# 11

# Aging and Long-Term Memory: Deficits Are Not Inevitable

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The study of memory encompasses a wide range of phenomena that, together, lie at the center of the individual's cognitive, social, and personal functioning. Indeed, a recent textbook on human memory begins: "If we had no memory, in the broadest sense of the term, we would not be able to function. Memory is essential for all activities" (Neath & Surprenant, 2002, p. 1). The authors note that memory is involved when we ride a bicycle, read, have a conversation, create imagined events, and formulate and update an image of one's self. This diversity was not much acknowledged in the research literature until the onset of the cognitive revolution in the 1960s. However, much of the history of the last 35 to 40 years of research on memory has seen both basic work done on the subdivisions of memory (e.g., working memory, long-term memory, etc.) and an increasing interest in understanding the embeddedness of memory in other cognitive, social, and biological functions. Indeed, we note that very recent work on the roles of social and biological factors is in the process of changing our views about the degree to which we may have overestimated the aspects of memory that really do change with healthy aging. These moderating factors are discussed in the final section of this chapter. We begin, however, with a classic view of aging and memory, a view that suggests that there is variability in the degree to which one can expect to see changes in performance.

Here, we focus on long-term memory, and in this literature, there are replicable findings of age-related decline, stability, and even in some cases, increase in memory performance. Thus, a central fact about memory in the later years of life is the *variability* of age patterns. As well, a number of factors are now known to contribute to this variability, including the cognitive ones that were of initial interest to the field (e.g., type of memory test, familiarity of the materials, concurrent demands), participant characteristics (e.g., verbal ability, education level, domain expertise), biological factors (e.g., circadian synchrony, physical fitness), and social and emotional variables (e.g., activation of negative age stereotypes, remembering in the service of interpersonal goals).

Given this diversity of outcomes and the wide range of factors known to play a role in that diversity, it is hardly surprising that a variety of theoretical accounts of aging and memory have been proposed and that they continue to garner support from at least a subset of the empirical findings on age-related differences in memory. The relevant theoretical frameworks include ones emphasizing age-related declines in speed of mental processing (e.g., Salthouse, 1996), in resources for effortful processing (e.g., Craik, 1986), in the ability to bind or to form associations among elements of an input (e.g., Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000), and in inhibitory processing or executive functions (e.g., Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999; West, 1996; for overviews, see Balota, Dolan, & Duchek, 2000; Park, 2000; Zacks, Hasher, & Li, 2000). In addition, it is increasingly clear that views encompassing social and emotional factors (e.g., Charles, Mather, & Carstensen, 2003; Hess, Auman, Colcombe, & Rahhal, 2003) are also important to our understanding of how memory is impacted by normal aging.

At a global level at least, there are significant parallels between the literatures reviewed in this chapter and in Ornstein, Haden, and Elischberger's chapter (Chapter 10, this volume) on children's memory development. For example, similar to the findings for older adults, the research on children's memory demonstrates variability in age effects across different forms of memory (e.g., conditioning vs. event recall) and also as a function of various contextual and task demand variables (e.g., prior knowledge, retrieval demands of the memory test). Additionally, although the specific issues and perspectives differ, investigators of both children's and older adults' memory have recently shown increased interest in the impact of social and emotional factors. These latter effects may be challenging to all theories of aging and memory, in part because the widely reported age differences on some memory tasks can be overcome by instructions, materials, and other factors that are probably noncognitive in origin.

Our review of the aging and memory literature is selective but tries to give a flavor of the richness of the findings as well as of the diversity of theoretical viewpoints. The chapter is organized into three major parts. The first is a brief summary of major empirical generalizations about aging and memory that will serve as background for the second section, which focuses on episodic memory (or deliberate, intentional memory for particular events) and includes discussions of research on mechanisms of retrieval and on memory errors (source and false memories). These topics are of considerable current interest, are being studied from different theoretical perspectives, and make contact with research on memory development in children. The final section considers noncognitive (social, biological) factors that have important moderating effects on age-related differences in memory. These findings are changing the understanding of memory and aging in the same way as such factors changed our understanding of memory and development.

## MAJOR FINDINGS ON AGING AND MEMORY

Spurred on by theoretical considerations as well as striking dissociations in behavioral and neurocognitive findings (e.g., dissociations in the memory effects of localized brain damage), memory researchers have, over the last 30 years, increasingly come to the conclusion that long-term memory, like the memory system as a whole, is not a unitary system. Although the field still lacks consensus on a full-blown model of the architecture of long-term memory, there is fair agreement about the major subdivisions of long-term memory. At the highest level, a distinction is made between *explicit* or *declarative memory* and *implicit* or *nondeclarative memory*. Explicit memory is measured by tests that invoke deliberate, conscious retrieval of information stored in memory. By contrast, implicit memory tests measure the effects of prior experience or learning through performance in the absence of deliberate recollection—for example, by increases in accuracy and/or decreases in reaction time when a response to a particular stimulus is repeated.

Various subdivisions of both explicit and implicit memory have also been proposed. Within explicit memory, the distinction between *semantic* and *episodic* memory (Tulving, 1972) is of particular relevance to aging. Semantic memory includes our vast storehouse of general knowledge of such things as the meanings of words and concepts or facts about the world in which we live. This information is not tied to specific time-space parameters. Episodic memory, on the other hand, includes our memories of information associated with specific events and is defined by the ability to retrieve features of the spatial/temporal context in which the event was experienced.

