expected in older adults. In addition, the self-relevant nature of aging stereotypes might be associated with higher levels of accessibility and greater breadth of application (e.g., more situations associated with activation) in later life, leading to more pervasive effects.

In an initial study in this area, Levy (1996) examined the impact of implicit stereotype activation on performance in a series of memory tasks (recall of words, activities paired with photos, and dots placed on a spatial array). She found that older adults' performance improved following positive stereotype activation and worsened following negative stereotype activation, although the strength of this effect was somewhat variable across tasks. Using a similar procedure, Stein, Blanchard-Fields, and Hertzog (2002) only partially replicated these results. However, recent research by Hess et al. (2004), using two different methods to implicitly prime positive and negative aging stereotypes, did replicate Levy's basic findings. Specifically, older adults' free recall of a word list was about 10% worse following exposure to the negative prime than to the positive prime. These findings, taken with those from studies of young adults, demonstrate the potential impact of negative stereotypes in later life as well as the pervasiveness of this impact. They also suggest that stereotypes may have a direct effect on performance through relatively automatic goal structures, with associated activation of beliefs or conscious reactions being unnecessary for performance to be affected. The inconsistency in the strength of priming effects across studies is somewhat troubling but may reflect the use of different types of tasks with different demands on cognitive resources across studies. Perhaps most important for present purposes, however, is the reliable impact of stereotype activation observed by Hess et al. with a widely used memory task (free recall) that has shown consistent age effects and is affected by the availability and efficient use of cognitive resources.

In sum, the research discussed in this area provides further support for the proximal influence of aging-related beliefs on memory. There is substantial evidence for the existence of negative stereotypes about aging and memory in our culture, as well as evidence that such stereotypes are reflected in the self-referent beliefs of older adults. In addition, evidence was also provided regarding linkages both between self-referent beliefs and performance and between cultural stereotypes and memory performance. Research also indicates that there are specific situational factors that may enhance the effects of beliefs on performance. Important for present purposes, some of these situational factors (e.g., emphasis on the diagnostic value of laboratory tests for assessing memory ability, advertising for older adults to participate in memory research) are common components of many laboratory studies of aging and memory. This raises the possibility that the testing context in interaction with cultural stereotypes may exaggerate the strength of aging effects on memory performance. In addition, the fact that the impact of aging stereotypes on performance appears to strengthen with age suggests another nonability proximal influence underlying the typically observed age differences in memory performance.

Context and Interindividual Variation

In the previous section, the focus was on proximal factors that influenced normative, intraindividual variation in the course of memory development. In this section, the discussion turns to distal influences, with the primary concern being the identification of contextual factors that may result in variation in the course of memory change across individuals. Consistent with a contextualist view of memory and aging, the following general hypothesis might be proposed: The nature and severity of aging effects on performance are influenced by the characteristics and behaviors of individuals and the contexts in which they function. In this section, evidence relevant to this hypothesis is examined, with the focus being on the moderating effects of health status, lifestyle, and specific experience. These areas were selected primarily because of the reasonable quantity or quality of studies on these topics.

Health

The role of biological factors has already been discussed, with an eye toward identifying potential normative variation in such factors as a determinant of intraindividual change in memory performance. One conclusion from that research was that subclinical pathological conditions (e.g., presenile dementia) may underlie some of the observed age effects, thereby highlighting the potential influence of nonnormative variations in biological factors associated with health. Given the cumulative nature of health-related effects across the life span as well as the higher rates of health problems in later life, health status is one nonnormative factor that may have an important impact on the course of memory change and the degree to which individuals experience memory problems late in life. Any health issue affecting the integrity of the nervous system should impact the course of memory in later life. The results of many studies indicate quite clearly that health, both in terms of general aspects and more specific problems, has an important effect on memory functioning. Several recent investigations have shown that significant amounts of age-related variance in memory performance are accounted for by indicators of health status. For example, Nilsson et al. (1997) examined the relationship between various aspects of memory functioning and health in 1,000 adults aged from 35 to 80. Little relationship was observed between performance and subjective health. However, more objective indices (e.g., systolic blood pressure) accounted for substantial age-related variance in memory performance (e.g., free recall of words and sentences) that could reasonably be considered to reflect the controlled processing mechanisms discussed earlier. Specifically, age accounted for 34% of the variance in performance, and objective health indicators accounted for 62% of this age-related variance.

Studies using self-report measures of health (e.g., Earles, Connor, Smith, & Park, 1997; Hultsch, Hammer, & Small, 1993; Perlmutter & Nyquist, 1990) have also observed relationships with memory performance, although the strength of these associations and the degree to which they accounted for age-related variance in memory are reduced relative to observations using more objective measures (e.g., Nilsson et al., 1997). For example, Hultsch et al. (1993) examined health–memory relationships in a sample of 55–86-year-olds using a self-report health status indicator (e.g., perceptions of overall health, reported symptoms and diseases). It was found that this measure was significantly associated with memory performance (working memory, word and text recall) and that it accounted for small but significant amounts of age-related variance. It is important to note, however, that Hultsch et al. (1993) found that health was most important in accounting for variance in basic information-processing aspects of memory (e.g., working memory) that are reflective of controlled processing mechanisms. Similar findings were obtained by Perlmutter and Nyquist (1990) using a wider age range (20–80+). A study by Salthouse, Kausler, and Saults (1990) that included 362 adults aged 20–79 found little relationship between memory performance (paired-associate learning, memory span) and self-rated health. This study, however, used more general subjective assessments of health (e.g., self-report of health on a 5-point scale) than the just discussed studies, which may have diminished the strength of health–behavior relationships.

