

# Understanding How Prior Knowledge Influences Memory in Older Adults

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## Abstract

Older adults have a harder time than younger adults remembering specific events and experiences (episodic memory), whereas the ability to use one's general knowledge either improves or remains stable over the life span. Our focus is on the sometimes overlooked but critical possibility that this intact general knowledge can facilitate older adults' episodic memory performance. After reviewing literature that shows how prior knowledge can support remembering in aging as well as lead it astray, we consider open questions including whether prior knowledge is used only to fill in the gaps after a memory failure and when older adults might need to be instructed to apply their prior knowledge. Overall, we situate our claims within theories of cognitive aging, arguing that prior knowledge is a key factor in understanding older adults' memory performance, with the potential to serve as a compensatory mechanism.

## Keywords

aging, knowledge, episodic memory, memory compensation

Even healthy older adults show declines in episodic memory, meaning that they remember fewer specific events and with less detail, compared with younger adults (for reviews, see Balota, Dolan, & Duchek, 2000; Craik & Byrd, 1982; Craik & Jennings, 1992; Park, 2000). In contrast, older adults' general knowledge tends to be spared and continues to increase with age (e.g., Dixon, 2003; Park, 2000). This pattern holds throughout older adulthood (until extreme old age, which begins around the age of 90). In the studies reviewed here, the "older adults" typically range in age from their 50s to late 80s, with most being between 65 and 85. Our focus is not on documenting older adults' episodic memory declines or their vast knowledge, both of which are well established; instead, our focus is on the interaction between these two types of memory. In the aging and memory literature, prior knowledge is not often thought of as contributing to older adults' ability to remember specific events. When prior knowledge is discussed, it is emphasized as leading older adults astray in remembering, such that they think stereotypically, generalize inappropriately, forget new information that does not fit with what they already know, and falsely remember items that they did not actually encounter.

This review has three main goals: (a) to document the critical role of prior knowledge in understanding older

adults' remembering of episodic memories, (b) to demonstrate that prior knowledge can facilitate accurate remembering, sometimes eliminating age differences in memory performance or even leading older adults to outperform their younger counterparts, and (c) to situate the results within current theories of cognitive aging and identify open questions.

First, we broadly describe the types of knowledge that are spared in the aging process. Then, we document how prior knowledge can have both negative and positive influences on older adults' memories of specific events: The very same mechanisms that can increase memory errors can also benefit older adults' memory performance. The juxtaposition of the negative and positive influences of prior knowledge raises many open questions; we discuss a select few of these, offering (the beginnings of) answers based on the existing literature. Throughout this review, we draw on relevant theories of cognitive aging, including automatic and controlled processes, recollection and familiarity, interference theory, and inhibition. We conclude with a discussion of the

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supportive aspect of older adults' intact knowledge as a potential compensatory mechanism in memory.

### Intact Aspects of Memory in Aging

Across a variety of materials and experimental procedures, older adults exhibit difficulties remembering details related to particular events (i.e., episodic memories; for reviews, see Balota et al., 2000; Craik & Jennings, 1992), such as words (e.g., Park, 1996; Park & Shaw, 1992; Perlmutter, 1978; Shaw & Craik, 1989), narratives (Adams, 1991; G. Cohen, 1979; Reder, Wible, & Martin, 1986), and autobiographical memories (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). Older adults are especially impaired at remembering contextual details (Burke & Light, 1981; Hess & Pullen, 1996; Light, 1992; Park & Puglisi, 1985), showing deficits in identifying the sources or origins of their memories (Craik, 1986; Hashtroudi, Johnson, & Chrosniak, 1989). Compared with younger adults, older adults struggle to distinguish internal sources (e.g., one's thoughts versus actions; Rabinowitz, 1989), external sources (e.g., two different individuals or books; Kausler & Puckett, 1981), and even between internal and external sources (e.g., one's thoughts versus listening to another person; McIntyre & Craik, 1987). However, not all of memory suffers (Dixon, 2003; Glisky & Glisky, 1999; Schaie, 1996; Schaie & Labouvie-Vief, 1974). For example, older adults remember 60% to 80% of their college grades as many as 54 years after graduating (Bahrack, Hall, & Da Costa, 2008) and are almost completely unimpaired on recognizing faces of high-school classmates up to 35 years later (Bahrack, Bahrack, & Wittlinger, 1975).

Critically, knowledge (i.e., crystallized intelligence; Cattell, 1963; Labouvie-Vief, 1977; Schaie, 1970; Schretlen et al., 2000) remains available in memory (Brod, Werkle-Bergner, & Shing, 2013) and often increases with age (Cornelius & Caspi, 1987; Staudinger, Cornelius, & Baltes, 1989). For instance, older adults retain and use knowledge from their formal education (e.g., math; Bahrack & Hall, 1991), continue adding to their vocabularies with advancing age (e.g., Arbuckle, Cooney, Milne, & Melchior, 1994; Bahrack, 1984; Bowles & Poon, 1985; Burke & Peters, 1986; Mitchell, 1989; Perlmutter, 1978), and correctly remember many more facts about the world than do younger adults (e.g., Botwinick & Storandt, 1980; McIntyre & Craik, 1987; Perlmutter, 1978). However, knowledge is broader than words and facts; in this review, the term *knowledge* also includes general knowledge about the world (including autobiographical knowledge; Levine et al., 2002), schemas, work-related skills, and practical abilities gained over a lifetime. Such knowledge is not typically associated with memories of particular instances because it has been acquired through

countless learning experiences in formal education and daily life (Charness & Bieman-Copland, 1992; Lachman & Lachman, 1980).

For the most part, older adults are capable of bringing their considerable knowledge to bear in a variety of situations (see reviews: Charness & Bieman-Copland, 1992; Craik, 2000; Hoyer, Rybash, & Roodin, 1989; Lachman & Lachman, 1980; Light, 1991, 1992; Light & Burke, 1988; Salthouse, 1982; in contrast, see Peelle, Chandrasekaran, Powers, Smith, & Grossman, 2013), although they may sometimes be slower to respond than younger adults or experience difficulties with retrieval (e.g., Brod et al., 2013; Burke & Shafto, 2004). For example, older adults are just as good as younger adults at generating the actions that make up everyday activities (demonstrating intact schemas; Light & Anderson, 1983), at determining whether specific words fit particular sentence contexts (Little, Prentice, & Wingfield, 2004), or at judging the plausibility of events taking place within particular story contexts (Reder et al., 1986). More generally, whether testing typists (Salthouse, 1984), pianists (Krampe & Ericsson, 1996), pilots (Hardy & Parasuraman, 1997; Morrow, Leirer, Altieri, & Fitzsimmons, 1994), bank managers (Colonia-Willner, 1998, 1999), graphic designers (Lindenberger, Kliegal, & Baltes, 1992), accountants and bookkeepers (Castel, 2007), or professors (Shimamura, Berry, Mangels, Rusting, & Jurica, 1995), older adults in the work force typically show few age-related decrements in their productivity or expertise in their field (see also Charness, 1981; Perlmutter, 1988; Salthouse, 1994; Waldman & Avolio, 1986, 1993; in contrast, Meinz & Salthouse, 1998; Salthouse, 1990).

