10 Metamemory and memory efficiency in older adults

Learning about the benefits of priority processing and value-directed remembering

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> Selection is the very keel on which our mental ship is built. And in the case of memory its utility is obvious. If we remembered everything, we should on most occasions be as ill off as if we remembered nothing.
>
> William James (1890, p. 680)

> [I]t is a triumph of life that old people lose their memories of inessential things, though memory does not often fail with regards to things that are of real interest to us. Cicero illustrated this with the stroke of a pen: No old man forgets where he has hidden his treasure.
>
> Gabriel Garcia Márquez (2005, p. 10)

INTRODUCTION/OVERVIEW

People need to remember important information in order to function efficiently. This includes remembering to buy necessary and important items at a grocery store, to pack essential items for a trip, to report important symptoms to a physician, or the main points from this chapter. Thus, the ability to select and remember important information is critical at any age. The ability to allocate attention and monitor memory capacity strategically can allow us to remember important or "high-value" information; we refer to this as value-directed remembering. In order to attend successfully to important information, which often occurs at the expense of other lower value but competing information, one has to be aware of how memory works and, more specifically, how memory can often fail. The ability to accomplish this requires metacognitive processes—more specifically, metamemory.

Metamemory is the knowledge and awareness about one's own memory and how memory works more generally. Thus, metamemory plays a key role when one is learning how to focus strategically on important information. The present chapter reviews age-related changes in metamemory, examines how goals and biases influence what is encoded by older adults, discusses when and how older adults can (and often need to) focus strategically on important information, and presents current research on this topic. A conceptual and computational framework is presented that demonstrates how metacognition and priority processing influence what information is later remembered. We conclude by discussing future directions and implications regarding age-related changes in memory, metamemory, and the value-directed remembering approach.

METAMEMORY IN OLDER ADULTS

During a recent conversation, an older adult revealed some interesting observations about his memory. He said his memory was declining, and as a result he realized he had to pay extra attention when something was important to remember (e.g., ask the person to say it again, write it down). While he claimed to remember important things often, when he did forget something important, he was again reminded about how his memory was declining. He noted that this cycle of events, while at times very frustrating, reminded him of how his memory works, and when it fails. This anecdote illustrates that age-related changes in memory are often accompanied by self-reported observations of this phenomenon, especially when individuals notice that they are forgetting something important or are forgetting more frequently. The present chapter reviews how memory, metacognition, and the value of what one remembers interact during advancing age, and it outlines current research that addresses this issue.

Older adults are aware of age-related changes in memory performance (Hertzog & Hultsch, 2000) and often feel they have less control over their memory abilities (Lachman, 2006). Older adults are also highly susceptible to stereotype threat, so even subtle "reminders" about aging lead to poorer memory performance (Hess, 2005; Levy, 1996; Stein, Blanchard-Fields, & Hertzog, 2002). In addition, older adults frequently report anxiety when faced with memory-demanding situations and challenges (Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005), which can then lead to poorer memory performance.

As mentioned earlier, metamemory is the knowledge and awareness about one's own memory and how memory works more generally. The anecdote at the beginning of the section is an example of metamemory (i.e., someone's observations about his or her own memory), and while personal observations such as these are often informative, experimental research on the topic has uncovered interesting and potentially useful findings. The literature regarding the impact of aging on metamemory abilities is mixed (see Hertzog & Hultsch, 2000). In some situations, older adults have exhibited either over- or underconfidence regarding how well they think they can remember information; in other instances, older adults display relatively accurate metacognitive judgments regarding both remembering and forgetting (e.g., Halamish, McGillivray, & Castel, in press; Hertzog, Kidder, Powell-Moman, & Dunlosky, 2002), possibly due to the lifelong experiences they have with memory use and the frequency in which they experience memory failures.

Interestingly, while older adults often express negative beliefs about their memories' capabilities, in some cases they may initially overestimate their ability to recall information (e.g., Bruce, Coyne, & Botwinick, 1982; Connor, Dunlosky, & Hertzog, 1997; Lachman & Jelalian, 1984; Murphy, Sanders, Gabriesheski, & Schmitt, 1981; Rast & Zimprich, 2009), whereas in other situations they may underestimate it (e.g., Coyne, 1985). An inability to monitor, predict, and assess one's own memory has obvious negative consequences. It can result in disappointment or embarrassment in situations where an individual is not able to remember what they think they will be able to remember. It can also lead to instances of forgetting, potentially resulting from the failure to allocate necessary time or effort needed to encode useful or important information. However, if one is aware of things that one might forget, one can learn to spend more time rehearsing that information, leading to better memory.

Optimal metamemory functioning involves accurately assessing one's own memory abilities and using memory principles to enhance memory performance. 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 asking participants what information they feel they need to restudy or study for shorter or longer periods of time (a form of metacognitve *control*). Bruce and colleagues (1982) found that although JOLs were similar for younger and older adults when learning a list of words, older adults recalled significantly fewer words (see also Connor et al., 1997), supporting the notion that older adults may suffer from metamemory monitoring as well as memory impairments (Pansky, Goldsmith, Koriat, & Pearlman-Avnion, 2009; but see Lovelace & Marsh, 1985; Rabinowitz, Craik, & Ackerman, 1982).