Distinctions have also been proposed between different subtypes of nondeclarative memory (e.g., procedural memory for highly practiced skills, classical conditioning), but we limit our discussion to the type of implicit memory that has received the most attention in aging research—namely, *repetition priming*. Repetition priming studies involve a two-phase procedure in which the first phase uses an orienting task (e.g., pleasantness ratings) to expose participants to some experimental materials (e.g., pictures, words, etc.). This is followed by a test phase in which the processing of the previously presented items (e.g., on a perceptual identification or fragment completion task) is compared to that of new items to determine the amount of benefit from the prior exposure.

With these distinctions in mind, we turn to findings for age effects on three major components of long-term memory: repetition priming, semantic memory, and episodic memory. Figure 11.1, from Nilsson (2003), presents cross-sectional data that were collected as part of the Betula project, an ongoing longitudinal, prospective study of memory development in adulthood that began in 1988 (see, e.g., Nilsson et al., 1997). Three of the four panels in the figure (all but panel c) display typical results from tests measuring different forms of long-term memory performance. Similar patterns of findings have been obtained in numerous studies that have examined an array of long-term memory functions in older adults (e.g., see Figure 1.1 in Park, 2000, and Figure 1 in Park et al.,

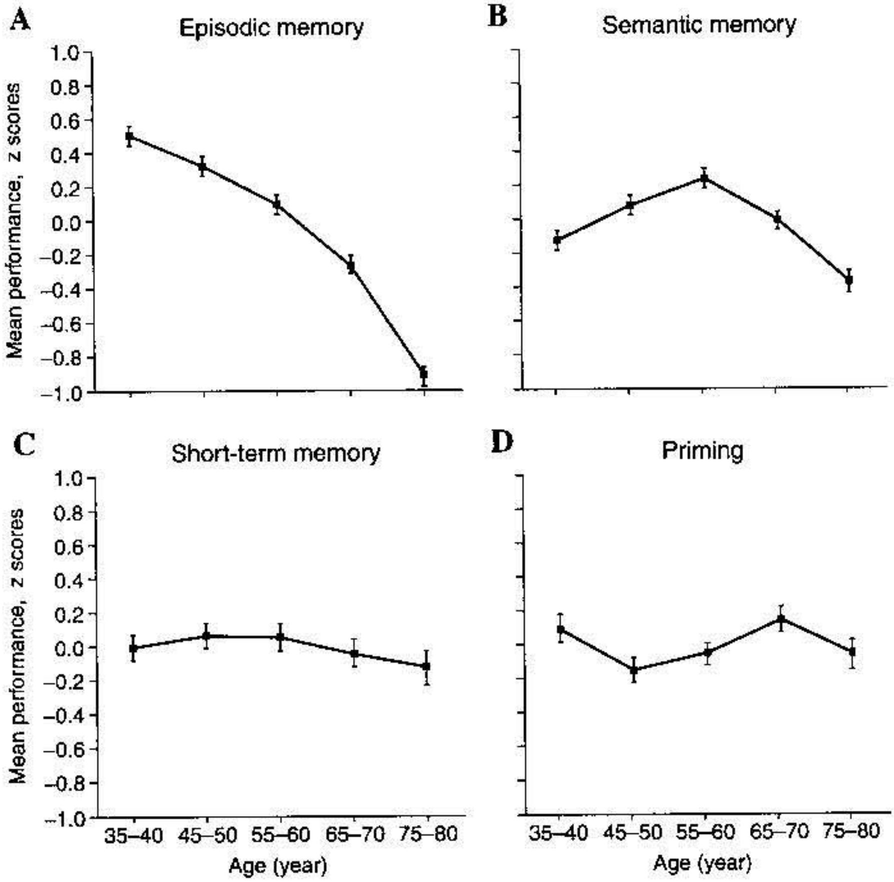


FIGURE 11.1. Mean performance as a function of age in tasks assessing episodic memory, semantic memory, short-term memory and the perceptual representational system. (From Nilsson, 2003, p. 9. Reprinted with the permission of Blackwell Publishing.)

2002). In other words, the age patterns shown in Figure 11.1 are quite robust and the figure provides a good, albeit very global, summary of findings on aging and long-term memory. It is apparent that there is considerable variation in age-related differences across different forms of long-term memory.

### Repetition Priming

Analyses of findings on age differences in repetition priming, including formal meta-analyses, have consistently pointed to the conclusion that age differences in this form of implicit memory are quite small relative to age differences in episodic memory, and frequently nonsignificant in individual studies (cf. Fleischman & Gabrieli, 1998; La Voie & Light, 1994; Light, Prull, La Voie, & Healy, 2000). In addition, these analyses suggest that there is minimal variation in age effects across priming tasks that differ considerably in the types of processing involved. In particular, age differences in priming are small and roughly equivalent whether the experimental task is a so-called perceptual priming task (e.g., perceptual identification or picture naming) that relies on the processing of perceptual features or a so-called conceptual priming task (e.g., category instance generation or answering general knowledge questions) that relies on the processing of conceptual or meaning features. (The data in Figure 11.1d are based on a perceptual priming task, stem completion.) Likewise, age effects do not, on average, differ between *item* and *associative* priming, the former referring to priming effects deriving from the repetition of individual familiar items (words, pictures of common objects) and the latter to priming effects deriving from repetition of novel stimuli or novel connections between known items. In view of the findings of large age deficits on explicit measures of memory for new associations (see below), it is somewhat surprising that age deficits are not larger on associative than on item priming measures.

With respect to lifespan patterns, Ornstein et al. (Chapter 10, this volume) mention that performance on implicit memory shows minimal developmental change (p. 144) and, more generally, that children from a very young age show similar patterns of effects on "nonverbal measures" including those such as conditioning that are generally included in the implicit/nondeclarative memory category (pp. 144–145). These findings indicate parallels in the early years to the relative constancy of implicit memory in the later years of life.