It is interesting to note that also spared is older adults' knowledge about the way that memory works, an important facet of the multidimensional construct of metamemory. The Task subscale of the Metamemory in Adulthood Scale specifically assesses older adults' understanding about how general memory processes work (requiring ratings of statements like "For most people, facts that are interesting are easier to remember than facts that are not"; Dixon, Hulstsch, & Hertzog, 1988). Typically, no age differences emerge between older and younger adults on this subscale (Cavanaugh & Poon, 1989; Hulstsch, Hertzog, Dixon, & Davidson, 1988; for an exception, see Dixon & Hulstsch, 1983). Similarly, older adults understand that it should be easier to recognize high-frequency words than low-frequency words (Bruce, Coyne, & Botwinick, 1982) and correctly believe that it is easier to remember related, organized, interesting, understandable, and/or concrete materials (as opposed to unrelated, unorganized, uninteresting, incomprehensible, and/or abstract materials; Perlmutter, 1978).

The literature is more mixed regarding older adults' ability to apply their general knowledge about memory



**Fig. 1.** Example ambiguous stimuli from Koutstaal et al. (2003).

processes (e.g., Dodson, Bawa, & Krueger, 2007; Halamish, McGillivray, & Castel, 2011; Marquie & Huet, 2000; Perlmutter, 1978; Toth, Daniels, & Solinger, 2011). Older adults are sometimes overconfident in their memories, showing poor calibration to their actual performance (Dodson et al., 2007; Toth et al., 2011); in other cases, older adults accurately judge their forgetting, adjusting their estimates of their performance accordingly (Halamish et al., 2011). Additionally, older adults are capable of using strategic processes, such as allocating additional study time to high-value information, matching younger adults on memory for those items (Castel, Murayama, Friedman, McGillivray, & Link, 2013). In contrast, they are sometimes unable to reallocate their study time on the basis of task difficulty (Froger, Sacher, Gaudouen, Isingrini, & Taconat, 2011). Knowledge about memory may be a special case of general knowledge because one's memory itself changes during aging (unlike most facts about the world). One's self-efficacy and motivation (e.g., Cavanaugh, 1989; Dixon & Hultsch, 1983) may matter more in the domain of memory, even if one's knowledge about memory is intact. Furthermore, implementing one's knowledge about memory requires executive control (e.g., Bouazzaoui et al., 2010) and effective monitoring (e.g., Bieman-Copland & Charness, 1994; Hultsch et al., 1988), two processes impaired in aging.

Overall, the evidence discussed in this section flies in the face of the unfortunate but widely held belief that old age is a time of degradation and a lack of productivity (R. N. Butler, 1974; Mergler & Goldstein, 1983). Instead, it is more consistent with the idea that "acquired knowledge is the magic potion that allows older workers to avoid declines in processing efficiency" (Charness, 2000, p. 104). Note that "processing efficiency" here refers to more than just memory, including other work-related skills such as problem solving. Some researchers even consider older adults to be natural general knowledge "experts" as a result of a lifetime of learning (Hoyer et al., 1989; Perlmutter, 1988; for knowledge-related social expertise, see Hess, 2006; Hess, Osowski, & Leclerc, 2005; Leclerc & Hess, 2007).

## How Prior Knowledge Affects Older Adults' Episodic Memories

Thus far, we have reviewed what is impaired versus spared with aging, contrasting age-related declines in episodic memory to maintained knowledge. The main question is how these two types of memories interact: How does knowledge influence older adults' remembering of specific events? Across many studies, older adults are more likely to falsely remember things that are consistent with their prior knowledge than are younger adults, thereby making errors of commission as well as errors of omission (for reviews, see Schacter, Koutstaal, & Norman, 1997; Schacter, Norman, & Koutstaal, 1998). This data pattern captures the focus in the literature: When considering how knowledge guides remembering of specific events, the literature emphasizes knowledge leading older adults astray (e.g., Alba & Hasher, 1983; Burke & Light, 1981; Charness, 2000; Chen, 2004).

To illustrate this prototypical pattern, consider work by Koutstaal and colleagues, where younger and older adults were asked to remember lists of related pictures (e.g., a series of musical instruments; all objects were common ones). At test, older adults were more likely to falsely recognize related but nonpresented pictures (lures, for example, a harp) than were younger adults (Koutstaal & Schacter, 1997; Koutstaal, Schacter, & Brenner, 2001). To examine the contribution of prior knowledge, Koutstaal et al. (2003) asked participants to study ambiguous pictures. Critically, half of the participants received familiar labels (e.g., "lamp") that made it possible to interpret the ambiguous pictures (see Fig. 1), whereas the others did not. On a later recognition test, older and younger adults performed similarly in the no-label condition and were unlikely to falsely recognize perceptually related but nonpresented pictures. In contrast, when the pictures had been labeled initially, older adults falsely recognized many more new related pictures than did the younger adults. Age-related increases in false recognition were observed only when older adults could bring their prior knowledge to bear, namely, when the ambiguous figures had received familiar labels at study (see Simons et al., 2005, for converging evidence from semantic dementia patients). The literature is full of examples similar to this one, showing that prior knowledge can influence memory to a degree that is no longer facilitative (e.g., Arbuckle et al., 1994; Botwinick, 1984; Ceci & Tabor, 1981; Hess, McGee, Woodburn, & Bolstad, 1998; Labouvie-Vief & Schell, 1982; Radvansky, Copeland, & von Hippel, 2010).

Of course, prior knowledge facilitates learning under a variety of circumstances, regardless of age (Anderson, 1981; Bransford & Johnson, 1972; Glynn, Britton, & Muth, 1985; Kole & Healy, 2007; Kole, Healy, Fierman, &

Bourne, 2010; Schustack & Anderson, 1979). However, there are situations in which older adults benefit more from applying their knowledge than do younger adults, sometimes eliminating age differences in memory (Craik & Jennings, 1992; Hess, 1990, 2005; Hess & Pullen, 1996; Laurence, 1967a, 1967b; Reyna & Mills, 2007; Woodruff-Pak & Hanson, 1995). For example, older adults remember more words than younger adults if the study phase capitalizes on their intact schematic verbal knowledge (Matzen & Benjamin, 2013). In this study, older and younger adults studied words presented alone (e.g., “tailspin,” “floodgate”) and words embedded in sentences (e.g., “The fighter plane went into a tailspin after it was hit by enemy fire”). On a subsequent recognition test, older adults were better than younger adults at recognizing words that had been studied in sentences. Older and younger adults were equally likely to mistakenly accept new items (false alarms), and there were no age differences in correctly recognizing words that had been studied alone. Critically, the authors attributed older adults’ superior performance to “skills honed through years of reading expertise” (Matzen & Benjamin, 2013, p. 765), allowing them to make better use of the sentence contexts. More broadly, as reviewed below, some of the same experiments demonstrating the detriments of knowledge also provide evidence that knowledge can support older adults’ accurate remembering.

