CHAPTER

33 Impact of Aging on Thinking

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Abstract

This chapter discusses the impact of aging on judgment and decision making, problem solving, reasoning, induction, memory, and metacognition, as well as the influence of expertise, training, and wisdom. In addition, the chapter presents theories of cognitive aging and addresses the ways in which changing goals (such as emotional goals) in old age can alter the processes and outcomes associated with cognitive operations. There is a wealth of research documenting age-related cognitive declines and impairments in areas such as decision making, reasoning, problem solving, category learning, and memory. However, in addition to addressing the potential difficulties older adults may experience when performing demanding cognitive operations, this chapter also examines certain situations and variables that have been shown to lessen or ameliorate age-related differences in performance. Lastly, the impact of training, expertise, and wisdom are discussed as they relate to successful cognitive aging.

Key Words: aging, cognitive aging, decision making, memory, metacognition, problem solving, reasoning, inductive learning, training, expertise, wisdom

As an increasingly large proportion of the population falls into the category of "senior citizen," it is vital to understand and explore how aging impacts cognitive functioning. Even during normal, non-pathological aging (which is the exclusive focus of this chapter) there is a large amount of evidence that older adulthood is associated with a decline in certain cognitive abilities, some of which are summarized in Figure 33.1 (McCabe et al., 2010; see also Craik & Salthouse, 2008). As Figure 33.1 illustrates, there are substantial declines in working memory capacity, episodic memory, executive functioning, as well as the speed at which information is processed. However, as Figure 33.1 also shows, aging does not negatively impact all functions to the same degree, if at all; and there is growing evidence that potential age-related deficits are moderated by other important factors such as goals, motivation, and prior knowledge (e.g., Zacks & Hasher, 2006). The current chapter will first discuss some of the major theories regarding age-related cognitive changes, as well as theories that address important changes during life-span development, more generally. This chapter will then review some classic as well as more recent findings within the areas of judgment and decision making, problem solving, reasoning, inductive learning, memory, and metacognition in older adults. In addition, the roles of emotion, expertise, training, and wisdom will be discussed as they relate to various aspects of cognition.

Cognitive Aging Theories

A number of theories have been proposed to explain why cognitive capabilities are so susceptible to the effects of aging. These theories focus on possible mechanisms driving age-related changes, and they highlight situations in which older adults are more or less likely to experience difficulties.

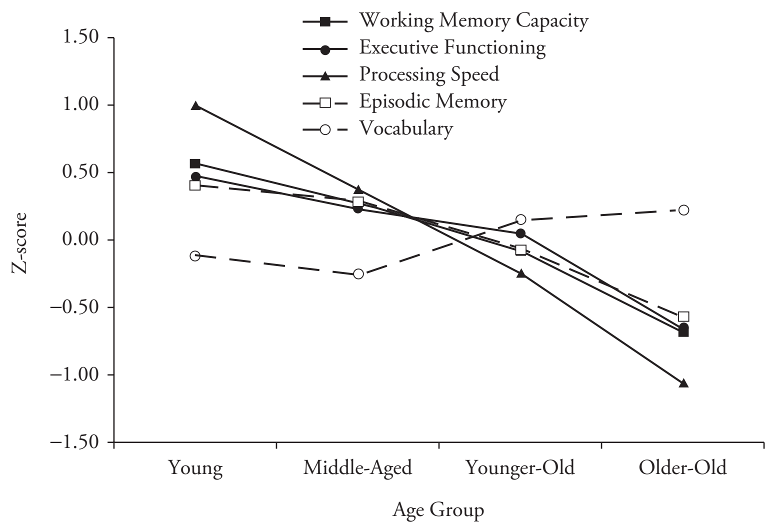

Fig. 33.1 Age-related differences in performance within various cognitive domains. The figure shows that aging is associated with declines in working memory capacity, executive functioning, processing speed, episodic memory, but an increase in vocabulary knowledge. (From McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010. Copyright © 2010 by the American Psychological Association. Reproduced with permission.)

Although certainly not an exhaustive review of existing theories, this section discusses those that have received wide support within the cognitive aging literature: the general slowing theory, the reduced resources theory, the inhibition deficit theory, prefrontal theories, as well as the selective optimization with compensation theory and the socioemotional selectivity theory (both of which are more general theories of life-span development).

General Slowing Theory

The general slowing theory posits that a reduction in the speed with which cognitive processes operate occurs during aging (see Fig. 33.1, which shows a steep decline in processing speed), and this reduction in processing speed accounts for the majority of age-related variance on a variety of cognitive tasks (Henninger, Madden, & Huettel, 2010; Salthouse, 2000). For example, there is evidence that measures of speed share upward of 50%–75% of the age-related variance on numerous cognitive tasks (Salthouse, 1996). Salthouse (1996) suggests that there are two mechanisms responsible for the relationship between speed and cognition: limited time and simultaneity. Limited time plays an important role in that the time needed to perform later cognitive operations can become restricted when large portions of available time are taxed with earlier operations. Simultaneity refers to the idea that outputs of earlier cognitive processes may be lost by the time that later processing is completed (as can occur when there are multiple demands on working memory), thus potentially creating situations in which relevant information is no longer available when it is actually needed.

Reduced Resources Theory

The reduced resource theory is similar to the general slowing theory, in that they both assert that a general change in specific cognitive abilities can account for large age-related changes in cognition. However, rather than positing a reduction in speed of processing, the reduced resources theory proposes that aging reduces the availability and/or the ability to successfully allocate attentional resources necessary for efficient performance on cognitive tasks (Craik & Byrd, 1982). For example, when older adults are placed under divided attention (which reduces the amount of attention available for other tasks), there is a larger detrimental impact on performance compared with younger adults also under divided attention (Anderson, Craik, & Naveh-Benjamin, 1998; Park, Smith, Dudley, & Lafronza, 1989). The reduction in available attentional resources can make it difficult for older adults to engage in more cognitively demanding operations, such as elaborative encoding during memory operations, which is considered necessary for effective consolidation and retrieval of to-be-remembered information (Craik & Salthouse, 2008).

Inhibition Deficit Theory

While there is evidence for age-related general cognitive slowing and a reduction in resources such as attention (which limit the amount of information one can process), other theories have proposed that older adults' troubles stem from the processing of too much (irrelevant) information. Hasher and colleagues (Darowski, Helder, Zacks, Hasher, & Hambrick, 2008; Hasher & Zacks, 1988; Lustig, Hasher, & Zacks, 2007) have suggested that older adults may suffer disproportionately from deficits in inhibitory processes (inhibition deficit theory), and this, in turn, can lead to poorer performance on cognitive tasks. An efficient system requires control and inhibition of irrelevant information in order to function properly, and thus it requires working memory and attention. Older adults in particular may have difficulty suppressing inappropriate or irrelevant responses, controlling the focus of attention, and keeping irrelevant information out of working memory and the focus of attention. As Figure 33.2 depicts, inefficient inhibition, therefore, can lead to information unrelated to the "goal path" entering working memory, resulting in a disruption of task operations. These non–goal path thoughts can involve irrelevant environmental details, personal memories and concerns, and interpretations that are inconsistent with current goals. Furthermore, decreased inhibitory functions can reduce the ability to switch attention from one target to another, and it can lead to misinterpretation of information, inappropriate responses, and also forgetting.

Prefrontal Theories

From a more neurological perspective, there is evidence that the prefrontal regions of the brain, which are responsible for many higher order cognitive operations (see Morrison & Knowlton, Chapter 6), are particularly susceptible to age-associated atrophic changes (Cabeza, 2001; Raz et al., 1997). Such specific, age-related changes in the prefrontal cortex likely contribute to cognitive decline in older adults (West, 1996). In particular, performance on tasks reliant on dorsolateral prefrontal function (e.g., executive functioning and working memory) seem to be the most negatively affected during the normal aging process, whereas tasks associated with ventromedial prefrontal areas (e.g., social behavior regulation and emotion) are less affected (MacPherson, Phillips, & Della Sala, 2002). Furthermore, it has been suggested that it is the compromised integrity of not only the dorsolateral prefrontal regions but the dopamine projections to the prefrontal cortex that contribute to age-related cognitive declines (Braver & Barch, 2002). For example, there is evidence that dopamine and dorsolateral dysfunction contribute largely to older adults' deficits on tasks in which cognitive control is necessary, such as efficient inhibitory control, working memory, and attention (Braver & Barch, 2002).