### Semantic Memory

Semantic memory is another area of relatively preserved performance across the adult lifespan. The data in Figure 11.1b are derived from vocabulary and general knowledge tests, and as is frequently found with similar measures, show an increase in semantic memory performance through the early 60s followed by a gradual decline. However, steeper age deficits do occur on certain semantic memory tests (e.g., Nyberg et al., 2003). These are generally semantic memory tests that put a premium on rapid retrieval of information from memory, as, for example, in fluency tests that measure the number of words beginning with a particular letter or from a particular category that a participant is able to produce in a short time. The greater age deficits on such tasks relative to, for example, a multiple-choice test, are generally assumed to be due to retrieval difficulties rather than to deficits in semantic memory representations themselves. Semantic memory (apart from speed of retrieval) appears to be an area of relatively spared cognitive functioning in old age.

### Episodic Memory

As is suggested by the data in Figure 11.1a, age patterns for episodic memory differ significantly from those for repetition priming and semantic memory. Indeed, one of the clearest results to emerge from research on aging and memory is the strong age-related declines in explicit memory for recently experienced events—that is, on episodic memory tests for new information. Such deficits have been consistently demonstrated in both cross-sectional and longitudinal studies, with a wide variety of materials, and with various episodic memory tests (including free recall, cued recall, yes/no and forced-choice recognition, and source memory tests). A closer look at the episodic memory findings from the Betula study (summarized in Figure 11.1a) provides a clear demonstration of the pervasiveness of age-related decline in episodic memory. The eight episodic memory tests administered to Betula study participants include measures of "prospective memory, face recognition, name recognition, action memory, sentence memory, word recall with or without a distractor task, source memory, and memory for activities" (Nilsson et al., 2002, p. 186). Consistent with numerous other studies, the Betula project has demonstrated robust age deficits on each of these measures (e.g., Nilsson et al., 1997, 2002). Indeed, significant negative age trends are seen in normative data on episodic memory measures included in standardized neuropsychological assessments of memory, such as the Logical Memory component of the Wechsler Memory Scale (Wechsler, 1997) and the California Verbal Learning Test (Norman, Evans, Miller, & Heaton, 2000). Given that event recall and use of strategic encoding and retrieval processes are both aspects of episodic memory, it is clear from Ornstein et al.'s review (Chapter 10, this volume) that robust age differences are also true of children's memory development.

### Summary

This brief overview of findings on three subtypes of long-term memory clearly demonstrates the theme of variability in age patterns for different memory functions. In the next part of this chapter we delve more deeply into the component of long-term memory that appears to show the largest age deficits, episodic memory.

## FURTHER EXPLORATION OF AGE DIFFERENCES IN EPISODIC MEMORY

The overall pattern of poorer episodic memory performance with increasing age as is displayed in Figure 11.1a masks some intriguing complexities. More specifically, an examination of different episodic memory tasks and different testing conditions reveals interesting and seemingly important variations in the precise pattern of age differences. A prominent example of such differential age trajectories within episodic memory is the pattern of age effects typically found for recall versus recognition tests. Early evidence (e.g., Schonfield & Robertson, 1966) indicated that recognition tests show smaller age declines than recall tests, a result that continues to receive confirmation. Among the more recent findings are the results of Nyberg et al.'s (2003) structural equation modeling analyses of the performance of 925 individuals between the ages of 35 and 80 from sample 3 of the Betula study. These data support a division of episodic memory into recall and recognition subcomponents. As well, they find that the recall factor shows greater age deficits than the recognition factor. One account of the differential age trajectory for recall and recognition (Bäckman, 1989; Craik, 1986; Craik & McDowd, 1987) presumes a reduction in cognitive resources. Because of this, older adults generally engage in less self-initiated processing than do younger adults, including (in the present instance) less of the kind of strategic search processes that are essential for good recall but that are less important for recognition. Similar arguments have been made in the child development literature with respect to the relative age invariance on recognition, as compared to recall tasks (see Ornstein et al., Chapter 10, this volume, pp. 144–145). In any case, the recall-recognition differences in older adults are also consistent with a more general theoretical perspective on the processes underlying episodic memory, the *dual-process* viewpoint, to which we now turn.

### Recollection and Familiarity

Although far from new (e.g., Bahrick, 1970), the dual-process approach has received considerable recent attention as a possible basis for integrating a broad range of episodic memory findings, including findings relating to age differences. This theoretical perspective encompasses a body of specific models that propose that episodic retrieval is dependent on the dual processes of *recollection* and *familiarity* (for recent reviews, see Light et al., 2000; Rugg & Yonelinas, 2003; Yonelinas, 2002). Although there is some variation in the specific definitions proposed by different authors, the following from Rugg and Yonelinas (2003) is representative: "recollection depends on a relatively slow process . . . which yields qualitative information about the previous study events (e.g., when or where an item was studied). By contrast, familiarity reflects a purely quantitative 'strength-like' memory signal" (p. 313).

A common claim of dual-process views (Light et al., 2000; Rugg & Yonelinas, 2003) is that recall tasks are more heavily dependent on recollection processes than are recognition tasks. More specifically, it is argued that familiarity alone can support accurate recognition performance, especially on recognition tasks using forced-choice procedures and/or dissimilar distractors (Bastin & Van der Linden, 2003), whereas recollection processes are the primary basis of accurate recall. With respect to aging, it is further argued that, because of the differential impact of aging on the underlying neural mechanisms or other factors (see below), recollection processes show greater age-related declines than familiarity processes.