We classify these examples into two general kinds: ones that involve older adults’ overreliance on domain-specific knowledge and those that involve overreliance on schemas drawn from a wealth of past experiences. For each set of examples, we first briefly review the costs of knowledge, which have already been thoroughly discussed in the broader literature. Critically, we then go on to highlight the ways in which prior knowledge can facilitate older adults’ accurate remembering. We draw on theories of cognitive aging to explain these patterns.

### ***Costs and benefits of relying on domain-specific knowledge***

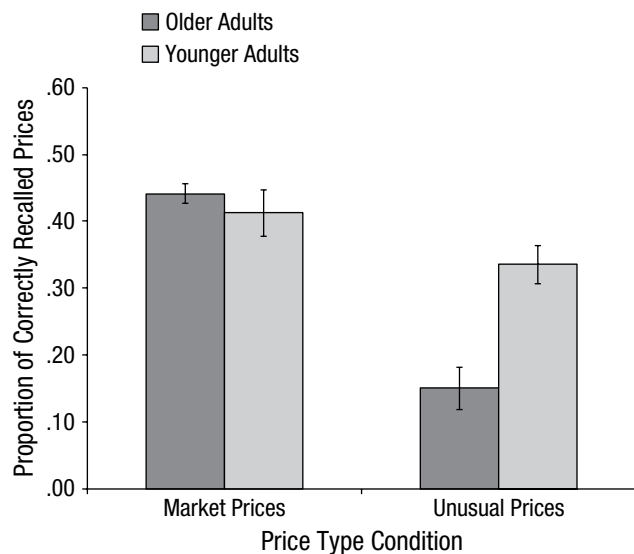
By *domain-specific knowledge*, we mean knowledge that is specific to a particular academic area (e.g., mathematics), hobby (e.g., chess), skill (e.g., spelling), or everyday event (e.g., grocery shopping). We use the term *domain-specific* because knowledge in one such area does not necessarily mean that a person has similar levels of knowledge in another of these areas.

***Costs of prior knowledge.*** Botwinick put forth that “advanced age is associated with a lowered ability to unlearn that which is already integrated into well-established thought and behavior systems” (1984, p. 71). When asked to explicitly go against prior knowledge, older

adults find it very difficult to comply. For instance, compared with younger adults, older adults struggle when asked to recall *false* multiplication equations (e.g.,  $3 \times 4 = 2$ ) that violate preexisting knowledge of multiplication products (Ruch, 1934). The same effect is observed with recently studied misspellings, with older adults struggling to remember misspellings that contradict prior knowledge, although older and younger adults were equally able to correctly note misspellings during the study phase (MacKay, Abrams, & Pedroza, 1999). Older adults are also more likely than younger adults to persist in spelling homophones (e.g., great/grate) in the way they are most frequently used in English (e.g., great), even after hearing a sentence that used the infrequent form (e.g., grate; Howard, 1988). A final example involves remembering fairy tales. Fairy tales are so overlearned for older adults that they have difficulty learning and remembering modified versions of these well-known stories (Dalla Barba, Attali, & La Corte, 2010). That is, compared with younger adults, older adults are more likely to intrude events and details from the original fairy tales (which the authors refer to as “confabulations”) when recalling modifications of well-known fairy tales (see also Attali & Dalla Barba, 2012; De Anna et al., 2008).

***Protective prior knowledge.*** In contrast, overrelying on domain-specific knowledge can also support older adults’ veridical memory, eliminating age differences. For example, the realism of grocery prices affects older adults’ recall of prices presented in the laboratory (Castel, 2005). Younger and older adults studied pictures of common groceries, each of which was priced at market value or an unusual price; at test, participants were asked to recall the price of each grocery item. Realism of price did not affect younger adults but had a large influence on older adults. That is, older adults remembered many more realistic prices than unusual ones (see Fig. 2), and this benefit was strong enough to boost older adults’ recall of realistic grocery prices to the level observed in younger adults.

Prior knowledge can also protect older adults from reproducing erroneous (misleading) facts about the world. For instance, after reading errors in stories that contradict well-known facts (e.g., a reference to “paddling around the largest ocean, the Atlantic Ocean”), older adults were less likely than younger adults to use story errors to later answer related general knowledge questions (e.g., “What is the largest ocean on earth?”; Marsh, Balota, & Roediger, 2005; Umanath & Marsh, 2012). This result was surprising because a large literature demonstrates that older adults are typically more suggestible to misleading information than are younger adults (e.g., G. Cohen & Faulkner, 1989; Dywan & Jacoby, 1990; Karpel, Hoyer, & Toglia, 2001; Loftus,



**Fig. 2.** Proportion of prices correctly recalled as a function of age and price type condition. Adapted from Castel (2005). The error bars reflect standard errors.

Levidow, & Duensing, 1992; Mueller-Johnson & Ceci, 2004; Norman & Schacter, 1997; Roediger & Geraci, 2007; Schacter, Koutstaal, Johnson, Gross, & Angell, 1997; Thomas & Bulevich, 2006). Critically, compared with younger adults, older adults were better able to recover from exposure to errors and instead later produced the correct answers (correctly saying that the Pacific is the largest ocean after reading the misleading reference to the Atlantic). This pattern held even when participants failed to notice story errors while reading and when older and younger adults were statistically matched on a baseline measure of prior knowledge (Umanath & Marsh, 2012). Similar age effects occurred with the Moses Illusion, wherein people often answer “two” in response to the distorted question “How many animals of each kind did Moses take on the ark?” Critically, this error typically occurs even though participants are explicitly told to watch out for such errors and regardless of one’s ability to demonstrate knowledge of the relevant information (e.g., that Noah, not Moses, is the figure in this biblical passage) in another part of the experiment (e.g., Erickson & Mattson, 1981). Regarding age effects, older adults were more likely than younger adults to answer these distorted questions, as opposed to marking them as “wrong” or saying “I don’t know” (Umanath, Dolan, & Marsh, 2014). However, on a later general knowledge test, older adults were less affected by having answered distorted questions; older adults were more likely to recover from exposure to errors and respond correctly than were younger adults. Of course, the argument that knowledge can serve a protective role hinges on the assumption that older adults have such knowledge

stored in memory. When older adults hold misconceptions instead, some evidence suggests that they show the same overreliance on their knowledge, resulting in a cost of prior knowledge (Okun & Rice, 1997; Rice & Okun, 1994).