Selective Optimization With Compensation Theory

In addition to theories that focus on the mechanisms driving declines in cognitive function during aging, there are also theories that explore the contributing factors to successful cognitive aging. Selective optimization with compensation (SOC; Baltes & Baltes, 1990) asserts that successful aging is related to a focused and goal-directed investment of limited resources into areas that yield optimal returns. Thus, older adults can selectively choose certain options in order to maximize performance based on their goals, compensating for impairments by optimizing performance in these specific, goal-related domains (see also Riediger, Li, & Lindenberger, 2006, for the adaptive nature of SOC). As the SOC theory suggests, older adults are able to successfully allocate limited resources when appropriate motivation (such

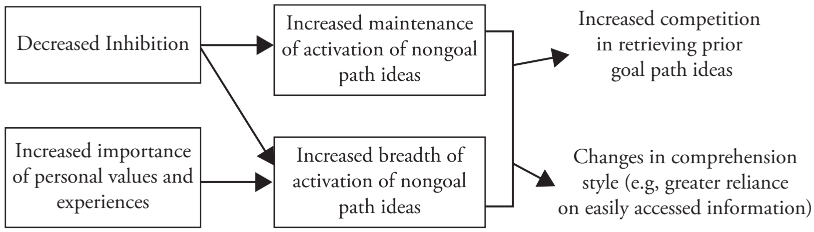

Fig. 33.2 Theoretical framework depicting the consequences of reduced inhibitory control as well as changing goals. (Adapted from *Psychology of Learning and Motivation*, Vol. 22, Hasher & Zacks, "Working Memory, Comprehension, and Aging: A Review and a New View," p. 213, Copyright 1988, with permission from Elsevier.)

as personal relevance and accountability) is present, enhancing performance (Germain & Hess, 2007; Hess, Rosenberg, & Waters, 2001). Furthermore, Heckhausen (1999; Heckhausen & Schulz, 1995) suggests that individuals have to take on the regulation of losses in aging-related resource in order to function efficiently, and if successful, such regulation can aid efficient cognitive function.

Socioemotional Selectivity Theory

Lastly, although not a theory of cognitive aging per se, the socioemotional selectivity theory (SST; Carstensen, 1992; 1995) highlights the importance of changing goals and motivations during aging. The SST asserts that people have some sort of awareness of the time left in life, and when time is seen as open ended (as it may be for young, healthy adults), goals and motivations are focused on acquiring information, experiencing novelty, and expanding one's knowledge. When time is seen as more limited (as may be the case for older adults), motivation and goals focus more on monitoring the environment in order to optimize emotional meaningfulness and emotional functioning. Depictions of the trajectories of these changing motivations are displayed in Figure 33.3, which show that in middle-to-older adulthood social motives shift from being more knowledge driven to more emotionally driven. Evidence supporting this theory has shown that older adults are better than younger adults at regulating emotions (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000), prefer to spend time with more emotionally meaningful (compared to novel) social partners (Fredrickson & Carstensen, 1990), and are more likely to remember information emphasizing emotional relative to novelty-seeking information (Fung, Carstensen, & Lutz, 1999). Thus, while this framework is not a specific theory of cognitive aging, it has implications for the approach that older adults may take toward decision making, problem solving, remembering information, and achieving emotional goals.

Summary

The purpose of this brief and selective review of theories regarding cognitive aging was to bring to the fore some of the possible mechanisms driving age-related changes in cognition. As was discussed, older adults may experience difficulties on cognitive tasks due to decreases in the speed (and thus efficiency) with which cognitive processes operate, decreases in the availability of attentional resources and/or in the ability to effectively allocate attention, and decreased ability to successfully inhibit irrelevant and intrusive competing information. Furthermore, age-related cerebral atrophy occurs at disproportionately higher rates within regions of the frontal lobe, an area that is largely responsible for many of the higher order cognitive operations. At the same time, life-span theories of aging suggest that older adults may approach tasks and situations in a qualitatively different manner than younger adults (e.g., older adults may have different goals) and, at times, can selectively allocate resources in order to compensate for deficiencies in cognitive abilities. It is important to consider these theories, and other potential frameworks, as we now review and discuss the effects of age within specific areas of cognition.

Judgment and Decision Making

As individuals age they are faced with a number of life changes and often need to make important decisions involving aspects such as medical care and retirement, in addition to the everyday decisions faced by most individuals. Thus, an understanding of judgment and decision-making abilities in older adults is of paramount importance. Research has suggested that the decision-making ability of older adults in everyday life may be compromised

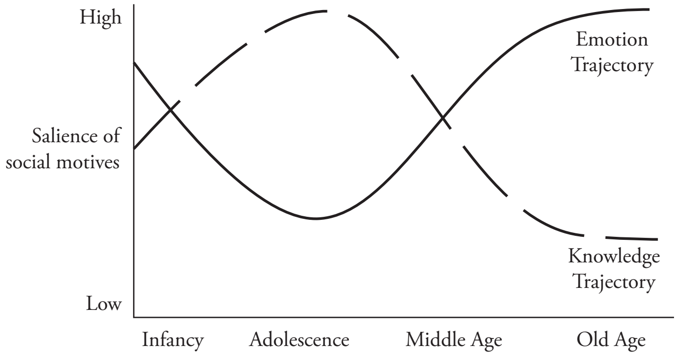

Fig. 33.3 Idealized depiction of changes in two social motives across the life span as predicted by the socioemotional selectivity theory. (Adapted from Carstensen, Gross, & Fung. Copyright 1997 by Springer Publishing Company Inc. Reproduced with permission of Springer Publishing Company, Inc.)

relative to younger and middle-aged adults (Peters, Finucane, MacGregor, & Slovic, 2000; Thornton & Dumke, 2005). In particular, older adults may make more comprehension errors and display less consistency in their preferences (Finucane et al., 2002), and they may exhibit poorer decision-making abilities when the task requires more cognitively demanding strategies (Mata, von Helversen, & Rieskamp, 2010). Furthermore, a decline in more controlled, deliberative processing and an increased reliance on more automatic, heuristic processing may lead to less effective or poorer decisions among older adults (dual-process model; see Peters, Hess, Västfjäll, & Auman, 2007; also Evans, Chapter 8). In this section we will highlight not only the instances in which age-related deficits are observed but also situations in which deficits are not present. We will also consider the impact of goals and motivations on the aging decision maker.

In the real world, individuals are often charged with making decisions in the face of gains, losses, risks, and uncertainty; the ability to decide advantageously in these situations is of great importance. Laboratory-based studies of decision making in the presence of the aforementioned factors have frequently utilized the Iowa Gambling Task (IGT), originally developed by Bechara and colleagues (Bechara, Damasio, Damasio, & Anderson, 1994), which presents individuals with the opportunity to either gain or lose large monetary amounts. In the IGT, there are four decks of cards, and each card has either a positive (gain) or negative (loss) monetary amount on the reverse side. Subjects are allowed to select cards freely, one at a time, from any deck, with the task ending once they have selected 100 cards. There are always two "good" decks, which consist of smaller immediate gains and lower overall losses, and two "bad" decks, which contain very large gains but also larger long-term losses. To be successful on this task, one must learn to choose predominately from the "good" decks and avoid the "bad" decks.