Some longitudinal studies have also examined relationships between changes in health and changes in memory performance. For example, Albert et al. (1995) followed 70–79-year-old adults over a 2-year period and found that amount of strenuous activity and peak expiratory flow rate were significant predictors of the degree of cognitive change—indexed in part by nonverbal (spatial recognition) and verbal (word recall) memory—over that period. In contrast, Hultsch, Hertzog, Small, and Dixon (1999) did not observe any relationship between initial level of or change in self-reported health and change in memory functioning over a 6-year period in a group of individuals aged 55–87 at initial assessment. The discrepancy in results may have to do, once again, with the use of more subjective indices of health status in the Hultsch et al. study.

There is also a fair amount of research on the relationship between cognition—including memory—and specific health problems. For example, cardiovascular disease and diabetes are associated with lower levels of memory functioning (for a review, see Waldstein, 2000). The prevalence of these two conditions is also associated with age in adulthood, suggesting that at least some degree of aging-related memory decline might be associated with specific health problems. Indeed, research has shown that high blood pressure in midlife or persistent high blood pressure is associated with lower levels of memory functioning and greater levels of decline (e.g., M. F. Elias, Wolf, D'Agostino, Cobb, & White, 1993; Swan, Carmelli, & La Rue, 1996). Similar findings have been obtained for diabetes, with additional evidence that the impact of diabetes on later cognitive functioning is greater for those with hypertension than for those without (e.g., P. K. Elias et al., 1997). Finally, research on terminal decline indicates that memory—in this case, digit span—like other aspects of cognitive functioning, tends to decline precipitously just prior to death (Johansson & Berg, 1989). This suggests that biological decrements associated with declining health preceding death are more important determinants of memory decline than aging per se.

In sum, there is substantial evidence linking memory deficits and decline to disease processes that have a probabilistic relationship with aging, with this linkage being stronger when objective rather than subjective indices of health are used. Some caution should be exercised in that many studies rely on cross-sectional data, which limits our ability to discover temporally based causal connections and increases the probability of sample selection effects. Fortunately, there is emerging longitudinal data that support the general implications of this research. These findings also do not provide strong evidence for the inevitability of significant decline—at least until late in life—given that some of the just discussed factors are only probabilistically related to age and may be to a certain extent influenced by lifestyle factors. Thus, whereas normative change may occur, it may be the case that distal factors under the control of the individual (e.g., health promoting behaviors) or the environment (e.g., opportunities to engage in such behaviors) will influence the rate and degree of change, leading to significant individual variability.

Lifestyle

Behaviors of the individual or factors associated with the environment in which he or she functions may influence the course of memory development and contribute to interindividual variation therein. Such contextual variables may operate somewhat indirectly through their impact on health, as discussed above, or they may operate more directly by having a specific influence on memory skills themselves. In this section, the focus is on studies that examine what might be characterized as lifestyle factors. Specifically, research is reviewed that investigates the relationships between specific activities of the individual and memory functioning.

Work and leisure activities. Several studies have examined how both the nature and frequency of activities engaged in by individuals in the course of everyday life influence aging effects on memory. In one of the first investigations of this nature, Craik, Byrd, and Swanson (1987) found that older participants assumed to have higher activity levels exhibited higher levels of memory performance (paired-associate learning, free word recall) and required less environmental support to bolster their performance than did presumably less active older adults. Unfortunately, activity level was inferred indirectly from measures such as place of residence, leading to the possibility of selection effects associated with these measures. Hill, Wahlin, Winblad, and Bäckman (1995) attempted to disentangle the effects of age and activity on need for environmental support in a sample of 253 adults aged from 75 to 96 years. They found that self-reports of active lifestyle and exercise were positively correlated with memory performance (free and cued word recall), and they accounted for 2%–10% of the variance across memory tasks even after controlling for age and education. Of theoretical importance is the fact that the variance accounted for by the lifestyle factors was greatest when environmental support was lowest. In other words, active lifestyle was associated with the ability to engage in self-initiated strategic activities necessary for supporting performance, suggesting a link between context and the efficiency of specific controlled processing mechanisms hypothesized to be affected by aging.

Other studies have also investigated the relationship between lifestyle factors and memory, with varying degrees of success. Luszcz, Bryan, and Kent (1997) tested 951 adults ranging in age from 70 to 96 years. Significant positive correlations were obtained between memory (e.g., incidental memory for pictures and symbols) and engagement in activities at home and in the community—assessed using the 21-item Adelaide Activities Profile (Clark & Bond, 1995)—with noncognitive summary variables (including activity) accounting for 37–45% of age-related variance on three memory measures. When considered within the context of other health and ability factors, however, the contribution of activity was substantially reduced. This most likely reflects the transactional nature of these variables. For example, Luszcz et al. also found that self-rated health was correlated with engagement in activities. Whereas it is likely that activity level might be predictive of maintenance of many aspects of functioning, including those associated with health, it is likely that poor health limits involvement in activities as well as the potential impact of such involvement on memory.