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 assigned lower JOLs (i.e., words they judged as more difficult to recall) compared to those word that had been given higher JOLs (judged as more likely to remember). However, younger adults exhibited this effect to a much greater extent, indicating that age-related differences were present in the degree to which monitoring was used to allocate study time effectively. Dunlsoky 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, with both groups selecting to restudy the items to which they had assigned lower JOLs. Thus, it appears that both younger and older adults learn to restudy information that they feel is more difficult to remember, suggesting that aging may not necessarily compromise monitoring and control skills.

This is a short and selective review of the metamemory and aging literature, but what we hoped to highlight is that while in some cases older adults do not display accurate metacognition, in many instances older adults' metamemory is as accurate as that of younger adults, if not even more insightful. For a more comprehensive discussion of metamemory and aging, including other types of metamemory assessments such as "feeling of knowing" (FOK) judgments, the "tip of the tongue" (TOT) phenomenon, and strategy use, see Hertzog and Hultsch (2000) or Dunlosky and Metcalfe (2009).

We will now review the factors that influence how older adults allocate attention and memory resources in a strategic fashion and how task goals and metacognitive monitoring can play a central role in later memory performance. Specifically, we will show that metacognitive processes can modify the scope of attention and the contents of memory; we will refer to this as the "metacognition modifying attention" (or MMA) hypothesis. The MMA hypothesis states that the need to encode high-value information and the awareness of a fixed or limited memory capacity can lead to the efficient allocation of attention toward important information at the expense of other, competing information. MMA involves the interaction between goals and evaluative processing (deciding what is important to remember), attentional control (being able to direct attention successfully to this information), and adjustment of metacognitive monitoring (learning about memory capacity) with appropriate feedback and task experience—factors that will be discussed in the following sections.

MEMORY EFFICIENCY AND THE STRATEGIC USE OF MEMORY CAPACITY

Most studies of episodic or working memory involve measures of memory capacity, accuracy, or quality, and older adults typically display deficits in these domains (but see Zacks & Hasher, 2006). However, very little research has examined measures of "memory efficiency," which involves evaluating how one focuses on important information, given memory capacity constraints. Older adults need to use memory efficiently, given memory impairments, and this involves prioritizing what is important to remember while being aware that not all information can be retained; we refer to this as value-directed remembering. Assigning value or utility to characteristics or options in the context of decision making has been a central component to theories regarding choice behavior (Tversky, 1969, 1972); however, in the context of memory research, very little emphasis has been placed on the value of to-be-remembered information and how older adults might use value to guide encoding and retrieval operations.

To determine if something is important to remember, people use "evaluative processing," which leads to the assignment of some sort of value to the information, and this process can be influenced by a variety of factors (see Castel, 2008). Most typically, value is based on how important the information is for the current goals of the individual, whether this information is consistent or inconsistent with prior knowledge, and motivation and anticipated future use of this information (e.g., Hess, Rosenberg, & Waters, 2001).

In the present chapter and viewpoint, the term *selectivity* refers to focusing on certain items or events that are perceived to be of high value, possibly at the expense of lower value information. As suggested by Riediger and Freund (2006), a more general form of "motivational" selectivity may involve two forms: (1) *focusing* on high value/important information, while also (2) *limiting* or *restricting* the access of lower value or more peripheral information. In the context of metacognition and goals influencing this process, one can consider the following example. When packing for a trip, one needs first to pack important and necessary items (e.g., clothes, money, etc.) and then include other, more peripheral items (e.g., books, camera, etc.), if space permits. In addition, it may be strategic first to pack the most important items, to ensure that these are not forgotten.

The conceptual framework of selection, optimization, and compensation (SOC; Baltes & Baltes, 1990; see also Riediger, Li, & Lindenberger, 2006, for the adaptive nature of SOC) posits 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 goals, compensating for impairments by optimizing performance in specific, goal-related domains. This type of selectivity can be focused on achieving certain goals and can also be "loss based" (Freund & Baltes, 2002) as older adults adjust their goals in response to feedback or losses in order to attain desired and realistic outcomes eventually. In a similar vein, Heckhausen (1999; Heckhausen & Schulz, 1995) suggests that individuals have to take on the regulation of aging-related resource losses in order to function efficiently; this can lead to an improvement in efficient cognitive function. More recently, Hess (2005) has highlighted the "adaptive nature of cognition" and suggested that numerous factors (such as goals, social contexts, and characteristics of the individual) can influence selectivity and moderate age-related memory impairments.

Relating life span development theory to experimental studies of memory, a useful approach (although not typically incorporated in cognitive aging research) was outlined in Jenkins's (1979) tetrahedral model of memory experiments. Similarly to the SOC model, this model also emphasizes the sensitivity of memory to context, such that memory performance in a given situation is determined by interactions between four categories of variables: participant characteristics and goals, the cognitive strategy necessary for good performance, the nature of the to-be-remembered materials, and the manner in which one assesses performance. Extending Jenkins's ideas to cognitive aging, Hess (2005) has highlighted the need for a more multidimensional approach within the study of memory and aging in order to understand and explore the constellation of factors that influence and possibly mitigate the memory impairments so often observed in older adults.