Several studies suggest that, on average, older adults are more likely to make disadvantageous decisions on the IGT compared with younger adults (Denburg et al., 2007; Denburg, Tranel, & Bechara, 2005; Fein, McGillivray, & Finn, 2007). Figure 33.4 displays the average number of cards selected from the good decks (i.e., decks C and D) minus the number chosen from the bad decks (i.e., decks A and B) for both younger and older adults across blocks of 20 cards. The pattern clearly shows less advantageous decision making by older adults. Furthermore, even studies that have reported few age differences on this task have found overall flatter learning curves among older individuals (i.e., they take longer to adopt a successful strategy; see Wood, Busemeyer, Koling, Cox, & Davis, 2005). It may be the case that older adults are more sensitive to gains and less sensitive to losses than younger adults (Friedman, Castel, McGillivray, & Flores, 2010; Samanez-Larkin et al., 2007), which could partially account for their lower overall performance on the IGT. That is, individuals who place more emphasis on the larger gains, and deemphasize the larger

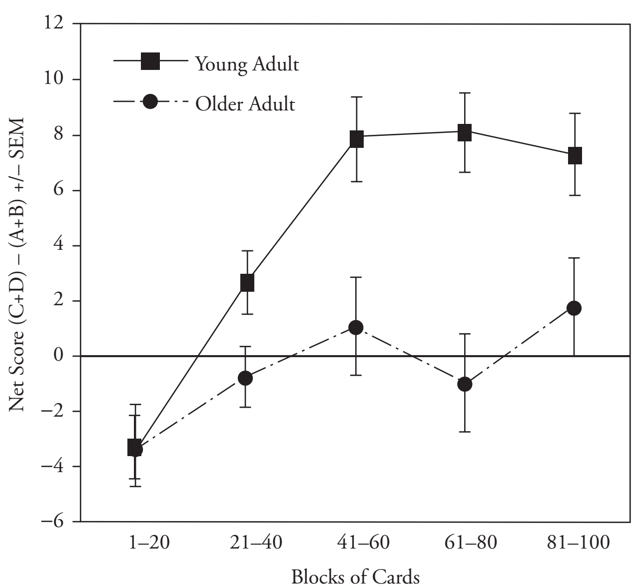

Fig. 33.4 The average number of cards selected from the good decks (*C* and *D*) minus the bad decks (*A* and *B*) across blocks of 20 cards for both younger and older adults. (From Denburg et al., 2007, reprinted with permission from John Wiley and Sons.)

losses, may continue to select cards from the "bad" decks. Alternatively, it has been suggested that these age-related differences on the IGT may in fact be a result of, or mediated by, declines in other cognitive abilities such as processing speed and explicit memory function (Henninger et al., 2010). What is particularly concerning, however, is that older individuals who perform poorly on the IGT are also more likely to fall prey to deceptive and fraudulent advertising (Denburg et al., 2007). What makes this alarming is the fact that older adults are often preferentially targeted by fraudulent schemes (American Association of Retired Persons, 1996), and thus some older adults may be at an increased risk of becoming victims of such crimes.

Despite evidence suggesting age-related deficits in decision making, a number of studies have found that older adults' decision-making ability is not always compromised (Kim & Hasher, 2005; Kovalchik, Camerer, Grether, Plott, & Allman, 2005). Older adults, if given the opportunity, can become more adaptive and adopt different compensatory strategies (Mata, 2007), consistent with the previously discussed selective optimization with compensation theory. For instance, although older adults often review less information and take longer to process it, older adults are capable of adopting more complex, less heuristic-based decision-making strategies when the environment requires the use of such strategies (Mata, Schooler, & Rieskamp, 2007; Pachur, Mata, & Schooler, 2009) or if properly motivated (Kim, Goldstein, Hasher, & Zacks, 2005).

To illustrate this point, consider the framing effect, a phenomenon in which decisions and choices are altered by the way in which the options are presented. The most commonly known example is the Asian disease problem originally examined by Tversky and Kahneman (1981). When presented with this problem, individuals are more likely to demonstrate risk seeking in their choice when the options are framed as losses (400 out of 600 people will die), and risk aversion when the options are framed in terms of gains (200 out of 600 people will be saved; Tversky & Kahneman, 1981). If individuals rely on more automatic, heuristic processing when presented with these types of problems, they are more likely to fall victim to the framing effect. Thus, it is not surprising that older adults, who may rely on more heuristic-based processing styles due to limited resources, show larger framing effects than younger adults (Kim et al, 2005). However, when asked to provide justification for their choices (i.e., have appropriate motivation), older adults (and younger adults) adopted a more systematic processing and no longer showed susceptibility to the language in which options were framed (Kim et al., 2005). It is also important to note that regardless of whether older adults review less information and rely on more heuristic-based processing when making decisions, reviewing less information does not necessarily lead to poorer quality of decisions (Mata & Nunes, 2010). In addition, recent work has shown that older adults actually prefer fewer choices when making decisions, and that their performance is related to numerical processing ability, general slowing, and working memory capacity (e.g., Peters et al., 2007; Reed, Mikels, & Simon, 2008; Tanius, Wood, Hanoch, & Rice, 2009).

While motivation certainly plays a role in enhancing the decision quality of older adults, goals (emotional and social goals in particular) influence decision making and choice evaluation in key ways as individuals age. Studies examining decision making within emotional or social realms have often found no age-related difference (MacPherson et al., 2002). As proposed by the socioemotional selectivity theory (SST), emotional regulation and enhancing emotional well-being may be important goals for older adults. If this is the case, then older adults may process and remember information surrounding decisions differently than do younger adults. For example, on a task assessing decisions for health care plans and doctors, it was found that older adults reviewed a greater proportion of positive compared to negative material than did younger adults, and they remembered the doctors and health plans they had chosen more positively (Lockenhoff & Carstensen, 2007). Additional studies have also found that older adults often remember their decision choices as having more positive features (Mather & Johnson, 2003) and are more satisfied with their decisions compared with younger adults (Kim, Healey, Goldstein, Hasher, & Wiprzycka, 2008).

The SST has further proposed that older adults may see time as more limited than do younger adults and thus may see their time as more "valuable." Given this hypothesis, older adults may be less susceptible to sunk cost effects, a common decision-making bias in which people continue to invest either time or money when prior investments have been made, despite limited prospects for positive returns (see LeBoeuf & Shafir, Chapter 16). In one study, older and younger adults were presented with scenarios in which, for example, they had paid a certain amount of money to see a movie. Participants were told to imagine that shortly into the movie, they realized that it was not very good and were not enjoying it, and were given options to stop watching or continue watching for various lengths of time (Strough, Mehta, McFall, & Schuller, 2008). Strough and colleagues found that older adults were much less likely to demonstrate the sunk cost bias (i.e., continue watching the movie) than were younger adults. Thus, at least under some circumstances older adults may make more rational, "normatively correct" decisions than do younger individuals, possibly reflecting greater consideration of whether their previous investments of either time or money are currently yielding optimal positive returns.

Summary

Research has documented substantial deficits in judgment and decision making in older adults. For example, older adults make less advantageous decisions, rely more on heuristics when forming judgments and making decisions, and often review less information compared with younger adults. However, when appropriate motivation is present, age-related differences can be reduced and older adults process information in a more deliberate and appropriate manner. Changes in emotional goals may lead older adults to focus on more positive compared to negative aspects related to the decision-making process. Lastly, changes in time horizons (i.e., awareness of limited time left in life) can, in specific instances, result in more appropriate decisions by older adults.

Problem Solving, Reasoning, and Induction

The ability to solve problems, reason logically, classify objects into appropriate categories, and to sensibly come to novel conclusions based on known facts or rules are all critical abilities required to successfully manage one's way through life. Research presented in the following sections will address age-related declines within these specific domains (e.g., Salthouse, 2005; Thornton & Dumke, 2005), along with the impact that goals, strategies, and prior knowledge have on older adults' performance. In addition, strategies and instances that have a positive effect on older adults' abilities will be examined.

Problem Solving

There is evidence that the ability to effectively solve problems (see Bassok & Novick, Chapter 21) is reduced in later adulthood. For example, a meta-analysis of 28 separate studies concluded that problem solving is not spared from typical age-related declines (Thornton & Dumke, 2005). Older adults' performance is lower than other age groups on both traditional, laboratory-based problems (Denney & Palmer, 1981), practical problems (Denney, Pearce, & Palmer, 1982), and even on problems specifically designed to give older adults an experience advantage (e.g., what an elderly woman should do if she needs to go somewhere at night, but she cannot see well enough to drive at night and it's too far to walk; Denney & Pearce, 1989). Older adults may also review less information and generate fewer strategies during problem solving (Berg, Meegan, & Klaczynski, 1999). Furthermore, these deficiencies in everyday problem-solving tasks among older adults have been associated with measures of executive functioning, memory, verbal ability, and speed of processing (Burton, Strauss, Hultsch, & Hunter, 2006).