At least two different procedures have been developed to study the contributions of recollection and familiarity to various tasks and their potential differential rates of decline with aging: the *process-dissociation procedure* and/or the *remember-know procedure*. In a typical instance of the former procedure (first used by Jacoby, 1991), participants study items under two or more conditions or arranged in two or more lists and then are tested in two types of memory tests. In the *inclusion* test participants are told to recall or recognize any studied items, whereas in the *exclusion* condition they are instructed to recall or recognize only a specified subset of studied items (e.g., those that were presented in the second of two lists). According to the analysis of Jacoby and colleagues (e.g., Jacoby, 1991; Jacoby, Yonelinas, & Jennings, 1997), whereas performance on inclusion tests benefits from independent contributions of familiarity and recollection, accurate performance on the exclusion test is dependent on the recollection of qualitative information about how and when the item was initially studied. This analysis serves as the basis for equations that can be applied to inclusion and exclusion test data to provide quantitative estimates of the familiarity and recollection processes for particular conditions and for particular groups of subjects (for details see Jacoby, 1991; Jacoby et al., 1997).

In the remember-know procedure, standard yes/no or forced-choice recognition test conditions are combined with introspective reports about the qualitative characteristics of the memories that resulted in a judgment that a particular test item was "old" (i.e., had been included in the study list). Participants are asked to distinguish between items they judged to be old because they explicitly recall some qualitative information about the study episode (*remember* items) and items they judged to be old because of an acontextual feeling of familiarity (*know* items). These two types of reports map onto recollection and familiarity, respectively (Light et al., 2000; Rugg & Yonelinas, 2003; Yonelinas, 2002).

Regardless of method, age differences are typically larger for recollection than for familiarity (for recent reviews, see Light et al., 2000; Yonelinas, 2002). More specifically, age deficits are uniformly significant on measures of recollection derived from both the process-dissociation (e.g., Jennings & Jacoby, 1993) and remember-know (e.g., Java, 1996) procedures. The pattern of age differences for familiarity estimates is somewhat more variable, with some studies reporting age constancy (e.g., Java, 1996; Jennings & Jacoby, 1993) or even higher familiarity scores (Parkin & Walter, 1992) on the part of older adults and others reporting age deficits (e.g., Mark & Rugg, 1998), albeit smaller than those for recollection. According to Yonelinas (2002), the latter outcome is associated with high levels of overall recognition and thus may reflect distortions relating to ceiling effects. Such qualifications aside, there seems to be a general consensus in the literature that "normal aging disrupts recollection but leaves familiarity largely unaffected" (Yonelinas, 2002, p. 471).

To provide concrete illustrations of this pattern, we briefly review two recent studies using remember-know and process-dissociation procedures. In the first, Bastin and Van der Linden (2003) used the remember-know procedure to investigate age-related differences on two types of recognition tests—yes/no and forced-choice. The comparison of the two types of recognition tests was predicated on findings from prior research (especially with amnesic patients) suggesting that relative to yes/no recognition memory performance, forced-choice recognition performance is more dependent on familiarity and less dependent on recollection. Various predictions that follow from these suggestions were confirmed by Bastian and Van der Linden in a study that used unfamiliar faces as the test materials. In particular, in addition to confirming the suggestions of a greater contribution of familiarity to forced-choice than to yes/no recognition, Bastian and Van der Linden found the expected greater age deficit for a yes/no than for a forced-choice test. These differences as a function of type of recognition test were associated with an overall age decrease in recollection and an increase in familiarity.

Our second example from the recent literature is a study by Davidson and Glisky (2002) that employed the process-dissociation procedure to investigate the contribution of recollection and familiarity to age differences on a yes/no word-recognition test. Study of two lists of words was followed by either an inclusion test (respond "yes" if the item was on either studied list) or an exclusion test (respond "yes" only to items from one of the two study lists). An important aspect of this study was the examination of hypotheses about the brain structures supporting recollection and familiarity. As summarized by Davidson and Glisky, findings from various sources (including studies of patients with localized brain damage as well as ERP and neuroimaging data) suggest that recollection relies on both medial temporal lobe and frontal lobe structures, whereas familiarity is primarily associated with medial temporal lobe structures (see also Rugg & Yonelinas, 2003; Yonelinas, 2002). To pursue these suggestions, the present study employed a neuropsychological test battery that Glisky and colleagues (Glisky, Polster, & Routhieaux, 1995; Glisky, Rubin, & Davidson, 2001) had previously shown reliably distinguishes among older adults who have selective impairments of either frontal lobe or medial temporal lobe function or both. Familiarity and recollection estimates from four groups of older adults, representing all possible combinations of high and low frontal lobe and high and low medial temporal lobe function as measured by the Glisky battery, were compared to estimates from a group of young adults. Relative to the young adults, familiarity estimates were significantly reduced only in the low medial temporal lobe subgroups of older adults, and recollection estimates were significantly reduced in both the low medial temporal lobe and low frontal lobe subgroups. These data thus support, at least in a general way, proposals about the neural substrates of recollection and familiarity, and they suggest that age deficits in both recollection and familiarity vary among older adults in accordance with an individual's functioning of the relevant brain mechanisms.

The assertion that recollection relies on frontal and medial temporal lobe structures is also interesting because structural and neurophysiological data indicate that these structures (and within the medial temporal lobe, particularly the hippocampus) show greater age-related change than other brain regions (Raz, 2000). However, the story is as yet incomplete. For example, it is presumed that the medial temporal lobe structures underlying recollection and familiarity are at least partially nonoverlapping, but the specific details have yet to be worked out. One proposal (Rugg & Yonelinas, 2003; Yonelinas, 2002) is that the hippocampus plays a critical role in recollection and that familiarity depends more on extra-hippocampal/perirhinal structures. If supported by additional research, such proposals may provide at least a partial explanation of why recollection typically shows greater age deficits than does familiarity.