**Theoretical explanations for age-related overreliance on domain-specific knowledge.** All explanations of older adults’ overreliance on their knowledge rest on the idea that older adults’ prior knowledge is stronger than recent episodic memories or otherwise more accessible in memory. Retrieving prior knowledge is thought to be a relatively automatic process, requiring less conscious effort; critically, such processes are maintained with advancing age ( Craik & Jennings, 1992; Hasher & Zacks, 1979; Light, 1991, 1992; Roediger, Balota, & Watson, 2001). At the same time, there are age-related declines in controlled processes; this deficit translates into problems resolving interference and inhibiting knowledge when it is not relevant.

Older adults’ proclivity to rely on prior knowledge seems to be a clear instantiation of proactive interference, wherein older memories block access to more recently encountered information. Older adults are more susceptible to proactive interference than younger adults (for reviews, see Jacoby, Hessels, & Bopp, 2001; Winocur, 1982). For example, consider a modified A-B/A-C task requiring participants to learn lists of words to criterion, wherein participants first learned one set of word pairs (A-B) and then another set (A-C). When participants were asked to recall the A-C list (given the A part of the pair), older adults remembered fewer A-C word pairs and instead reported items from the A-B list, demonstrating greater susceptibility to proactive interference than did younger adults (Ebert & Anderson, 2009). Older adults have this problem when remembering word triplets (Jacoby, Wahlheim, Rhodes, Daniels, & Rogers, 2010), lists of objects (Loewenstein, Acevedo, Agron, & Duara, 2007), and faces (Flicker, Ferris, Crook, & Bartus, 1989), among other things. Proactive interference also causes problems for older adults when completing the Stroop task (Borella, Delaloye, Lecerf, Renaud, & de Ribaupierre, 2009) and when making social judgments based on trait information (Hess et al., 1998). Returning to one of our earlier examples, the proactive interference account would explain older adults’ difficulty in remembering recently encountered incorrect equations (e.g.,  $3 \times 4 = 2$ ; Ruch, 1934) in the following way: the well-learned correct solution (i.e., 12) was more accessible in memory and thus blocked access to the recently encountered erroneous one.

Age-related inhibitory deficits provide a very similar explanation of these same data (Hasher, Tonev, Lustig, & Zacks, 2001; Hasher & Zacks, 1979, 1988; Hay & Jacoby,

1999; Jacoby & Rhodes, 2006). The idea is that older adults often struggle to suppress partially activated information even if it is irrelevant to the task at hand (e.g., Balota et al., 2000; Hasher & Zacks, 1979, 1988; Kensinger & Schacter, 1999; Malmstrom & LaVoie, 2002), and even when explicitly asked to do so (e.g., Anderson, Reinholz, Kuhl, & Mayr, 2011; Duchek et al., 1995). In the example of remembering the equation  $3 \times 4 = 2$ , the inhibition account would parallel the interference account, except that the memory error would involve failing to suppress one's knowledge of the correct answer. Whether the difficulty is due to prior knowledge blocking access to recent memories or a failure to inhibit prior knowledge, the result is the same: Older adults end up relying on prior knowledge even if more recent experiences contradict that knowledge. This bias can result in benefits (e.g., Kim, Hasher, & Zacks, 2007; see also Rowe, Valderrama, Hasher, & Lenartowicz, 2006) or in costs (e.g., Ebert & Anderson, 2009).

### **Costs and benefits of relying on schemas**

**Costs of prior knowledge.** Older adults show preserved schematic knowledge, retaining generic knowledge of concepts, events, and relationships developed from past experience; however, reliance on such knowledge can lead older adults to make errors when remembering. The Koutstaal work described earlier (and illustrated in Fig. 1) is an example of schema-driven memory errors, with older adults more likely to falsely recognize pictures that matched the schemas of earlier lists than are younger adults. Similarly, after studying generic scenes (e.g., a kitchen), older adults are more likely than younger adults to claim they saw prototypical objects (e.g., a pot) that were not actually presented (versus less common ones; Hess & Slaughter, 1990). A well-known example of schematic remembering is the Deese-Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995), where participants study lists of highly related words (e.g., *bed, rest, tired, snooze*) and are later likely to falsely recall and recognize a critical related but nonpresented target word (e.g., *sleep*). The DRM illusion is stronger in older adults than in younger adults, in both recall and recognition (Balota et al., 1999; K. M. Butler, McDaniel, Dornburg, Price, & Roediger, 2004; Norman & Schacter, 1997; Roediger & McDaniel, 2006; Tun, Wingfield, Rosen, & Blanchard, 1998), with older adults also intruding more related words in addition to the target (Balota et al., 1999). A similar result occurs after studying lists of category exemplars (as opposed to associates; Meade & Roediger, 2006; see also Rankin & Kausler, 1979; A. D. Smith, 1975).

Schemas (in the form of stereotypes) also guide how older adults attribute the sources of their memories (Mather, Johnson, & De Leonardis, 1999). In a prototypical study showing this effect, older and younger adults read passages and watched videos about individuals who strongly fit particular stereotypes (e.g., Democrat, athlete). These videos also showed each individual saying a few statements contradictory to his or her dominant stereotype. On a later test, participants judged whether each of a series of statements had been presented previously and, if so, identified which video character had made the statement. Our focus here is on whether older and younger adults were able to attribute statements to the correct characters (source memory). First, for presented statements, there were no age differences in ability to correctly attribute stereotype-consistent statements, but older adults were less accurate at attributing inconsistent statements (for which their schemas would lead them astray) than were younger adults. Second, for new statements that were consistent with a character's stereotype, older adults were more likely than younger adults to falsely recognize them, attributing these new statements to the stereotype-consistent individual.

A final example involves schemas for spatial information. In one study, older and younger adults studied a layout that matched people's schemas for a prototypical one-story house. Critically, some participants were told the layout was a "building," and others were told it was a "house." Younger and older adults performed similarly when reconstructing the house, but younger adults outperformed older adults when the layout had been labeled as a building. Older adults' memories for the "building" layout contained far more house-related features and arrangements than did younger adults' recall; for example, compared with younger adults, older adults were more likely to mistakenly move closets to rooms that would be bedrooms in a prototypical house (Arbuckle et al., 1994: Experiment 3).

**Benefits of prior knowledge that accompany the costs.** A careful reader would have noticed that many of the studies listed in the "costs" section also can be used to illustrate the benefits of using schemas when remembering. That is, age differences are minimized when to-be-remembered information is schema consistent. When statements were stereotype consistent in the Mather et al. (1999) study, there were no age differences in source memory. Similarly, in the spatial layout study just described, there were no age differences in reconstructing the "house" layout. Older adults could use their schematic knowledge of house layouts to facilitate their remembering of the blueprints. Younger adult performance did not depend on the relevance of the schema activated (and performance was not at ceiling), whereas

older adults improved when the right schema was activated, to the point of eliminating age differences in memory.