Despite difficulties with problem solving later in life, it may be that practical, realistic problems differ from the types of tasks used in typical laboratory settings. Although aging has been shown to negatively impact everyday problem-solving abilities (Thornton & Dumke, 2005), these age-related differences are much smaller than those observed on traditional problem-solving tasks (Denney & Palmer, 1981), suggesting that life experience and prior knowledge can moderate age-related declines. For example, Crawford and Channon (2002) gave younger and older adults a range of everyday situations that presented problems for which they needed to generate potential solutions for (e.g., resolving an issue with a neighbor's barking dog). They found that while older adults generated fewer solutions compared with younger adults, these solutions were of a higher quality, which could be attributed to their greater life experience in dealing with these types of everyday problems (similar to findings regarding the role of expertise late in life; see Charness, 1981a, 1981b). That is, Crawford and Channon suggest that older adults may have a more well-defined knowledge base from which to draw possible solutions and make more efficient use of such knowledge compared to younger adults.

While typical problem-solving experiments are tested in a laboratory or controlled setting, problem solving in "real-life" occurs in a more complex and social environment. Many older adults talk about their problems with friends and family members, which has led to several studies within the last decade exploring problem solving with older adults in the context of collaboration (Cheng & Strough, 2004; Kimbler & Margrett, 2009; Strough, Cheng, & Swenson, 2002; Strough, Hicks-Patrick, Swenson, Cheng, & Barnes, 2003; Strough, McFall, Flinn, & Schuller, 2008). For example, Cheng and Strough (2004) had either individual or collaborative same-sex pairs of younger and older adults plan a cross-country trip to go to a wedding. Although younger adults took less time and performed better at planning the trip overall, collaborating in a pair was advantageous for both age groups to the same extent, illustrating another strategy older individuals may employ to maintain everyday functioning.

As some of the previously mentioned research suggests, older adults may approach interpersonal problems in a qualitatively different manner than younger adults. It has been shown that older adults may use more effective problem-solving strategies than younger adults when faced with problems that are interpersonal in nature (e.g., conflicts with friends or family; Blanchard-Fields, Mienaltowski, & Seay, 2007). Furthermore, a number of studies have highlighted the fact that older adults are more likely to use (Blanchard-Fields, Chen, & Norris, 1997; Blanchard-Fields, Jahnke, & Camp, 1995) and prefer (Watson & Blanchard-Fields, 1998) emotionally focused problem-solving strategies compared with younger adults, particularly within interpersonal contexts, although both groups tend to use problem-focused strategies more often overall (Blanchard-Fields et al., 1995). One reason why older adults may use emotionally focused strategies more often than younger individuals could stem from differences in goals between the two age groups. It has previously been suggested that maintaining emotional well-being is an important goal for older individuals (e.g., Carstensen, 1992). It has been established that prioritization of emotional regulation has a sizable influence on the types of problem-solving strategies that are likely to be utilized by older adults (Coats & Blanchard-Fields, 2008; Hoppmann, Coats, & Blanchard-Fields, 2008). That is, older adults are more likely to endorse more passive emotional regulation strategies when solving interpersonal problems (Blanchard-Fields et al., 1997; Blanchard-Fields et al., 2007; Blanchard-Fields, Stein, & Watson, 2004; Coats & Blanchard-Fields, 2008), possibly due to their desire to maintain emotional stability and balance, particularly within their interpersonal relationships.

Lastly, it is important to note that areas such as everyday problem solving are a multidimensional construct, often with little relation between the different measures used (Allaire & Marsiske, 2002; Marsiske & Willis, 1995). Furthermore, performance is also modulated by such factors as education (Thornton & Dumke, 2005) and health (Diehl, Willis, & Schaie, 1995). In addition to the factors mentioned earlier, older adults, at times, do perform better when faced with a situation relevant to their own age group, analogous to an "own-age" bias (Artistico, Orom, Cervone, Krauss, & Houston, 2010). Other factors such as positive feedback (Soederberg-Miller & West, 2010), experience, and strategic flexibility have also been shown to improve older adults' problem-solving and decision-making abilities (Hicks-Patrick & Strough, 2004).

Reasoning

Similar to findings observed in problem solving, the capability to effectively reason is negatively impacted during aging. Difficulties in reasoning ability are apparent by looking at older adults' performance on the Raven's Progressive Matrices Task, which shows a clear decline across the adult life span (Salthouse, 1993; 1994; Salthouse & Skovronek, 1992). The Raven's task requires participants to identify an appropriate option to fill in a missing cell on a matrix grid that becomes progressively more difficult across trials. Figure 33.5 contains examples of the Raven's Matrices (Fig. 33.5a), displaying problems of varying difficulty (i.e., the number of relations within the problem). A summary of older and younger adults' performance on this task (Fig. 33.5b) reveals significant age-related differences at all levels of difficulty.

In addition to Raven's Matrices, age-related performance deficits have also been observed on other reasoning tasks. For example, older adults performed worse than younger adults on a propositional reasoning task that presented individuals with a series of premise pairs (e.g., A > B, B > C, C > D), and then required them to draw inferences about a new pair (e.g., A ? C) (Ryan, Moses, & Villate, 2008). On tasks assessing analogical reasoning, older adults perform less accurately compared with younger and middle-aged adults (Viskontas, Morrison, Holyoak, Hummel, & Knowlton, 2004). Viskontas and colleagues found that this age-related deficit in analogical reasoning was present even at low levels of relational complexity, and it became more pronounced when problems contained an increasing

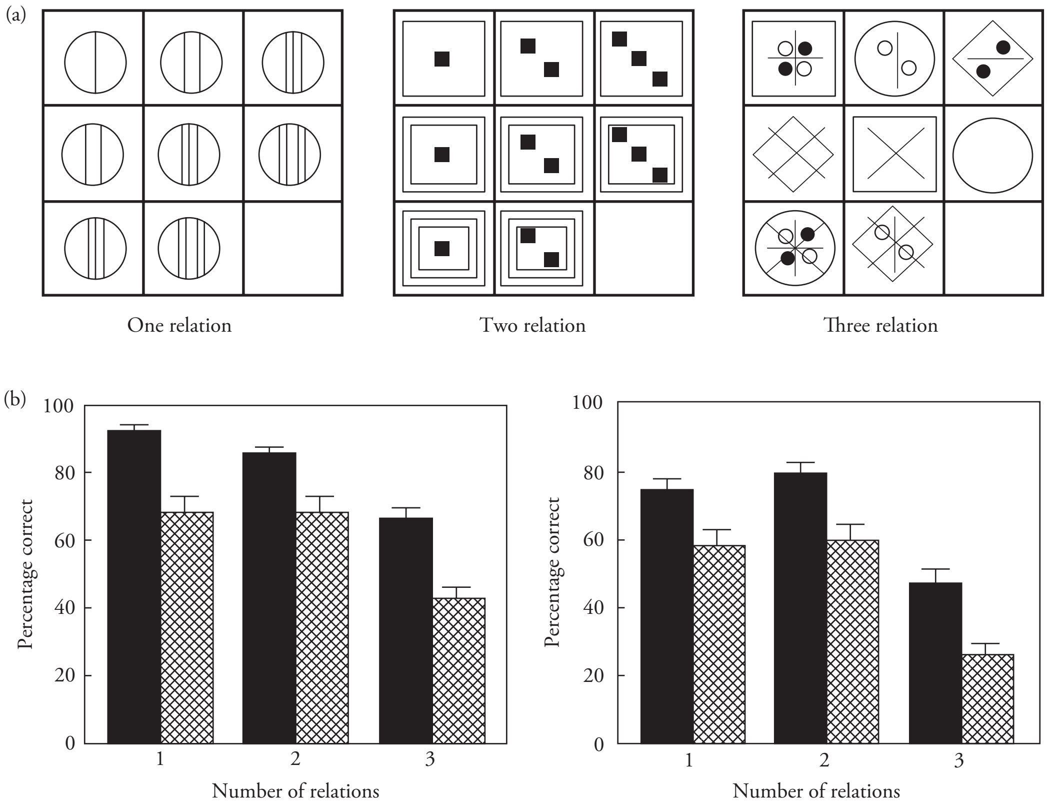

Fig. 33.5 a. A series of example patterns from Raven's Progressive Matrices Task with one, two, or three relations. Participants were given each matrix one at a time and asked to complete the missing cell with the appropriate pattern. Note that as the number of relations within a matrix increases, the task becomes more difficult to solve. b. Results for Raven's Progressive Matrices in younger adults (black bars) and older adults (gray bars). The results show significant age-related differences for both simultaneous (*top*) as well as sequential (*bottom*) conditions. Error bars indicate standard error of the mean. (Figures 33.5a and 5b taken from Salthouse, 1993 and reproduced with permission the British Journal of Psychology © The British Psychological Society.)