As the above examples suggest, when combined with task analyses, neurocognitive considerations, and the use of various experimental paradigms, dual-process views provide the foundation for integrating a diverse array of findings on age-related differences in episodic memory and, as suggested by the Davidson and Glisky study, potentially also individual differences among older adults.

## Items and Associations of Items or Features

Closely related to the dual-process views we have just considered, and also possible candidates for accounts of heterogeneity of age effects in episodic memory, are views that distinguish between episodic memory for the individual elements (features, components, or items) of an input and memory for pairings between items (Naveh-Benjamin, 2000) or between items and contextual features (Chalfonte & Johnson, 1996). A number of studies have demonstrated that age-related deficits are smaller for items than for item-item or item-feature combinations even if the age groups are equated on memory for individual items. For instance, Naveh-Benjamin and colleagues (2000, 2001; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003; see also Castel & Craik, 2003) have carried out a series of experiments in which study of a list of paired items is followed by independent tests of memory for the items and for the associations between the items. The consistent outcome of these experiments is a greater age deficit in the associative memory tests relative to the item memory tests. This outcome is interpreted by Naveh-Benjamin as a manifestation of a general age-related deficit in association formation, the *associative deficit hypothesis*. A closely related view, the *feature binding deficit view*, has been applied by Johnson and colleagues (e.g., Chalfonte & Johnson, 1996; Mitchell, Johnson, Raye, & D'Esposito, 2000) to findings (from experiments using arrays of differently colored objects) that demonstrate a disproportionate age deficit in memory for combinations of features (e.g., item and color information) relative to memory for individual features (e.g., item or color information).

There is considerable overlap between the associative/binding deficit views and the dual-process recollection-familiarity view. In particular, the definition of recollection as involving retrieval of qualitative information about the earlier study event implies that a recollected memory contains not only the core item of information but also contextual features (e.g., location, temporal order, surface appearance) and perhaps other items experienced in the same context. If so, it is a small step to argue that associative/feature binding deficits in older adults account for their reduced recall of qualitative contextual information about earlier experiences and thus their lower levels of recollection, and also to argue that older adults' relatively intact item/element memory serves as the basis for relatively intact familiarity processes. Despite the possibility of making such connections, it remains to be seen whether the associative deficit and feature binding deficit views can be fully integrated with the more traditional dual-process distinction between recollection and familiarity. For now, it seems to us that research on certain topics draws more heavily on one set of views than the other. Research on recall-recognition differences is heavily based on the familiarity-recollection distinction; in contrast, research on age-related differences in source memory and in memory errors (topics to which we now turn) frequently invokes notions of associative/feature binding deficits.

## Source Memory

*Source memory* refers to the ability to remember the conditions surrounding the encoding of a particular episodic memory. Research on source memory typically employs a broad definition of source that, in addition to information directly specifying the source of the experience (e.g., was the event directly experienced or imagined; did person A or B report the event?), encompasses various aspects of the encoding context, including perceptual, spatio-temporal, affective, and social features (cf. Glisky et al., 2001). Consequently, source memory and context memory are largely interchangeable terms in the relevant literature and will be treated as such in the following discussion.

A meta-analysis by Spencer and Raz (1995) indicated that age deficits in memory of source/contextual features are both large (average age effect size, *d*., was ~0.9) and fairly uniform across feature type (perceptual qualities, input modality, spatial location, external source vs. self-generation, etc.). For example, visual perceptual features such as spatial location and the color, case, and font of verbal items are less well remembered by older than younger adults (e.g., Chalfonte & Johnson, 1996; Naveh-Benjamin & Craik, 1995). Likewise, relative to younger adults, older individuals show poorer memory for perceptual features of auditory inputs such as the speaker's voice (e.g., Bayen & Murnane, 1996). Temporal order memory is also reduced in older adults (e.g., Dumas & Hartman, 2003). And finally, age deficits are found for features that would be considered relevant within even a narrow definition of source, including features such as whether particular items were presented visually versus auditorially (e.g., Light, La Voie, Valencia-Laver, Albertson-Owens, & Mead, 1992), or in video versus photo format (Schacter, Koutstaal, Johnson, Gross, & Angell, 1997), or were seen in a video versus mentioned in a questionnaire about the video (Mitchell, Johnson, & Mather, 2003), or were overtly produced by the individual (or read or heard) versus imagined in response to a prompt from the experimenter (e.g., Hashtroudi, Johnson, & Chrosniak, 1990; for more complete reviews of this literature, see Spencer & Raz, 1995; Zacks et al., 2000.)

A central issue in the literature on aging and source memory is whether age deficits in memory for context are *differentially greater* than those in memory for content. Larger age effects for source than for content memory implies that source memory involves age-sensitive mechanisms (e.g., item and context binding) that are relatively unimportant for content memory. By contrast, similar size age effects for source and content memory suggest that similar factors contribute to the age deficits for both types of information. The results of Spencer and Raz's (1995) meta-analysis provided fairly conclusive evidence of greater age effects on memory for context than on memory for content: In contrast to the large average age effect size for context/source memory, the average age effect size for content was only moderate (*d*. ~ 0.6). Spencer and Raz's findings also suggested that, in contrast to memory for content, age deficits in context memory are unaffected by type of test (recall or recognition), but that older adults have particularly poor memory for general contextual features (e.g., spatio-temporal information) as compared to information that is more directly tied to target content (e.g., target color or size). More recent data add further evidence to these general patterns of results, including the differential impact of aging on memory for source information (e.g., Dywan, Segalowitz, & Arsenault, 2002; Larsson & Bäckman, 1998; Newman, Allen, & Kaszniak, 2001). Because of the considerable overlap in relevant theoretical views, we consider theoretical accounts of age effects in source memory in conjunction with proposals about age differences in memory errors (our next topic).