THE EFFECTS OF GOALS AND RELEVANCE ON MEMORY IN OLDER ADULTS

People are often presented with more information than they can later remember, such as when listening to an hour-long lecture or, more practically for some older adults, when presented with a lengthy list of side effects of a given medication. Thus, it is critical to decide what information is important to remember, attend to this information, and encode it as valuable so that it can later be retrieved. This is especially true for older adults, who have widely documented impairments in attentional control and memory (Balota & Faust, 2001; McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010) such that it is imperative to learn how to select what information should be remembered. Thus, the rememberer's goals play a key role in determining what information is attended to and how that information is deemed important to remember.

Typically, the goal in most experimental studies of episodic memory is to remember as much information as possible. Older adults usually show pronounced deficits in memory capacity (they remember less information), as well as deficits in memory quality and accuracy, compared to younger adults (see Koriat & Goldsmith, 1996). However, when more specific goals are set, the role of motivation to achieve these goals can lead to important insights regarding age-related differences in memory performance.

Several studies have examined how motivated cognition and goal-directed memory influence memory performance in old age. Much of this work has examined how emotional information is processed by younger and older adults and the strategic and adaptive use of goals in memory and decision making. It has been suggested that emotional regulation and emotional well-being are an important goal for older adults (e.g., Carstensen

1992, 1995). Investigations into the influence of emotional goals on memory have often found a "positivity ~~effect~~" in older adults' memories.

Specifically, relative to younger adults, older adults are more likely to remember positive emotional information relative to negative emotional information (Mather & Carstensen, 2005, Tomaszczyk, Fernandes, & MacLeod, 2008). However, under divided attention, older adults do not show this positivity effect, suggesting that it may result from the strategic allocation of attention (Mather & Knight, 2005). Additionally, Fung and Carstensen (2003) found that older adults tend to favor and remember advertisements that are consistent with emotional goals, suggesting that emotional regulation can influence and motivate what older adults remember.

Older adults may perform well on more naturalistic memory and decision-making tasks because they involve more everyday forms of memory and reasoning (e.g., Castel, 2005; Rahhal, May, & Hasher, 2002; Rendell & Craik, 2002; Tentori, Osherson, Hasher, & May, 2001). Thus, it may be possible to reduce memory impairments by using materials that lend themselves well to typical memory and decision-making challenges faced by younger and older adults outside the laboratory. What remains unclear is how these groups weight various components of a task, and the MMA approach seeks to emphasize the role of evaluative processing by older adults, leading to adaptive and efficient performance (cf. Schacter, 1999).

The manner in which value is subjectively and internally assigned to information, such as choice features, positive and negative emotional valence, or components of a decision-making process, is critical. Older adults may be more aware of the need to use value to guide encoding and retrieval, relative to younger adults, and it is this observation that might reinforce the need to prioritize how information is processed (e.g., evaluating the relevance or priority of information) in order to lead to efficient memory performance.

Hess and colleagues (Germain & Hess, 2007; Hess et al., 2001; see also Hess & Emery, Chapter 8, this volume) have investigated the role of personal relevance and its impact on memory performance in older (and younger) adults. For example, 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 to one describing a younger target person, and this accuracy increased under situations in which they were held accountable for their responses (increased motivation). Furthermore, older adults benefited 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 also with more efficient processing, and these effects were stronger within the older adult sample. Additionally, personally relevant material was shown to down-regulate the impact of the distracting information, suggesting that relevance can act to moderate the effects of interference from competing information. These findings suggest that older adults are able to allocate cognitive resources selectively when appropriate motivational influences are present (Hess et al., 2001; see also Tomaszczyk et al., 2008).

Older adults clearly have different goals relative to college students in terms of memory performance in the context of life span development and possibly also on laboratory-based memory tests (see also Carstensen, 1995), so it seems sometimes problematic to compare older adults to younger adults in these types of situations (see Castel, 2008). For example, Labouvie-Vief (1990) suggests that knowledge *acquisition* is more associated with young adulthood, whereas knowledge *utilization* may be more relevant in middle and later adulthood (see also Ardelt, 1997, 2000).

In a typical memory experiment setting, older adults may not be accustomed to memorizing large amounts of information or using esoteric methods to commit arbitrary information to memory, and often do not encounter the constant tests and exams that are common practice for college students. Younger adults who are college students could in fact be classified as "expert memorizers," in a much different sense than older adults, given the emphasis that is often placed on memorizing information and terminology when studying for exams, perhaps at the cost of being selective. Older adults may use evaluative processing to remember selectively only certain types of information, often at the cost of being able to remember large amounts of information or specific arbitrary details. Similarly, experts of various ages learn to attend to key features, such as when viewing a chess game or distinguishing between birds or different artistic styles, depending on the domain of expertise (Ericsson, Charness, Feltovich, & Hoffman, 2006). Beilock and Carr (2001) found that expert golfers focus on important features during domain-specific tasks (e.g., putting), but then later report lengthy but more generic or gist-base memory for the prior episode, relative to novices who report more specific episodic details (see also Castel, 2008).

Older adults may learn to become experts in terms of how to evaluate what information is important to remember, at the expense of details that are often not well remembered (Koutstaal, 2006). Adams (1991) and Adams, Smith, Nyquist, and Perlmutter (1997) have shown that older adults recall the gist of stories, as well as more interpretative information, whereas younger adults are better at recalling specific details of a story. This suggests that older adults use memory in different ways, especially in terms of the abstraction and retrieval of gist, and perhaps think that the retention and communication of the gist or main points are more important than recollection of specific details. Determining what information is important to remember and effectively retaining and commutating this information is a critical function and involves the strategic control of encoding and retrieval operations.