number of irrelevant traits that favored incorrect responses. Age-related declines in reasoning ability have been attributed to multiple sources, including general slowing (Salthouse, 2000), neurological changes to the prefrontal cortex (Krawczyk et al., 2008), differences in relational organization (Ryan et al., 2008), inhibitory decrements (Viskontas et al., 2004), and deficits in working memory (Kyllonen & Christal, 1990; Viskontas, Holyoak, & Knowlton, 2005).

Despite fundamental age-related differences in reasoning performance, the same mechanism may drive reasoning in both younger and older adults. For example, although older adults performed worse than younger adults on the Raven's Progressive Matrices Task, the types of errors both age groups committed (e.g., failure to identify all of the relevant variables needed to determine the correct solution, misunderstanding that some elements of the problem are not relevant to the solution) were similar to one another, suggesting similar underlying mechanisms (Babcock, 2002; Salthouse, 1993). Furthermore, it has been found that these age-related deficits in reasoning can be reduced when using existing relational information within semantic memory (e.g., prior knowledge) as an analog for new learning (Ostreicher, Moses, Rosenbaum, & Ryan, 2010). There may even be specific situations in which older adults' lifetime of acquired wisdom and experiences result in superior reasoning abilities compared with younger adults (Grossmann et al, 2010; we return to this issue in the section on "Wisdom and Successful Aging").

Induction

Induction, or category learning (the ability to successfully place novel stimuli into one or more appropriate groups; see Rips, Smith, & Medin Chapter 11), has also been found to be susceptible to age-related declines (e.g., Filoteo & Maddox,

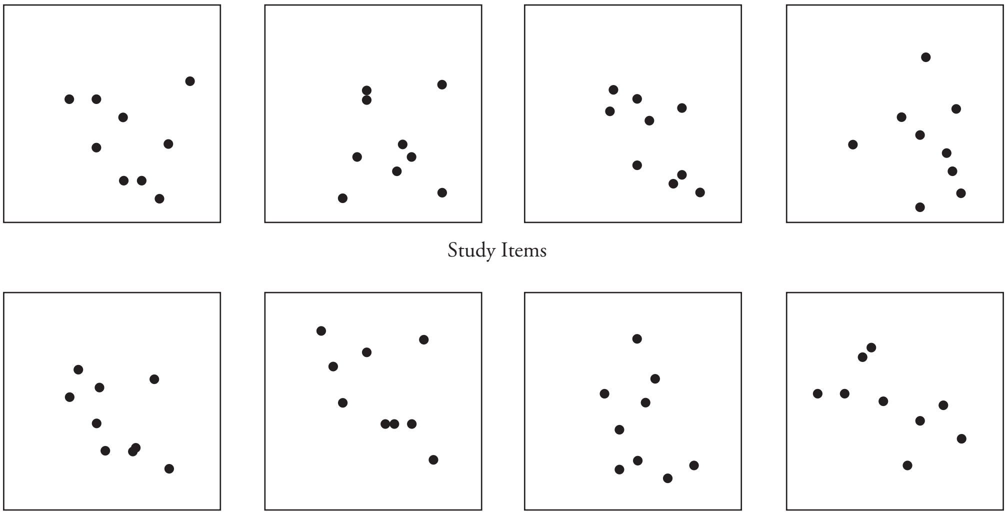

Fig. 33.6 Examples of dot patterns that are presented during study (*top*) and test (*bottom*). The study items are all distortions of the prototype dot pattern. The test items include the training prototype, high and low distortions of the prototype, and random dot patterns.

2004; Racine, Barch, Braver, & Noelle, 2006). One classic task used to assess category learning is the dot classification task (Posner & Keele, 1968). In this task participants are shown a series of dot patterns that are distortions of a predetermined prototypical pattern, examples of which are displayed at the top of Figure 33.6. Participants view a series of these patterns, and then during test are given the prototype pattern, high and low distortions of the prototype, as well as random dot patterns and are asked to categorize them (example test stimuli are displayed in the bottom portion of Fig. 33.6). Compared with younger adults, older adults have been shown to be less successful at correctly categorizing the test stimuli (Davis, Klebe, Bever, & Spring, 1998), and they retain less information about exemplars presented in the set (Hess & Slaughter, 1986). This increased difficulty in inductive learning tasks has been linked to general cognitive slowing, which can make it more difficult for older adults to successfully integrate information (Henninger et al., 2010; Mutter & Plumlee, 2009; Salthouse, 2000).

Similar to the processes involved in induction, older adults have been found to have difficulty in set-shifting (Ridderinkhof, Span, & van der Molen, 2002) and to exhibit more errors (Boone, Ghaffarian, Lesser, & Hill-Gutierrez, 1993; Rhodes, 2004) relative to younger adults on the Wisconsin Card Sorting Task. Although older adults are capable of learning rules, the inability to appropriately switch or think “flexibly” may explain their reduced performance on induction tasks (see also Friedman & Castel, 2010; Koutstaal, 2006).

Despite increased difficulties with induction, older adults may benefit from specific learning parameters during the induction process. For example, Kornell, Castel, Eich, and Bjork (2010) demonstrated that although older adults did worse than younger adults on an assigned induction task—correctly identifying novel paintings from artists they had previously studied—both age groups benefitted from the same schedule of learning. Specifically, older and younger adults’ performance increased when exemplars from an artist were presented spaced further apart rather than massed together during the learning phase. Thus, spacing benefitted induction across both age groups, suggesting that mechanisms supporting inductive learning stay constant during aging (see also Jamieson & Rogers, 2000). Furthermore, Blieszner, Willis, and Baltes (1981) demonstrated that the ability to modify inductive learning and reasoning performance through interventions and training remains intact across the adult life span.

Summary

The areas of problem solving, reasoning, and inductive learning are subject to sizable age-related declines. It is well documented that older adults demonstrate declines on both traditional, and to a lesser extent, everyday problem-solving tasks. In addition, much of the research conducted on older adults' reasoning capabilities reveal large age-associated decrements, even on tasks with relatively low levels of relational complexity. Although there is less research on inductive learning and aging, the existing literature supports the conclusion that older adults' capacity to learn categories is also compromised, and that they have difficulty learning categories that require rapid updating and the incorporation of new changing rules (such as on the Wisconsin Card Sorting task). However, there appear to be some contexts in which older adults are capable of performing just as well, if not better, than younger adults despite age-related cognitive declines. For example, older adults may generate fewer solutions to problems, but the quality of the solutions generated can, at times, be on par with younger adults. There is also evidence that older adults approach interpersonal problems in a qualitatively different way than younger adults, and their ability within this area of problem solving remains relatively intact. Furthermore, reasoning and induction tasks that allow older adults to utilize prior knowledge and experience also tend to show fewer age-related deficits.