Erber and Szuchman (1996) examined the relationship between self-reported activity preferences and memory performance in groups of young (18–32 years) and older (63–81 years) adults. They found that preference for cognitively challenging activities was positively correlated with older adults' memory performance (e.g., name recall, digit span) but not with that of the younger adults. Once again, however, the nature of this relationship in older adults was confounded in that activity preference did not account for significant memory variance when verbal ability was controlled. In contrast, Christensen et al. (1996) found that, although the relationship was modest, self-reported engagement in activities (6-item scale) predicted memory performance (e.g., word recall, face recognition) in a sample of 664 adults aged 70–89, even after controlling for factors such as sensory functioning, health, and education. Age continued to be a significant predictor of memory performance after controlling for activity, but activity also predicted performance when age was entered in the regression equation before it. In a similar vein, Arbuckle, Gold, and Andres (1986) examined memory (forward digit span, free recall of words, memory for text) in relation to various contextual factors in a sample of 285 adults aged from 65 to 93 years. They found that 33% of the variance in a composite memory index was accounted for by education, activity (i.e., participation in 11 different social roles) and various personality factors, with age accounting for only an additional 2% of the variance above and beyond that accounted for by these variables.

Using data from the Victoria Longitudinal Study (VLS), Hultsch et al. (1993) found a positive association between measures of active (physical activities, integrative information processing, novel information processing) and passive (social activities, self-maintenance, passive information processing) lifestyle and word and text recall in 55–86-year-old adults. Consistent with the findings of Christensen et al. (1996), active lifestyle accounted for 20%–35% of the age-related variance in memory performance even when health status was controlled. Cockburn and Smith (1991) tested a group of 94 older adults (70–93 years) using the Rivermead Behavioural Memory Test. They found that self-reported frequency of engagement in various types of activities was a significant predictor of name recall, face recognition, and route learning and that activity level accounted for twice as much variance as did age in the overall profile score for this test.

Salthouse, Berish, and Miles (2002) also examined the extent to which self-reports of activity engagement, and the cognitive demands of those activities, moderated age differences in episodic memory (e.g., prose recall, word list recall). Age was found to be associated with a decrease in engagement in cognitively demanding activities, but there was no evidence that engagement mediated or moderated the relationship between aging and memory. The manner in which engagement was assessed in this study, however, may have affected the ability to identify such relationships. Specifically, the engagement index was based on both frequency of engagement in specific activities and self-reports of the cognitive demands associated with those activities. It is likely that these latter reports are fairly subjective and could conceivably be biased by existing levels of ability. For example, individuals experiencing cognitive difficulties may rate relatively simple tasks as complex, resulting in high engagement scores for those individuals. Whereas this is an interesting finding in its own right, the potential confounding of objective and subjective aspects of cognitive demands muddies interpretation of the memory–activity relationships in this study.

Although the just reviewed research does provide some support for a relationship between lifestyle factors, such as frequency of engagement in social and cognitive activities and memory performance, the cross-sectional nature of these studies limits our ability to make causal inferences. Fortunately, longitudinal evidence regarding the relationship between activity, memory, and aging is starting to accumulate. One influential set of studies by Schooler and colleagues (Schooler & Mulatu, 2001; Schooler, Mulatu, & Oates, 1999) has demonstrated a linkage between middle-aged and older adults' cognitive functioning and their participation in both substantively complex work and cognitive leisure activities. Using relatively large and representative samples from a longitudinal study, Schooler and colleagues found reciprocal relationships between cognitive functioning and engagement in complex work or leisure activities, with complexity based on the extent to which thought and independent judgment are required in dealing with diverse and ill-defined problem situations. Of importance, these effects were relatively independent of health status. One possible concern about this research for present purposes is that the measure of cognitive functioning during the first two waves of the study was based on traditional (e.g., embedded figures) and nontraditional (e.g., frequency of "agree" answers to questions during the assessment interview) measures of intellectual ability. This complicates generalizations to the domain of memory. The most recently reported wave of testing (1994/1995), however, included more standard measures of cognitive functioning, including one assessing memory: free recall of 20 words. It was found that these measures formed a unitary intellectual functioning factor along with the previously used indices and that the previously observed relationships between complexity of activity and intellectual functioning were still present using this more comprehensive factor. This, plus the fact that memory performance had one of the highest loadings on the intellectual functioning factor, provides evidence that engagement in cognitively complex activities supports memory performance in old age.

Hultsch et al. (1999) examined activity–memory relationships over a 6-year period using data from the VLS. They observed that both initial level of and change in novel information-processing activities (e.g., language learning, playing bridge) in middle-aged and older adults were positively associated with changes in working memory (i.e., those with higher and stable levels of activity were less likely to exhibit decrements over time). Similarly, Mackinnon, Christensen, Hofer, Korten, and Jorm (2003) found that declines in memory (word recall and recognition, address recall) were correlated with changes in activity levels in an older (70–93 years) sample of 887 individuals tested over a 7-year period. In addition, although a general decline in performance as a function of age was observed, this trend was not significant in those individuals who maintained levels of functioning over this period.