Au: "commutating" or "communicating"?

THE VALUE-DIRECTED REMEMBERING APPROACH AND FINDINGS

Value-directed remembering requires the ability to allocate attention and monitor memory capacity in order to remember important or "high-value" information (see Castel, 2008). Thus, the value-directed remembering approach is concerned with how people can selectively remember important information at the expense of less important information. One method to examine the impact of value or importance on memory performance in an experimental setting is to have to-be-remembered items in a list assigned a range of different values. This differs from typical memory experiments in which each item, picture, or word pair is of equal importance to remember. By assigning different values to to-be-remembered items, one can determine how participants use value to guide encoding and retrieval processes and how they adaptively focus on high-value information.

In the "selectivity" paradigm (Castel, Balota, & McCabe, 2009; Castel, Benjamin, Craik, & Watkins, 2002; Castel, Farb, & Craik, 2007; Castel, Lee, Humphreys, & Moore, 2011; Hanten et al., 2007; Watkins & Bloom, 1999), participants are presented with a list of 12 words, and each word is paired with a different numeric value ranging from 1 to 12 (e.g., table 5, uncle 9, apple 2, pilot 6, etc.; see left panel in Figure 10.1). In some variants of this procedure, the value is presented immediately after the word to ensure that participants do not simply ignore low-value words. Participants are told that they should try to remember as many words as they can for a later recall test so that they maximize their score. The score is the sum of the associated values of the recalled words, and the experimenter informs participants of their scores once they have recalled the words. Following this feedback, participants are then tested with additional lists and encouraged to remember the high-value words in order to maximize their performance, although recalling any word will lead to a higher score.

The results from a selectivity experiment are displayed in the right panel of Figure 10.1, where the probability of recall is plotted as a function of point value. Younger adults perform quite well and on average recall more words than older adults, but in some instances do not appear as selective, recalling both high- and low-value words (Castel et al., 2002). Importantly, after some experience with the task (participants are given numerous unique lists, one after another), participants become aware that they cannot remember all of the words (because the words are presented fairly rapidly at encoding). Thus, participants begin to focus on or select the highest value words to remember in order to boost their score. Older adults are quite efficient at selectively remembering high-value words (i.e., the 12-, 11-, and 10-point value words) in light of knowing that they will likely only be able to remember three or four words. Thus, as can be seen in Figure 10.1, age-related differences in memory essentially disappear for high-value words and are greatest for the lower value words.

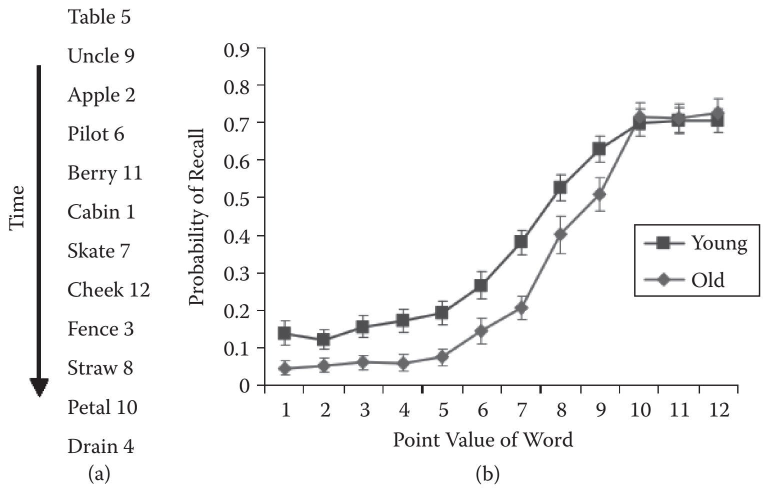

FIGURE 10.1 The selectivity procedure (panel A) and results (panel B) from the selectivity paradigm. Panel A: the participants are presented with a list of 12 words (one at a time), with each word having a unique value ranging from 1 to 12, and the values randomized across the serial positions. Participants recall the words with the goal to maximize their score, are given feedback about their score, and then engage in successive new lists and feedback about their score. Panel B: the results in terms of the probability of recall for younger and older adults as a function of point value. (Adapted from Castel, A. D. et al., 2002, *Memory & Cognition, 30,* 1078–1085; Castel, A. D. et al., 2007, *Memory & Cognition, 35,* 689–700.) There are no age differences for high-value items (12-, 11-, and 10-point words), whereas age differences exist in memory performance for other, lower values.

It is important to note that participants were told their score after the recall of each list and were then given another new list (in some cases doing this up to 48 times), so after the first few lists participants learned to become more selective in order to maximize their score (see Figure 10.2). An efficiency measure known as the "selectivity index" can also be calculated; this compares the participant's score relative to an ideal score based on the number of words recalled. For example, if an individual recalled three words, an ideal score would be 10 + 11 + 12 = 33 (i.e., recalling the top three words); however, if an individual's actual score was 8 + 10 + 12 = 30, then the selectivity index would be the actual score divided by the ideal score, actual/ideal = 30/33 = .91 (see Castel et al., 2002, for more details about the selectivity index).