Memory and Metacognition

Memory

Our memory is a vital component of who we are as individuals, and it allows us to efficiently interact with and understand the world. Not only do our memories contain information about our past experiences and what we know, but they influence our current and future actions. While there are many physical and psychological changes that accompany the aging process, one of the most oft-voiced concerns among many older adults is the decline in memory functioning. In fact, 50%–80% of older adults report subjective memory complaints (Levy-Cushman & Abeles, 1998). Older adults' subjective experience of memory difficulties has proven to be a well-founded concern, with many decades of research demonstrating that memory functioning declines with advancing age (e.g., Craik & Salthouse, 2008; Kausler, 1994). It is important to note, however, that there are numerous "types" of memory (e.g., episodic, semantic, working, procedural) and, as was shown earlier in Figure 33.1, aging may disproportionately impact these types of memory, with some, but not all, tasks associated with age-related deficits (Craik & Salthouse, 2008; Kausler, 1994; Zacks & Hasher, 2006). Implicit or nondeclarative types of memory such as priming, skill learning, and classical conditioning, which rely more on automatic processes, generally show little to no age-related declines (e.g., Fleischman, Wilson, Gabrieli, Bienias, & Bennett, 2004; Laver, 2009; Light & Singh, 1987; Nilsson, 2003). Furthermore, semantic memory (i.e., memory for facts, world knowledge) is well preserved across the life span and in some instances, such as vocabulary knowledge (as is shown in Fig. 33.1) may even increase slightly (Lavoie & Cobia, 2007; Verhaeghen, 2003). Unlike implicit and semantic memory, however, large age-related declines are often observed in assessments of episodic memory (i.e., memory for past events) and working memory (i.e., short-term storage and manipulation of information; Verhaeghen & Salthouse, 1997).

It has been suggested that older adults' decline in explicit memory abilities can be attributed to declines in processing speed (Salthouse, 1996), attentional deficits (Craik & Byrd, 1982), and inefficient inhibitory mechanisms (Hasher & Zacks, 1988; Lustig, Hasher, & Zacks, 2007). One other potential contributor to older adults' deficiencies in episodic memory is their relative inability to form and retrieve links among single bits of information, referred to as associative memory (Castel & Craik, 2003; Naveh-Benjamin, 2000; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003; Old & Naveh-Benjamin, 2008). Examples of associative memory include (but are not limited to) remembering who said what (source memory), order of information presentation, which items appeared together (item pairs), or whether something was seen or heard. Deficits in associative memory abilities make it difficult to create new associations between event information or units, thus limiting the ability to encode information effectively and later retrieve it (Chalfonte & Johnson, 1996).

In addition to the deficits often observed on associative memory tasks, older adults show a tendency to "falsely remember" information (Jacoby & Rhodes, 2006) and may, at times, be more captured by misleading information compared to younger individuals (Jacoby, Bishara, Hessels, & Toth, 2005). It has been proposed that this tendency to misremember or falsely remember may be due to an increased reliance on more automatic memory processes such as familiarity, in light of difficulties with more controlled memory processes (i.e., precise recollection;

Jacoby & Rhodes, 2006). While the reliance on familiarity and the ability to remember the "gist" can lead to accurate recall and create conditions that allow for more flexibility within memory and transfer of learning to novel situations (Koutstaal, 2006), it also often leads to higher occurrences of false remembering. For example, Jacoby (1999) had older and younger adults read a list of words one, two, or three times (thus increasing familiarity with those words when they were read multiple times). Participants then heard a separate list they were told to remember. During test, participants were told they would see words they had both read and heard, but only to respond to words that were heard. Interestingly, the increased repetition of the read words decreased younger adults' false recognition, but increased older adults' false recognition, indicating that older adults were relying more on familiarity of material during responding, possibly due to difficulties with exact recollection.

Although some degree of memory loss and memory changes may be inevitable with age, research is beginning to show that even in the types of memory most vulnerable to senescent changes, the ability to remember valuable, meaningful, and goal-relevant information may remain largely intact (Zacks & Hasher, 2006). As previously discussed, the socioemotional selectivity theory posits that older and younger adults have different motivations and goals concerning social interactions and emotional regulation, and this can have an impact on what older adults attend to and remember. Older adults have been shown to preferentially attend to positive compared with negative information (Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Mather & Carstensen, 2003), and this differential allocation of attention can either enhance or decrease memory for emotional information. Thus, it is not surprising that older adults frequently remember a higher proportion of positive relative to negative information (i.e., they demonstrate a positivity bias), whereas younger adults either do not show this pattern or display a negativity bias in memory on both laboratory tasks (Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2005; Mather & Knight, 2005) as well as in their spontaneous autobiographical memories (Schlagman, Schulz, & Kvavilashvili, 2006; Tomaszczyk, Fernandes, & MacLeod, 2008). Consistent with the idea that emotional biases in memory may be a result of goal-directed processes (see Molden & Higgins, Chapter 20), older adults with the most pronounced positivity bias are those who also score highest on tests of cognitive control capabilities (Mather & Carstensen, 2005).

Similar to emotional materials, information and scenarios that utilize more real-world, realistic, or relevant materials may serve to increase attention, motivation for remembering, and allow for the use of prior knowledge, thereby mitigating age-related memory impairments. Figure 33.7 displays the results of a study conducted by Castel (2005) that examined memory for prices of everyday grocery items. If the items were realistically priced, there were no age-related associative memory impairments for prices of grocery items, whereas large age-related decrements were present when older adults were asked to remember unrealistic prices. This finding highlights what a marked impact the utilization of meaningful, "real-world" materials can have on older adults' performance on memory tasks. That is, when required to remember information that is consistent with prior knowledge, older adults can reduce their reliance on effortful, self-initiated processes (which may be detrimentally effected in aging), improving both encoding and retrieval memory operations (Castel, 2008; Craik & Bosman, 1992; McGillivray & Castel, 2010).

Hess and colleagues (Germain & Hess, 2007; Hess et al., 2001) have investigated the role of personal relevance and its impact on memory performance in older (and younger) adults. Hess et al. (2001) found that older adults were more accurate in their recollection of information related to a narrative describing an older target person (increased relevance), compared with one describing a younger target person, and this accuracy increased in situations

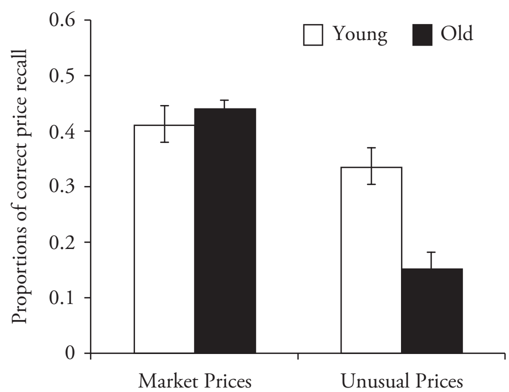

Fig. 33.7 The average proportion of correctly recalled prices by younger and older adults for the market value and unusually priced items. (From Castel, 2005. Copyright © 2005 by the American Psychological Association. Reproduced with permission.)

in which they were held accountable for their responses (increased motivation). Furthermore, older adults' memory benefitted to a greater extent from increasing motivation and relevance than did younger adults. Extending these findings, Germain and Hess (2007) demonstrated that increased relevance was strongly associated not only with memory performance but with more efficient processing, and that these effects were stronger within the older adult sample.

Motivation to remember and relevance are not always products of the to-be-remembered information but can reflect other situational variables. Adams and colleagues have investigated memory for stories, manipulating who participants (both younger and older women) were asked to retell a story to (an experimenter or a young child) (Adams, Smith, Pasupathi, & Vitolo, 2002). When the listener was an experimenter, younger adults recalled more propositional content than did older adults, but this age difference disappeared when the listener was a young child. Furthermore, when the listener was a child, both younger and older participants engaged in more elaborations and repetitions while retelling the story, but older adults were more adaptive in adjusting the complexity levels given the age of the listener. These findings underscore the importance of the context (in particular, social contexts) in which one is asked to recall information, and the degree to which differing context provides motivation to both younger and older adults.