Although findings from the majority of these studies support the activity–memory link, there are several things to keep in mind about this research. First, most of the measures of lifestyle and activity used in these studies are self-report, leaving open the possibility that they are less than accurate indices of functioning. Second, the relationships between lifestyle and cognitive change are often small. This is not necessarily damning to a linkage between these factors, in that it may reflect the aforementioned problems with measures or the use of relatively select samples. At the same time, however, it may simply reflect a relatively small association. Third, other factors associated with memory (e.g., health) may influence engagement in the types of activities that support memory. This has a potentially complicating effect on interpretation of activity–memory relationships, although some researchers (e.g., Schooler & Mulatu, 2001) have found these relationships to persist even after controlling for health. Finally, it may also be that the observed relationships between lifestyle factors and memory reflect the possibility that changes in activity represent reactions to changes in cognitive ability rather than activity level mediating cognitive change. Hultsch et al. (1999) noted this very possibility and found that structural equation models depicting both types of relationships were similar in the degree to which they fit the data.

It is also possible that other factors can explain the activity–memory relationship. For example, smoking, alcohol consumption, and preexisting health conditions may determine both the degree to which one engages in activity and cognitive decline, with broader distal influences such as socioeconomic status and education accounting for additional variance in these predictors. A recent study by Aartsen, Smits, van Tilberg, Knipscheer, and Deeg (2002) was suggestive of just this point. They examined the alternative models discussed by Hultsch et al. (1999) in relation to cognitive change over a 6-year period in a large Dutch sample of adults aged 55 to 85. They found little evidence for initial levels of activity (frequency of engagement in 23 social, experiential, and developmental activities) or memory (word recall) predicting change in either of these measures when correlated error terms for these latent constructs at each time of test were included in the model. When the correlated error terms were not included, thereby not controlling for unknown confounds at each test, significant cross-lagged effects were observed from activity at initial test to memory at follow-up. Given that engagement in activities and cognitive ability were correlated with factors such as education and functional ability, Aartsen et al. argued that activity level, in and of itself, may not be the important determinant of cognitive decline. Rather, it may be that activity and health are tied to specific life circumstances that account for the relationship between activity and memory performance. This is not to say that activity is unimportant in explaining aging-related changes in memory performance; it simply suggests that its operation is not totally independent of other factors in the individual's life.

Finally, it is also important to note that lifestyle factors other than those related to disease may affect memory through their impact on specific brain structures. For example, individuals who experience chronic stress—either owing to stressful life events or poor coping strategies—may have specific physiological responses that will impact brain structures underlying memory performance. The relationship between blood pressure and memory has already been noted. More intriguing in this regard are studies examining the linkage between glucocorticoid levels, hippocampal volume, and memory performance in normal aging. For example, Lupien et al. (1998) observed that older adults who have experienced an increase in cortisol levels over a 5-year period and who currently have elevated levels exhibited poorer memory performance (verbal recall of objects) and reduced hippocampal volume compared with those with currently moderate cortisol levels who have experienced a decrease in these levels over the same period. Although the memory and brain volume data were only collected at the end of the study, Lupien et al. found that the variation in brain volume across groups was specific to the hippocampus, suggesting that the effect was related to cortisol levels. Related results were obtained by Seeman, McEwen, Singer, Albert, and Rowe (1997), who found that changes in cortisol levels over a 2.5 year period were correlated with changes in women's memory performance (word and story recall) over the same period. Similar findings were obtained by Greendale, Kritz-Silverstein, Seeman, and Barrett-Connor (2000).

These results are particularly important for a contextual perspective on memory and aging. Although these studies do not explicitly examine lifestyle, they do suggest that physiological responses associated with exposure to stress affect brain structures that support some of the memory functions observed to decline with age. Given that the effects on structure and function are correlated with time, the impact of stress should be more observable in older than in younger adults. To the extent that lifestyle (broadly defined) results in differential exposure to stressors and the development of effective coping strategies, then it appears that variability across individuals in decline in memory functioning in later life might be attributable to such factors.

Physical activity. More relevant to the linkage between lifestyle factors and changes in the biological structures that support memory is research that examines the impact of physical activity on performance. Given that aerobic activity has specific benefits on such things as cell growth in the hippocampus and dopamine receptor density in the brain (see Colcombe & Kramer, 2003), it has been hypothesized (Kramer et al., 1999) that the physiological benefits associated with aerobic exercise may result in the maintenance or improvement of cognitive skills (including memory) in later life. There is evidence from both cross-sectional and longitudinal studies that physical fitness is associated with cognitive performance (for reviews, see Dustman, Emmerson, & Shearer, 1994; Etnier et al., 1997), although such studies suffer from similar selection effects and problems with determining causation as those in the previous section.