Older adults also rely on schemas when reconstructing prose passages (see Hess & Pullen, 1996, for a review). In a representative study, participants read passages about a character named Jack who performed both typical actions while eating at a restaurant (e.g., “Jack asked the waiter for the check”) and atypical actions (e.g., “Jack put a pen in his pocket”; Hess, 1985). Older adults showed a larger advantage for typical actions (over atypical) than did younger adults. More generally, the more prior knowledge older adults can apply, the smaller the age difference in memory. Atypical actions can be further broken down into those that do versus do not fit within a schema (schema relevance); for example, “the waiter was extremely rude to Jack” is atypical but still fits within the general script for eating out. However, “Jack put a pen in his pocket” is atypical when eating out but also is not relevant to the eating-out script. Age differences were minimized when participants could make use of preexisting knowledge, such that recall of atypical-relevant events showed a smaller age difference than atypical-irrelevant ones and recall of typical-relevant events showing the smallest age difference (Hess & Tate, 1992; see also Hess, Donley, & Vandermaas, 1989).

***Theoretical explanations for age-related overreliance on schemas.*** Older adults’ tendency to overrely on schemas is consistent with dual-process theories of aging, which make a distinction between controlled and automatic processing. As described earlier, older adults have deficits in controlled processing, which translate into difficulties with encoding and retrieving episodic memories ( Craik, 1986; Hess, 2005). But knowledge has been characterized as being applied automatically (e.g., Craik & Jennings, 1992; Light, 1991, 1992), with knowledge coming online whenever applicable (e.g., Balota et al., 2000; Hess et al., 1998; Lachman & Lachman, 1980; Light, 1991, 1992; Naveh-Benjamin, Craik, Guez, & Krueger, 2005). As a result, schemas are automatically accessed and applied when people try to understand the world (Hess, 1990; Labouvie-Vief & Schell, 1982). Older adults seem to be particularly likely to do so and may then overcompensate for potential deficits in the efficiency of controlled processes related to memory (Hess, 1990; Wingfield & Stine, 1991).

***Summary.*** Older adults overrely on their domain-specific knowledge and existing schemas. Such prior knowledge can lead to memory errors, as rememberers struggle to ignore and inhibit previous knowledge and learn new information. This reliance is consistent with the relative sparing of automatic processes in old age, as compared

with declining controlled processes. However, the same overreliance on knowledge can bolster older adults’ memories to the level of younger adults and even protect older adults from acquiring erroneous knowledge. As long as older adults’ stored knowledge is accurate, which it often is (B. L. Schwartz, 2002), these protective benefits are likely to occur alongside any costs.

## **Selected Open Questions and Future Directions**

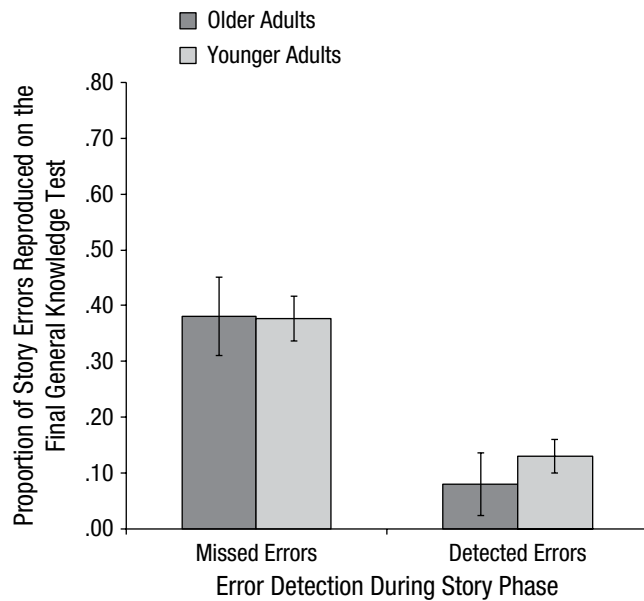
Although it is clear that prior knowledge affects older adults’ remembering, a number of open questions remain with surprisingly few data to resolve them. Basic questions about aging and memory—including “Does prior knowledge have more of an influence on encoding or retrieval or an equal effect on both?”—remain unanswered. Our discussion focuses on open questions for which the literature allows some speculation.

### ***Are episodic memory failures required for reliance on prior knowledge?***

Prior knowledge clearly plays a role when older adults cannot remember the details of an encounter (i.e., an episodic memory failure). The question addressed here is whether it is only when such memory is lacking that people rely on prior knowledge to fill in the gaps (e.g., Bayen, Nakamura, Dupuis, & Yang, 2000; Jacoby, 1999; Spaniol & Bayen, 2002). By this account, older adults rely on prior knowledge more than do younger adults because older adults have more gaps in their memories that need to be filled. Some of the work reviewed above draws on this “strategic guessing” or “accessibility bias” (Jacoby, Marsh, & Dolan, 2001) explanation of older adults’ memory performance (e.g., Mather et al., 1999).

Some of the strongest evidence for this position comes from Hay and Jacoby (1999), who made this argument using a simple paradigm to study what the authors termed “habits” (people’s tendencies to respond in a particular way, based on past experience). To create “habits,” participants experienced an initial learning phase wherein a stimulus word (e.g., *knee*) was presented with one related word (e.g., *bone*) more often than another (e.g., *bend*). Then participants studied a list of specific pairs and later took a cued recall test on this second list (*knee*—\_\_\_; see also Jacoby, Bishara, Hessels, & Toth, 2005). Older adults were impaired at remembering the critical list and especially had trouble when the to-be-remembered responses contradicted the habits set up earlier in the experiment. Older adults showed a deficit in recollection, meaning a difficulty in recalling the specific pairs from the critical list, but were no different from younger adults in relying on habit (and thus showed no additional benefit when





**Fig. 3.** Proportion of story errors reproduced on the final general knowledge test as a function of age and whether errors were detected. Adapted from Umanath and Marsh (2012). The error bars reflect standard errors.

remembering pairs that were habit consistent). In other words, older adults relied on habit (the authors' equivalent of prior knowledge) only after failing to recollect the specific word pair and having to guess (see also Jacoby, Debner, & Hay, 2001; Jacoby, Hessels, & Bopp, 2001).