### Memory Errors

Source confusion is an important memory error in its own right, but it is also often invoked in accounts of other types of errors. This is particularly clear in research involving experimental models of eyewitness memory, including research using the Loftus post-event misinformation paradigm (e.g., Loftus, Miller, & Burns, 1978). In typical instances of this paradigm, participants view a live enactment or a video or a series of slides of an event such as a burglary or a car accident, and then are asked to complete a questionnaire on the depicted event. The questionnaire contains misinformation in the form of subtle suggestions about specific objects or actions that conflict with the actual information in the enacted event. When participants are subsequently asked to report, either on recall or recognition tests, what they observed in the original enactment, the suggested misinformation is frequently incorporated into their memory reports. Among others, Johnson and colleagues (e.g., Johnson, Hashtroudi, & Lindsay, 1993; Lindsay, 1994) have argued that these errors, in large part, reflect source-monitoring failures in which the participant confuses suggested information with witnessed information. Such confusion is facilitated by the semantic overlap between the witnessed event and the questionnaire and by the fact that any given piece of information could have been both in the original event and in the questionnaire, so remembering that the information was in the questionnaire does not rule out its also having been in the original event (cf. Mitchell et al., 2003). In other words, the misinformation paradigm entails challenging source-monitoring demands. Indeed, in a recent misinformation paradigm study, Mitchell et al. (2003) found that older adults were more likely than younger adults to misattribute items suggested in a questionnaire to the preceding video of a burglary and also that older adults had greater confidence in those misattributions.

As part of a recent study using an individual differences/structural equation modeling approach to age-related differences in memory errors, Lövdén (2003) included versions of three other procedures that have been frequently used to induce "false" memories—i.e., memories of information or events that were not actually presented. In each case, study materials were presented that elicit associatively or semantically related (nonpresented) items as memory intrusions. The first procedure used by Lövdén was a category-cued recall test in which lists of category members that include most but not all of the strongest items are presented for study. After a filled delay, participants are cued with the category names and asked to recall the presented items. Previous research has demonstrated a significant level of false recall of the omitted category members. Lövdén's second procedure, the Deese-Roediger-McDermott (DRM) procedure (Roediger & McDermott, 1995), also uses lists of associatively semantically related words. In this case, the words in each list are all associates (e.g., *thread, pin, eye, sewing*, etc.) of a critical nonpresented word (*needle*). This critical word is likely to occur as an intrusion—that is, as a false memory—whether memory is tested by recognition or recall. Finally, Lövdén also used a paradigm developed by Koutstaal and Schacter (1997) in which sets of pictures of items from various categories (e.g., shoes, chairs) are used as the study materials. The recognition test includes new pictures from the studied categories (related lures) as well as pictures of unrelated objects. False alarms to the related lures occur at a much higher rate than to the unrelated new pictures.

Although there are some exceptions (Kensinger & Schacter, 1999), the typical outcome with respect to age differences in the above paradigms is an increase in false recall or recognition for older adults in the face of decreased or age-equivalent memory for presented items (e.g., see Balota et al., 1999; Koutstaal & Schacter, 1997). Lövdén's (2003) experiment confirmed these findings with a sample of 146 participants ranging in age from 20 to 80. False memory increased with age on each of the three memory tasks, whereas veridical memory either decreased (category-cued recall, DRM) or remained constant (picture memory task). In addition, false and veridical memory were negatively correlated across individuals, and confirmatory factor analysis of the false memory data, as well as other individual difference variables, indicated that false memory scores from the three tasks all loaded on a common false-memory factor.

The literatures reviewed in this and the previous sections suggest a consistent pattern of age-related increases in the occurrence of memory intrusions and distortions. That is, using a variety of procedures and materials, older adults have been found to be more likely than younger adults to confuse nontarget information with semantically and associatively related target information and to include such nontarget information in their memory reports. In the next section, we attempt to relate the memory error findings to the dual-process viewpoints discussed earlier.

### Recollection, Familiarity, and Memory Errors: Possible Commonalities

Although it is far from certain that a common underlying factor accounts for the basic developmental patterns that have been found in studies examining age differences in recollection and familiarity, source memory, and memory errors, there seems to be a common empirical thread. As has been suggested by Craik and others (e.g., Craik, 2002), older adults appear to be more disadvantaged relative to younger adults when the memory test calls for retrieval of detailed, precise information about the encoding event than when the memory test can be performed on the basis of more general information that (in many cases) captures the meaning of the encoded event rather than its perceptual and contextual details. If this is a reasonable, broad summary of the major findings in the areas reviewed above, the question arises: what is (are) the mechanism(s) underlying this general pattern?

A variety of answers have been proposed to this question. One proposal is that reduced cognitive resources in older adults (e.g., Craik, 1986) results in reduced spontaneous use of elaborative strategies such as categorization and organization during encoding. Similar encoding outcomes, as well as reduced strategic processing during retrieval, have also been attributed to decreased frontal lobe functioning in older adults (e.g., Glisky et al., 1995; Moscovitch & Winocur, 1995). As these two examples suggest, despite invoking different causal mechanisms, proposed encoding deficits are a common theme for accounts of the greater age deficits in memory for details than for general meanings of experienced events. That is, it is frequently argued that older adults are less able than younger adults to encode into memory the perceptual and contextual details of inputs and/or to bind such features to target information. This possibility is fully consistent with the associative deficit hypothesis of Naveh-Benjamin (2000) and the binding-deficit view of Chalfonte and Johnson (1996). One further type of supportive evidence comes from the use of instruments such as the Memory Characteristics Questionnaire (MCQ; Johnson, Foley, Suengas, & Raye, 1988) to assess participants' recollections of the perceptual details, spatial and temporal context, affective responses, and so on that accompanied encoding of remembered items or events. The questionnaire results indicate that, in comparison to younger adults, older adults remember fewer perceptual (e.g., color) and contextual (e.g., list position) details of the encoding event for actually presented items, and they also show less difference in MCQ reports between veridical memories and falsely recalled or recognized items (Hashtroudi et al., 1990; Norman & Schacter, 1997). That is, the MCQ data, like much of the research we surveyed above, suggest that older adults encode fewer distinguishing features of events than do younger adults.