Of greater relevance to an understanding of context effects, however, are intervention studies that randomly assign participants to conditions in order to assess the effects of exercise. A recent meta-analysis of this literature by Colcombe and Kramer (2003) found that exercise has systematic, positive effects on cognitive functioning. Of interest for present purposes, these researchers also found that the effect sizes associated with exercise were greater on those tasks assessing executive control (g = .68) and controlled processing (g = .46) than on those associated with visuospatial processes (g = .43) or speed (g = .27). Although few of these studies directly assessed memory performance, the types of processes categorized as controlled or executive control functions (e.g., inhibition, working memory) are directly relevant to the normative age differences in memory identified earlier. Of further interest is a recent study by Colcombe et al. (2003) that examined the linkages between aging, physical fitness, and neuronal loss. Using MRI to examine 55 individuals aged from 55 to 79 years, these researchers found that the benefits of physical fitness—in terms of preserved tissue—were most pronounced in those cortical regions most affected by aging. The participants included in this study were not part of a random-assignment intervention study, so caution must be exercised in interpreting the results. Taken together with the results of intervention studies, however, there is reasonable empirical support for level of physical activity having an impact on aging-related decline in both neural structures and cognitive performance.

In sum, there is growing evidence that the activities in which an individual engages have an important influence on the trajectory of memory change associated with the aging process. Research suggests that maintenance of functioning is associated with an active lifestyle, engagement in substantively complex work and leisure activities, and physical exercise. Note that concerns can still be raised about the findings in this area. Most important among these is the fact that behaviors associated with these factors do not occur in isolation, making identification of specific causal linkages difficult. For example, older adults who have high activity levels may also have strong social networks, which have been shown to be protective against cognitive (including memory) loss over time (Seeman, Lusignolo, Albert, & Berkman, 2001). Intervention studies of the type conducted to examine the impact of physical exercise may prove beneficial in disentangling such linkages. In addition, health-related factors that are also associated with memory functioning may limit engagement in the types of behaviors shown to be positively associated with memory performance. Note, however, that many health-related limiting factors (e.g., cardiovascular disease, diabetes) are influenced by the individual's behaviors (e.g., exercise, diet), suggesting potential control over normative aging-related memory decline.

The possibilities for control can be seen, to a certain extent, by research suggesting that specific contextual factors influence the incidence of Alzheimer's disease (AD) and the associated memory problems. For example, education has been shown to be a protective factor against the development of AD (e.g., Gatz et al., 2001). It is likely that this protection, however, is related to factors associated with education, such as level of cognitive activity, access to health care, nutrition, and knowledge related to health maintenance (Bäckman, Small, Wahlin, & Larsson, 2000; Gatz et al., 2001). This conclusion is bolstered by recent cross-cultural research by Hendrie et al. (2001), who observed that the incidence of AD was much lower in Yoruba individuals in Nigeria than in African American individuals residing in Indianapolis, even though the former group had a much lower level of education. Yoruba were observed, however, to have a diet lower in cholesterol and higher in antioxidants, which may account for the lower rate of incidence. It is important to recognize that AD is not a normal aspect of the aging process. However, the linkage between specific environmental factors and incidence rates, along with the possibility that a portion of the aging-related variance in memory performance may be related to older individuals in study samples who are in preclinical stages of the disease (Sliwinski, Lipton, Buschke, & Stewart, 1996), further highlights the importance of context in influencing the observed course of memory functioning.

Specific Experience

For the most part, the link between activity and memory has been conceptualized in general terms, with the assumption being that participation in everyday activities should increase cognitive activity, which in turn should exercise and maintain memory. An alternative way in which experiential factors may be examined is through the investigation of links between memory performance and experience in specific domains. The availability of structured knowledge and extensive practice in the use of specific memory operations within a particular domain might result in the attenuation of typical aging-related patterns of memory performance observed in atypical or unfamiliar contexts. There are two ways in which such relationships have been investigated. One is by examining the differences in aging effects on memory performance in situations that vary in terms of the extent to which they tap into generic knowledge, that is, knowledge that is assumed to be available to most individuals within a culture as a function of everyday experiences. A second method involves investigating the effects of expertise, in which the interaction between more idiosyncratic knowledge or skill and performance is examined.

Generic knowledge. With respect to generic knowledge, investigations of aging effects have typically focused on materials or situations with which most individuals are presumed to have familiarity or experience. The results of such studies have been somewhat mixed, with both young and older adults tending to benefit from task-relevant knowledge. When interactions with age do occur, however, it is almost always in terms of knowledge differentially bolstering older adults' performance and attenuating age differences (for a review, see Hess & Pullen, 1996). For example, in studies of the impact of script structure on memory, Hess and colleagues (Hess, 1985; Hess, Donley, & Vandermaas, 1989; Hess & Tate, 1992) found that age differences in both recall and recognition performance decrease as the to-be-remembered materials increase in typicality and relevance to the script. Age differences in memory for spatial information are also moderated by the availability of task-relevant knowledge, with older adults exhibiting a disproportionate benefit relative to younger adults when the to-be-remembered information is consistent with past experience (Arbuckle, Cooney, Milne, & Melchior, 1994; Hess & Slaughter, 1990; Kirasic, 1991; Waddell & Rogoff, 1981). Related results have been obtained by Wingfield and colleagues (Wingfield, Lahar, & Stine, 1989; Wingfield, Poon, Lombardi, & Lowe, 1985), who found that the provision of syntactic and prosodic cues had a disproportionate benefit on older adults' memory for word strings, especially when demands on resources were high (e.g., rapid presentation rate).