In fact, under certain conditions (such as immediate free recall), older adults have displayed a higher selectivity than younger adults because they consistently recalled only the highest value words, whereas younger adults recalled high- and some additional low-value words (Castel et al.,

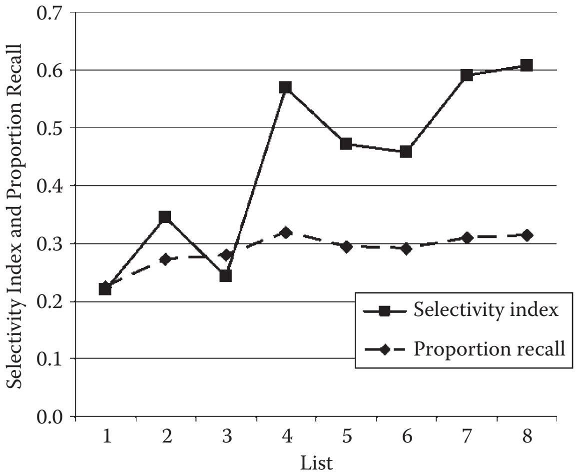

FIGURE 10.2 The selectivity index (derived from participants' overall point value score relative to an ideal score) and proportion of words recalled as a function of task experience (list number) for older adults. (Adapted from data in Castel, A. D. et al., 2002, *Memory & Cognition, 30,* 1078–1085; Castel, A. D. et al., 2007, *Memory & Cognition, 35,* 689–700.) While recall remained relatively stable across lists, the selectivity index increased with task experience.

2002). Because younger adults' overall recall is typically higher than older adults' performance, the index may indeed be somewhat biased. However, it has provided a useful index of performance for several populations. For example, children with attention-deficit/hyperactivity disorder (ADHD) and older adults with very mild Alzheimer's disease have shown specific impairments in selectivity (Castel et al., 2011; Castel, McCabe, & Balota, 2009), suggesting that selectivity is related to attentional control, as suggested by the MMA hypothesis. Thus, as it posits, a central component to the strategic use of memory is the ability to direct necessary attention to important information.

To illustrate how older adults learn to become more efficient in the selectivity task, Figure 10.2 shows performance (in terms of the selectivity index and proportion of words recalled) as a function of list. Recall performance improved slightly after the first few lists and then remained stable. Although older adults did not display high selectivity for the first few lists, after several lists, older adults became more selective by focusing on encoding higher value items, leading to higher efficiency scores (as reflected by the selectivity index). Although not shown in the figure, younger adults showed a similar trend, but with higher overall recall across all lists. Thus, it may be necessary to learn about how to be efficient, and this requires some experience with the task (and may be related to other changes in strategy and control by older adults; see Spieler, Mayr, & La Grone, 2006; Touron, 2006). It may be that older adults engage in an efficient form of event-based prospective memory with practice (e.g., McDaniel, Einstein, Stout, & Morgan, 2003) in terms of remembering to remember higher value information because this is reinforced with many trials and feedback about score in the selectivity paradigm.

Recent ongoing work from our laboratory has examined how younger and older adults learn about memory capacity in a "gambling" experiment (McGillivray & Castel, 2011). In this study, we used a modified version of the selectivity task. As each word-point value pair was presented, participants had to decide if they wanted to "bet" on whether or not they would be able to recall the word: If they recalled the word, they received the points associated with it, but if they failed to recall the word, they were penalized by that same point value. If participants did not bet on the pair, whether the word was remembered or not did not affect their score. How do older adults place their bets in such a task and how does this change with task experience? The results are displayed in Figure 10.3.

For the first list, younger adults received a low yet positive score, whereas older adults bet on more words than they actually later remembered, resulting in a negative score which suggests a metacognitive failure. However, with list experience, both groups increased their score as older adults

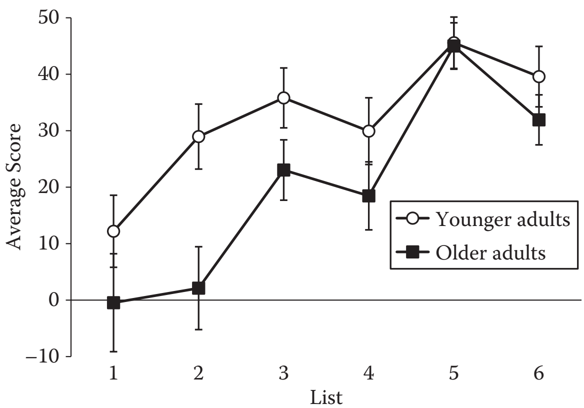

FIGURE 10.3 The average score on each list for both younger and older adults in the point-value "gambling" experiment. (Adapted from McGillivray, S., and Castel, A. D., 2011, *Psychology and Aging, 26,* 137–142.) Scores were calculated by adding the points associated with words that participants "bet" on and successfully recalled and then subtracting the points associated with the words they bet on and failed to recall. Both groups initially bet on more words than later remember (overconfidence). However, with task experience, both groups show improvement and learn to calibrate their bets to their actual memory capabilities, resulting in an increase in score.

learned to bet exclusively on and successfully recall the high-value items. In fact, by lists 5 and 6, older and younger adults obtained comparable scores, despite the fact that younger adults were able to recall significantly more words. This initial metacognitive failure for older adults on the first few lists then led to a recovery due to awareness about how focusing on less, but more important, information can improve performance on later lists. Thus, it may be necessary for both younger and older adults to learn about memory capacity and this requires some experience with the experimental task as well as feedback about score. These findings are consistent with research on the importance of task experience in updating and possibly improving metacognitive judgments and strategies (Dunlosky & Hertzog, 2000; Matvey, Dunlosky, Shaw, Parks, & Hertzog, 2002).