Reduced encoding of distinguishing details would be expected to have a direct impact on the ability to discriminate target from related nontarget memories, but it could also have more strategic effects on post-encoding processing. In particular, if older adults have fewer episodic features to work with, they may well give greater weight to the information they do encode as well as younger adults do—namely, the semantic or gist information. However, in the paradigms under consideration, gist is a poor guide to the source of a piece of information or even whether it actually occurred (for further discussion of these issues, see e.g., Lövdén, 2003; Mitchell et al., 2003).

Thus a reasonable case can be made that encoding deficits contribute to age-related differences in recollection, source memory, and memory errors. Nonetheless, there are other findings that, at the least, complicate conclusions about encoding deficits by suggesting that the supportive evidence may be tied to the use of explicit memory measures that require deliberate, conscious access to information in memory. A clear example of findings that suggest caution comes from the recent study by Koutstaal (2003). The study compared younger and older adults' memory for pictures of common objects (e.g., key, chair, banana) across three different memory tests. Older adults showed the typical increase in false alarms to related lures (different exemplars of studied objects) on a standard old/new recognition test, but they also showed *equal* benefits to younger adults from the repetition of the studied exemplar (versus a new one) on the two other tests—a test requiring recognition judgments on the basis of item type rather than exact repetition (i.e., "old" was the correct response for a new key as well as the original key) and an implicit memory test measuring repetition priming on a size-judgment task. Koutstaal (2003) interprets this pattern of findings as indicating "that older adults do, indeed, encode differentiating perceptual details—possibly even to the same extent as do younger adults, at least for certain types of task-relevant features" (p. 192), but they seem to use such features less effectively in deliberate retrieval situations.

Koutstaal's (2003) results are consistent with findings from the implicit-memory literature (summarized earlier) that demonstrate robust perceptual priming and associative priming effects in older adults. Given the small age effects on these types of memory (e.g., Light et al., 2000), it appears that older adults may encode the perceptual features of individual items (perceptual priming) and novel connections between items (associative priming) nearly as well as younger adults. If so, we need to look at the conditions of deliberate retrieval for a complete explanation of age differences seen on episodic memory tasks. We may also expect to find situations in which older adults do not show age deficits, even on memory tasks that involve deliberate access to perceptual or contextual details (e.g., source information). The next section of this chapter reviews evidence relevant to these possibilities.

## FACTORS THAT MODERATE OLDER ADULTS' EPISODIC MEMORY PERFORMANCE

The focus in this section is on recent findings suggesting that, as is the case for research comparing younger and older children (see Ornstein et al., Chapter 10, this volume), a variety of experiential, social, and affective factors can impact the performance of younger and older adults when recalling specific single events or remembering new associations between items or between target items and their contexts. When these factors are taken into account, there is good evidence that older adults can at least occasionally do as well as younger adults.

Consider the following findings from Castel (in press). In one of his experiments, younger and older adults learned paired associate lists of grocery products and prices. In one list, the prices were quite realistic and in the other they were unrealistic, overestimating some and underestimating other prices by wide margins. The memory test required participants to recall the prices that had been paired with each product on the study list. Based on other work in the area, this test should have been a sensitive test of age differences in binding, but the findings showed an interesting deviation from the pattern expected on that basis. Castel found the usual age differences for lists with unrealistic prices, but no age differences for realistic prices—even though the criterion of correct was stringent: If a product was listed as being sold at $1.79 during learning, only the answer "$1.79" was counted as correct!

Another example of excellent binding on the part of older adults comes from a series of studies in which items of information (e.g., trivia statements or facts about pharmaceuticals) were introduced, in each instance with a covarying perceptual feature. For example, in a study using trivia statements as materials (Rahhal, May, & Hasher, 2002), each statement was read by a male or female speaker, one of whom (according to the scenario provided to participants) always told the truth while the other only spoke falsehoods. In another study people learned the names and uses of pharmaceuticals (May, Rahhal, Berry, & Leighton, 2004). Here, drugs were located on the left or right of a warehouse that had had a flood that damaged all the drugs on one side. After specific facts were presented, older and younger adults were given the target items (trivia statements in one study, drug names in another). One half of the participants in each age group were tested on the perceptual features (who said it, he or she in the trivia study; and where was it, left or right in the warehouse, in the pharmaceuticals study); the other half were tested on the conceptual features (was the statement true or false; can the drug be sold or not). Across four experiments using materials analogous to these, the results were the same: older adults did less well than younger adults on the perceptual details, but did as well as the young adults on the conceptual details. Across the studies, older adults knew whether a statement was true or false, whether a drug could be sold or not, whether food could still be eaten or not, and who was a good or bad person (May et al, 2004; Rahhal et al., 2002). This performance pattern strongly suggests that older adults successfully bind some information (e.g., a statement) to other information (e.g., its truth or falseness) as well as younger adults. Thus, the binding-deficit notion cannot be universally applied to older adults since they clearly do not show it for at least some materials.