Hess (1990) argued that the disproportionate bolstering effects on older adults' memory observed in studies such as these are due to knowledge providing an easily accessed encoding structure for organizing relevant information that places few demands on—and thus may compensate for—limited cognitive resources. When such a structure is unavailable, forcing participants to actively engage in encoding activities, older adults' performance suffers.

Expertise. Other studies have examined the effects of more specific types of experience by comparing the performance of different-aged experts and novices in memory tasks that vary in the extent to which they tap into the area of expertise, in terms of both content and process. The areas of expertise examined in such research are rather diverse, including flying (Morrow, Leirer, & Altieri, 1992; Morrow, Leirer, Altieri, & Fitzsimmons, 1994; Morrow, Menard, Stine-Morrow, Teller, & Bryant, 2001; Morrow et al., 2003), music (Meinz, 2000; Meinz & Salthouse, 1998), chess (Charness, 1981), bridge (Charness, 1979; Clarkson-Smith & Hartley, 1990), baseball (Hambrick & Engle, 2002), graphic design (Lindenberger, Kleigl, & Baltes, 1992), and the game of Go (Masunaga & Horn, 2001). Of primary interest in these studies was whether or not expertise would attenuate the effects of age on performance. In every case, expertise was demonstrated to have a positive impact on performance in participants of all ages, with the effects being specific to tasks associated with the area of expertise. In other words, the expertise effects could not be attributed to the experts having better general memory skills. Rarely, however, did expertise moderate age effects on performance, with the effects of age and expertise generally being additive in nature. In those cases in which aging effects were attenuated by expertise, they were not eliminated (e.g., Lindenberger et al., 1992; Morrow et al., 1994), with the degree of attenuation appearing to be limited by task difficulty (e.g., Charness, 1981; Morrow et al., 2001).

As with generic knowledge, research testing predictions regarding the moderating impact of expertise on aging memory has tended to emphasize the compensatory benefits of knowledge on performance. Another, less frequently investigated possibility is that expertise may modify specific cognitive mechanisms that support memory functioning. Consistent with this hypothesis, Clarkson-Smith and Hartley (1990) found that older adults who were active members of bridge clubs had superior working memory skills (e.g., reading span) when compared with similarly aged individuals who did not play bridge. Given that individuals in these two groups did not vary on a variety of other factors, such as education, verbal ability, and processing speed, these researchers argued that the differences could be accounted for by greater exercising of working memory skills in those who played bridge.

In a similar vein, Shimamura, Berry, Mangels, Rusting, and Jurica (1995) examined memory skills in young (30–44), middle-aged (45–59), and older (60–71) university professors to test the hypothesis that an active mental life would preserve such skills in later life. Performance of these professors was compared with that of standard young and old samples similar to those used in many studies in the literature. Performance declined with age on a paired-associate task, with the nature of the age effects being very similar across samples. When working memory was examined using the self-ordered pointing task, the professors performed better than participants in the standard sample. Although they performed worse than younger professors, the older professors did exhibit a greatly reduced error rate over blocks of trials relative to older adults in the standard sample. Finally, in a test of prose recall, young adults in the standard sample recalled more than older adults. Professors, however, recalled more than both of these groups, with no age differences being observed. An obvious concern with this research involves selection effects associated with cognitive ability in the professor group as well as the comparability of this group with the standard group on factors other than experience. The research is suggestive, however, that engagement in mental activities may have an ameliorating effect on aging-related decline, with the effects being greater for skills more closely linked to characteristic activities of the profession (e.g., prose recall) than for those with less clear linkage (e.g., paired-associate learning). Christensen and colleagues (Christensen, 1994; Christensen, Henderson, Griffiths, & Levings, 1997) conducted a similar type of study but did not find that academic status moderated aging effects on memory (e.g., word recall, figure recognition). Compared with the older professors in Shimamura et al. (1995), however, those in the Christensen studies were retired and about 10 years older on average, perhaps suggesting less recent and frequent engagement in the cognitive activities necessary for maintaining function.

Masunaga and Horn (2001) have recently provided related evidence by demonstrating that expertise in the game of Go was associated with the development of specific abilities—*expertise working memory* and *expertise deductive reasoning*—that were relatively independent of more general abilities reflecting the same skills. They in turn found that intensive practice accompanying increasing age was associated with significantly reduced aging-related decline in working memory functioning within the domain of Go.

In sum, there is evidence that aging effects on memory are affected by the specific experience of the individuals within a particular domain, with effects being of two primary forms. One effect appears compensatory in nature, with experience-based knowledge appearing to benefit older adults because it provides an easily accessible organizational structure that minimizes demands on processing resources and thus limits the impact of reductions in cognitive resources. More relevant for present purposes are studies by Clarkson-Smith and Hartley (1990), Masunaga and Horn (2001), and Shimamura et al. (1995) that focused on specific memory processes, such as those associated with working memory. Findings from this research suggest that extensive practice in a specific domain may have a beneficial impact on specific memory functions associated with controlled processing mechanisms. Whereas such findings are clearly supportive of a contextual perspective, this support must be tempered by the fact that these findings may be subject to sample selection effects associated with both the cross-sectional nature of the research as well as the use of preexisting groups (i.e., experts vs. nonexperts).