In a similar manner, Castel et al. (2007) employed a selectivity procedure in which words were paired with either negative or positive point values. Thus, participants had to focus on high-value items, but avoid encoding and later recall of the negative-value items. The incentive to focus on positive value in this case was reinforced because participants were instructed that recalling negative-value information would reduce their score. Both younger and older adults successfully recalled the positive, high-value information. Interestingly, much like younger adults, older adults did not recall any of the negative-value information. However, on a later surprise recognition test for all items, older adults were in fact more likely to recognize the negative-value words, relative to younger adults. This finding suggests that older adults did, in fact, process these words perhaps due to poorer inhibitory control (Hasher & Zacks, 1988) and perhaps took longer to code them as negative-value information, due to general cognitive slowing (Salthouse, 1996).

The observation that older adults do in fact initially encode negative, low-value, or irrelevant information is consistent with impairments in inhibitory control found in the directed forgetting paradigm (Bjork, Bjork, & Anderson, 1998). When given cues to remember or to forget certain items, older adults recall more of the "forget" items under certain conditions, suggesting that they have difficulty inhibiting the encoding and later recall of these items (e.g., Zacks, Radvansky, & Hasher, 1996). More recently, Sahakyan, Delaney, and Goodmon (2008) found that both younger and older adults could selectively forget the no longer relevant "forget" information. However, the directed forgetting paradigm does not allow for the examination of how value can influence control over encoding or how task experience can reduced age-related differences; these are critical issues in the present context, given that older adults can learn to rely on value to guide encoding operations. Thus, the idea that older adults can prioritize what information to commit to memory may have important implications for training efficient use of memory (e.g., Benjamin, 2008; Dunlosky & Hertzog, 1998).

We have recently examined how value influences binding in the context of associative memory and faces. A vast amount of research has shown that older adults display an associative deficit (for a review, see Old & Naveh-Benjamin, 2008), and this deficit is present for binding other information to faces, such as names, ages, and other faces (e.g., James, 2006; McGillivray & Castel, 2010; Naveh-Benjamin, Guez, Kilb, & Reedy, 2004; Rendell, Castel, & Craik, 2005; Rhodes, Castel, & Jacoby, 2008). However, the importance of selectively remembering certain "high-value" faces may have a strong effect on how well associative information is encoded by older adults.

To examine this issue, Friedman, Castel, McGillivray, and Flores (2010) had participants study faces, and each face was paired with a dollar amount ranging from $0 to $1,000. Participants were told that the dollar amount reflected how much money they had lent this person and that, if they later correctly recalled exactly how much the person owed them when cued with the face, they would "collect" the money. In general, both younger and older adults recalled a higher value for the faces that owed them more money (see Figure 10.4). Specifically, older adults were very accurate for the high-value faces, but less so for the lower value faces, relative to younger adults.

In a follow-up experiment, participants viewed faces that were paired with either a negative or positive amount of money (ranging from $1 to $100), with negative values indicating that ~~they~~ "owed" this person the stated value and positive values indicating that that person owed the participant the stated value. Interestingly, younger adults showed similar

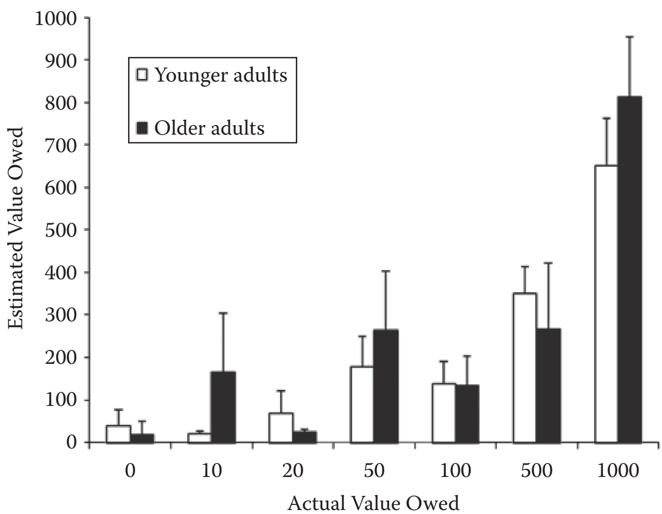

FIGURE 10.4 The average response for the amount of money that each face "owed" the participant. Participants were encouraged to guess if they could not remember the precise amount, and the average response is displayed as a function of the actual amount associated with each face. In general, both younger and older adults provided a greater estimate for the faces that owed more money, providing some evidence for remembering "gist-based" values associated with the faces.

performance for the negative and positive values, with better memory for the extreme values. However, older adults displayed better performance for the positive extreme values, but were significantly impaired for all of the negative extreme values, relative to younger adults. Thus, older adults may be more sensitive to value if it is framed in terms of gains, rather than losses, and this is consistent with their later associative memory performance observed in the present task (see also Denburg, Tranel, & Bechara, 2005; Kovalchik, Camerer, Grether, Plott, & Allman, 2005; Peters, Hess, Vastfjall, & Auman, 2007). This may also be consistent with the positivity bias literature (e.g., Mather & Carstensan, 2005), in that associative information that is presented as more positive relative to the individual is better remembered. In general, this finding indicates that older adults can bind certain value information with faces and may use strategies that bias how well they remember faces as well as the associated value information.