However, is it necessary for older adults (and others) to experience an episodic memory failure in order to rely on their prior knowledge? It is interesting to note that there are numerous counterexamples showing that prior knowledge is important for remembering in old age even without a failure of episodic memory (e.g., Hess & Follett, 1994; Koutstaal, 2003; Koutstaal et al., 2003). For example, when asked to recall a story, younger adults were more likely to add to and distort the story when their overall recall was poor; in contrast, older adults were more likely to include such additions when their recall was good (S. W. Smith, Rebok, Smith, Hall, & Alvin, 1983). The authors suggested that these deviations in older adults' story recall were unlikely to be due to inability to remember story details but, instead, due to processing differences (see Adams, 1991; Adams, Smith, Nyquist, & Perlmutter, 1997). Similarly, episodic memory deficits did not drive the surprising finding that older adults were less likely than younger adults to use story errors (e.g., the Atlantic is the largest ocean) to answer later general knowledge questions (Umanath & Marsh, 2012). To examine whether the errors were encoded during story reading, participants were asked to press a key each time they noticed an error. The focus here is on missed errors, which may or

may not have been encoded. If an age-related deficit in episodic memory drove later suggestibility, older adults should have reproduced fewer missed errors than their younger counterparts. Instead, older and younger adults were equally likely to use missed story errors to answer later general knowledge questions (see Fig. 3; Umanath & Marsh, 2012).

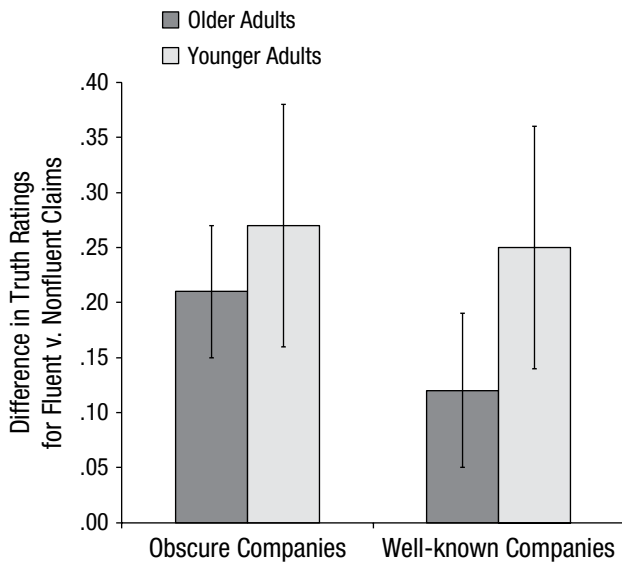
Prior knowledge can even enhance older adults' recollection in remembering, promoting memory for vivid details and rich contextual information. In younger adults, "remember-know" judgments have been used to support claims that prior knowledge can benefit recollection, with participants instructed to label experiences of vivid detailed remembering as "remembered" and experiences of general familiarity without specific details as "known." For example, people with greater knowledge of Star Trek are more likely to later say they "remembered" sentences from recently read short stories about the show, indicative of recollection, as compared with novices (Long & Prat, 2002). Extending these ideas to aging, consider older and younger adults' remember-know judgments when making recognition judgments about studied and unstudied names of actors (Toth et al., 2011). Critically, prior knowledge was manipulated through the era of the actors' fame: 1950s or 1990s, with the assumption that older adults would have more knowledge of 1950s actors than younger adults, and vice versa for the 1990s actors. As expected, older adults correctly recognized more names of 1950s actors than did younger adults, but, in an interesting finding, they also ascribed significantly more "remember" judgments (and less "know" judgments) to the 1950s names than did younger adults (for a similar finding using odor stimuli, see Larsson, Oberg, & Bäckman, 2006).

Overall, even though older adults clearly use prior knowledge to fill in the gaps given an episodic memory failure, we argue that such failures are not a prerequisite for reliance on prior knowledge. Furthermore, prior knowledge can even promote older adults' recollection, bolstering their phenomenological feelings of remembering (as opposed to knowing).

### ***Do the effects of prior knowledge depend on a match between new content and stored knowledge?***

It is unsurprising that prior knowledge often supports accurate remembering in highly valid environments (see Kahneman & Klein, 2009), where what an individual needs to remember matches the individual's expectations of the situation (e.g., when grocery prices are realistic; Castel, 2005). Just as highly valid situations promote smart decision making in professionals (Kahneman & Klein, 2009) and older consumers (Yoon, Cole, & Lee, 2009),





**Fig. 4.** Differences in truth rating values for fluent versus nonfluent claims as a function of age and prominence of companies referenced in claims. Adapted from Parks and Toth (2006: Experiment 2). The error bars reflect standard errors.

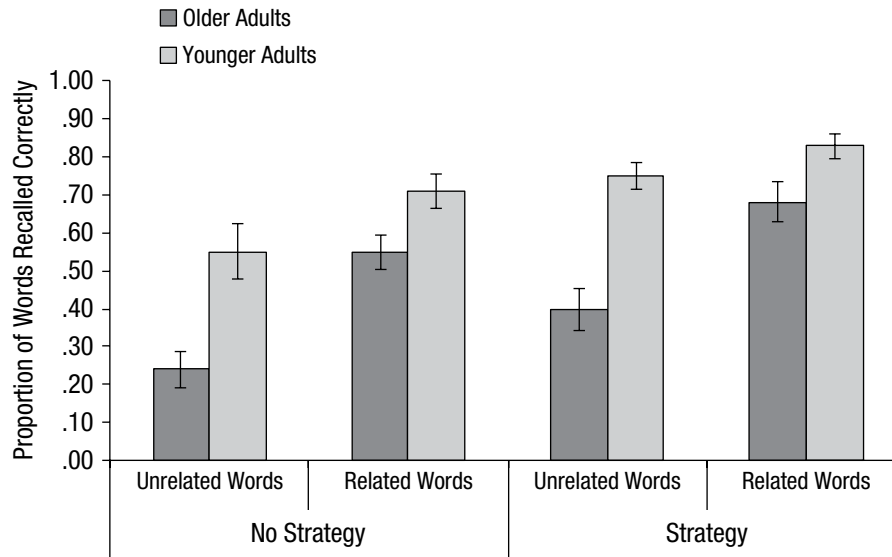
they may promote the use of prior knowledge to support remembering. Conversely, highly invalid situations may promote resistance to suggestibility because the new to-be-learned information contradicts older adults' knowledge. So the simple explanation about the relationship between aging and suggestibility involves match: Older adults will be more suggestible to the extent that prior knowledge matches or otherwise supports a memory error, but they will be less suggestible to the extent that prior knowledge contradicts the memory error. Earlier, we reviewed how older adults are particularly susceptible to the DRM illusion (misremembering related nonpresented words at a higher rate than younger adults) but less suggestible when faced with stories that contain misleading information about the world. In the DRM paradigm, the false memory arises from the schema of the list, meaning that prior knowledge supports the error. In contrast, in the learning from fiction paradigm, the error contradicts stored knowledge, meaning that prior knowledge helps the learner to resist misinformation.