A final example of preserved memory comes from a quite different memory task than we have considered so far—that of recalling or retelling a story. In a series of studies, Adams and colleagues (Adams, 1991;

Adams, Labouvie-Vief, Hobart, & Dorosz, 1990; Adams, Smith, Nyquist, & Perlmutter, 1997) have demonstrated that the recollections of older and younger adults are not the same, with young adults being at an advantage when the typical (in this literature as elsewhere) criterion of specific details (or number of propositions) recalled is used. However, older adults recall the gist of the presented stories quite well and their recalls tend to include more integrative and interpretive information than those of younger adults. There is also evidence that when the quality of the retold story is assessed by both younger and older listeners (who are blind with respect to the age of the teller), both age groups rate the stories told by older adults as being better, more interesting tales (James, Burke, Austin, & Hulme, 1998). A particularly interesting study in this area was recently carried out by Adams, Smith, Pasupathi, and Vitolo (2002). Groups of older and younger women were asked to learn a story (a version of either a children's fable or a Sufi folk tale) so that they could retell it either to a 5–6-year-old child or to a young adult experimenter. The usual finding of greater propositional recall by younger participants was replicated when the listener was a young adult but not when the listener was a young child. In addition, both age groups made appropriate adjustments for the comprehension abilities of child listeners, using more elaborations and repetitions and decreasing the complexity of the more complex story when speaking to a child as compared to an adult listener. In fact, the complexity adjustment was greater in the case of the older tellers. Adams et al. (2002) interpret these and related findings in relation to the impact of the social context on remembering. They suggest that older adults do well at story retelling, particularly when the listener is a young child, because this task meshes well with the social cognitive goals of aging, which include transmission of social-cultural knowledge to younger generations. In the present context, a major point of the findings in this area is that older adults can do well (by some criteria better than young adults) in a memory task even when recall is assessed.

What "binds" these findings together and makes them so different from the larger literature on aging and episodic memory? Before offering some speculations, we acknowledge that recent work shows many ways in which older adults' performance in memory tests can be improved relative to typical levels of performance.

For one thing, there are age differences in circadian arousal patterns that impact a number of cognitive functions, including memory (e.g., Hasher, Goldstein, & May, 2005; Hasher et al., 1999; Intons-Peterson, Rocchi, West, McLellan, & Hackney, 1999; West, Murphy, Armilio, Craik, & Stuss, 2002; Yoon, May & Hasher, 1999). A substantial majority of older adults are morning-type people and deliberate memory is best at times that are in synchrony with one's arousal pattern (i.e., in the morning for most older adults; see May, Hasher & Stoltzfus, 1993). In the Intons-Peterson et al. (1999) study, for example, false memories of the sort we discussed earlier were differentially increased for older adults when they were tested at their nonoptimal times (in the afternoon). Such observations are nontrivial because the younger adults against whose performance older adults' memory is typically measured are most decidedly not morning-type people, biasing estimates of age differences whenever time of testing is uncontrolled, allowing a majority of participants (at the preference of typically young experimenters) to be tested in the afternoon (May et al., 1993).

Another aspect of the testing situation may be noted: The identical task instructions delivered to younger and older adults may well have very different impacts on members of the two age groups. Consider first an early study by Zacks, Hasher, and Sanft (1982). Some participants were fully informed about an upcoming free-recall task; these instructions boosted the performance of high-achieving university students relative to other students from the same group who did not know that a memory test was forthcoming. In other words, instructions regarding a deliberate memory task may well boost the performance levels of college students (see also Rahhal, Hasher, & Colcombe, 2001). But what is the impact on older adults of task instructions that emphasize memory? Rahhal et al. (2001) suggest that such instructions may well *lower* the performance of older adults. We assume that university students are challenged by such instructions whereas older adults are to some small degree distressed by them.

One explanation for this reduced performance with memory instructions lies with stereotypes that older adults hold for themselves with respect to memory ability (versus the very different views that younger adults may hold for themselves): if negative stereotypes get triggered in an experimental context and do so differentially for older adults, we can expect (for any number of reasons including motivational and physiological changes) reduced performance (see e.g., Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, in press; Hess, 2000; Hess et al., 2003).

There is also some evidence of the importance of time perspective, particularly of the subjective judgment of time remaining—for example, time to graduation for college students and the time to anticipated mortality and morbidity for older adults. Both younger and older adults make different social choices and prefer different materials (e.g., among advertisements) when time seems limited compared to when time horizons are expanded (e.g., Carstensen, 1993; Fung & Carstensen, 2003). The impact of this factor on memory remains to be seen (but see Charles et al., 2003), but it might ultimately prove to be potent, as it has been shown to be in choice.

If, as Carstensen and her collaborators have argued, older adults have a different set of goals from younger adults (and there is certainly classic evidence on this; see Rokeach, 1973, see also Adams et al., 1997; Labouvie-Vief, 1985), the tasks and materials we have given to older adults may differentially disadvantage them. More so than young adults, older adults may set their own agendas, focusing on information that they see as personally useful or important and satisficing otherwise. To borrow other terms from the decision literature, older adults may be more inclined to engage in shortcuts characteristic of heuristic information-processing styles than are younger adults in experimental settings in which deliberate memory is at stake. That they can engage in more detailed (or analytic) processing styles is clearly seen in studies in which materials are more engaging than is typically the case (e.g., Adams et al, 2002; Castel, in press; Rahhal et al, 2002).

Taken together, these recent findings suggest that we may have seriously underestimated the memory abilities of older adults, as the developmental literature once seriously underestimated the cognitive and memory abilities of younger children. The understanding of greater than anticipated memory abilities in very young children grew slowly in that literature, and we presume an understanding of memory ability in older adults will begin to grow in the aging literature as well.

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