A PRIORITY-RECALL MODEL: THE PRODUCT OF PRIORITY PROCESSING

It is clear that older adults are capable of remembering information that is presented as being either more valuable or more in line with emotional and social goals. While these findings in and of themselves are quite revealing, it is necessary to try to understand how and why important information is better encoded and remembered, as well as factors that moderate the effect. The benefits of priority processing can be illustrated in a more computational manner by considering the interaction between the importance of information and when it actually needs to be recalled.

Anderson and Schooler (1991, 2000) note that the probability that a memory will be needed shows reliable relationships with frequency, recency, and patterns of prior exposures of that memory. They also introduce the "need" probability, which is the future probability that the rememberer will need a particular memory trace—a variable akin to value or priority of the information. To capture how memory is influenced by the perceived importance of the material, as well as the time interval that occurs between initial study and later retrieval, a simple two-parameter model can be derived that illustrates how memory is a product of several key variables that contribute to value-directed remembering.

The current conceptual and computation framework is based on the value-directed remembering approach, with value or priority dictating whether information will be needed and later remembered. The basic necessary computations and variables are such that the rememberer computes an assignment of priority value (PV)—how important the information is—and also time of recall value (TRV)—when this information needs to be recalled to satisfy the goals associated with the information. The product of these two variables would give an estimate regarding the probability of later recall, as shown in the following equation:

Probability of Recall = Product of the Priority Value (PV) × Time of Recall Value (TRV)

or, more simply, using the stated abbreviations:

$$p(\text{later recall}) = PV \times TRV$$

where PV and TRV can be expressed as values between 0 and 1. Larger values of the priority variable (PV) indicate greater priority. Larger values of the time variable (TRV) reflect greater immediacy, whereas smaller values reflect more distance in time (i.e., a longer retention interval).

This equation and relationship between PV and TRV can be illustrated in the following examples. Imagine that while reading this chapter, you notice a reference to a paper you want to include in a book you are currently writing. You thus (either implicitly or explicitly) assign a priority value for the item (because it is important for the book that you are trying to finish, let us assign it .95), and also a time period to remember it later (later today, when you are writing your book, so it is assigned .90). The ensuing computation regarding the probability that you later recall this information would then be .95 × .90 = .86—a fairly high probability, which is a desirable result.

Alternatively, while reading this chapter, perhaps you are reminded about older adults and memory, which makes you think of your great aunt, which then reminds you that her birthday is coming up next month. You want to remember to buy a birthday card for her sometime soon and then put it in the mail. In this case, let us say the priority value is medium to high (e.g., .80), but the time period to remember this is in a week or two (e.g., .20). Thus, the probability that you later remember to do this is .80 × .20 = .16 (which might explain why the card arrives late or does not arrive at all!). It may be the case that older adults have a higher minimum threshold in terms of the probability of successfully remembering something (e.g., the probability must be .40 or greater to remember exact information fully), whereas a younger adult's threshold may be lower, leading to a greater chance of recall and perhaps greater precision of recall.

While the model is an overly simplistic approach, it does illustrate how value or priority (as well as when the information needs to be recalled) can greatly contribute to memory performance. There are many other variables that could be included—notably, age of the individual, the conditions of encoding and retrieval, and cues and prior knowledge that might aid encoding and later retrieval, such as level of expertise if the material is in a specific domain (see also Castel, 2008). The retention of emotional information could also be highlighted in the model because positive emotional information leads to an assignment of high value for older adults, reflecting a form of priority binding (e.g., MacKay & Ahmetzanov, 2005) for this type of salient information (see also Kensinger, 2009). Thus, the PV can be top-down, assigned consciously, and be based on the goals or agendas of the individual (Ariel, Dunlosky, & Bailey, 2009) or could be more data driven and based on certain characteristics of the information (e.g., McDaniel et al., 2003).

The TRV is typically goal driven, but is often dictated by external schedules because one would need to recall the information at a certain time (e.g., for a student, during an exam), as opposed to at any later time (e.g., once the exam is over, the retrieval of the needed answer is not as helpful). Variability in the TRV can result in recalling needed information well after the desired retrieval time, such as remembering a colleague's name 10 minutes after you failed to introduce him to a group of friends. Thus, another variable that could be added is the level of specificity in which you need to remember the information, and the specificity of the retrieval time period—something that is often modified with age (Craik, 2002). For example, remembering more generally to mail your great aunt's birthday card "sometime next week" versus remembering to send the card on Wednesday, before noon, could be introduced into this type of model. Lastly, this model requires empirical testing, and informative data can be generated only when to-be-remembered information differs in value.