However, the influence of prior knowledge on older adults' suggestibility seems to be more complicated than just a match versus mismatch situation. The most relevant data involve the illusory truth effect, whereby people rate easy-to-process statements as truer than ones that are more difficult to process (Begg, Anas, & Farinacci, 1992; D echene, Stahl, Hansen, & Wanke, 2010; Hasher, Goldstein, & Toppino, 1977; M. Schwartz, 1982). For example, having seen a statement earlier makes it easier to read the second time, and this eased reading is interpreted as evidence for truth (because on average true

items have been encountered more frequently than false ones; Unkelbach, 2006). Although rarely studied in older adults, some data suggest that prior knowledge could make older adults less vulnerable to the illusory truth effect (Parks & Toth, 2006). Participants read statements that were either embedded in conceptually related paragraphs (making them easier to read) or incongruent paragraphs. Critically, half of the statements referenced well-known companies (e.g., "National Geographic photographers are not allowed to enhance their pictures through computer technology") and half referred to lesser-known companies (e.g., "ViewSonic's UltraSlim computer monitor is less than three inches thick"). As is typical of studies on illusory truth, the statements were of ambiguous truth value such that participants were unlikely to already know whether the statements were true or false. Younger adults showed the illusory truth effect regardless of company familiarity, rating easier-to-read statements as truer than statements from incongruent paragraphs. In contrast, older adults showed a trend toward a reduced truth effect when the statements referenced well-known companies (see Fig. 4). This finding suggests that prior knowledge can potentially serve a protective function even when it does not directly contradict information that can influence older adults' judgments. The influence of prior knowledge on suggestibility should not be reduced to simple situations of match versus mismatch, although more research on this intriguing question is needed.

### ***When do older adults need to be instructed to rely on their prior knowledge?***

It is unclear when older adults will spontaneously apply knowledge versus need to be instructed to apply knowledge. Consider a study that illustrates both a spontaneous benefit from knowledge as well as the need for instruction. Participants learned related (e.g., *cat-paws*) and unrelated pairs (e.g., *cat-pencil*); the relatedness of the pairs reflects stored knowledge (Naveh-Benjamin et al., 2005). Critically, half the participants were told to use a meaning-based strategy when encoding the words (creating a sentence or image linking each pair of words). Control participants were simply told to remember the pairs. Both older and younger adults benefited from the meaning-based strategy, but regardless of the strategy instruction, older adults benefited more than younger adults when the to-be-remembered words were related (see Fig. 5; Naveh-Benjamin et al., 2005). This study captures the current state of the literature: Sometimes older adults spontaneously apply knowledge (e.g., taking advantage of the relatedness of the word pairs), and other times they need to be instructed to do so (e.g.,



**Fig. 5.** Proportion of correctly recalled words as a function of age, strategy instruction, and relatedness of words in studied word pairs. Adapted from Naveh-Benjamin, Craik, Guez, and Krueger (2005). The error bars reflect standard errors.

requiring instructions that direct their attention toward meaning).

There are many examples of older adults requiring explicit instruction to use meaning-based strategies. For example, older adults remembered more words when explicitly told to categorize them than when no instruction was given (Hultsch, 1971, as cited by Botwinick, 1984; see also Ceci & Tabor, 1981). Age differences disappeared in a pattern-learning task when older adults were told that the relationships among new stimuli fit an explicit analogue of a familiar pattern (e.g., rock–paper–scissors whereby rock “crushes” scissors, scissors “cuts” paper, etc.; Ostreicher, Moses, Rosenbaum, & Ryan, 2010). Having the analogue differentially improved older adults’ performance compared with younger adults. More broadly, instructing older adults to apply knowledge-based strategies can be viewed as a type of environmental support (external cues that support memory; Craik, 1983, 1986), reducing or eliminating age differences on episodic memory-based tasks (Bäckman & Nilsson, 1985; Glisky & Glisky, 1999; Laurence, 1967a, 1967b; see also Charness & Bosman, 1995).

However, we have already described numerous counterexamples: Older adults sometimes spontaneously apply their knowledge to facilitate remembering, such as when they used their knowledge of grocery prices and house layouts to support memory. Of course, it is not clear whether this application is deliberate or automatic, but what is clear is that it happens. We provide one more example here, to make the point. In Caplan and Schooler (2001), older and younger adults read pairs of conceptually related passages (meaning they shared underlying

deep structure); however, only some of the pairs were topically similar. For example, passages on the functioning of the mind and the functioning of microcomputers described different topics but were conceptually parallel. When passages were topically dissimilar and had no titles to guide understanding, younger adults remembered less than did older adults. The authors suggested that older adults were more likely to have spontaneously brought to bear their knowledge and noticed the parallels between the passages, benefiting memory.

This puzzle of why older adults spontaneously apply (and rely on) their preexisting knowledge in some situations but require explicit instructions in other cases is consistent with the state of the literature on aging and metamemory. Given that older adults have intact general knowledge about the way that memory works (as discussed above), it follows that older adults should be capable of spontaneously applying their knowledge. Conversely, because appropriately applying such strategies may require a variety of control processes that are impaired in aging, it is not surprising that older adults sometimes need to be explicitly instructed to use their preexisting knowledge.

### ***Is there anything “special” about older adults, or are they simply knowledge experts?***

As described in the “Intact Aspects of Memory in Aging” section, older adults who are domain experts often do not show age-related decrements in performance related to memory, problem solving, and other work-related

skills in their domain of expertise (e.g., Castel, 2007; Charness, 2000; Colonia-Willner, 1998, 1999; Krampe & Ericsson, 1996; Morrow et al., 1994; Salthouse, 1984; Shimamura et al., 1995; for exceptions, see Meinz & Salthouse, 1998; Salthouse, 1990). Regardless of age, expertise specifically facilitates episodic memory across many situations: Compared with novices, chess experts are better at remembering valid midgame chess positions (Chase & Simon, 1973); skilled electronics technicians are better at remembering circuit diagrams (Egan & Schwartz, 1979); and hiking experts are better at discriminating between studied and new dangerous mountain scenes (Kawamura, Suzuki, & Morikawa, 2007). So the question is, should we simply characterize older adults as knowledge “experts” who show the same types of effects in episodic memory as other experts?

The effects observed with older adults sometimes parallel the patterns observed in experts. Both older adults and experts show better memory performance in their domain of knowledge but are also more likely to misremember things as consistent with that knowledge base. For example, given a list of animal names, college-age football experts remembered more names that corresponded to football teams (e.g., rams, bears) than did nonexperts, but they also made more errors (e.g., falsely remembering nonpresented names, such as “dolphins”; Castel, McCabe, Roediger, & Heitman, 2007). Similar effects have been documented with investment experts (Baird, 2003) and gaming experts (Mehta, Hoegg, & Chakravarti, 2011).