Conclusion

The goal of this review was to examine the validity of a contextual view of adult age differences in memory through an exploration of research examining both alternative mechanisms accounting for systematic aging-related performance variance as well as factors that moderate the course of memory change in later life. Consistent with a life span contextual perspective, the evidence presented here provides support for a less monolithic view of the nature of aging-related variation in memory than implied by many studies based in the information-processing perspective. Whereas there is some evidence suggestive of systematic changes in brain structures and functions (e.g., PFC) underlying memory performance (Prull et al., 2000; Raz, 2000), the bases of such changes are still not clearly understood. For example, observed age differences in the patterns of activation obtained from neuroimaging studies have typically been attributed to neuronal loss or neurochemical change and associated compensatory mechanisms (e.g., Craik & Grady, 2002). It is possible, however, that this variation may also reflect use of inefficient strategies on the part of older adults, which may be related to contextual factors (e.g., task relevance) that influence cognitive engagement. In other words, patterns of activation may be reflections of strategy use rather than the other way around. In addition, there is evidence that some aging-related variation observed in memory and cognitive performance is attributable to health-related factors (Waldstein, 2000) that have a probabilistic, not inevitable, connection to age.

Of interest for a contextual perspective is the considerable amount of evidence of interindividual variation in the course of memory development during adulthood. Research has shown that engagement in substantively complex activities (e.g., Schooler, Mulatu, & Oates, 1999), an active lifestyle (e.g., Hill et al., 1995), physical exercise (Colcombe & Kramer, 2003), and exercise of specific skills (e.g., Clarkson-Smith & Hartley, 1990) are all associated with memory skills reflective of efficient controlled processing. In addition to the obvious relationships between things like physical exercise and health, there is evidence that some of these lifestyle factors are related to variations in the brain structures and functions thought to underlie observed age differences in memory (e.g., Colcombe et al., 2003; Lupien et al., 1998). Such evidence suggests that both the environment and individual exert a certain amount of control over the course of memory change.

This review also revealed evidence for mechanisms unrelated to the integrity and efficiency of the information-processing system as potential determinants of systematic intraindividual variation in memory performance. In particular, two general classes of such age-graded proximal influences were identified. First, research suggested that variation in memory performance might be associated with aging-related shifts in goals associated with social–cognitive functioning (e.g., Adams et al., 2002), perspectives of time (e.g., Carstensen & Turk-Charles, 1994), and cognitive resource conservation (e.g., Hess et al., 2001). A second general category of proximal influences is associated with culturally based stereotypes of aging, which may affect performance either indirectly through belief systems (Hertzog & Hultsch, 2000) or through a more direct route associated with their activation from situational cues (e.g., Bargh et al., 1996; Hess et al., 2003; Levy, 1996).

Note that the goal- and stereotype-based processes discussed here may not necessarily be independent of other aging-related changes (e.g., Freund & Baltes, 2002), including those associated with biologically based aspects of development. For example, some intrinsic goals (e.g., need for cognitive structure) that have been found to be predictive of engagement in complex cognitive activity have also been shown to be associated with variation in health-related resources (e.g., Hess, 2001), suggesting a possible linkage between changing biological and motivational systems. What is important, however, are the facts that (a) not all developmentally relevant goals are driven by changes in biological structures, (b) goals can determine the encoding and retrieval operations underlying mnemonic functioning, and (c) the effects of aging-related changes in biological process on memory performance may be mediated by goals associated with those changes (see also Kruglanski & Webster, 1996).

The list of contextual factors identified and reviewed here is by no means exhaustive. Other research exists that is relevant to a contextual perspective, but it was not included because of either the relatively small number of studies examining memory or limited relevance to understanding developmental processes underlying memory in adulthood. For example, research is beginning to emerge that examines the role of culture in determining the nature of age differences in basic cognitive functions, including memory (Hedden et al., 2002). Such research may be particularly informative not only in terms of identifying the effects of specific cultural experiences and belief systems on the aging of memory but also in terms of identifying the biological versus experiential bases of aging-related change (Park & Gutchess, 2002). Examination of the role of collaboration in memory functioning in later life may also provide important clues about adaptive and compensatory changes in memory functioning across the adult life span (Dixon, 1999). There is also evidence that age differences in memory performance are moderated by the time of day at which testing occurs (see Winocur & Hasher, 2002). Although these circadian rhythm effects are present in all individuals, aging-related changes in the actual time of day during which peak functioning occurs have obvious implications for valid assessment of age differences in optimal levels of performance. There is also evidence that time-of-day effects may be stronger in later life (e.g., Hasher, Chung, May, & Foong, 2002; R. West, Murphy, Armilio, Craik, & Stuss, 2002) although this is not always observed (e.g., Intons-Peterson, Rocchi, West, McLellan, & Hackney, 1999), perhaps reflecting process-specific relations. Nonetheless, these findings suggest another potential moderator of performance with implications both for assessment and understanding of age differences in memory.