Increasing relevance or importance of information can also serve to mitigate deficits in source memory (i.e., memory for information about the contextual details accompanying that event) so often observed among older adults. For example, no age-related differences were observed when older adults were asked to recognize whether a statement was true, false, or new (truth source), whereas large age-related differences were present when asked to identify the voice source (John or Mary said it) or whether it was a "new" statement (Rahhal, May, & Hasher, 2002). Similarly, older adults' memory performance equals younger adults' on source memory tasks when the to-be-remembered information has an emotionally relevant component (e.g., safety) (May, Rahhal, Berry, & Leighton, 2005). Lastly, recent research has shown that despite age-related memory declines, older adults are capable of remembering more important information just as well as younger adults, but this occurs at the expense of less important information (Castel, 2008; Castel, Benjamin, Craik, & Watkins, 2002; Castel, McGillivray, & Friedman, 2011; Castel et al., in press).

Metacognition

Although this section is largely concerned with memory, it is also important to understand metacognitive processes and how these processes are affected by aging. Metacognition (or more specifically, metamemory) refers to one's awareness of his or her own memory and how it works. Metamemory includes, but is not limited to, beliefs about one's memory skills and task demands, insight into memory changes, feelings and emotions about one's memory, and knowledge of memory functioning (Dunlosky & Metcalfe, 2009). Beliefs that older and younger adults may have about their memory abilities, in turn, can influence expectations for memory performance, effort exerted during a memory task, and the degree to which one chooses to place himself or herself in demanding memory situations, and it can even influence one's actual performance (Dixon, Rust, Feltmate, & Kwong See, 2007; Lachman, 2006; Lachman & Andreoletti, 2006). Older adults are often very aware of deficits in memory performance (Hertzog & Hultsch, 2000; Levy & Leifheit-Limson, 2009), making the study of metamemory very important in terms of developing strategies to combat age-related memory decline.

Experimental studies of metamemory tasks often involve asking participants to make judgments of learning (or JOLs) about what or how much they will later remember (a form of metacognitive *monitoring*), or by asking participants what information they feel they need to restudy or study for shorter/longer periods of time (a form of metacognitve *control*). Investigations into the effects of age on these variable have been somewhat mixed. While some studies have found that old adults exhibit a larger pattern of overconfidence in their memory abilities compared with younger adults (i.e., there is a larger discrepancy between JOLs and actual memory performance; Bruce, Coyne, & Botwinick, 1982; Connor, Dunlosky, & Hertzog, 1997), other studies have found little to no age differences (Hines, Touron, & Hertzog, 2009; Lovelace & Marsh, 1985; Murphy, Sanders, Gabriesheski, & Schmitt, 1981), or more accurate performance by older adults (Hertzog, Dunlosky, Powell-Moman, & Kidder, 2002; Rast & Zimprich, 2009). In addition, recent work suggests that, relative to younger adults, older adults are also aware of how much information they have forgotten when learning and recalling lists of items (Halamish, McGillivray, & Castel, 2011), suggesting that the monitoring of forgetting may be relatively intact in old age.

In regard to metacognitive control, Dunlosky and Connor (1997) observed that when older and younger adults were allowed to restudy words at their own pace, all participants spent more time studying items that they had been assigned lower JOLs (i.e., words they judged as more difficult to recall) compared with those words that had been given higher JOLs (i.e., judged as more likely to remember). However, younger adults exhibited this effect to a greater extent, indicating that age-related differences were present in the degree to which monitoring was used to effectively allocate study time. Dunlosky and Connor suggest that this difference in study-time allocation may even contribute to the lower overall memory performance in older adults. However, Dunlosky and Hertzog (1997) found that younger and older adults used a "functionally identical algorithm" in their selection of items for restudy, and both younger and older individuals adaptively selected to restudy the items they believed were not as well learned (Hines et al., 2009).

While the results surrounding metacognition and aging are somewhat mixed, it is encouraging that, at least under some conditions, monitoring and control over learning remains relatively intact throughout the life span. Even studies that have found sizable metacognitive deficits in older adults (e.g., Bunnell, Baken, & Richards-Ward, 1999) have also usually found that these deficits are less than those associated with actual memory ability. That is, metamemory abilities are likely better preserved in older adults than explicit memory abilities. This relative sparing suggests that older adults may be able to use metacognitive strategies to help overcome or compensate for age-related declines in memory performance.

Summary

Declines in older adults' memory abilities are perhaps one of the most widely documented findings within cognitive aging, and older adults frequently remark on their own difficulties with remembering. Older adults, more often than younger adults, remember less information overall, have difficulties forming associations between information, and are more likely to experience false or inaccurate memories. However, if the to-be-remembered information is more personally relevant, realistic (i.e., consistent with prior knowledge), valuable, or more emotionally meaningful, age-related differences can be reduced. Research examining older adults' metacognitive abilities has yielded mixed results, with some studies documenting impairments, and others finding no age-related changes. Thus, there is at least some evidence suggesting the abilities to correctly predict one's memory abilities and monitor one's learning processes remain somewhat intact, at least compared to explicit memory abilities. This could be a result of lifelong experience "working" and learning to understand one's own dynamic memory capacities.

Expertise and Training

A majority of the theories and evidence discussed earlier in this chapter indicate that older adults' cognitive performance across several domains declines with age (e.g., Salthouse, 1985). But what role might expertise or training play in mitigating these effects? Many cultures consider old age to be associated with maturity and vast amounts of experience, as can be illustrated in the medical, musical, and even business fields (Krampe & Charness, 2006). Indeed, a majority of Fortune 500 CEOs range in age from their late 50s to early 60s. This begs the question whether older adults who are considered "experts" in a certain profession or skill are exempt from age-related declines and can function just as efficiently in their trade as their younger counterparts. What role does training have in maintaining expertise in older adulthood and how does it differ from the training of young adults? Finally, are the effects of training long lasting and differentially beneficial in older adulthood?

Expertise

The first, and arguably most important, question to consider is whether older adults who are classified as experts in a specific skill are exempt from age-related declines. The results are somewhat mixed, depending on the nature of the assessment given and how related it is to the mastered skill (Morrow et al., 2003). For example, Castel (2007) tested younger and older adults, as well as a group of retired older accountants and bookkeepers for their ability to recall object, numeric, and location information (e.g., 26 cherries in a bowl). The results revealed that the older adult experts performed just as well as the older controls in recollection of object information (skill unrelated), but those same experts outperformed younger adults (and older adults) in their memory for the numeric information (skill related). This finding supports the notion that there are some basic limitations to expertise in old age, in the sense that mastery in one skill (recall of unrelated numbers) does not necessarily translate into high performance of another skill that is less related (recall of objects; see also Salthouse & Maurer, 1996).

However, expertise within some fields may serve to enhance certain cognitive capabilities, such that there may be some transfer effects into other domains (Chase & Ericsson, 1982; Krampe & Charness, 2006). To illustrate this point, Shimamura and colleagues (1995) examined the ability to recall prose information (pertaining to various topics) in younger, middle-aged, and older professors, as well as in college-educated younger and older adult "nonprofessor" controls. Older adult controls displayed deficits in recalling prose information relative to younger controls. However, processing and remembering dense passages is something that professors do frequently and is thus an area in which they could be considered experts. Among the groups of professors no age-related differences were found, despite the fact that the to-be-remembered material was not directly related to their fields of study. These results suggest there can be benefits for remaining highly cognitively active in old age, in that it may mitigate declines in certain memory abilities.

Similarly, Krampe and Ericsson (1996) suggest that lifelong experience and use of an acquired skill is sufficient to sustain lifelong expertise (Meinz, 2000; Meinz and Salthouse, 1998; Salthouse, 1991; Salthouse et al., 1990; but see Krampe, Engbert, & Kliegl, 2002; Krampe, Mayr, & Kliegl, 2005). This assumption was supported by Charness (1981a; 1981b) who found that although older adult chess players came up with fewer potential moves than their younger equivalents, the moves they selected were of equal quality. Thus, even older adults who are classified as experts are still susceptible to reduced cognitive resources and have to consider only the valuable or relevant information as opposed to every possible option. Indeed this "refinement" may also be associated with training or maintenance of expert skill levels, and many older adults claim that their practice is more "efficient" than when they were younger (Krampe, 1994; Krampe & Ericsson, 1996). This is consistent with the selective optimization with compensation model which claims that older adults can use novel or alternative means to counter losses in certain functions (Baltes & Baltes, 1990).