If older adults are simply knowledge experts, then age differences should be eliminated when older and younger adults are matched in their stored knowledge. However, this is not always the case. For example, Salthouse (1984) found that older expert typists made fewer transposition errors (e.g., typing “word” as “wrod”) than younger expert typists. Similarly, as described earlier, older and younger adults performed quite differently on the Moses Illusion, even when they both had the necessary knowledge stored in memory (Umanath et al., 2014). Of course, conditionalizing memory performance on the knowledge check does not mean that knowledge was equally strong in older and younger adults, but these data provide initial evidence that having knowledge is not enough for younger adults to look like older adults.

It may actually be impossible to decouple age and expertise. For example, consider a study of expert pianists (Krampe & Ericsson, 1996). Older adult experts were often just as good as younger expert pianists at remembering and playing complicated sets of keystrokes, but the older experts reported having significantly more accumulated practice. This explanation for the lack of an age difference demonstrates an innate confound: Older adults have (a) been exposed to the domain material for

many more years and (b) likely been experts on the material for many more years than any younger adult expert comparison group. This confound is difficult to eliminate. Even if younger and older adults show the same level of knowledge, there can always be the counterargument that older adults have “stronger” expertise because of more years of exposure (e.g., Salthouse, 1984). Creating expertise in the laboratory is not a reasonable solution, as equating learning is a challenge, and expertise takes years to develop. Because of these obstacles, it may not be possible to empirically answer the question of whether age effects are any different from expertise in knowledge.

## A Compensatory Mechanism

When considering memory compensation, the reader may think of external memory aids, such as calendars, alarm clocks, and Post-it notes, which are in fact commonly used by older adults (Bäckman, 1985; Dixon & de Frias, 2007; Dixon, de Frias, & Bäckman, 2001; Dixon, Hopp, Cohen, de Frias, & Bäckman, 2003; Glisky & Glisky, 1999; Lovelace & Twohig, 1990). More generally, the literature focuses on how external cues in the environment can support remembering in aging (Bäckman & Nilsson, 1985; Glisky & Glisky, 1999; Laurence, 1967a, 1967b; see also Charness & Bosman, 1995), as reflected in Craik’s environmental support hypothesis (1983, 1986). However, compensation can be much broader than that. Bäckman and Dixon’s (1992) define compensation as “the development and use (automatic or deliberate) of existing or latent skills to maintain or surpass normal levels of proficiency” (described in Charness & Bosman, 1995, p. 148). Older adults do report using internal memory aids (cognitive strategies) to boost memory, including concentrating harder, using imagery, mentally rehearsing the to-be-remembered material, purposefully encoding contextual information to help reconstruct material later, elaborating on material, mentally sorting information, and attempting to create connections to one’s knowledge base (Cavanaugh, Grady, & Perlmutter, 1983; see Lovelace & Twohig, 1990, for other internal mnemonic strategies). Such reports are in line with older adults’ intact general knowledge of how memory works (Bruce et al., 1982; Cavanaugh & Poon, 1989; Dixon et al., 1988; Hultsch et al., 1988; Perlmutter, 1978).

So how should we answer the question “can acquired knowledge compensate for age-related declines in cognitive efficiency?” (Charness, 2000, p. 99). Our present answer is “sometimes,” and particularly unclear are the requirements that need to be in place to capitalize on older adults’ preserved knowledge (e.g., see **Selected Open Questions and Future Directions** earlier in this article). A key direction for future research should be

figuring out how to use older adults' preserved knowledge as a foundation for memory interventions. Like many other researchers (e.g., Arbuckle, Vanderleek, Harsany, & Lapidus, 1990; Bäckman, 1985, 1989; Borella et al., 2009; Glisky & Glisky, 1999; Labouvie-Vief & Gonda, 1976; Reyna & Mills, 2007; Woodruff-Pak & Hanson, 1995), Bäckman (1985, p. 197) says that "practically no experiments have been run focusing on the relation between semantic memory abilities and episodic remembering." Though Bäckman's article was written in 1985, it does not seem that work has progressed that much in investigating this issue directly.

## Conclusions

We have reviewed a broad literature to demonstrate that older adults often use their prior knowledge when attempting to remember events and the details of those events. From an anthropological perspective, an increased reliance on knowledge with age may reflect a potential shift in memory function from knowledge acquisition (i.e., new learning) to knowledge dissemination (Hess, 2005; Hess & Pullen, 1996; Mergler & Goldstein, 1983). In this context, remembering the details of specific events is less important (R. N. Butler, 1974; G. D. Cohen, 2005; Mergler & Goldstein, 1983), and instead, memory is more affected by values, goals, prior knowledge, and emotion (Castel, 2008; Fung & Carstensen, 2003; Hess, 2006). The application of prior knowledge plays out in both negative and positive ways; it can lead the rememberer astray but can also support veridical memory. Sometimes knowledge compensates for age-related declines in episodic memory, helping older adults match or even surpass the performance of younger adults. Of note is that such effects are not limited to memory but extend to stereotyping (e.g., Radvansky et al., 2010), consumer behavior (e.g., Yoon, 1997; Yoon et al., 2009), and social cognition more generally (e.g., Hess, 2006; Hess & Follett, 1994; Hess & Kotter-Grühn, 2011; Hess & Pullen, 1994).

One important issue is whether to characterize older adults' reliance on knowledge as a benefit or a cost; is it that older adults benefit from relying on knowledge or are impaired when they cannot use it? The aging and memory literature tends to emphasize the latter, "glass half empty" perspective; we focus on the former, "glass half full" perspective, which could have cascading benefits for the field and for older adults' everyday memory experiences. Many literatures have these kinds of varying perspectives, where the same data or domain can yield entirely different interpretations. For example, consider the treatment of heuristics and biases in the decision-making literature. Some researchers focus on how these heuristics can lead us to make errors (i.e., errors of

intuitive judgment; e.g., Tversky & Kahneman, 1974), whereas others focus on how such heuristics can support decision making (i.e., the marvels of experts; e.g., Klein, Calderwood, & Clinton-Cirocco, 1986). Kahneman and Klein (2009), two strong advocates for the different perspectives respectively, concluded that both positions are true. Similarly, returning to the contrasting views at hand, both positions are likely true, depending on various factors. Regardless of whether the glass-half-full or glass-half-empty perspective is taken here, the bottom line is that older adults are often capable of matching (and sometimes outperforming) younger adults when prior knowledge can be used.

This review provides a number of directions for future research. First, we need to understand when knowledge supports veridical remembering versus leading the rememberer astray. Second, we need to understand when older adults will spontaneously apply (and rely on) their preexisting knowledge versus when they need instruction to do so. Third, we need to find a way to disentangle expertise effects from age effects. Most critically, future research must investigate the benefits of relying on prior knowledge, examining its potential as a compensatory tool. Just like people in any other stage of development, older adults have limitations that they must learn to cope with, and as researchers, it is imperative that we pursue the possibility that intact knowledge may provide a tool for optimizing memory in aging.

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