The relative importance and contribution of the various contextual influences examined here is still subject to a fair degree of speculation given the paucity of focused research designed for such purposes. A systematic quantitative analysis of, for example, effect sizes associated with different factors would also be useful in this regard. The diversity of samples and research designs (e.g., lab experiments using extreme groups designs, longitudinal studies, analyses of archival data) examined in the present review as well as varied statistical means for examining context effects (e.g., interaction effects using analysis of variance, moderating and mediating effects using regression, path coefficients based on structural equation modeling), however, made such an analysis of the literature somewhat unfeasible at this point in time.

At the same time, an examination of effects from representative studies does indicate the potential importance of considering the mediating and moderating influences of multiple factors. For example, in research on stereotype influences (Hess et al., 2003, 2004, Experiment 2), the effect sizes associated with implicit (d =

0.96) and explicit (d = 0.90) stereotype activation on older adults' memory performance are almost as large as those associated with age following negative stereotype activation (ds = 1.36 and 1.02, respectively). Similar findings are found when goal influences are examined. For example, Fung and Carstensen (2003) observed that the memory advantage for emotional over nonemotional content of advertisements in older adults (d = 0.52) was larger than the overall difference between young and older adults (d = 0.08). The relative contribution of different contextual influences can also be seen in several studies. For example, on the basis of standardized path coefficients, Schooler and Mulatu (2001) found that leisure activity (.18) and socioeconomic status (.25) were almost as strongly related to maintenance of ability as age (−.21), whereas self-reported health status was a relatively poor predictor. Similarly, MacKinnon et al. (2003) found that changes in activity levels (.22) and grip strength (.30) were significantly associated with changes in memory performance, as was age (−.45), whereas change in self-reported medical problems was not (.02). The important point is that these studies demonstrate that a variety of distal factors account for significant variability in performance in adulthood, supporting a multidimensional approach to the study of aging and memory.

Whereas this review does suggest multiple determinants of aging-related variation in performance, it by no means denies the reality of some normative decline in memory. Almost every study cited in the present article presents some evidence of aging-related decrements in performance. For example, in studies providing support for the influence of nondeficit determinants on performance (e.g., Carstensen & Turk Charles, 1994; Hess et al., 2003), age differences in performance were typically moderated rather than eliminated. The reviewed research does suggest, however, that there is more variability in the rate and course of change in memory functioning as well as in the factors responsible for change than suggested by many studies in the literature. It is likely that normative change associated with basic information-processing mechanisms may be strongest toward the end of life as changes in the central nervous system place increasing constraints on functioning and minimize the influence of other factors (e.g., Li et al., 2004; Lindenberger & Baltes, 1997; Park, Nisbett, & Hedden, 1999).

Implications for the Study of Aging and Memory

The identification of multiple proximal and distal influences on age differences in memory performance is important at a number of levels. First and foremost, it provides a more thorough perspective on the factors that influence variations in memory performance across adulthood. The operative contextual factors identified in this review are consistent with the life span perspective on the study of development (P. B. Baltes, 1987; P. B. Baltes et al., 1979) in that they appear to reflect history-graded (e.g., cultural stereotypes), age-graded (e.g., developmentally based selection), and nonnormative (e.g., lifestyle) influences. The cognitive-aging process implicit in most current work on memory, presumably representative of age-graded programmed or environmental influences (see Clark, 1999), represents just one aspect of one of these categories of influence. The research discussed here argues for consideration of additional factors, such as goals and social context, as important explanations for both normative and individual variation in memory in adulthood. For the most part, these alternative influences are not inconsistent with the study of aging within an information-processing framework; they have just been neglected. This research also suggests that the commonly observed patterns of aging-related decline—in terms of timing and rate of change—may not be as universal as implied in much of the extant literature, with the probability of an individual conforming to observed patterns being in part related to his or her specific experiences. Within the context of Jenkins's (1979) model, the present review provides considerable evidence for a broader definition of context relating to subject characteristics, both in terms of proximal and distal influences.

Second, some of the contextual influences identified in this review have implications for assessment procedures in studies of aging and memory. Specifically, several studies suggested that situational factors that are unrelated to ability (e.g., stereotype activation, task relevance, time of day) may influence the extent to which age differences are observed in performance. The validity of observed age effects—in terms of the degree to which they reflect "true" ability differences—in any given study may be questioned to the extent that these factors were not considered in the design of the study. For example, recruiting older adults to participate in a study of aging and memory might result in stereotype threat in the testing situation, which in turn could depress their performance and compromise assessments of competence in the memory domain. Similar concerns are present when there are mismatches across age groups between participant goals or interests and the nature of the task. Motivational factors may help to explain discrepancies in performance observed using traditional ability assessment tasks and those obtained with more engaging tasks when both sets of tasks are thought to tap into the same skills (e.g., Garden, Phillips, & MacPherson, 2001).

Finally, the contextual factors identified in this review also have implications for the nature of prevention and intervention. For example, encouragement either to continue engagement in cognitively demanding activities, to participate in physical exercise, or to develop coping strategies to effectively deal with stress could result in greater probability of maintenance of memory abilities and preservation of crucial brain structures in later adulthood. In addition, it appears that the success of training programs designed to alleviate older adults' memory problems will be dependent not just on providing specific memory-based training experiences but also on restructuring of beliefs and counteracting stereotypes.

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