It should also be noted that these examples involve retrospective memory for the material in question and how important it is to remember, as well as prospective memory to carry out the tasks (e.g., Kliegel, Martin, McDaniel, & Einstein, 2001, 2004). The research on value and memory discussed so far focused on retrospective memory for the most part and kept the retention interval constant, as dictated by the experimenter. Thus, in order to explore the parameters introduced in this priority processing model fully, one would need to incorporate items/tasks that differ in importance, as well as when the information needs to be later retrieved, and this would be a useful avenue for future research.

FUTURE DIRECTIONS

Much of this chapter has focused on psychological, lab-based assessments of metacognition and memory and how the processing of important information can be "improved" through specific manipulations of goals, motivation, value, and task experience. However, this concept of improving or aiding memory has been garnering increased attention within other disciplines as well. Currently, information technology can seemingly enhance and complicate how we remember important information (see Azevedo, 2007) and thus this area is one that is well suited to utilize and incorporate the lessons we have learned in lab.

As older adults may become less reluctant to use information technology to assist memory function (Charness & Boot, 2010), the judicious use of memory and the interplay between metacognition and the use of information technology in old age is an emerging field. For example, in order to assist with the recording of life events in "memory," Microsoft has developed a wearable digital camera (the SenseCam) that is designed to passively take timed photographs of the environment and personal encounters. In addition, other companies are developing ways to "lifelog" and record almost every minute of one's sensory life experience so that this information can later be accessed if necessary (see Benjamin, 2008; Finley, Tullis, & Benjamin, 2010).

The problematic part of this (excessively) constant recording process is determining what information will, in fact, be needed at a later time. The selection process, as Williams James stated in 1890, is the key to filtering what information is important to remember because being able to remember everything is just as bad as remembering nothing. Marking certain information as important might assist this process so that a memory-assisting device can allow for later and rapid access of this "marked" high-value information, as opposed to having to sift through volumes of irrelevant information. Thus, given the ease of being able to record and store vast amounts of information on a computer chip, the human is left with the critical task of determining what is important—something that perhaps the human memory system is already accomplishing while you read this sentence.

Given the fact that we are constantly bombarded with both useful and irrelevant information and need to be selective about what to attend to, developing a sense of what is important seems critical to leading an efficient and enjoyable life. The ability to focus on, or learn to focus on, important information is a central theme of the value-directed remembering approach. Within the lab, the development and acquisition of this "priority learning" process can occur over the course of a brief training session with a specific memory task (see Figures 10.2 and 10.3).

In a broader context, this ability develops over the course of a college education, in that one (hopefully) learns how to focus on and extract important information in classes and from textbooks. For older adults, this likely occurs over the course of a lifetime in terms of being discerning about what information is important to remember for one's work and daily life. This ability to prioritize and strategically allocate resources toward encoding important information becomes particularly valuable as one ages, given challenges in overall memory function. This ability may be preserved or enhanced despite decline in executive control (MacPherson, Phillips, & Della Sala, 2002) and may be related to older adults' ability effectively ~~to~~ regulate other domains, such as emotion, when attempting to solve problems (Blanchard-Fields, 2007).

In the real world, people obviously vary in terms of what information they find important or interesting and what they wish to remember, and tasks in which the value of the information is predetermined (such as in the selectivity task) do not capture how subjective assessments of importance influence memory. Thus, future research should assess memory under conditions in which the assignment of value is under the subjective control of the individual. For example, when most people pack for an upcoming trip, there are several essential items that they pack (e.g., toothbrush, clothes); the ability to choose which items are more important and how this varies depending on where you are going could offer insight into how individuals prioritize and later remember important information.

When clear and salient cues are used to communicate importance (e.g., point value or a loud voice communicating a message) or when importance within a domain with which one is familiar and has experience (such as packing for a trip) is being determined, older adults may be efficient in terms of later remembering important information. However, if one must first determine importance and then allocate resources to what one believes is important when faced with an unfamiliar situation or set of materials, this could prove to be overly taxing, and memory may suffer. That is, if resources are spent simply trying to figure out how important something is, this could prevent those resources from being allocated to remembering the information or engaging in memory-enhancing strategies. Therefore, future research is needed in order to determine more precisely the conditions under which encouraging and implementing selectivity and priority processing will be beneficial or possibly detrimental to memory performance.

Finally, additional research is also needed to investigate further how metacognition can modify what we attend to and what we then later remember. At present, numerous studies indicate that metacognitive monitoring and control remain fairly 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 so than those associated with actual memory ability. That is, metamemory abilities are likely better preserved in older adults than explicit memory abilities. This is encouraging in and of itself such that older adults may be able to use metacognitive strategies and awareness to help overcome or compensate for age-related declines in memory performance, consistent with the "metacognition modifying attention" hypothesis. The dynamic ability that individuals have to learn about their own memory capacity and how this knowledge can lead to the efficient allocation of attention toward important information is an area of research that is rife with possibilities.

CONCLUDING COMMENTS

The present chapter outlines how, despite a variety of memory impairments, older adults can efficiently use memory by focusing on important information. Metacognition and goals can modify attention, allowing older adults to be selective about what and how much information they encode by placing priority on high-value information. How older adults learn to identify and remember important information remains an open question, and what is in fact important may be directly related to life experience, culture, and wisdom (see Grossmann et al., 2010; Na et al., 2010). Given that memory declines in old age, but metamemory is often spared or even enhanced, it is both realistic and optimistic to consider how metacognition allows older adults to remember important information effectively.

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