Training

Older adults, to some extent, can benefit from specific training designed to enhance or preserve cognitive abilities. A majority of studies have explored interventions to maintain, if not eliminate, age-related declines. For example, Willis et al. (2006) had older adults participate in a cognitive training intervention known as ACTIVE (Advanced Cognitive Training for Independent and Vital Elderly), which included memorial, inductive, and speed of processing training, and measured daily functions and cognitive abilities after an extensive delay (5 years). Although the training did not eliminate age-related functional declines in everyday activities, it did substantially slow their progression. Cavallini, Pagnin, and Vecchi (2003) illustrated similar findings by training working memory. Both younger and older adults benefited from the training, but younger adults' memory performance was still better than that of older adults. This study illustrates that although working memory does deteriorate in normal aging, older adults can still learn new information and strategies to counteract the decline (but see Dumitriu et al., 2010). Training can also lead to benefits in self-monitoring, making older adults more aware of what information they have not learned as well, which they should opt to study for longer periods of time (Dunlosky, Kubat-Silman, & Hertzog, 2003).

The long-lasting effects of training for older adults are comparable to those for younger adults, but daily use of the strategies learned is the best predictor of such benefits. For example, memory performance was similar to posttraining measures, given maintenance of practice for older adults after a 2-year delay (Bottiroli, Cavallini, & Vecchi, 2008). Derwinger, Neely, and Bäckman (2005) gave older adult participants either structured training or participant-generated mnemonic training. They found superior memory performance for the generated mnemonic group 8 months posttraining, even though the structured training group still showed a long-term benefit of training relative to controls (see also West, Bagwell, & Dark-Fruedeman, 2008). Benefits of training have also been demonstrated for shorter time scales. When using an incremented-difficulty approach (i.e., adding more and more intervening trials between test trials), older adults were able to correctly recollect information across increasing delays (Jennings & Jacoby, 2003). Overall, it appears as though cognitive training cannot completely eliminate declines in cognitive function (see

Hertzog, Kramer, Wilson, & Lindenberger, 2009), but it can be effective at slowing the rate of decline, especially if the training is incorporated into everyday life or the strategies used are self-generated, as the impact can be relatively long lasting.

Summary

Older adult experts are often exempt from age-related declines, but only for tasks that are related to the skill in which they acquired expertise. Even in light of declines, abilities that are frequently maintained or refined across the lifespan may allow older adults to continue to function optimally within skill-specific domains. While unable to completely stop or reverse age-related declines, cognitive training in older adulthood can slow declines via specific strategies designed to counteract specific detriments. In particular, self-generated techniques, and frequent use of learned strategies, make the benefits of training more robust and long lasting; however, the transfer of these skills to other domains is often limited.

Wisdom and Successful Aging

While it is clear that cognitive decline typically accompanies old age, many older adults are highly successful individuals who are high-functioning and are respected for their wisdom. For example, many CEOs, world leaders (or advisors), and deans of major universities are older adults who are recognized for their wisdom and expertise, and are entrusted with making important decisions and solving difficult problems (see also Salthouse, 2010). While the study and definition of wisdom is often elusive, most would conceptualize wisdom as expert knowledge or experiences that help inform future decision making and behavior (Baltes & Smith, 1990; but see Jeste et al., 2010). In addition, wisdom is often mentioned in the same breath as creativity and sometimes genius (see Sternberg, 1985, also Simonton, Chapter 25). Thus, while the concept of wisdom is still elusive in terms of a precise definition and components, it is clear that we can recognize the usefulness of wisdom, and we often turn to people rich in wisdom for guidance and trust their judgment. While various forms of cognitive processes seem to slow or are impaired in old age, it is widely believed that wisdom often increases with age and life experience. In fact, as discussed by Goldberg (2006) in his book *The Wisdom Paradox*, people associate wisdom with advancing age (Orwoll & Perlmutter, 1990) and also regard wisdom as one of the most desirable traits (Heckhausen, Dixon, & Baltes, 1989), clearly demonstrating there are some positive aspects to arriving at old age.

In an attempt to measure the contribution of age to social wisdom, Grossmann et al. (2010) had participants read stories about intergroup and interpersonal conflicts, and they were then asked to predict the end result of these conflicts. Compared to young and middle-aged adults, the older adults used higher order reasoning schemes that emphasize the need for taking multiple perspectives, allowing for compromise, and the recognition of the limits of knowledge (Grossmann et al., 2010). This finding suggests that in contrast to other types of reasoning that are typically measured in the lab and are found to decline with age (see Salthouse, 2000), some forms of social reasoning may actually improve with age and life experience.

Research has also shown that creative pursuits are influenced by age. Lehman (1953) outlined how production of superior lyrical poetry and music typically shows a peak between the ages of 25 to 29 but also again at the age range of 80 to 84 (see also Simonton, 1998). In addition, the cognitive processes that lead to creative output at an early age may be altered or controlled by completely different mechanisms than those that contribute to creative output in old age. This is clearly an avenue for future research, but what is apparent is that the odds of producing great work is related to the number of attempts, suggesting that perseverance and wisdom may enhance creativity in older adults. In addition, people often change roles due to lifelong experience, such as taking on new jobs, teaching roles, or advisor positions, or simply by taking different perspectives due to expertise and knowledge. The use of creativity and wisdom in later life can then be linked directly to successful aging (Adams-Price, 1998). For example, while Michelangelo and Einstein had some of their most productive years at an early age, their wisdom was then often called upon later in life to provide advice and insight regarding important decisions and events. Nora Ochs recently became the oldest person ever to finish college when, at age 95, she completed a degree in history and graduated on the same day as her 21-year-old granddaughter, demonstrating that perhaps the key to creativity and enjoyment in old age is engaging in active pursuits.

According to theorists Rowe and Kahn (1998), successful aging can be defined as a combination of several key elements. These include an absence of diseases and disabilities; dealing with changes in control, bereavement, and social support; maintaining high levels of physical and cognitive abilities; and preserving social and productive activities. From a more behaviorist perspective, toward the end of his career and well into old age himself, B.F. Skinner wrote a book on how to enjoy old age (Skinner & Vaughn, 1983). Although he outlined the numerous limiting factors associated with aging, he also focused on the many positive aspects of aging and the need to selectively focus on certain goals (c.f. Baltes & Baltes, 1990), as well as the need to have an optimistic perspective regarding life and development. While creativity, wisdom, and successful aging are central themes in life-span development, there is a clear need to better understand how specific cognitive processes and perspectives contribute to successful aging.

Conclusions and Future Directions

Although some declines in cognitive capabilities may be inevitable with age, a growing body of research has begun to emphasize the sizable impact that factors such as goals, motivation, prior knowledge, and experience have on older adults' performance across a variety of domains. In addition, given the broad and diverse changes that can accompany aging, future research needs to examine how thinking is impaired and enhanced in older adulthood by considering the effects of the factors mentioned earlier, as well as culture, wisdom, and expertise. It is not enough to document impairments, as research has identified many areas in which older adults show qualitatively different approaches to problem solving, incorporate emotional content when making decisions, and are often more experienced than younger adults. Thus, a more comprehensive and multidimensional approach to the study of age-related changes is warranted, one that considers the dynamic interaction of motivational, emotional, and biological changes and the impact these factors can have on cognitive processes (see also Hess, 2005). In addition, the manner in which older adults can judiciously determine what information is important, use that information to facilitate memory and decision making, and then communicate important information to others in an efficient manner, is an interesting avenue for future research (see also Castel, McGillivray, & Friedman, 2011). Lastly, the use of technology has greatly changed how people can access information when making decisions and when trying to remember information. Today, more and more older adults are using the Internet and hand-held devices (Charness & Boot, 2009). The access and use of technology, and how this modifies thinking for older adults (e.g., Small, Moody, Siddarth, & Bookheimer, 2009) is an important direction for future research.

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